Topic 3: Experiments

Four Principles of Experiment Design

1. **Control**

To account for confounding variables, assign participants to MULTIPLE different treatment groups

Treatment: the explanatory variable you are manipulating

1 group should be **control** (no treatment)

Super-effective: use **matched pairs** of "similar" subjects, put 1 in control and 1 in treatment

Twins make the BEST matched pairs!

2. **Randomize**

Assign subjects RANDOMLY to different groups

Goal: reduce bias, improve control

If using matched pairs, can randomly assign via coin-flip or similar

3. **Replicate**

Show the treatment has effects on MULTIPLE subjects - the more the better!

AND: design your study so that other scientists can easily recreate it

WARNING: if a study cannot be replicated, it loses scientific credibility!

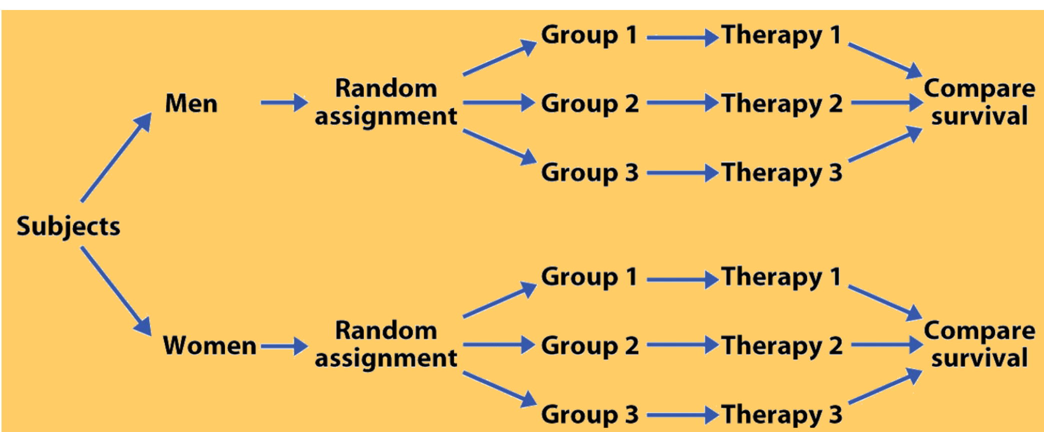
If it isn't REPEATABLE, it isn't BELIEVABLE!

4. **Block**

Experimental equivalent of stratifying

If you think a variable/characteristic is likely to influence outcomes, **BLOCK** subjects by that characteristic BEFORE assigning them to groups!

Block: break up experimental subjects into subsets according to a possible influential variable (**blocking variable)** that is NOT an explanatory variable



Ex: in medical studies, subjects are often blocked by gender because drugs often interact differently with different endocrine systems (hormone production/levels)

Practice: A study is designed to test the effect of light level and air quality on the growth rate of corn. The researcher also believes that light level and air quality might have different effects on corn grown in soil with different acidity levels, so wants to make sure varying soil acidity levels are equally represented in each group. Which of the options below is correct?

(A) There are 3 explanatory variables (light, air, soil) and 1 response variable (corn growth)

(B) There are 2 explanatory variables (light and air), 1 blocking variable (soil), and 1 response variable (corn growth)

(C) There is 1 explanatory variable (soil) and 3 response variables (light, air, corn growth)

(D) There are 2 blocking variables (light and air), 1 explanatory variable (soil), and 1 response variable (corn growth)

More Experiment Design Terminology: Eliminating Bias

- **Placebo**

A **placebo** is a "fake" treatment given to subjects in the control group, so that those subjects do not realize they are in the control group.

In pharmaceutical studies, this is often a "sugar pill"

WARNING: use of a placebo is almost always good scientific practice, BUT can have ethical difficulties in certain circumstances (e.g. "fake surgery")

- **Placebo Effect**

The **placebo effect** is a psychological phenomenon - subjects in a control group with a placebo receive no treatment, but they BELIEVE they are receiving treatment and experience effects that RESEMBLE expected treatment effects.

In experiments, we WANT the placebo effect in the control group! Need to show real treatment is MORE POWERFUL than placebo effect

- **Blinding**

"**Blinding**" refers to the practice of ensuring subjects don't know which group they are in (including the control group)

- **Double-Blind**

A **double-blind** study is one in which anyone CARRYING OUT the experiment (e.g. administering treatment, conducting follow-up interviews, collecting data) is ALSO unaware of which subjects are in which groups

Researchers' own hopes or expectations regarding the outcome of an experiment can shape how they interact with patients - even subconsciously! Double-blinding avoids this possible bias/skew.

(Fun fact: this is called the **Rosenthal effect**.)

Experiments vs. Observational Studies: A Comparison

Design differences lead to causation/correlation split AND generalizability split

Experiments benefit strongly from random sampling... but it's often infeasible, and we have to accept that limitation during design.

ideal experiment

most observational studies

	Random assignment	No random assignment	
Random sampling	Causal conclusion, generalized to the whole population.	No causal conclusion, correlation statement generalized to the whole population.	Generalizability
No random sampling	Causal conclusion, only for the sample.	No causal conclusion, correlation statement only for the sample.	No generalizability
	Causation	Correlation	

most experiments

bad observational studies

Observational studies never have random assignment, so random sampling is the only way to handle bias or confounders.

Big takeaway: Be careful to ONLY draw conclusions that align with your sampling and assignment methods.

More practice: Choose the option(s) below that describe differences between observational studies and experiments.

(A) Experiments take place in a lab while observational studies do not need to.

(B) In an observational study we only look at what happened in the past.

(C) Experiments use random assignment while observational studies do not.

(D) Observational studies are completely useless since no causal inference can be made based on their findings.

(E) Experiments involve active intervention/treatment, while observational studies are passive.