PS 211: Introduction to Experimental Design

Fall 2025 · Section C1

Lecture 2: More variables and research methods

Updates & Reminders

- The pre-course survey (linked on Slack in "general") is due by **Friday, Sep. 5** for a bonus point on the first exam.
  - Please fill this out! It will help us tailor the course to all students' backgrounds, and provide a dataset for us to analyze together.
- You should be working on having R and R Studio installed on your personal computer.
  - If you have not yet successfully installed them, please follow the instructions on Slack and come to office hours if you need help.

Review: Types of Variables

- **Continuous variables**
  - Quantitative only
  - Any value within a range; can have fractions (e.g., height, weight)
- **Discrete variables**
  - Quantitative or qualitative
  - Only specific values; no fractions (e.g., number of pets)

Review: Discrete Variables

- **Nominal**: categories with names (e.g., Democrat = 1, Republican = 0; numbers meaningless)
- **Ordinal**: rankings with order, but no fractions (e.g., 1st, 2nd, 3rd place)

Review: Continuous Variables

New material

Types of research, experimental variables, operational definitions, reliability & validity, confounds, hypothesis testing

Research methods to address psychological questions

Non-Experimental

- Naturalistic/Observational
- Case Studies
- Surveys & Questionnaires

Experimental

- Lab and field experiments

What is an experiment?

An experiment is a study in which independent variable(s) are manipulated to examine their effect on dependent variable(s).

- Involves *changing* or *manipulating* something
- Goal is to determine *causal* relations
- Requires *controlled* conditions

Defining variables

Independent Variable (IV): Has two or more levels (values); is manipulated to observe effects on the ...

Dependent Variable (DV): The outcome variable that we hypothesized would be affected by the IV.

Note: In non-experimental studies, independent variables are not manipulated, but instead are selected or observed as they naturally occur.

This is often the case in developmental studies, where age is an independent variable that cannot be manipulated.

Defining variables

Variables must be defined.

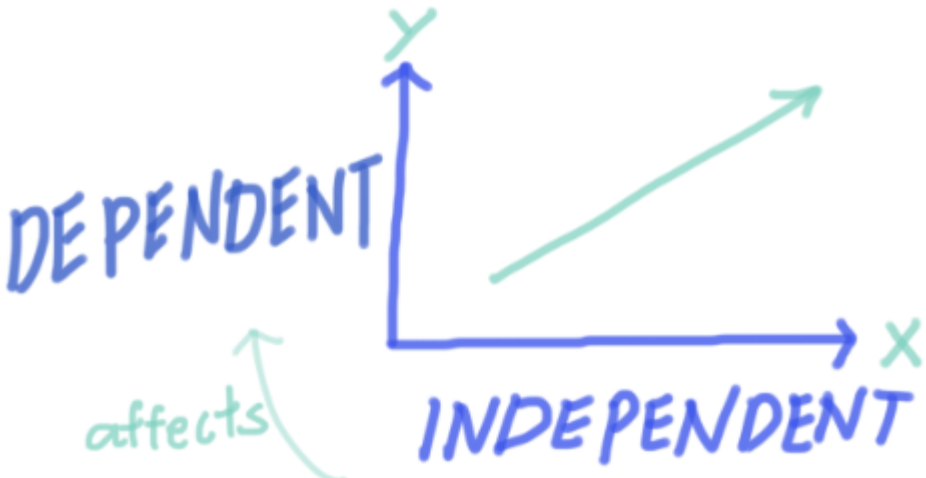
- Some are easy to define and measure: Year, height, age, etc.
- Some are harder: Happiness, anxiety, intelligence, etc.

Levels: Values that a variable can take on.

- Discrete variable example: "Type of pet" has levels "dog", "cat", "hamster", etc.
- Continuous variable example: "Reaction time" has levels from 0 to infinity.

Defining and graphing variables using X and Y

- **X** = Independent Variable (IV); goes on the X (horizontal) axis
- **Y** = Dependent Variable (DV); goes on the Y (vertical) axis



Non-experimental research: Correlational studies

Practice: Identifying Variables

A researcher wants to see if having students bring laptops to class affects their exam scores. Half the students are randomly assigned to bring laptops; half are not. At the end of the semester, all students take the same exam.

Is this an experiment?

Answer: Yes! The researcher is manipulating whether students bring laptops or not.

What is the IV and what are its levels?

Answer: IV = Laptop use; Levels = laptop, no laptop

What is the DV?

Answer: DV = Exam score

Practice: Identifying Variables

Correlations: Not always useful

The Problem of Confounds

- **Confounding Variable**: Vary along with the independent variable (IV) making it hard to isolate the causal effect of the IV on the dependent variable (DV).

Experimental design and confounds

- Well-designed **experiments** can control for confounding variables **and** allow for causal inferences.
- **Random assignment** helps ensure that confounding variables are equally distributed across conditions.

However, experiments can still have confounds if not properly designed.

Correlational vs. experimental study

Correlational vs. experimental study

- **Experimental study:**
  - Employees are randomly assigned to either have access to a wellness program or not.
  - The company then measures the number of healthy behaviors (e.g., exercise, healthy eating) reported by employees who have access to the program versus those who do not.

If there's a relation between access to the wellness program and healthy behaviors, what could you conclude from these results?

Answer: Having access to the wellness program causes employees to report more healthy behaviors.

Practice: Identifying Confounds

Reliability and Validity

Reliability: consistency across repeated measures

Validity: measuring what it's supposed to measure

Examples:

- A *reliable* scale gives the same weight each time.
- A *valid* scale gives the true weight.

Can a measure be...

Reliable but not valid?

Valid but not reliable?

Can a measure be...

Reliable but not valid?

- Yes! A broken scale that always reads 5 lbs too heavy is reliable (consistent) but not valid (not accurate).
- Yes! An IQ test may give you the same score each time (reliable) but not actually measure intelligence (valid).

Valid but not reliable?

Can a measure be...

Reliable but not valid?

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Valid but not reliable?

- No! If a measure is not consistent, it cannot be valid because it cannot be accurate.
- A measure can't measure what it's supposed to measure if it gives different results each time.
- Example: A scale that gives different weights each time is neither reliable nor valid.

Reliability in practice

- **Test-Retest Reliability**: consistency of scores over time (e.g., same test, different times)
- **Inter-Rater Reliability**: consistency between different raters/judges (e.g., two therapists rating the same session)
- **Internal Consistency**: consistency of items within a test (e.g., all items measuring the same construct)

Reliability and Validity: Example

- Imagine you want to run a study where you measure whether reading happy poems makes people feel happier.
- You select five different poems and ask ChatGPT to rate how happy each poem is on a scale from 1-10.
- You then ask participants to read one of the poems and rate how happy they feel on a scale from 1-10.

How could you determine if ChatGPT's ratings are reliable?

How could you determine if ChatGPT's ratings are valid?

How could you improve the validity of your rating scale?

Reliability and Validity: Example

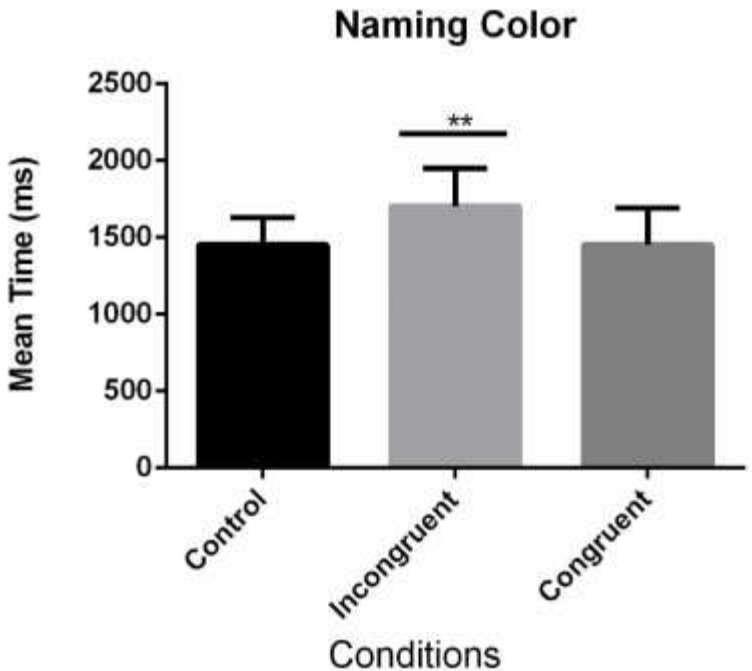
Experimental Example: The Stroop Task

- The Stroop Task is used to study how well people can suppress interference from "automatic" cognitve processes (like reading).
  - This is an important aspects of what's commonly referred to as "cognitive control."
- Participants see color words (e.g., "red", "blue", "green") printed in different colors and must name the ink color as quickly as possible.
- Two conditions:
  - **Congruent**: word meaning matches ink color (e.g., "red" in red ink)
  - **Incongruent**: word meaning does not match ink color (e.g., "red" in blue ink)
- Researchers measure reaction times (RTs) for naming the ink color in both conditions.

The Stroop Task: Let's try it!

The Stroop Task: Let's try it!

The Stroop Task: Typical results



What is the IV and what are its levels?

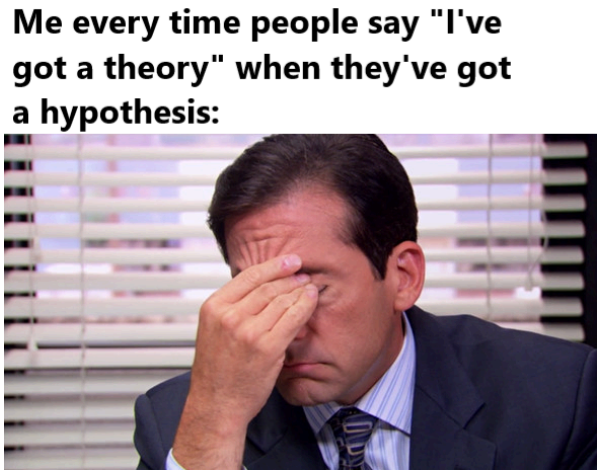
Answer: IV = Task condition; Levels = Congruent, Incongruent, (and sometimes Control)

What is the DV?

Answer: DV = Reaction Time (RT) to name ink color

Hypothesis Testing

- **Hypothesis**: A proposed explanation for a phenomenon, often involving a relation between two or more variables.
- **Hypothesis testing**: The process of collecting and analyzing data to determine whether there is evidence that supports the hypothesis.



Operational definitions: Needed to test hypotheses

- **Operational definitions**: Specify the observations or procedures used to measure or manipulate a variable.
  - Example: Happiness could be operationally defined as "self-reported happiness on a 1-10 scale" or "number of smiles in a 5-minute video""

How could you operationalize musical artist popularity?

Answer: Musical artist popularity could be operationalized as "number of monthly listeners on Spotify" or "social media followers across platforms."

How could you operationalize math ability?

Operational definitions: They're hard!

One of the biggest challenges in experimental psychology research is coming up with good operational definitions for the variables you want to study.

- Abstract concepts (e.g., intelligence, happiness, anxiety) can be hard to define and measure.
- Poor operational definitions can lead to unreliable or invalid results.

How would you operationalize anxiety in a research study?

Answer: Anxiety could be operationalized as:

- self-reported anxiety levels on a questionnaire.
- cortisol levels in saliva samples.
- heart rate during a task.

Operational definitions: They're hard!

Answer: Anxiety could be operationalized as:

- self-reported anxiety levels on a questionnaire.
- cortisol levels in saliva samples.
- heart rate during a task.

Each of these definitions captures an aspect of anxiety, but it's unlikely that any one of them fully captures the construct.

You have to create operational definitions that are well-suited to your specific research question, hypothesis, and context.

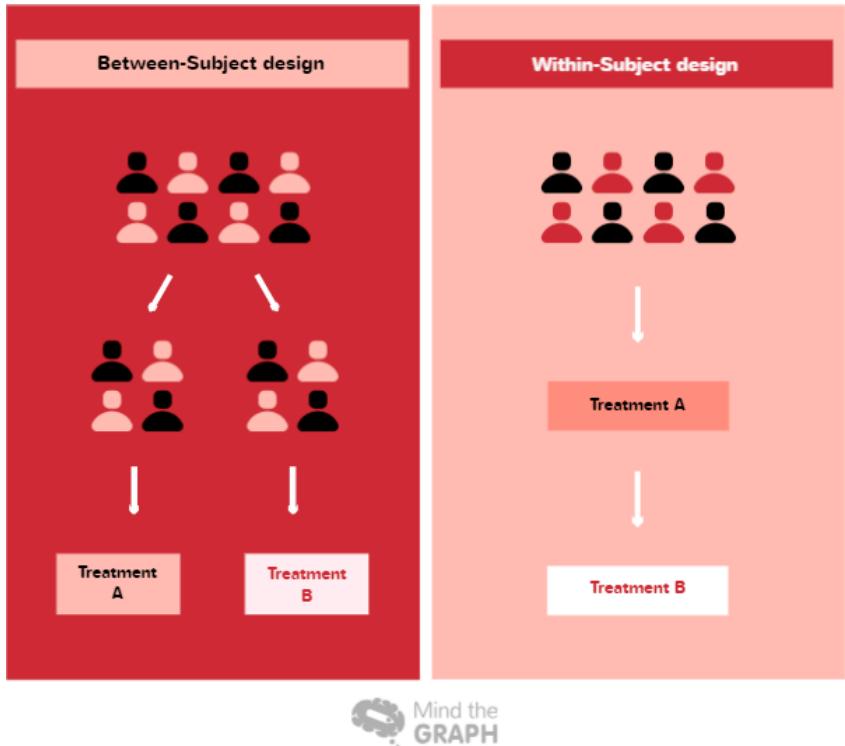
Between- vs. Within-Subjects Experimental Designs

Between-subjects experiment:

- An experiment in which participants experience only one level of the IV.
- Comparisons are made between different groups of participants.

Within-subjects experiments:

- An experiment in which participants experience all levels of the IV.
- Comparisons are made within the same participants.



Between- vs. Within-Subjects: Practice

Putting concepts together: Practice

In this study, is age group a discrete or continuous variable?

Answer: Discrete. Age group is categorical (children vs. adults).

In this study, is age group a nominal, ordinal, interval, or ratio variable?

Answer: Ordinal. Age group has an inherent order (children are younger than adults), but the difference between groups is not necessarily equal.

How could you change the design to make age a continuous variable?

Answer: You could measure the exact age of each participant (in years) instead of categorizing them into groups (children, adolescents, adults).

Is this a correlational or experimental study?

Answer: Both! The researcher manipulates one of the independent variables (Stroop condition) to observe its effect on the dependent variable (reaction times). However, age group is a naturally occurring variable that is not manipulated, making it correlational in that respect.

That's all for Lecture 2!

See you next class. Please remember to:

- Fill out the pre-course survey.
- Install R and R Studio before the next lecture.
- Come to office hours if you need help!