INNOPOLIS UNIVERSITY

Lab 07

Experimental Designs II

Applied statistics and experiments

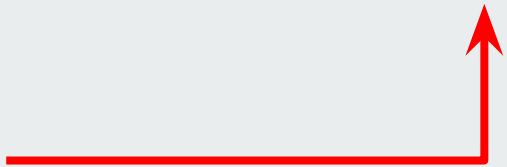
October 2024

Agenda

1. Quasi-experimental design
    1.1. Non-equivalent control group design
    1.2. Counterbalanced design
    1.3. Interrupted time series design
    1.4. Multiple time series design
    1.5. Regression discontinuity analysis design
2. Factorial design

Lecture Recap

https://quizizz.com/join



Join and enter game code

Quasi-experimental designs

The characteristics of these designs:

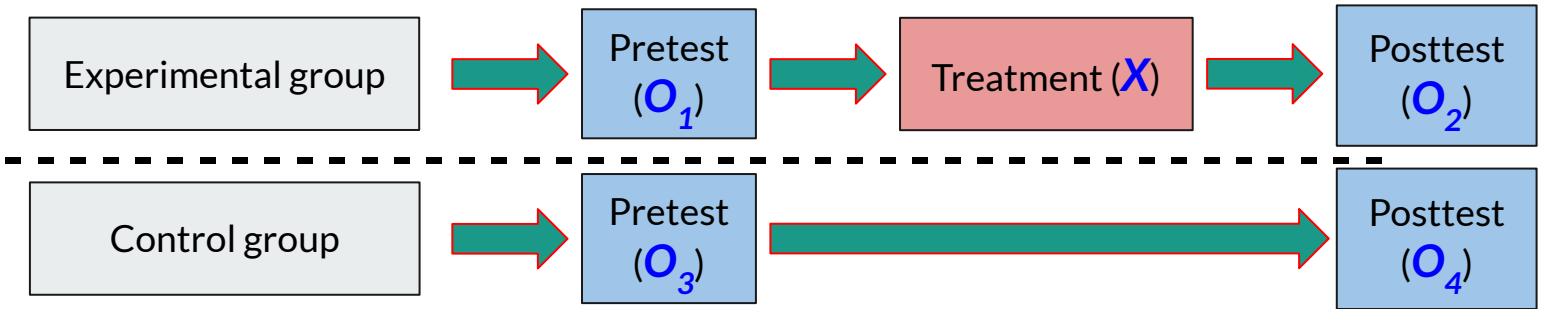
- Have manipulation or control
- Generally lack randomization
- Are generally prospective in nature
- Are moderate in scientific validity

Quasi-experimental designs

- Do not provide full control of potential extraneous variables.
- Do not have random assignment usually ethically or logistically just not possible.
- When the researcher lacks the full control over the scheduling of treatments which makes a true experiment possible.
- When it is not logistically feasible or ethical to conduct a randomized controlled experiment.
- Higher external validity.
    - they often involve real-world interventions instead of artificial laboratory settings.
- Lower internal validity than true experimental designs.

Nonequivalent Control Group

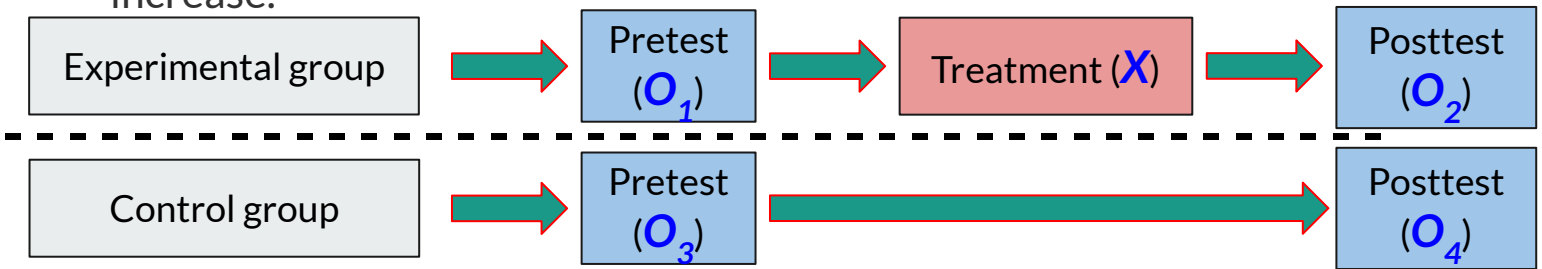
- The experimental and the control groups are selected without random assignment.
- Both groups take a pretest and posttest.
- Only the experimental group receives the treatment.
- Stronger than static-group comparison design due to the pretest.



Nonequivalent Control Group

Example:

- Researchers are interested in whether a causal relationship exists between income and happiness. The income, is the independent variable and the happiness, is the dependent variable.
- Two groups are selected and only one group will obtain an increase (100$) in the income. We measure the happiness of participants before and after the increase.



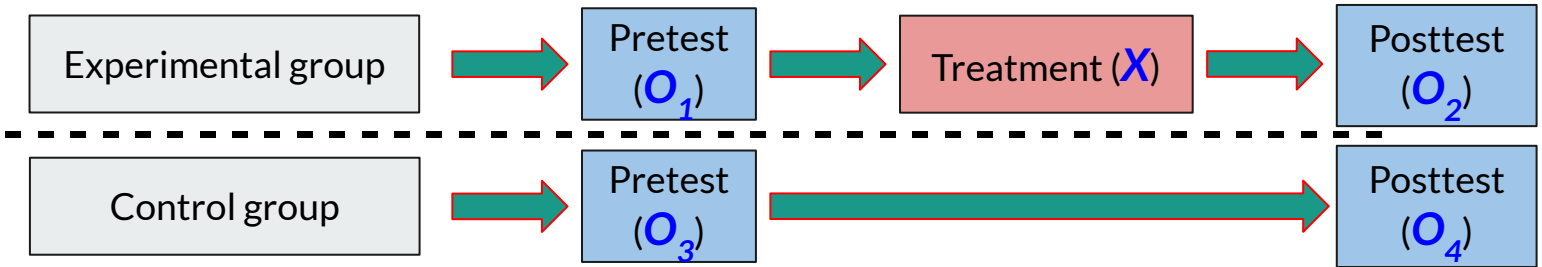
Nonequivalent Control Group

Possible threats to internal validity:

- Interaction of selection and history.
- Interaction of selection and maturation.
- Interaction of selection and testing.
- Selection, Mortality, and Regression.
- Interaction of X and testing (external)

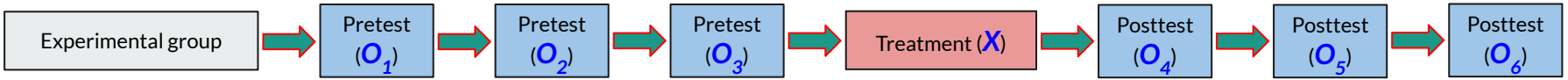
Not a threat

- Maturation
- Testing
- Instrumentation
- History



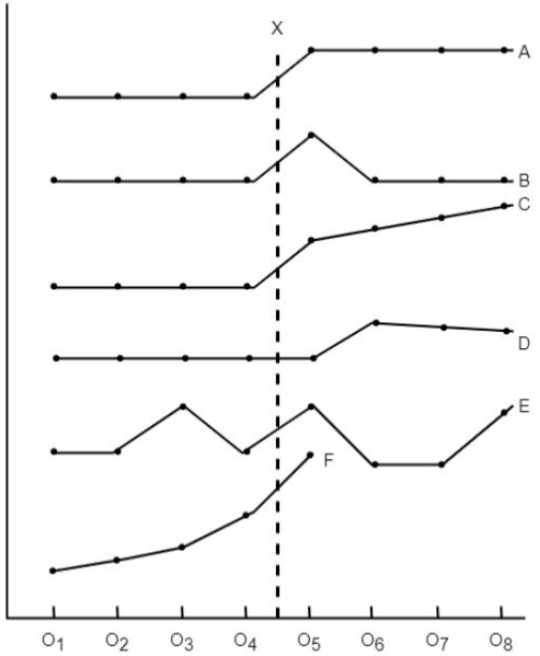
(Interrupted) Time-series design

- A single experimental group is selected without random assignment.
- The group is repeatedly pre-tested (baseline), administered treatment, and then repeatedly post-tested.
- Effect of treatment is demonstrated by discontinuity in the pretest versus posttest responses.
- Useful when equivalent comparison group cannot be identified.



(Interrupted) Time-series design

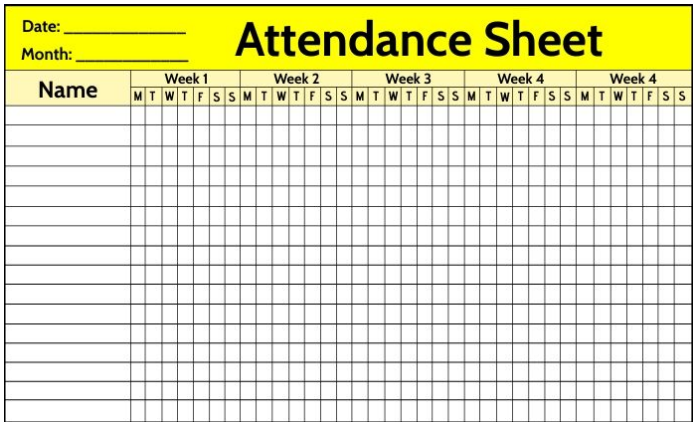
The benefit of many measurements is that comparing only two measurements (pretest-posttest) can tell you only if there is a significant difference before and after a treatment is applied but repeated measurements can provide a picture of overall fluctuation in measurements and also allows estimation of lasting effect of treatment.



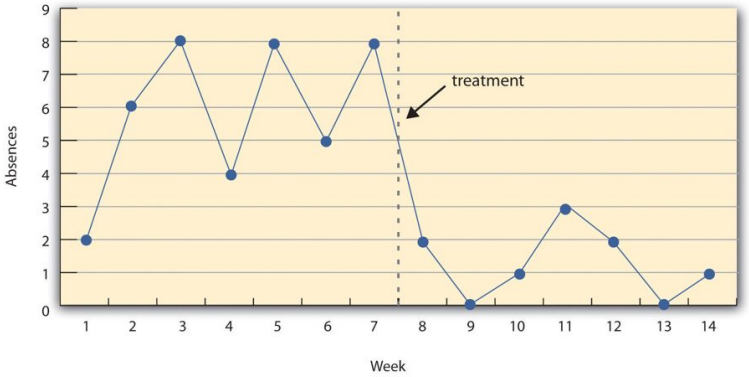
(Interrupted) Time-series design

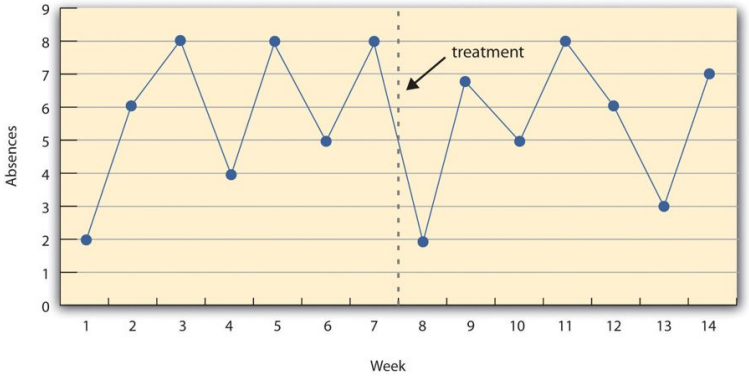
Example:

- Researchers wants to study the number of student absences per week in EM course. The treatment is that the instructor begins publicly taking attendance each week so that students know that the instructor is aware of who is present and who is absent.



(Interrupted) Time-series design





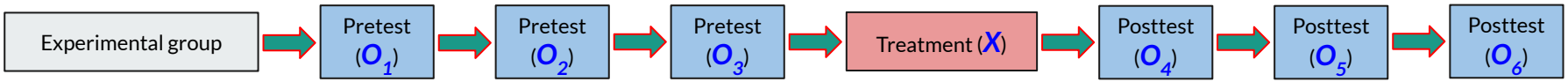
Example:

- Two line graphs charting the number of absences per week over 14 weeks. The first 7 weeks are without treatment and the last 7 weeks are with treatment. In the first line graph, there are between 4 to 8 absences each week. After the treatment, the absences drop to 0 to 3 each week, which suggests the treatment worked. In the second line graph, there is no noticeable change in the number of absences per week after the treatment, which suggests the treatment did not work.

(Interrupted) Time-series design

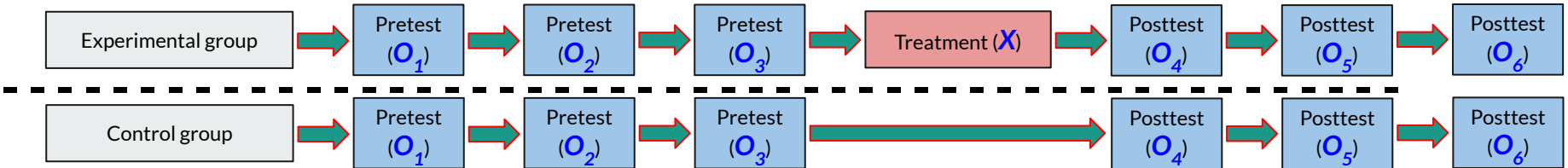
Possible threats to validity:

- Internal:
  - History.
  - Instrumentation (maybe).
- External:
  - Interaction of X and testing.
  - Interaction of X and selection (maybe).



Multiple time series design

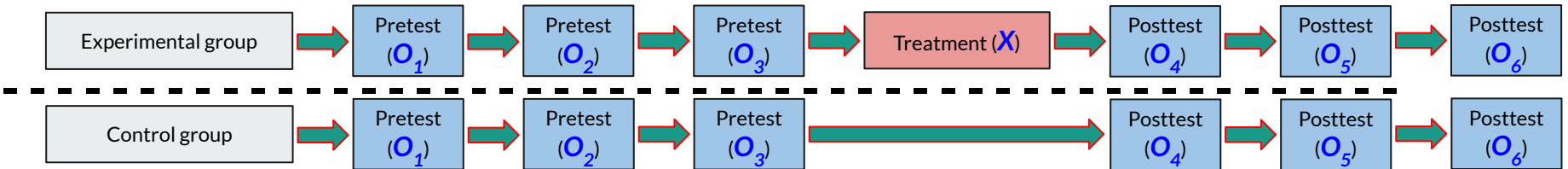
- An experimental group and a control group.
- Multiple pre-tests and a post-tests are conducted.
- Introduced as a new design to avoid threats of Non-equivalent control group design and Interrupted time series design.



Multiple time series design

Example:

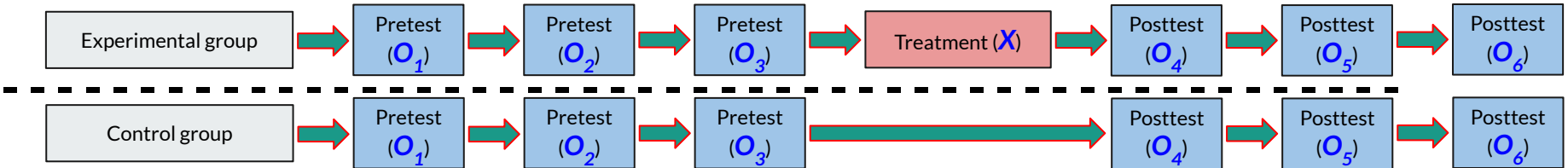
- Take two groups A and B. The instructor counts the absences weekly in both groups without announcements then, at week 7 he begins publicly taking attendance in group A only each week.



Multiple time series design

Threats to validity:

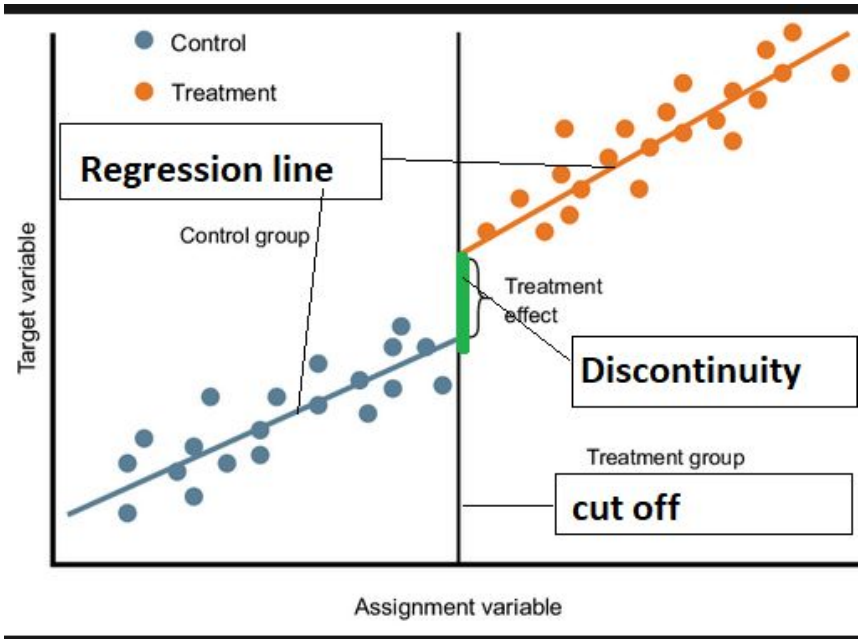
- Almost all internal threats are controlled.
  - Interaction of selection and history (could be a threat).
- External:
  - Interaction of X and testing.
  - Interaction of X and selection.



Regression discontinuity design

- It has become a prominent method for causal inference since the 2000s.
- Assignment of treatment and control is not random but rather based on some clear-cut threshold (or cutoff point) of an observed variable.

C	O	X	O
C	O		O



C indicates that groups are assigned by means of a cutoff score,

Regression discontinuity design

Example:

- For example, suppose we are interested in the effect of scholarship on students' grade performance. How can we decide those who get the treatment (here: scholarship) and those who do not get it? We could use a test/exam.
- The test has a minimum score of 0 and a maximum score of 1000. Those who get at least a 600 get the scholarship and those who get below 600 don't get it. Here, the running variable is the test score achieved by the students. The cut-off point is 600.

Factorial designs

- More than one independent variable.
- In some experimental situations, it is not enough to know the effect of a single treatment on an outcome.
    - More than one treatment

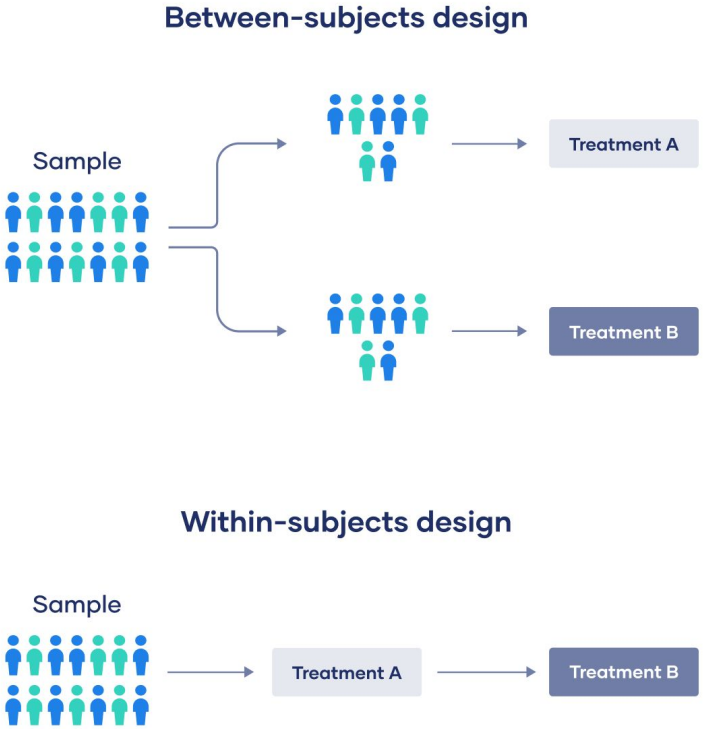
Factorial designs

- The word “within” means you’re comparing different conditions within the same group or individual.
- The word “between” means that you’re comparing different conditions between groups.

- There are three main types of factorial designs, namely “Within Subjects Factorial Design”, “Between Subjects Factorial Design”, and “Mixed Factorial Design”.
  - **Within Subjects Factorial Design:** In this factorial design, all of the independent variables are manipulated within subjects.
  - **Between Subjects Factorial Design:** Here, the subjects are assigned to different conditions and each subject only experiences one of the experimental conditions.
  - **Mixed Factorial Design:** This design is most commonly used in the study of psychology. It is named the ‘Mixed Factorial Design’ because it has at least one Within Subjects variable and one Between Subjects variable

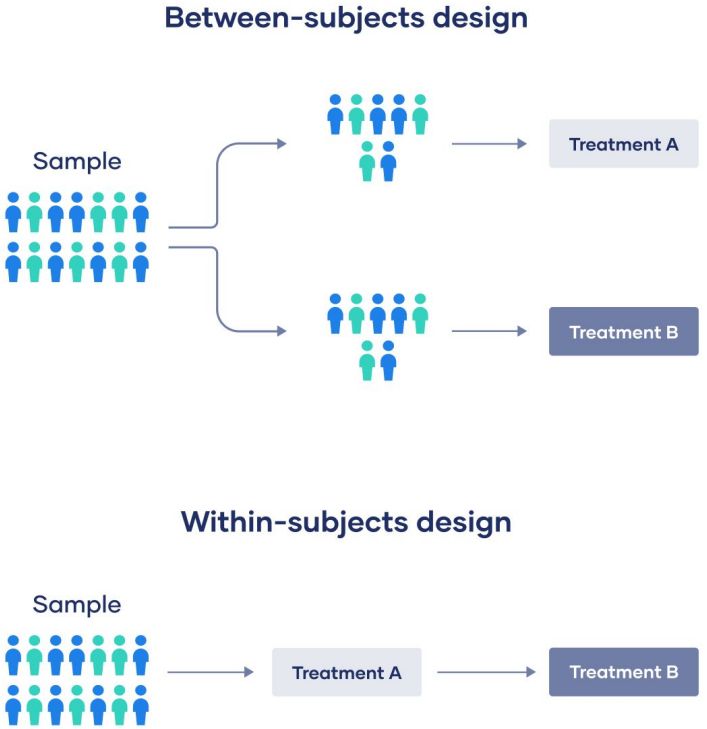
Factorial designs

- **Within Subjects Factorial Design:**
  - A study investigates the effects of caffeine and sugar on cognitive performance. Each participant would receive both caffeine and sugar, and their cognitive performance would be measured after each treatment.



Factorial designs

- **Between Subjects Factorial Design:**
  - A study that investigates the effects of two different types of therapy on depression. In this study, participants would be randomly assigned to one of two therapy groups, and their depression levels would be measured after the therapy.



Factorial designs

- **Mixed Factorial Design:**
  - A researcher might choose to treat cell phone use as a within-subjects factor by testing the same participants both while using a cell phone and while not using a cell phone (while counterbalancing the order of these two conditions). But he or she might choose to treat time of day as a between-subjects factor by testing each participant either during the day or during the night (perhaps because this only requires them to come in for testing once). Thus each participant in this mixed design would be tested in two of the four conditions.
- Regardless of whether the design is between subjects, within subjects, or mixed, the actual assignment of participants to conditions or orders of conditions is typically done randomly.

Factorial designs

- **Main effects** are the influence of each independent variable on the outcome in an experiment.
- **Interaction effects** exist when the influence on one independent variable depends on (or co-varies with) the other independent variable in an experiment.

Factorial designs

- A 2×2 factorial design is a type of experimental design that allows researchers to understand the effects of two independent variables (each with two levels) on a single dependent variable.

		Independent Variable 2	
		Level 1	Level 2
Independent Variable 1	Level 1	Dependent Variable	Dependent Variable
	Level 2	Dependent Variable	Dependent Variable

Factorial designs

- For example, suppose a botanist wants to understand th effects of sunlight (low vs. high) and watering frequency (daily vs. weekly) on the growth of a certain species of plant. This is an example of a 2×2 factorial design because there are two independent variables, each with two levels: (one dependent variable: Plant growth.)
- **Independent variable 1:** Sunlight
  - **Levels:** Low, High
- **Independent variable 2:** Watering Frequency
  - Levels: Daily, Weekly

		Watering Frequency	
		Daily	Weekly
Sunlight	Low	Plant Growth	Plant Growth
	High	Plant Growth	Plant Growth

Factorial designs

- **Main effects:**
  - *Main effect of sunlight on plant growth.*
    - We can find the mean plant growth of all plants that received low sunlight.
    - We can find the mean plant growth of all plants that received high sunlight.
  - *Main effect of watering frequency on plant growth.*
    - We can find the mean plant growth of all plants that were watered daily.
    - We can find the mean plant growth of all plants that were watered weekly.

		Watering Frequency	
		Daily	Weekly
Sunlight	Low	Plant Growth	Plant Growth
	High	Plant Growth	Plant Growth

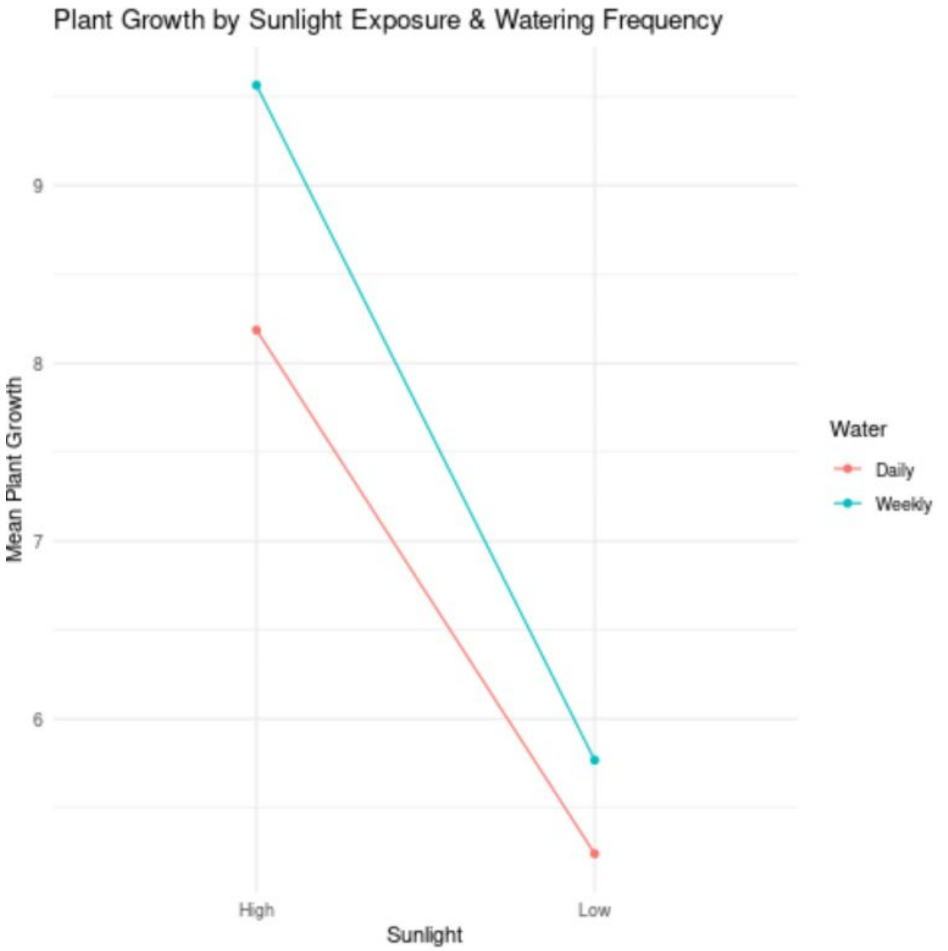
Factorial designs

- **Interaction Effects:**
  - *Does the effect of sunlight on plant growth depend on watering frequency?*
  - *Does the effect of watering frequency on plant growth depend on the amount of sunlight?*
  - *To determine if there is an interaction effect between the two independent variables, we need to graph the means to gain a better understanding of the effects and inspect whether or not the lines are parallel:*
    - *If the two lines in the plot are parallel, there is no interaction effect.*
    - *If the two lines in the plot are not parallel, there is an interaction effect.*

		Watering Frequency	
		Daily	Weekly
Sunlight	Low	Plant Growth	Plant Growth
	High	Plant Growth	Plant Growth

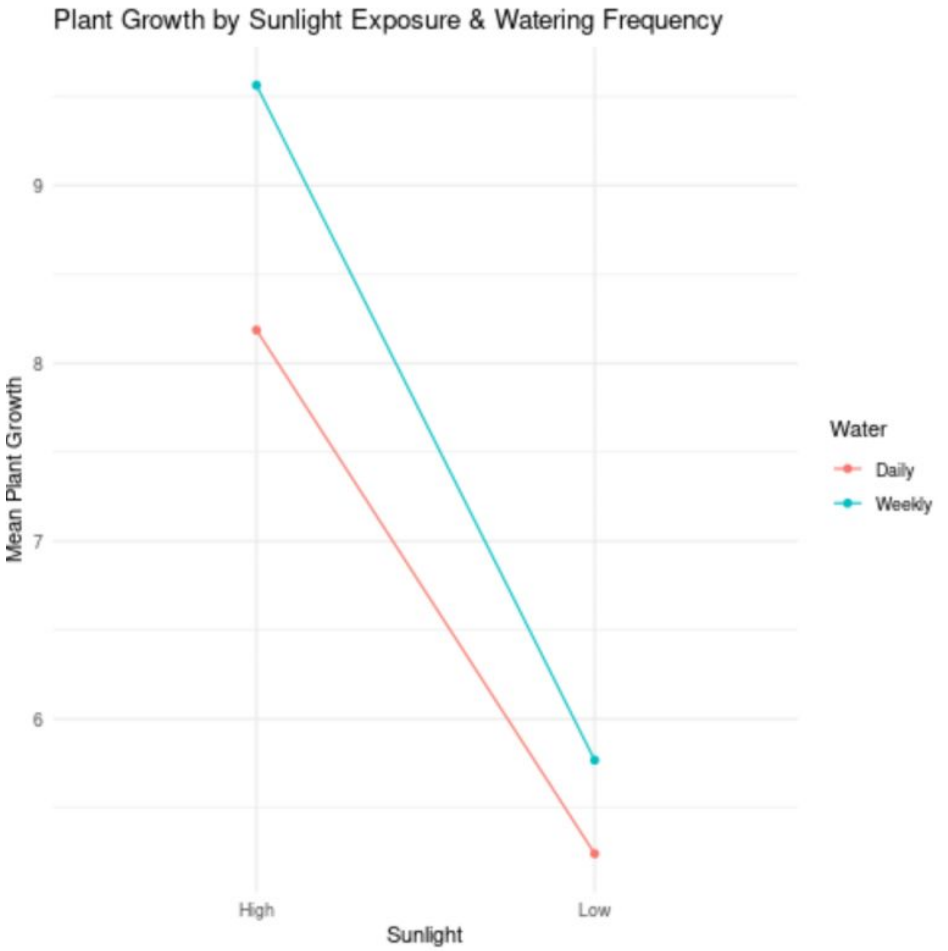
Factorial designs

- **Interaction Effects:**
  - *The mean growth for plants that received high sunlight and daily watering was about 8.2 inches.*
  - *The mean growth for plants that received high sunlight and weekly watering was about 9.6 inches.*
  - *The mean growth for plants that received low sunlight and daily watering was about 5.3 inches.*
  - *The mean growth for plants that received low sunlight and weekly watering was about 5.8 inches.*



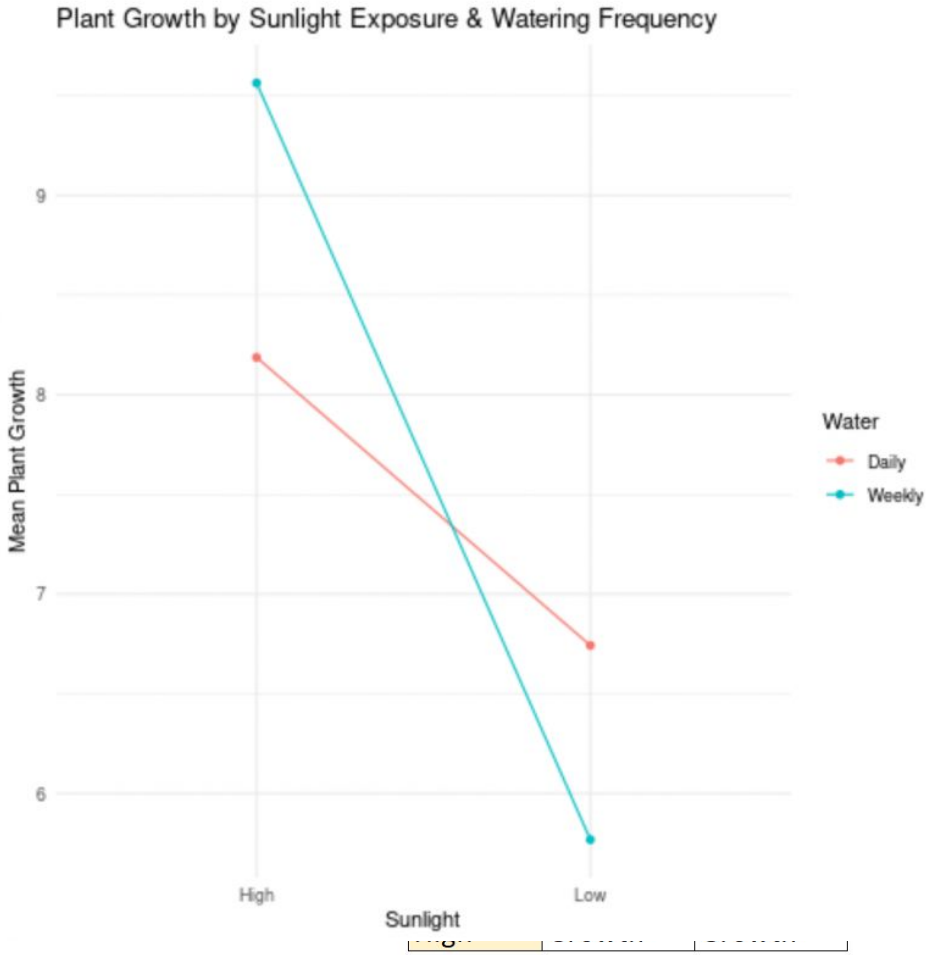
Factorial designs

- **Interaction Effects:**
  - *the two lines were roughly parallel so there is likely no interaction effect between watering frequency and sunlight exposure.*

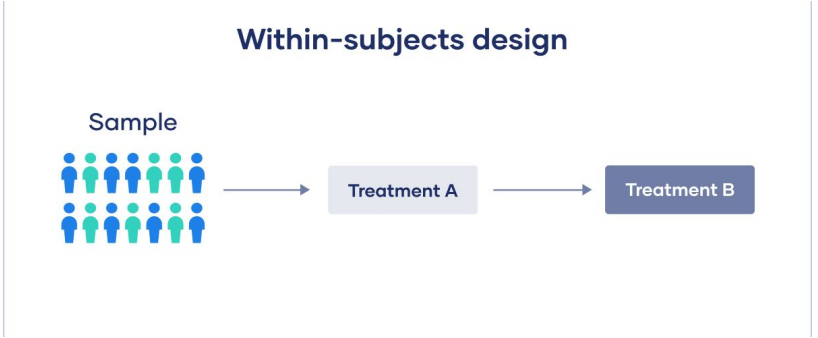


Factorial designs

- **Interaction Effects:**
  - *The two lines are not parallel at all (in fact, they cross!), which indicates that there is likely an interaction effect between them.*
  - *This means the effect that sunlight has on plant growth depends on the watering frequency.*
  - *So, sunlight and watering frequency do not affect plant growth independently. Rather, there is an interaction effect between the two independent variables.*



Within Subject Designs

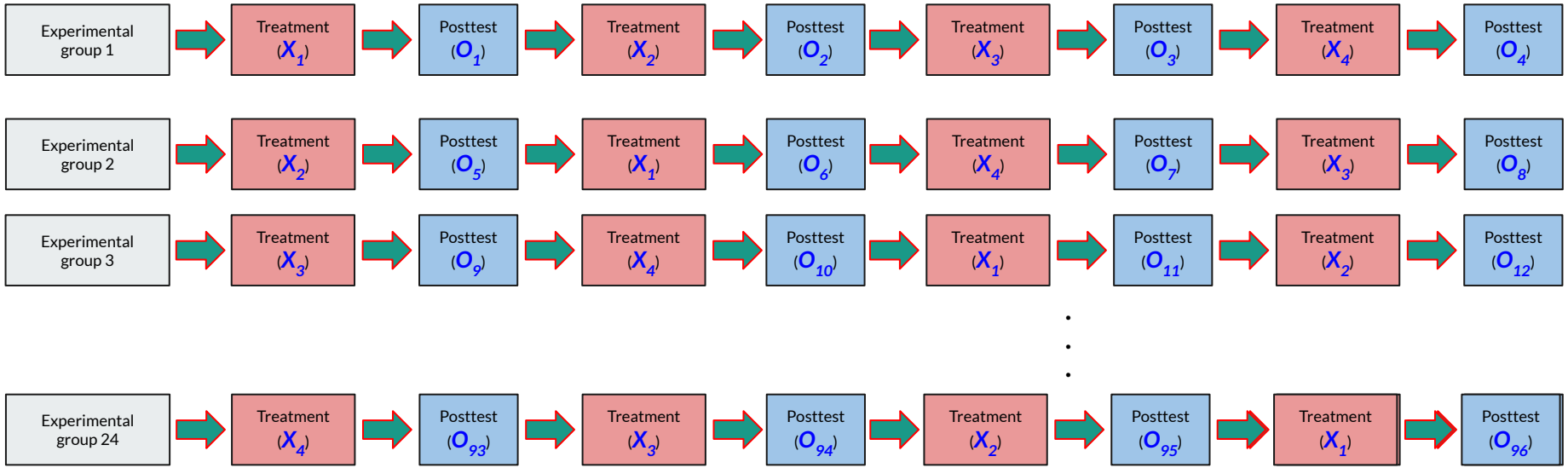


- The primary disadvantage is that they can result in **order effects.**
  - An order effect occurs when participants' responses in the various conditions are affected by the **order** of conditions to which they were exposed. One type of order effect is a carryover effect.
  - **A carryover effect** is an effect of being tested in one condition on participants' behavior in later conditions.
    - *Practice effect:* participants perform a task better in later conditions because they have had a chance to practice it
    - *Fatigue effect*, where participants perform a task worse in later conditions because they become tired or bored.
    - *Context effect:* being tested in one condition can also change how participants perceive stimuli or interpret their task in later conditions.

complete counterbalancing

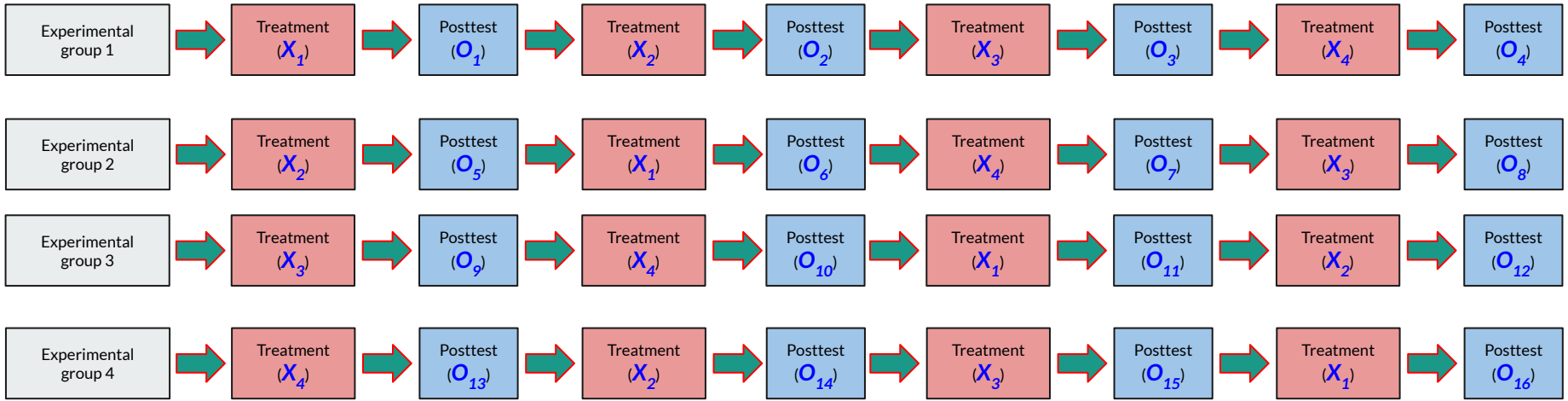
Counterbalanced design

n! groups
n!xn measurements
Here n=4



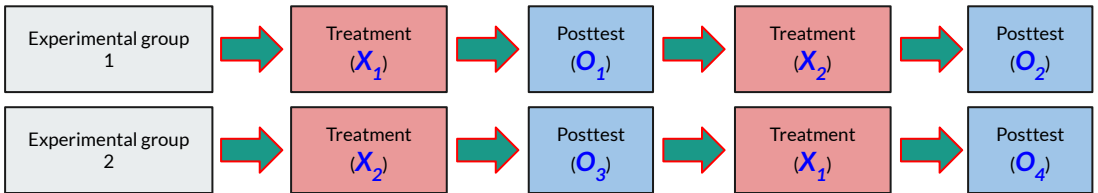
Latin square design

n groups
nxn Latin square
Here n=4



Counterbalanced design

- It is often employed when several interventions are being tested concurrently.
- After random selection from the population, the study subjects are divided up into independent groups.
- Each group receives each intervention, but in a different order from the other respective groups.
- An observation of the outcome is taken after each series of interventions in the counterbalanced design.
- The counterbalanced design is a powerful design because each participant serves as their own control and multiple interventions can be tested at the same time.



References

- https://opentextbc.ca/researchmethods/chapter/quasi-experimental-research
- https://www.scalestatistics.com/counterbalanced-design.html
- https://conjointly.com/kb/nonequivalent-groups-design/
- https://www.masterclass.com/articles/quasi-experimental
- https://helpfulprofessor.com/quasi-experimental-design-examples/

Attendance

https://baam.duckdns.org

Questions?