

Lecture 4: Chapter 3, Section 4

Designing Studies

(Focus on Experiments)

- Definitions
- Randomization
- Control
- Blind Experiment
- Pitfalls
- Specific Experimental Designs



Looking Back: *Review*

- **4 Stages of Statistics**
 - Data Production
 - Displaying and Summarizing
 - Probability
 - Statistical Inference

Looking Back: *Review*

- 2 Types of Study Design
 - **Observational study:** record variables' values as they naturally occur
 - **Drawback:** **confounding variables** due to self-assignment to explanatory values
 - **Example:** *Men who drink beer are more prone to lung cancer than those who drink red wine*
(what is the confounding variable here?)
 - **Experiment:** researchers control values of explanatory variable
 - *If well-designed, provides more convincing evidence of causation.*



Definitions

- **Factor:** an explanatory variable in an experiment.
 - **Treatment:** value of explanatory variable imposed by researchers in an experiment.
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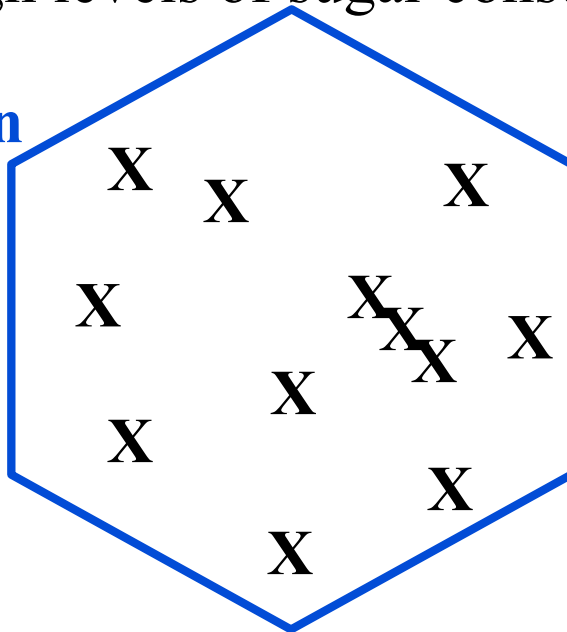
A **control group** (individuals receiving no treatment or base-line treatment) may be included for comparison.

If individuals are human, we call them **subjects**.

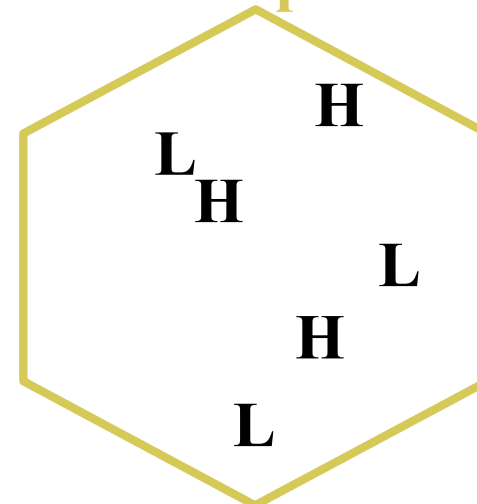
Example: *Randomized Controlled Experiment*

- **Background:** To test if sugar causes hyperactivity, researchers **randomly** assign some children to low and others to high levels of sugar consumption...

Population



Sample

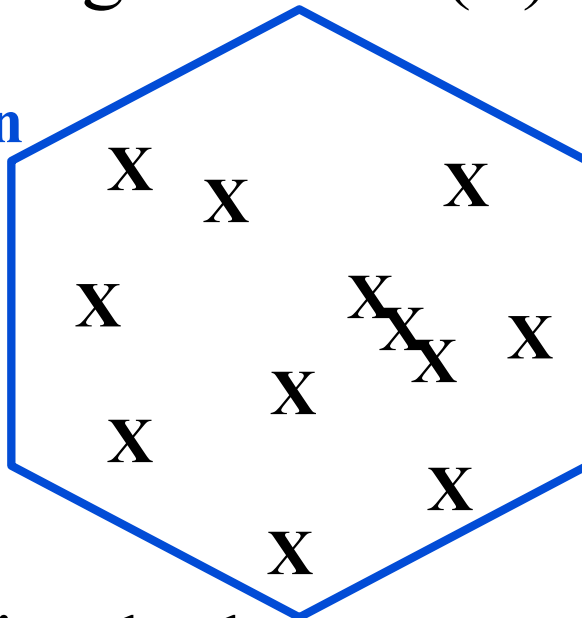


- **Question:** Why are **random** assignments best?
- **Response:** Randomization helps rule out

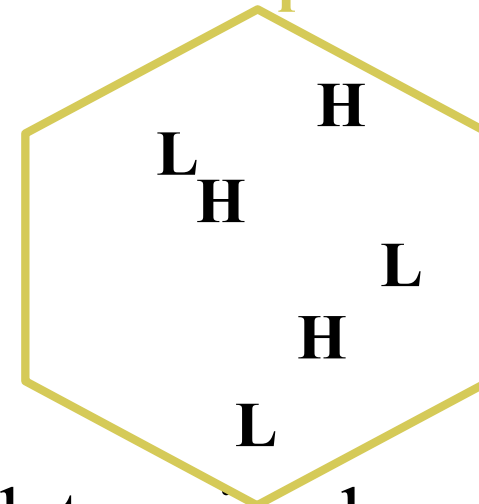
Experiment vs. Observational Study

In an experiment, **researchers** decide who has low sugar intake (L) and who has high (H).

Population



Sample



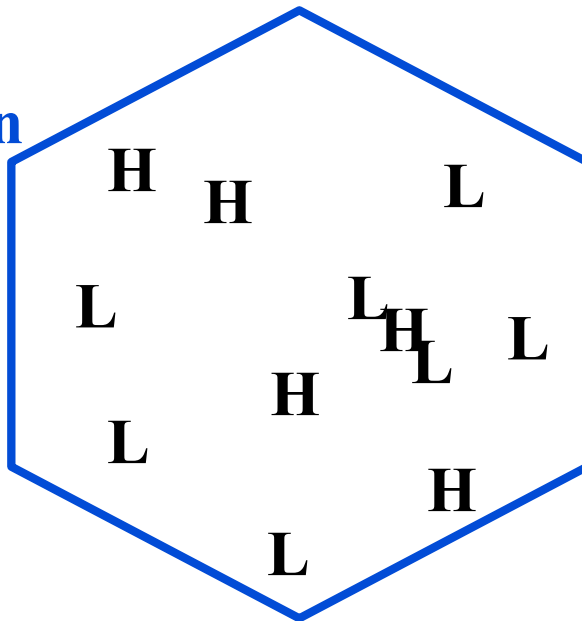
Sugar intake has not yet been determined.

Researchers **assign** sugar intake L or H.

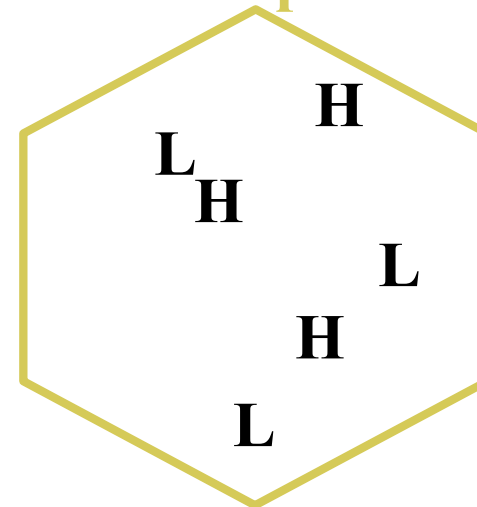
Experiment vs. Observational Study

In observational study, **individuals** have already chosen low (L) or high (H) sugar intake.

Population



Sample



Researchers make **no changes** to sugar intake.

Example: Randomize at 1st or 2nd Stage?

- **Background:** Consider two **selection** issues in our sugar-hyperactivity experiment:
 - What individuals are included in the study?
 - Who consumes low and high amounts of sugar?
- **Question:** At which stage is randomization important?
- **Response:**
 - **1st stage:** Individuals studied _____
(Otherwise _____ may be an issue.)
 - **2nd stage:** Assignment to sugar (L or H) _____
Volunteering which treatment to get is _____



Must an experiment have a control group?

Recall our definition:

- **Experiment:** researchers manipulate explanatory variable, observe response

Thus, experiment may have no control group...

- if all subjects must be treated
- if simulated treatment is risky
- if the experiment is poorly designed

As long as researchers have taken control of the explanatory variable, it is an experiment.



Definitions: Three Meanings of “Control”

- We **control** for a confounding variable in an observational study by separating it out.
- Researchers **control** who gets what treatment in an experiment by making the assignment themselves, ideally at random.
- The **control** group in an experiment consists of individuals who do not receive a treatment per se, or who are assigned a baseline value of the explanatory variable.



Double-blind Experiments

Two **pitfalls** may prevent us from drawing a conclusion of causation when results of an experiment show a relationship between the so-called explanatory and response variables.

- If **subjects** are aware of treatment assignment
- If **researchers** are aware of treatment assignment



Definitions

- The **placebo effect** is when subjects respond to the *idea* of treatment, not the treatment itself.
- A **placebo** is a “dummy” treatment.
- A **blind** subject is unaware of which treatment he/she is receiving.
- The **experimenter effect** is biased assessment of (or attempt to influence) response due to knowledge of treatment assignment.
- A **blind** experimenter is unaware of which treatment a subject has received.

Example: *Subjects Not Blind*

- **Background:** Suppose after children are randomly assigned to consume either low or high amounts of sugar, researchers find proportion hyperactive is greater for those who consumed higher amounts.
- **Question:** Can we conclude sugar causes hyperactivity?
- **Response:**

Practice: 1.2 p.11

Practice: 1.2 p.11

Practice: 1.2 p.11

Improvement:



Example: *Experimenters Not Blind*

- **Background:** Suppose after children are randomly assigned to diets sweetened either artificially or with sugar, researchers find proportion hyperactive is greater for those who consumed sugar.
- **Question:** Can we conclude sugar causes hyperactivity?
- **Response:**

More problematic if responses are assessed

Improvement:



Best Evidence of Causation

In general, conclusions of causation are most convincing if a relationship has been established in a **randomized controlled double-blind experiment**.

***A Closer Look:** In the original studies reporting a relationship between sugar and hyperactivity, conducted in the 1970's, experimenters may have been aware of the children's diet when they assessed behavior (randomized controlled **single-blind**). Many studies since then have failed to establish a relationship.*



Other Pitfalls in Experimentation

- Lack of realism (lack of ecological validity)
- Hawthorne effect (people's performance is improved due to awareness of being observed)
- Non-compliance
- Treatments unethical
- Treatments impractical/impossible to impose

Example: *Hawthorne Effect, Lack of Realism*

- **Background:** Suppose researchers want to determine if TV makes people snack more. *While study participants are presumably waiting to be interviewed, half are assigned to a room with a TV on (and snacks), the other half to a room with no TV (and snacks). See if those in the room with TV consume more snacks.*
- **Question:** If participants in the room with TV snack more, can we conclude that, in general, people snack more when they watch TV?
- **Response:** No: _____
(TV & snacking habits different in contrived setting);
_____ (if people suspect they're observed).

Example: *Non-Compliance in Experiment*

- **Background:** To test if sugar causes hyperactivity, researchers randomly assign 50 children to low and 50 to high levels of sugar consumption; 20 drop out of each group. For remaining children (30 in each group), suppose proportion hyperactive is substantially greater in the high-sugar group.
- **Question:** Can we conclude sugar causes hyperactivity?
- **Response:** _____ makes treatment and control groups different in ways that may affect response.

Example: *Another Flawed Experiment*

□ **Background:** To test if stuttering is a learned (rather than inborn) trait, a researcher in Iowa in 1939 randomly assigned subjects to...

■ Control: 11 orphans in ordinary speech therapy

■ Treatment: 11 orphans badgered and interrupted in sessions with speech therapist

Of the 11 in treatment group, 8 became stutterers.

□ **Question:** What's wrong with this experiment?

□ **Response:** _____



Examples: *Treatments Impossible/Impractical*

- Taller men get married sooner, promoted quicker, and earn higher wages...
- There is a link between obesity and low socio-economic status in women...

Height is impossible to control.

Weight is difficult to control.

Socio-economic status is too costly to control.



Modifications to randomized experiment

- **Blocking:** Divide first into groups of individuals who are similar with respect to an outside variable that may be important in relationship studied.
- **Paired design:** Randomly assign one of each pair to receive treatment, the other control. (*Before-and-after* is a common paired design.)

Looking Back: *blocking is to experimentation as stratification is to sampling.*



Example: *Blocked Experiment*

- **Background:** Study tested theory that use of stronger sunscreen *causes* more time in sun. Before vacation, 40+ students given weak sunscreen, 40+ given strong. Students recorded time spent in sun each day.
- **Question:** How to incorporate **blocking**, if researchers suspect location plays a role in relationship between type of sunscreen and amount of time spent in sun?
- **Response:**



Example: *Paired Experiment*

- **Background:** Study tested theory that use of stronger sunscreen *causes* more time in sun. Before vacation, 40+ students given weak sunscreen, 40+ given strong. Students recorded time spent in sun each day.
- **Question:** How to incorporate **paired design**, if researchers suspect location plays a role in relationship between type of sunscreen and amount of time spent in sun?
- **Response:**



Advantage of Paired Design

The paired design helps to ensure that treatment and control groups are **as similar as possible** in all other respects, so that if their responses differ, we have evidence that the treatment is responsible.

***Discussion Question:** Why do not just twins, but also researchers, flock to the annual festival in Twinsburg, Ohio?*

Example: *Combining Paired and Two-Sample Designs*

- **Background:** Studies often randomly assign one group to a placebo and the other to a drug. Responses to the variable of interest are assessed before and after a period of time, then compared to see benefits or side effects.
- **Question:** What aspect of the design is **two-sample**, and what aspect is **paired**?
- **Response:**
two-sample:
paired:



Lecture Summary (*Experiments*)

- Definitions
- Randomization; 2 stages of selection
- Control group
- “Blind” study design
 - Subjects blind to avoid placebo effect
 - Researchers blind to avoid experimenter effect
- Other pitfalls of experiments: lack of realism, Hawthorne effect, non-compliance, unethical or impractical treatment
- Specific experimental designs
 - Blocked
 - Paired or two-sample