

Homework (due Friday) 4.5c, 4.39, 5.51

Announcements:

- Friday will be review
- Remember, for midterm on Monday you should bring calculator and one sheet of notes. No cell phone use!
- No discussion on Monday

Chapter 4 and Section 5.5

Gathering Useful Data for Examining
Relationships
and
Correlation Does Not Prove
Causation

Research Studies to Detect Relationships

Observational Study:

Researchers *observe* or question participants about opinions, behaviors, or outcomes. Participants not asked to do anything differently.

Experiment:

Researchers *manipulate* something and measure the effect of the manipulation on some outcome of interest.

Randomized experiment: The participants are *randomly assigned* to participate in one condition or another, or if they do all conditions the *order* is randomly assigned.

Examples (details given in class)

Are these experiments or observational studies?

1. Mozart and IQ
2. Drinking tea and conception (p. 721)
3. Autistic spectrum disorder and mercury
<http://www.jpands.org/vol8no3/geier.pdf>
4. Aspirin and heart attacks (Case study 1.6)

Who is Measured: Units, Subjects, Participants

- **Unit:** a single individual or object being measured once.
 - If an experiment, then called an **experimental unit**.
 - When units are people, often called **subjects** or **participants**.
- Examples:
Students, women, autistic children, physicians

Explanatory and Response Variables

Explanatory variable (or *independent* variable) is one that may explain or may cause differences in a **response variable** (or *outcome* or *dependent* variable).

Explanatory	Response
Mozart, etc.	IQ
Drank tea or not	Conceived or not
Mercury level	Autistic or not
Aspirin or placebo	Heart attack or not

Confounding variables

A **confounding variable** is a variable that:

1. *Affects the response variable* and also
2. *is related to the explanatory variable*.

A potential confounding variable not measured in the study is called a **lurking variable**.

Confounding variables and causation

- **Randomized experiments:**
Confounding variables should be averaged out over the different treatment groups, so we *can* conclude change in explanatory variable *causes* change in response variable.
- **Observational studies:**
Confounding variables may explain an observed relationship between the explanatory and response variables, so we *cannot* conclude that a change in the explanatory variable *causes* a change in the response variable.

Examples: Confounding variable *affects* response, is *related* to explanatory variable

- Tea and conception: Possible confounding variable is drinking coffee:
 - It might *affect* probability of conception, and
 - It differs for tea drinkers and non-tea drinkers
- Autism and mercury: Possible confounding variable is genetic ability to shed mercury:
 - Same genetic pool may be more prone to autism
 - It would result in different mercury levels

Designing a good experiment

- Who participates? Can results be extended to a population?
- How are the units randomized to treatments?
- What controls are used?
- Should pairs, blocks, and/or repeated measures be used?

Who Participates in Randomized Experiments?

Participants are often **volunteers**.

Recall **Fundamental Rule for Inference**:

Available data can be used to make inferences about a much larger group *if the data can be considered to be representative with regard to the question(s) of interest.*

Volunteer group often meets this criterion.

Randomization: The Crucial Element to Rule out Confounding Variables

Randomizing the Type of Treatment:

Randomly assigning the treatments to the experimental units keeps the researchers from making assignments favorable to their hypotheses and also helps protect against hidden or unknown biases.

Ex: Physicians were randomly assigned to take aspirin or placebo.

Randomizing the Order of Treatments:

If all treatments are applied to each unit, randomization should be used to determine the *order* in which they are applied.

Ex: Order of listening conditions randomly assigned.

Control Groups and Placebos

Control Groups:

Treated identically in all respects except they don't receive the active treatment. Sometimes they receive a dummy treatment or a standard/existing treatment. Ex: Silent condition

Placebo:

Looks like real drug but has no active ingredient. Ex: Placebo looked just like aspirin

Placebo effect = people respond to placebos.

Blind, double blind; Double dummy

Blinding:

- **Single-blind** = participants do not know which treatment they have received.
- **Double-blind** = neither participant nor researcher making measurements knows who had which treatment.

Double Dummy: When treatments can't be blind

- Each group given two "treatments"...
- Group 1 = real treatment 1 and placebo treatment 2
- Group 2 = placebo treatment 1 and real treatment 2

Example: Compare nicotine patches and nicotine gum to quit smoking

Group 1: Nicotine patch + placebo gum

Group 2: Placebo patch + nicotine gum

Examples:

- Aspirin and heart attacks
 - Double blind. Neither the physicians participating nor their health assessors knew who had aspirin.
- Mozart and IQ
 - Single blind at best. Obviously students knew which condition they just had. Hopefully the person administering the IQ test didn't know.

Pairing, Blocking and Repeated Measures

Matched-Pair Designs

Use either two matched individuals or same individual receives each of two treatments. Special case of a *block design*. Important to randomize order of two treatments and use blinding if possible.

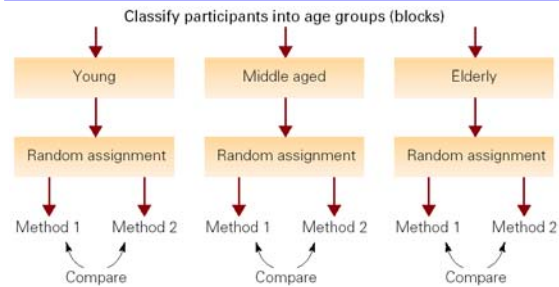
Block Designs – More efficient if units quite variable

Experimental units divided into homogeneous groups called **blocks**, each treatment randomly assigned to one or more units in each block. Goal: *Small* natural variability within blocks.

Repeated-measures designs

Blocks = individuals and *units* = repeated time periods in which they receive varying treatments (Mozart example)

Example from book: Compare two memorization methods, block by age



Terminology for various designs

■ Completely randomized experiment

- No blocks, no matched pairs, no repeated measures. Randomly assign a certain number of units to receive each treatment. Aspirin example.

■ Randomized block design

- Divide units into groups (blocks) of similar units; randomly assign treatments within each block. Ideal is one unit per block gets each treatment.

Special cases:

- Repeated measures: Each individual is his/her own block
- Matched-pairs design: Two units per block, same individual or matched to be similar (e.g. twins, same IQ, etc.)

Nicotine patch example:

- Who were the participants?
- Completely randomized experiment? Randomized block experiment? Repeated measures experiment? Matched pairs?
- Single blind, double blind, or neither?
- Control group, placebo, both, neither?

4.3 Designing a Good Observational Study

- **Disadvantage:** more difficult to try to establish causal links.
- **Advantage:** more likely to measure participants in their natural setting.
- It isn't always possible to do an experiment, for ethical or practical reasons.

Types of Observational Studies: Retrospective/ Prospective Case-control/ Cross sectional

Retrospective: Participants are asked to recall past events.
Example: Myopia study asked parents to recall infant night-light.

Prospective: Participants are followed into the future and events are recorded.
Example: Tea-drinking study, women kept food diaries for a year.

Case-Control Studies: A sample of "Cases" who have a particular attribute or condition are compared to "controls" who do not, to see how they differ on an explanatory variable of interest. The "case-control" variable is *usually* the response variable. (Example: Autism or not is the *response* variable.)

Cross-sectional Studies: Sample taken, then classified.

Advantages of Case-control Studies compared to "cross-sectional" studies

- Efficiency – may not get enough cases otherwise
 - Autism and mercury example. If they had chosen a sample of kids (cross-sectional) and measured mercury and whether they had autism, they would have had few autism cases.
- Reduction of potential confounding variables
 - Controls often chosen to be as similar to cases as possible in all other ways. For example, for cancer studies, possibly use a sibling or close friend of the cancer case (matched pairs). Idea is to have similar genetics and lifestyle.

Case Study 4.4 Baldness and Heart Attacks

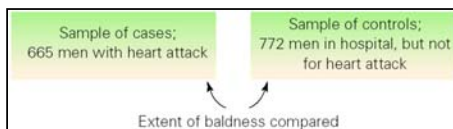
"Men with typical male pattern baldness ... are anywhere from 30 to 300 percent more likely to suffer a heart attack than men with little or no hair loss at all." *Newsweek, March 9, 1993, p. 62*

Case-control study

Cases = men admitted to hospital with heart attack
Controls = men admitted for other reasons.

Case/control variable: heart attack status (yes or no)

Explanatory variable: degree of baldness



4.4 Difficulties and Disasters in Experiments and Observational Studies

Confounding Variables and the Implication of Causation in Observational Studies

Big misinterpretation = reporting *cause-and-effect* relationship based on an observational study. No way to separate the role of confounding variables from the role of explanatory variables in producing the outcome variable if randomization is not used.

Extending Results Inappropriately

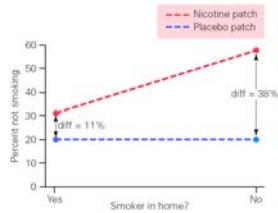
Many studies use convenience samples or volunteers. Need to assess if the results can be extended to any larger group for the question of interest.

Interacting Variables – not the same as confounding variables!

Another variable can *interact* with the explanatory variable in its relationship with the outcome variable. Results should be reported taking the interaction into account.

Example:

The difference between the nicotine and placebo patches is greater when there are no smokers in the home than when there are smokers in the home.



Hawthorne Effect and Experimenter Bias

Hawthorne effect

Participants in an experiment respond differently than they otherwise would, just because they are in the experiment. Many treatments have higher success rate in clinical trials than in actual practice.

Experimenter effects

Experimenters do subtle things unintentionally that help results match desired outcome, such as recording errors in their favor, treating subjects differently, etc. Mostly can be overcome by blinding and control groups.

(See example 4.5 – even mice responded to cues!)

Ecological Validity and Generalizability

When variables have been removed from their natural setting and are measured in the laboratory or in some other artificial setting, the results may not reflect the impact of the variable in the real world.

Example:

Women in the tea-drinking study may have altered their diets because they knew they were being monitored by the experimenters.

Relying on Memory or Secondhand Sources

- Can be a problem in retrospective observational studies.
- Try to use authoritative sources such as medical records rather than rely on memory.
- If possible, use prospective observational studies.

Example 4.7 on whether left-handers die young.

5.5 Correlation Does Not Prove Causation

Possible explanations for correlation:

1. There really is causation.
Ex: x = % fat calories per day; y = % body fat
Higher fat intake *does* cause higher % body fat.
2. Change in x may cause change in y , but confounding variables present as well that make it hard to separate.
Ex: x = parents' IQ; y = child's IQ
Confounded by diet, environment, parents' education level, quality of child's education, etc.

Additional reasons for observed correlation (other than x causes y):

3. No causation. Explanatory and response variables are both affected by other variables
Ex: x = Verbal SAT; y = College GPA
Common cause for both being high or low are IQ, good study habits, good memory, etc.
4. *Response* variable is causing a change in the *explanatory* variable (opposite direction)
Ex: Case study 1.7, x = time on internet, y = depression.
Maybe more depressed people spend more time on the internet, not the other way around.

Using Nonstatistical Considerations to Assess Cause and Effect (see page 707)

Here are some hints that may suggest **cause and effect from observational studies**:

- There is a **reasonable explanation** for how the cause and effect could occur.
- The relationship occurs under **varying conditions** in a number of studies.
- There is a **"dose-response"** relationship.
- Potential **confounding variables** are **ruled out** by measuring and analyzing them.

If statistically significant relationship is found, what can be concluded?

	Sample represents population for question of interest	Sample doesn't represent population
Randomized Experiment	Causal relationship, and can extend results to population	Causal relationship, but cannot extend results to population
Observational Study	Can't conclude causal relationship, but can extend results to population	Cannot conclude causal relationship, and cannot extend results to a population