Announcements:

- Midterm Friday. Bring calculator and one sheet of notes. Can't use the calculator on your cell phone.
- Assigned seats, random ID check.
- Review Wed. Review sheet posted on website.
- Fri discussion is not for credit (Q&A for midterm).
- Week 3 quiz starts at 4pm today, ends Wed at 3.

Homework (due Wed)

Chapter 6: #28, 38, 60

Chapter 6

Gathering Useful Data for Examining Relationships

Research Studies to Detect Relationships

Observational Study:

Researchers *observe* or question participants about opinions, behaviors, or outcomes. Participants are 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. 665)
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.**

Units for the 4 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 probably average 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:
  - In 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 (genetic makeup affects response of autism)
  - It would result in different mercury levels (related to explanatory variable)

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.

Example: Students listening to Mozart.

Example: Male physicians taking aspirin?

Randomization: Used 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*.

Ex: Order of listening conditions randomly assigned.

Replication

Replication in *one experiment*:

Multiple experimental units are assigned to each treatment. Need large sample sizes to get accurate statistical results.

Replication in *science*:

Different experimenters do the same experiment and hopefully get similar results, to make sure the results weren't due to a flaw in the experiment (if it was never replicated).

Control Groups and Placebos

Control group and/or control condition:

Treated identically in all respects except they don't receive the active treatment. Sometimes they receive a *dummy* treatment or a standard or 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 and Double Blind

- **Blinding:**
  - **Single-blind** = participants do not know which treatment they have received *or*
  - **Single-blind** = researcher measuring results doesn't know which treatment each person received, but participants do.
  - **Double-blind** = neither participant nor researcher making measurements knows who had which treatment.

Double Dummy

Used 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.

Block Designs

- **Block Designs – More efficient if units are quite variable**

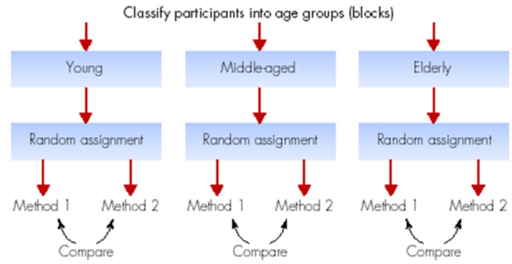
  Experimental units divided into homogeneous groups called **blocks**, each treatment randomly assigned to one or more units in each block.

  Goal: *Small* natural variability within blocks.

Special Cases of Block Designs

- **Matched-Pair Designs**
  Two matched individuals, or same individual, receives each of two treatments. Important to randomize order of two treatments and use blinding if possible.
- **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.
- Don't confuse *random assignment* with *random sampling* (from Chapter 5)

More Terminology

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?

6.3 Designing a Good Observational Study

- **Disadvantage:** more difficult to establish causal links; possible confounding variables.
- **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

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.

Types of Observational Studies:
Case-control/ Cross sectional

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 as possible to cases 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.

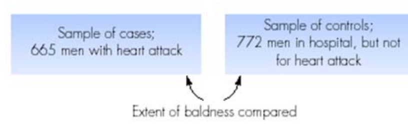
Case Study 6.4 *Baldness and Heart Attacks*

"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 (Case/Control is *response variable*)
Cases = men admitted to hospital with heart attack
Controls = men admitted for other reasons.

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

Explanatory variable: degree of baldness



Why relative risk often doesn't make sense, and must use odds ratio instead

	Heart attack	No heart attack	Total
Baldness	279	263	542
No baldness	386	509	895
Total	665	772	1437

The *column totals* were *chosen* to be about equal, so about equal numbers with and without heart attacks. Risk of heart attack if bald is *not* estimated by 279/542 = .515 (over half!). But we *can* compare *odds* of heart attack to no heart attack for bald and not bald.

6.4 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.
- Without randomization there is no way to separate the role of *confounding* variables from the role of *explanatory* variables in producing the response variable.

6.4 Difficulties and Disasters in Experiments and Observational Studies

Extending Results Inappropriately

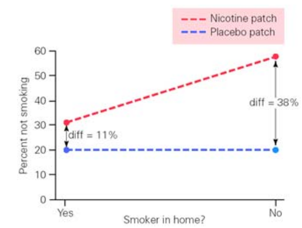
Many studies use convenience samples or volunteers. Need to assess if the results can be extended to any larger group for the question of interest.

Interacting Variables

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

Interacting Variables – not the same as confounding variables!

Example (p. 207): Difference between results for nicotine and placebo patches is greater when there are no smokers in the home than when there are smokers in the home.



Different from confounding variable

- If this had been an *observational study* asking about using nicotine patches, "other smokers at home" would have been a confounding variable
  - Affects response of quitting or not
  - Related to explanatory – using nicotine patches or not
- However, as a randomized experiment, proportion with other smokers at home should be similar for nicotine and placebo patch groups, so *not* related to explanatory variable.

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 6.6 – even rats 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. Less of a problem in observational studies.

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 6.8 on whether left-handers die young.

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

Examples:

	Sample represents population for question of interest	Sample doesn't represent population
Randomized Experiment	Mozart and IQ Nicotine patches	Aspirin and heart attacks: male physicians represent limited population
Observational Study	Autism and mercury Tea and conception	Website surveys, e.g. CNN "Quick Vote"

Homework, Due Wed

6.28
6.38
6.60