Experimental Design & Random Assignment

- principles of experimental design
- experimental design terminology
- random sampling & random assignment

Principles of experimental design

control	randomize
compare treatment of interest to a control group	randomly assign subjects to treatments

replicate	block
collect a sufficiently large sample, or replicate the entire study	block for variables known or suspected to affect the outcome

More on Blocking

- We would like to design an experiment to investigate if energy gels makes you run faster:
  - Treatment: energy gel
  - Control: no energy gel
- It is suspected that energy gels might affect pro and amateur athletes differently, therefore we block for pro status:
  - Divide the sample to pro and amateur
  - Randomly assign pro and amateur athletes to treatment and control groups
  - Pro/amateur status is equally represented in the resulting treatment and control groups

This way, if we do find a difference in running speed between the two groups, we will be able to attribute it to the treatment, the energy gel, and can be assured that the difference isn't due to pro status, since both pro and amateur athletes were equally represented in the treatment and control groups.

blocking vs. explanatory variables

- explanatory variables (factors)- conditions we can impose on the experimental units.

- blocking variables - characteristics that the experimental units come with, that we would like to control for.

- blocking is like stratifying,
    - blocking during random assignment
    - stratifying during random sampling

Practice

A study is designed to test the effect of light level and noise level on exam performance of students. The researcher also believes that light and noise levels might have different effects on males and females, so wants to make sure both genders are equally represented in each group. Which of the below is correct?

A. There are 3 explanatory variables (light, noise, gender) and 1 response variable (exam performance)

B. There are 2 explanatory variables (light and noise), 1 blocking variable (gender), and 1 response variable (exam performance)

C. There is 1 explanatory variable (gender) and 3 response variables (light, noise, exam performance)

D. There are 2 blocking variables (light and noise), 1 explanatory variable (gender), and 1 response variable (exam performance)

experimental design terminology...

placebo

fake treatment, often used as the control group for medical studies

placebo effect

showing change despite being on the placebo

blinding

experimental units don’t know which group they’re in

double-blind

both the experimental units and the researchers don’t know the group assignment

Practice

What is the main difference 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.

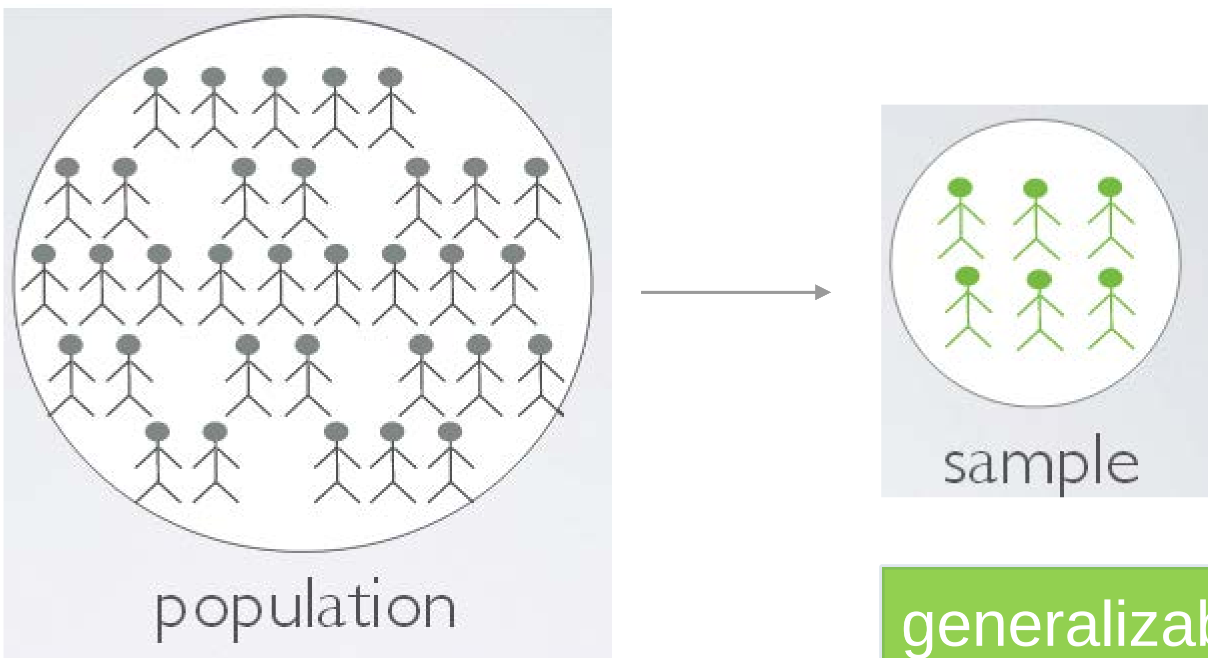
C. *Most experiments use random assignment while observational studies do not.*

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

random sampling

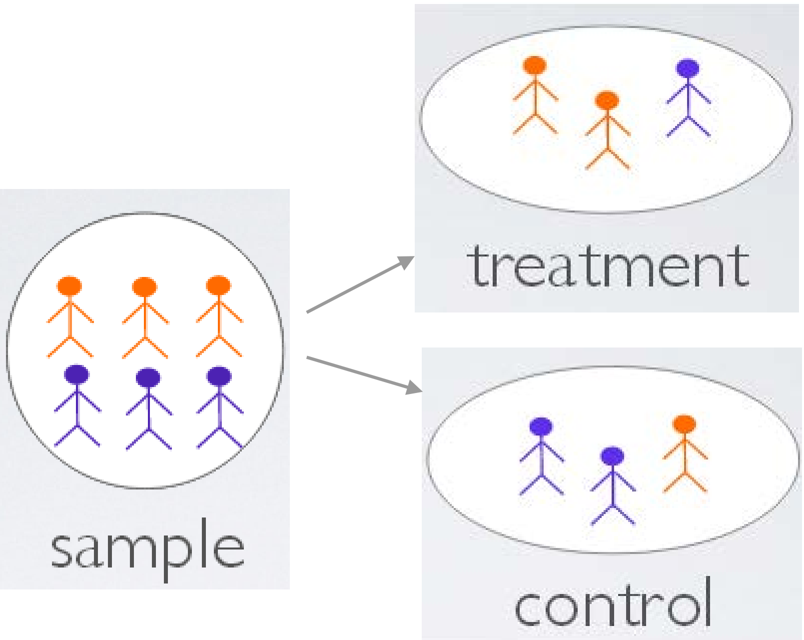
If subjects are selected randomly from the population, then each subject in the population is equally likely to be selected and the resulting sample is likely representative of the population.

Therefore the study's results are generalizable to the population at large.



generalizability

random assignment



causality

- Random assignment occurs only in experimental settings where subjects are being assigned to various treatments.
- The subjects exhibits slightly different characteristics from one another.
- Through a random assignment, these characteristics are represented equally in the treatment and control groups.
- This allows us to attribute any observed difference between the treatment and control groups, to the treatment being imposed on the subjects since otherwise these groups are essentially the same.
- In other words, random assignment allows us to make causal conclusions based on this study.

example

Serif

Sans Serif

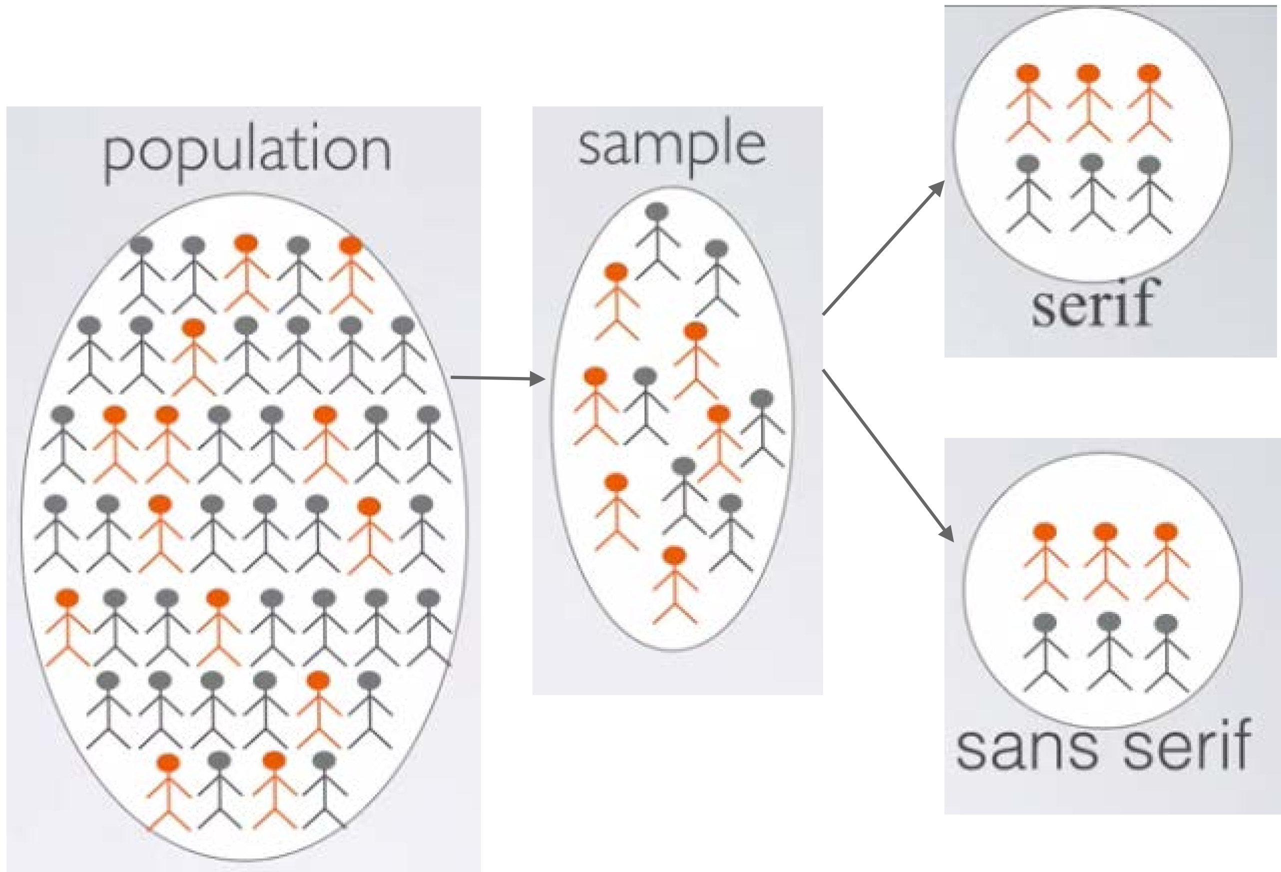
- Suppose we want to conduct a study evaluating whether people read Serif fonts or Sans Serif. In other words, without Serif fonts faster.
- Note that Serifs are these small decorative pieces on the ends of each character.

example

Serif

Sans Serif

- (1) randomly select subjects for your study from your population.
- (2) randomly assign the subjects in your sample to two groups; one where they read some text in serif font and the other where they read the same text in Sans Serif font.

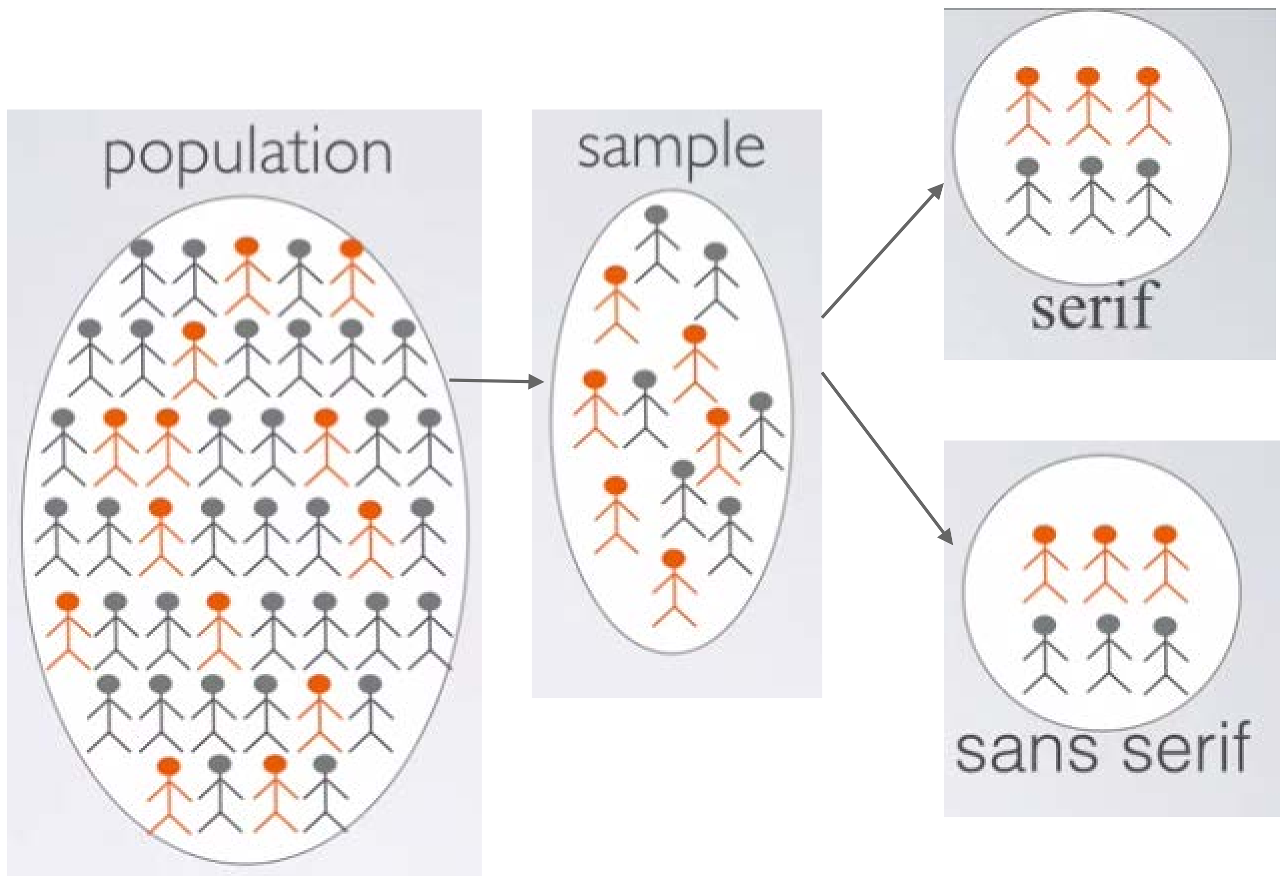


example

Serif

Sans Serif

- Through random assignment, we ensure that other factors that may be contributing to reading speed, indicated here with the different colors for the subject, are represented equally in the two groups. For example, fluency or how often the subject reads for leisure
- We call such variables con-founders or confounding variables.



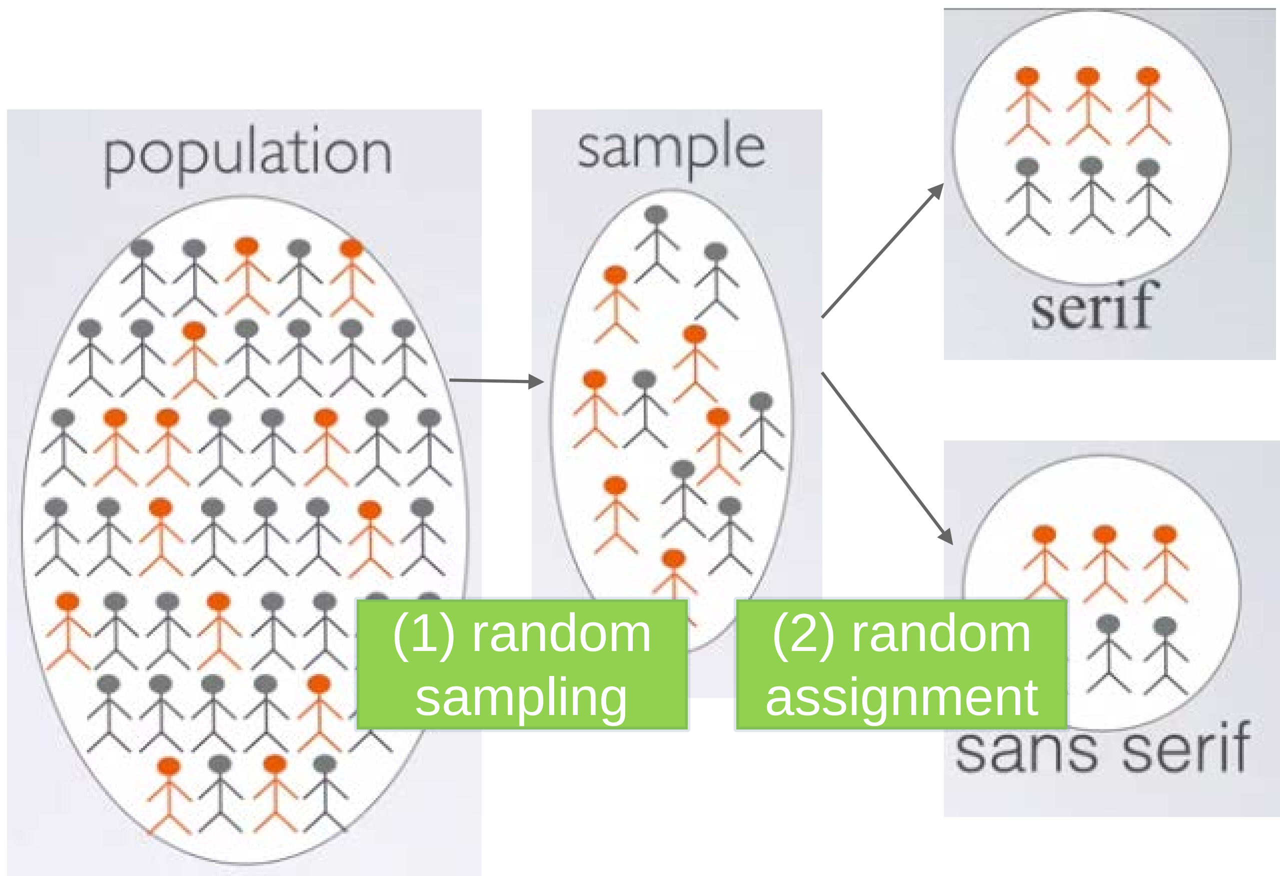
confounding variable

example

- In this setting, if we observe any difference between the average reading speeds of the two groups, we can actually attribute it to the actual treatment, the font type, and know that it is likely not due to the control confounding variable.
- Sampling happens first and assignment happens second.

Serif

Sans Serif



confounding variable

random assignment vs. random sampling

- A study that employs random sampling and random assignment can be used to make causal conclusions. these conclusions can be generalized to the whole population.

  This would be an ideal experiment

ideal experiment

	Random assignment	No random assignment	
Random sampling	causal and generalizable	not causal, but generalizable	Generalizability
No random sampling	causal, but not generalizable	neither causal nor generalizable	No generalizability
	Causation	Association	

random assignment vs. random sampling

- If the experimental units are humans, since it may be difficult to randomly sample people from the population and then impose treatments on them. This is why most experiments recruit volunteer subjects. You may have seen ads for these on a university campus or in a newspaper. Such human experiments that rely on volunteers employ random assignment but not random sampling.

ideal experiment

	Random assignment	No random assignment	
Random sampling	causal and generalizable	not causal, but generalizable	Generalizability
No random sampling	causal, but not generalizable	neither causal nor generalizable	No generalizability
	Causation	Association	

most experiments

These studies can be used to make causal conclusions, but the conclusions only apply to the sample and the results cannot be generalized.

random assignment vs. random sampling

- A study that uses no random assignment but does use random sampling, is your typical observational study. Results can only be used to make correlation statements, but they can be generalized to the whole population.

ideal experiment

most observational studies

	Random assignment	No random assignment	
Random sampling	causal and generalizable	not causal, but generalizable	Generalizability
No random sampling	causal, but not generalizable	neither causal nor generalizable	No generalizability
	Causation	Association	

most experiments

random assignment vs. random sampling

- one that doesn't use random assignment or a random sampling, only be used to make correlational statements, and these conclusions are not generalizable. This is an un-ideal observational study

ideal experiment

most observational studies

	Random assignment	No random assignment	
Random sampling	causal and generalizable	not causal, but generalizable	Generalizability
No random sampling	causal, but not generalizable	neither causal nor generalizable	No generalizability
	Causation	Association	

most experiments

bad observational studies