Experiments and Observational Studies

Stat 120

September 15 2023

Association and Causation

*Two variables are **associated** if values of one variable tends to be related to values of the other variable*

- *e.g. Families with many cars tend to own many television sets*

*Two variables are **causally associated** if changing the value of the explanatory variable influences the value of the response variable*

- *e.g. Studies show that taking a practice exam increases your score on an exam*

College Education and Aging

"Education seems to be an elixir that can bring us a healthy body and mind throughout adulthood and even a longer life," says Margie E. Lachman, a psychologist at Brandeis University who specializes in aging. "For those in midlife and beyond, a college degree appears to slow the brain's aging process by up to a decade, adding a new twist to the cost-benefit analysis of higher education - for young students as well as those thinking about returning to school."

Which of the following is true?

1. ***Explanatory Variable = brain aging; Response Variable = elixir***
2. ***Explanatory Variable = brain aging; Response Variable = college degree***
3. ***Explanatory Variable = college degree; Response Variable = brain aging***

▶ Click for answer

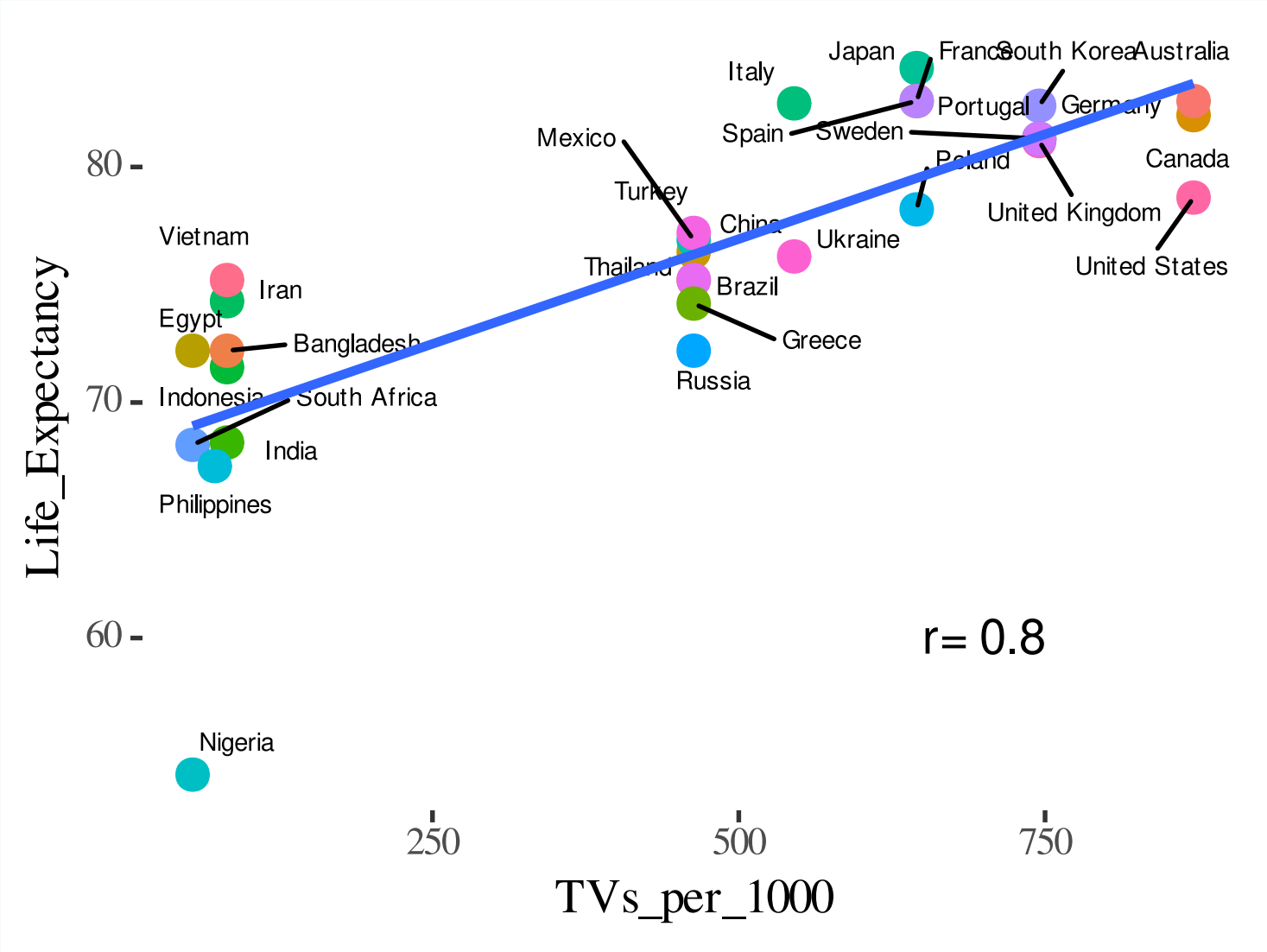
College Education and Aging

Based on this passage, should we conclude that obtaining a college degree causes a slowdown in the brain's aging process?

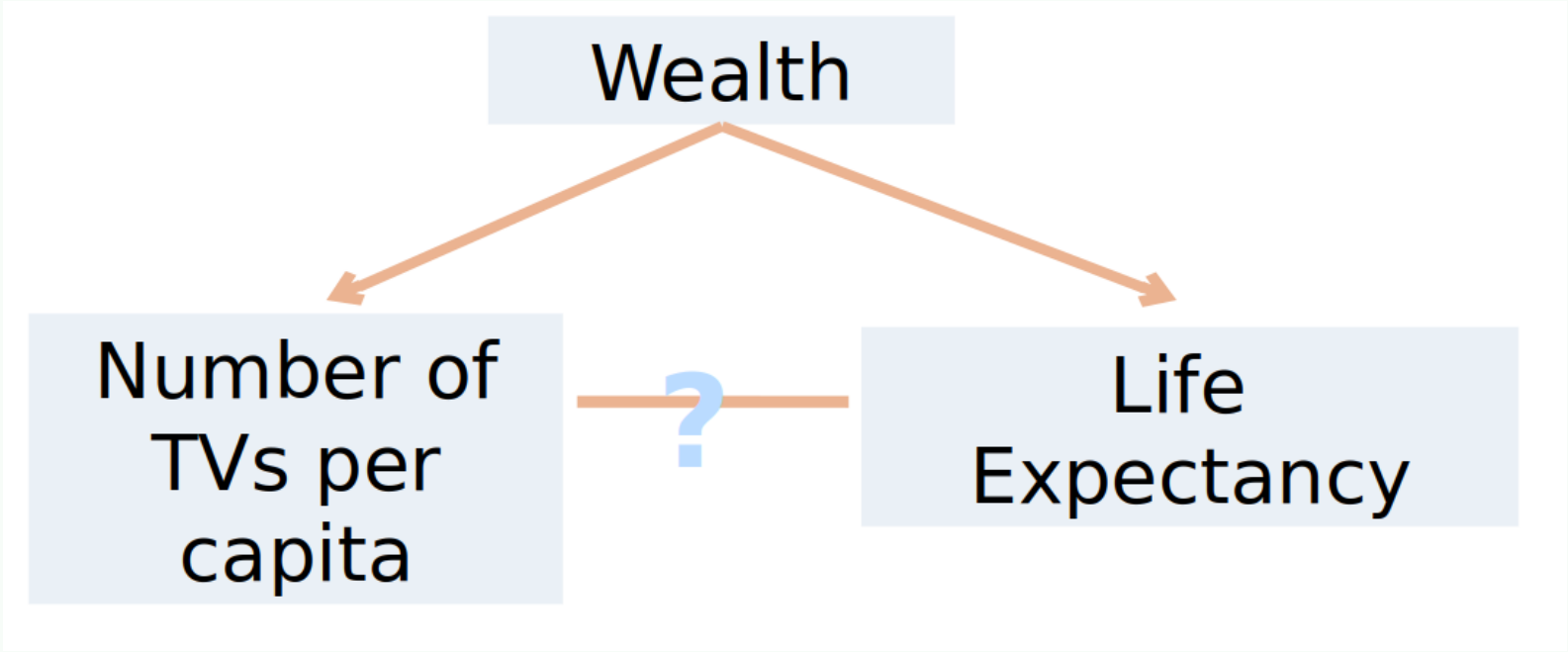
- Yes
- No

▶ Click for answer

Should you buy more TVs to live longer?



TVs and Life Expectancy



Extra lurking variable

Confounding Variable

A third variable that is associated with both the explanatory variable and the response variable is called a confounding variable

- **A confounding variable can offer a plausible explanation for an association between the two variables.**

Whenever confounding variables are present (or may be present), a causal association **CANNOT** be determined!

Experiment Vs Observational Study

An **observational study** is a study in which the researcher does not actively control the value of any variable, but simply observes the values as they naturally exist

An **experiment** is a study in which the researcher actively controls one or more of the explanatory variables

Experiment or Observational Study?

To examine whether farm-grown salmon contain more omega-3 oils if water is more acidic, we collect samples of salmon and water from multiple fish farms to see if the two variables are related.

- **Experiment**
- **Observational Study**

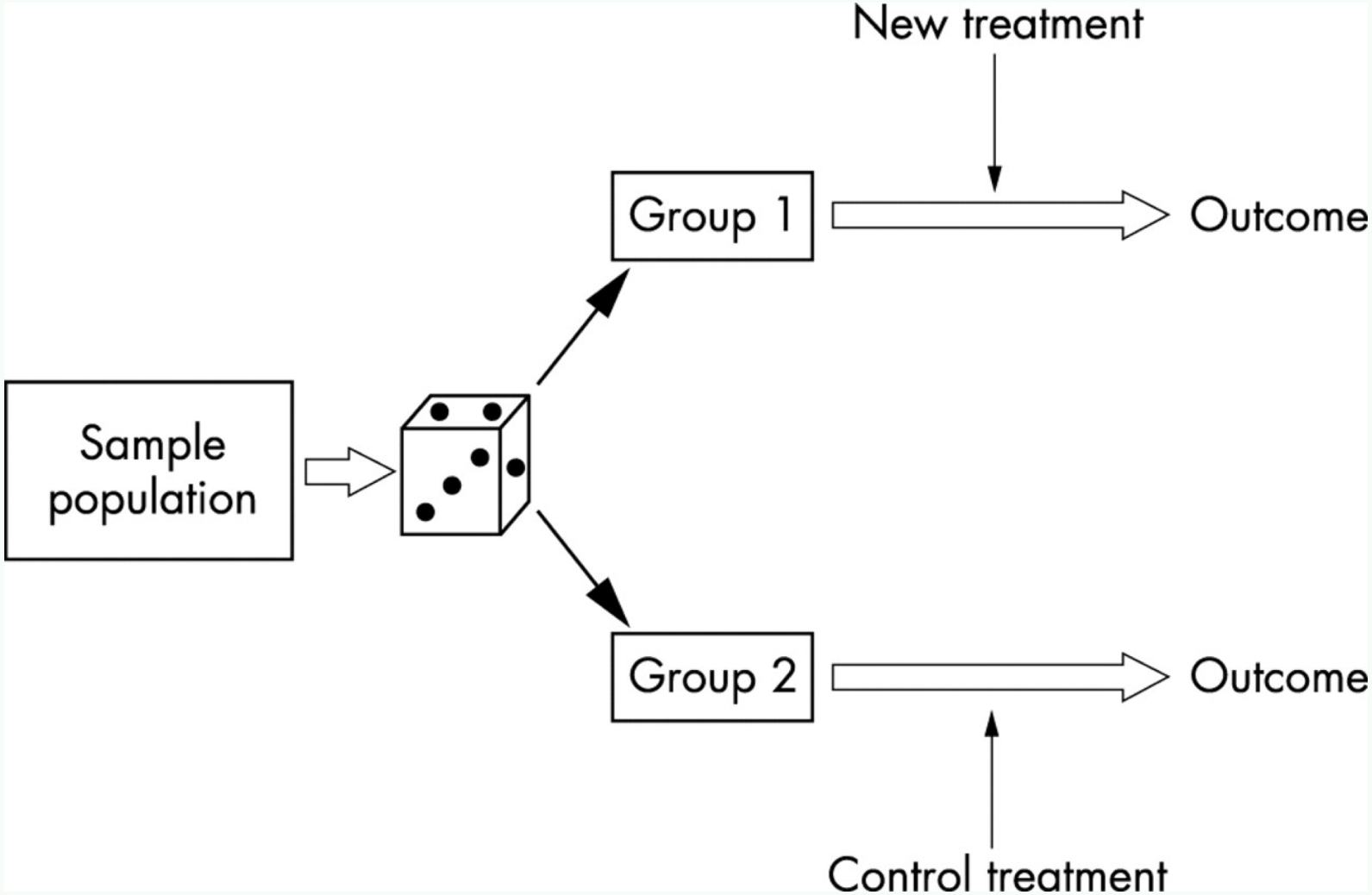
▶ Click for answer

Observational Studies and Confounding Variable

- ***There are almost always confounding variables in observational studies***
- ***Observational studies can almost never be used to establish causation!!***

To avoid confounding variables: Randomly assign values of the explanatory variable!

Randomized Experiments



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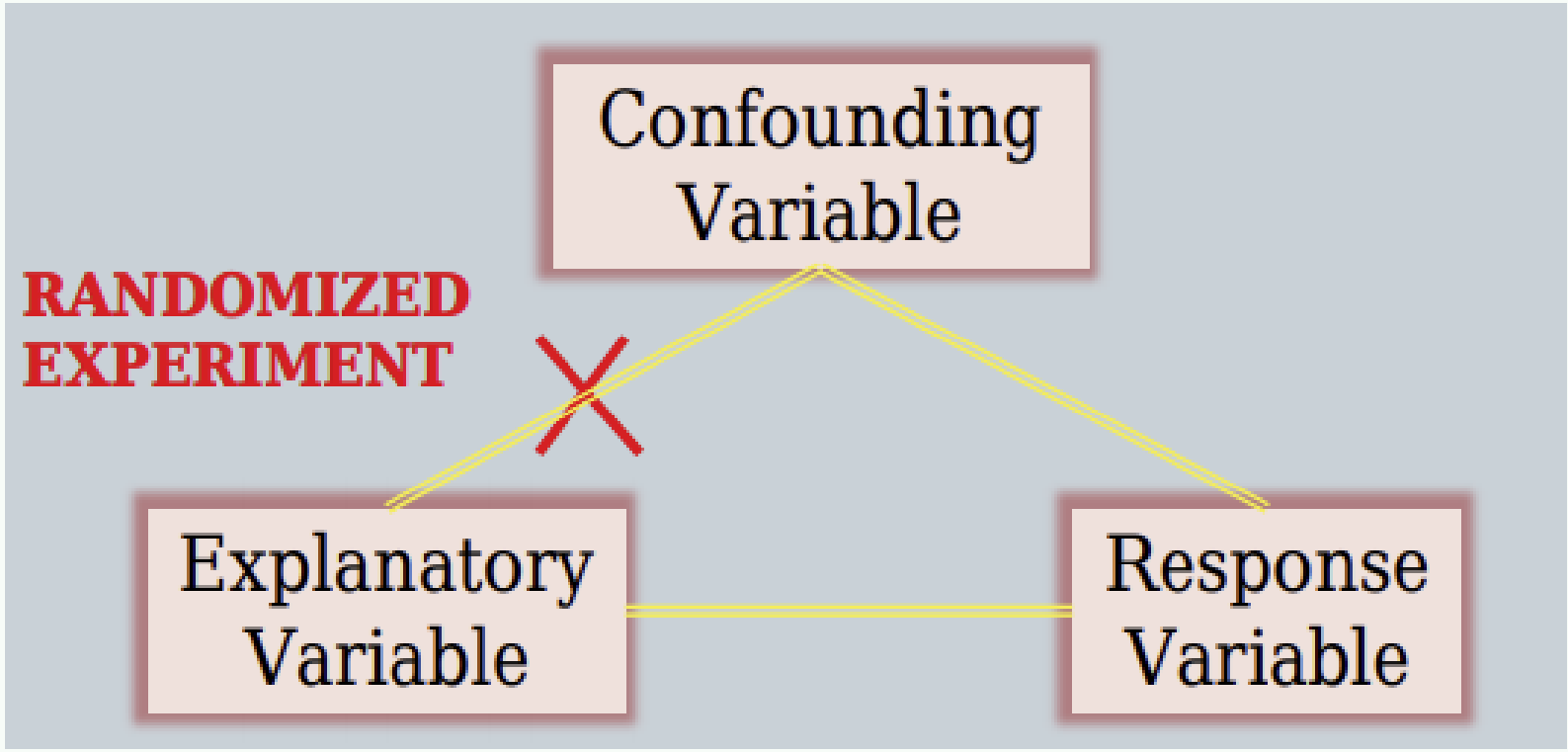
Randomized Experiments

- *In a **randomized experiment**, the explanatory variable for each unit is determined randomly, before the response variable is measured*
- *The different levels of the explanatory variable are known as **treatments***
  - *Randomly divide the units into groups, and randomly assign a different treatment to each group*
  - *Observe the response variable after treatments are applied*

Elimination of confounding variables



Because the explanatory variable is randomly assigned, it is not associated with any other variables. Confounding variables are eliminated!!!

Exercise and the Brain

- ***A sample of mice were divided randomly into two groups. One group was given access to an exercise wheel, the other group was kept sedentary***
- ***"The brains of mice and rats that were allowed to run on wheels pulsed with vigorous, newly born neurons, and those animals then breezed through mazes and other tests of rodent IQ" compared to the sedentary mice***

Is this evidence that exercise causes an increase in brain activity and IQ, at least in mice?

Randomized experiment can yield causal conclusions!

Knee Surgery, Control Groups

Study Context

- *Researchers investigated the effectiveness of knee surgery for arthritis.*
- *Patients who underwent surgery reported less pain.*

The Importance of a Control Group

- *To validate if the surgery was effective, a control group received a fake knee surgery.*
- *Results were indistinguishable between the control and treatment groups.*

Control Group

Placebo Effect

- **Control groups often get a placebo to measure the effect.**
- **It is estimated that 75% of the effectiveness of anti-depressant medication is due to the placebo effect.**

Question: Is this evidence that the surgery causes a decrease in pain?
Answer: No, control group results indicate that the placebo effect might be at play.

Source: The Placebo Prescription, NY Times Magazine, 1/9/00

Double-blinded Experiments

Nobody knows who gets what, not even the researchers.

Example: A new pill for blood pressure

- Some people get the real pill, others a fake.
- Both pills look the same so no one can tell.
- Researchers checking results don't know either, so it's fair.

Randomized Experiments Types: `randomized comparative experiment`

- ***Individuals are randomly assigned to a treatment or control group.***
- ***Most effective when the investigator has no prior knowledge of the individuals who are part of the experiment.***

Example: A researcher randomly assigns participants to either a drug treatment group or a control group to measure the effectiveness of the drug.

Randomized Experiments Types: `matched pairs experiment`

- ***Each individual in the experimental group is matched with an individual in the control group based on a specific criterion.***
- ***Most effective when the investigator has prior knowledge of the individuals involved in the experiment.***

Example: A researcher matches participants based on age, gender, and education level, then assigns one participant in the matched pair to the drug treatment group and the other to the control group to measure the effectiveness of the drug.

Variations of matched pairs experiments: Effectiveness of a training program

Before-After Test:

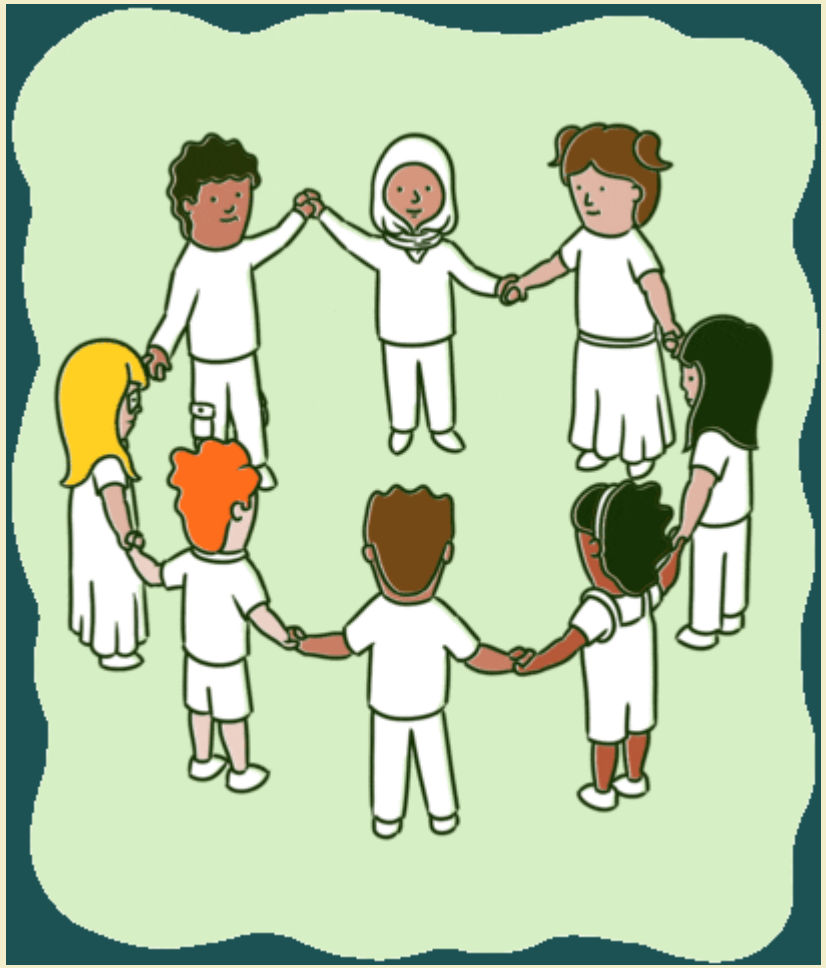
- Measure everyone's skill level before any training.
  - Example: Time each runner's 100m sprint.
- Train only one group.
- Measure again and compare.
  - Example: Time the 100m sprint again and see who improved more.

Two-Times Test:

- Everyone gets both training and no training, but in random order.
  - Example: Flip a coin to decide who gets training first.
- Measure skill after each.
  - Example: Time each 100m sprint after both.
- Compare the same person's times to see which training worked.

GROUP WORK 1

15:00



- Let's head over to course helper page to see some case studies
- Then we will work on a class activity