Current Topics in Human–Computer Interaction

Research Approaches in HCI

Prof. Dr. Jan Borchers
Media Computing Group
RWTH Aachen University

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https://hci.rwth-aachen.de/cthci

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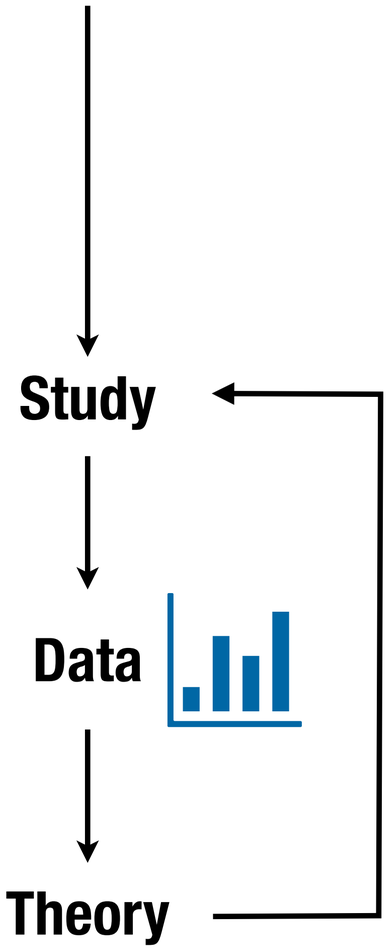
Review - Empirical

- What are three strategies for Empirical Research?
  - **Descriptive research:** X happens
    - Focus on the current state of each **individual** variable
  - **Relational research**: X and Y happen together
    - Measure **two or more variables** that **exist naturally** from each participant
  - **Experimental research:** X causes Y
    - **Manipulate** one or more variables and observe their **effects** on other variables

Review - Ethnography

- Collect data with different methods, e.g.:
  - Observation
  - Interview
- Code data and find patterns in it
- Create theories that explain the data
- Try to attack the theories by gathering more data
  - Leads to stronger theories



Ethnographic research

Three Approaches to HCI Research

Test

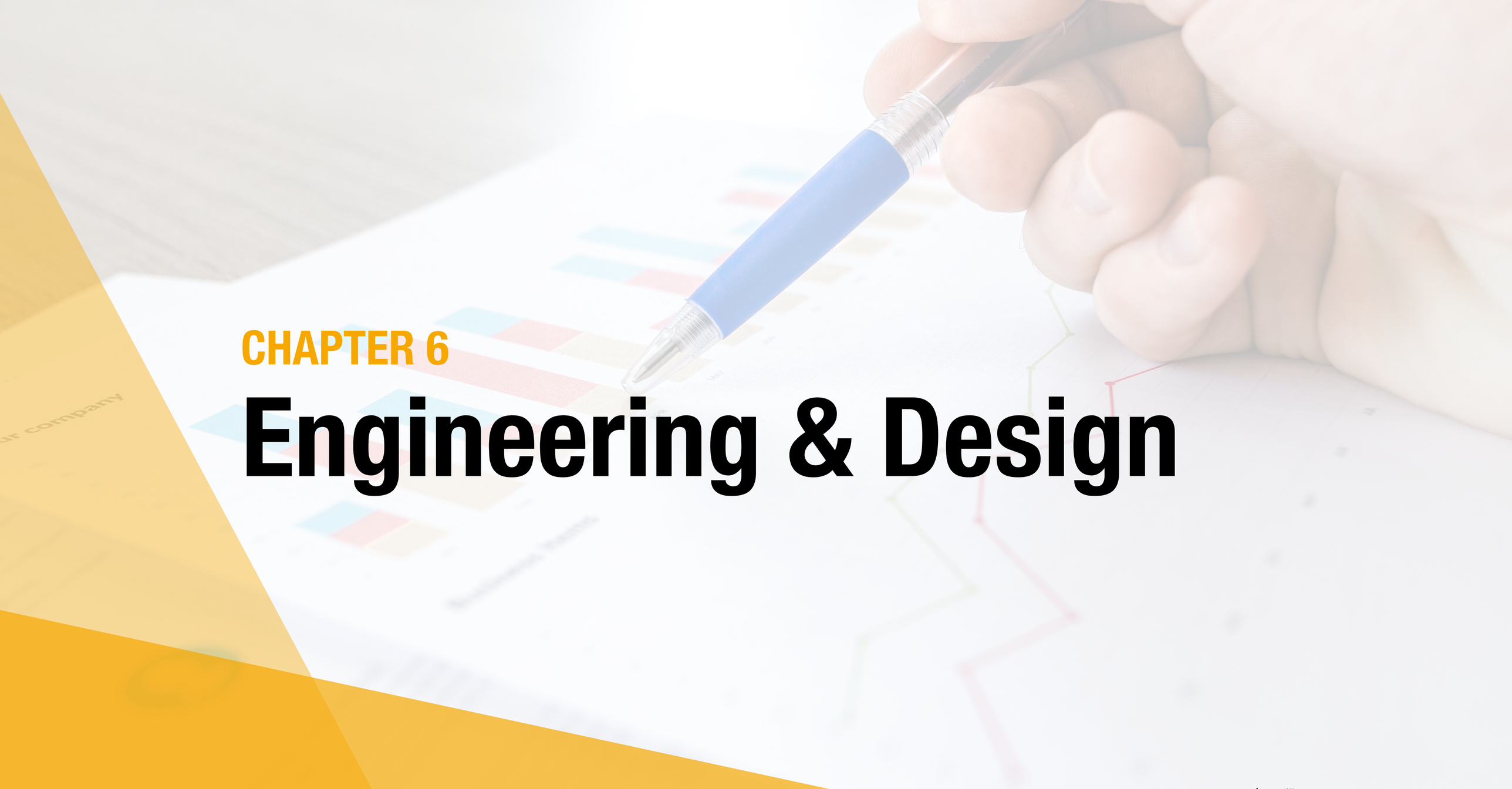
Empirical science

Observe

Ethnography

Make

Engineering & Design



CHAPTER 6

Engineering & Design

Engineering & Design

- Objective: solve a problem with a solution that works
- Key attributes:
  - **Compelling** target
    - **Solve a concrete, compelling problem** with demonstrated need
    - Solve a set of problems using a **unifying set of principles**
    - **Explore** how people will interact with computers in the future
  - **Technical** challenge
    - Requires novel, non-trivial algorithms or configuration of components
  - **Deployed** when possible
    - System is deployed, intended benefits and unexpected outcomes documented

[Adapted from: James Landay, James & Friends' Systems How To - A Guide to Systems & Application Research, NSF SoCS PI Meeting held at the University of Michigan '12]

Example: Skinput: appropriating the body as an input surface

- Harrison et al., Best paper CHI ’10 🏆
- Contributions & Benefits
  - “Skinput is a **technology** that appropriates the human body for acoustic transmission, allowing the skin to be used as a finger input surface.”

Skinput: Appropriating the Body as an Input Surface

Chris Harrison
chris.harrison@cs.cmu.edu

Desney Tan
desney@microsoft.com

Dan Morris
dan@microsoft.com

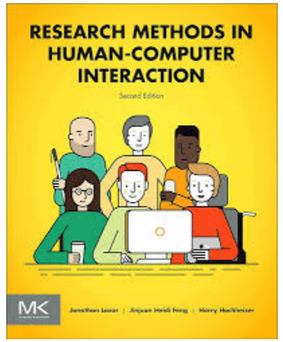
Human-Computer Interaction Institute

Carnegie Mellon

Microsoft

Source

Three Approaches to HCI Research



Test

Empirical science

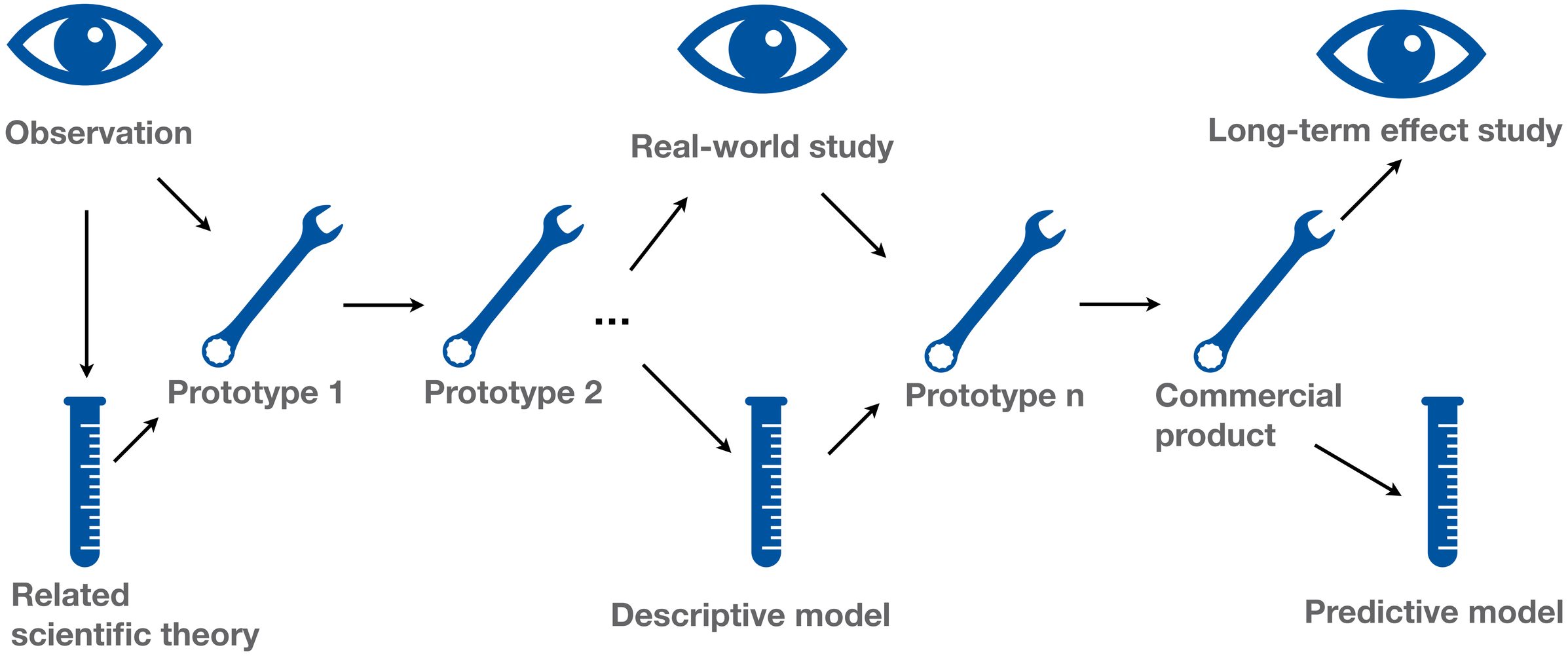
Observe

Ethnography

Make

Engineering & Design

The Messy Truth



Example: CommandMaps

- Contributions & Benefits:
  - “Introduces **CommandMap interfaces for mouse-based command invocation.** Theoretically and empirically demonstrates that their defining properties — spatially stable command locations and a flat command hierarchy — **improve user performance**.”

[Scarr et al., Improving Command Selection with CommandMaps, CHI ’12]

CHAPTER 7

Experimental Research

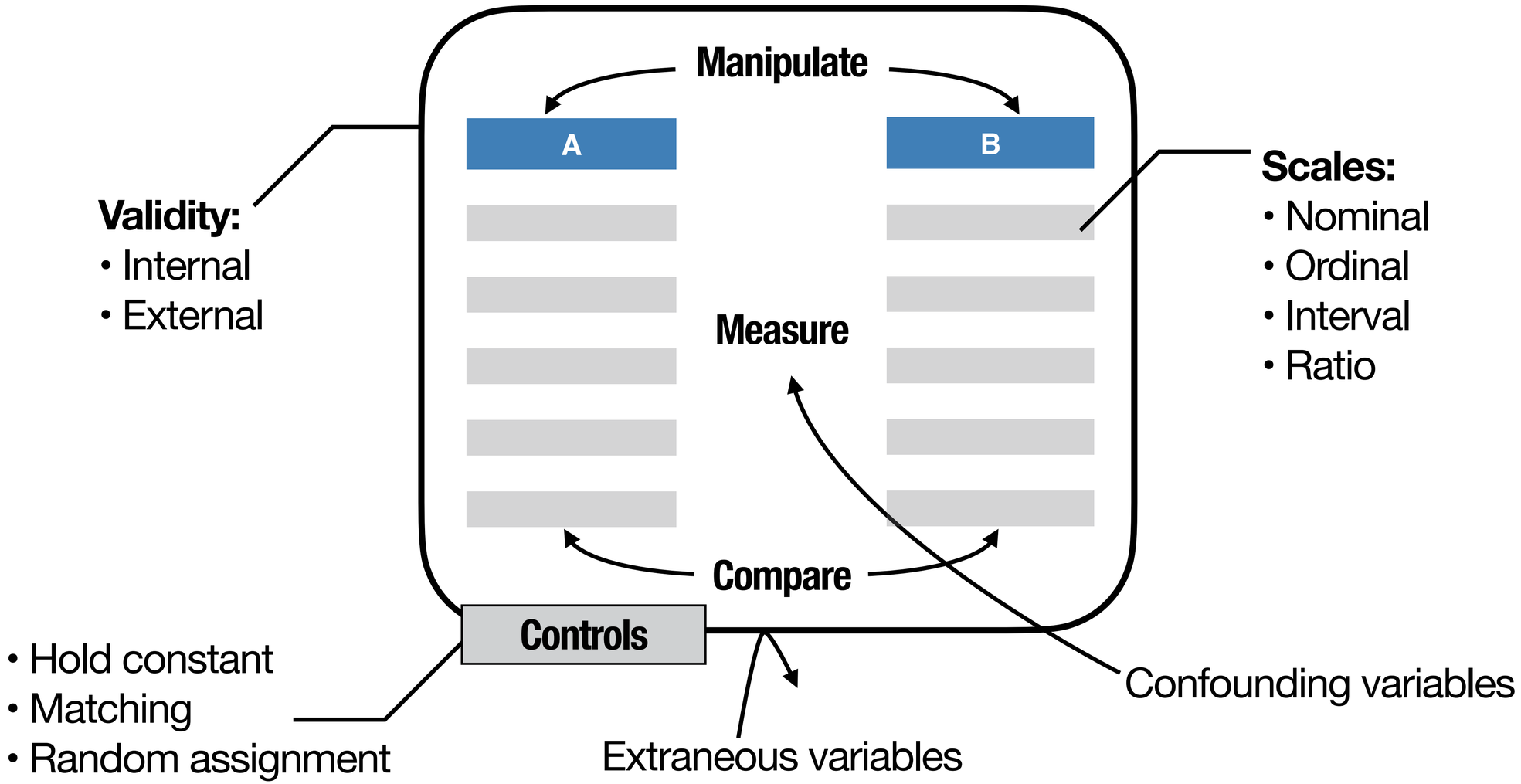
In-class Exercise: Operationalization

- **Research Question:**
  “Young participants have a significantly better memory than older participants”
- How could we study this?
- Variables?
- Operationalization?

Operationalization

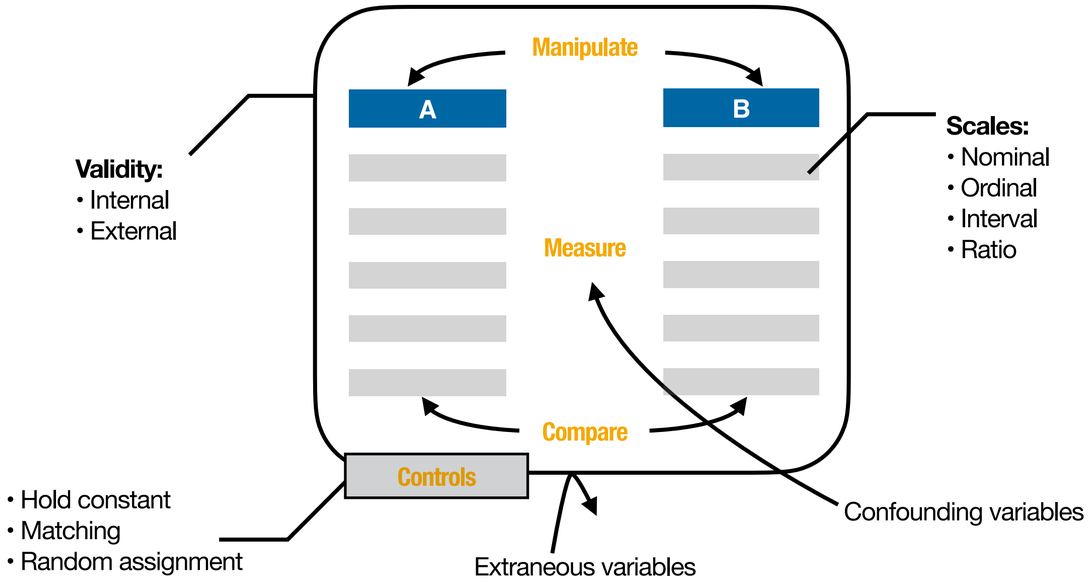
- **Hypothesis:**
  “Participants aged between 16 and 30 years will recall significantly more nouns from a list of twenty nouns than participants aged between 55 and 70.”

Basic Elements of Experimental Studies



Basic Elements of Experimental Studies

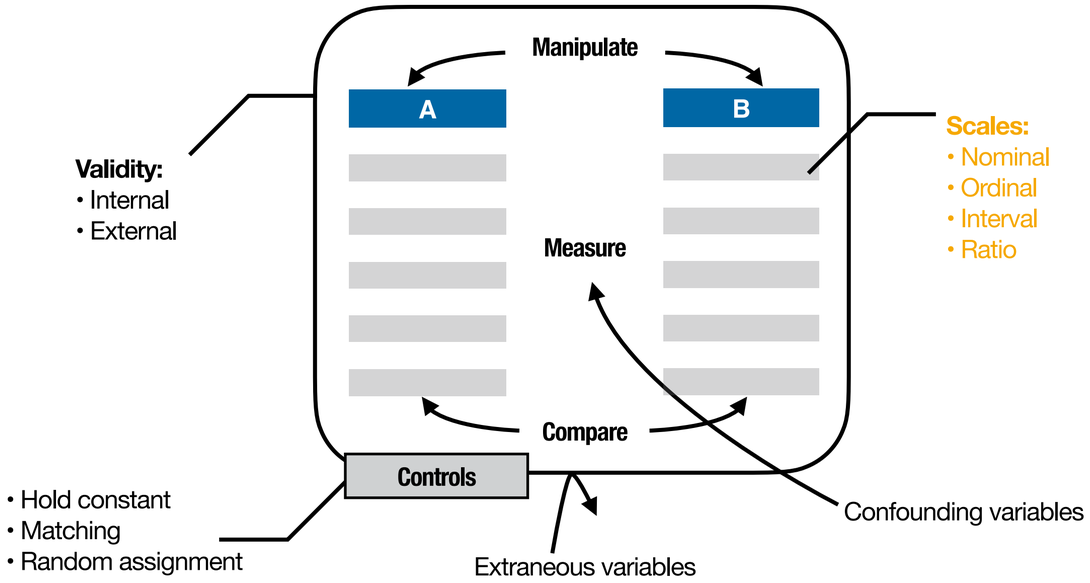
- **Manipulate** the value of the independent variable to create treatment conditions.
- **Measure** the value of the dependent variable in each treatment condition
- **Compare** the values between treatment conditions.
  Consistent differences between treatments are evidence of causality.
- **Control** other variables so they do not influence the independent and dependent variables.



Definitions from Gravetter and Forzano

Scales of Measurement

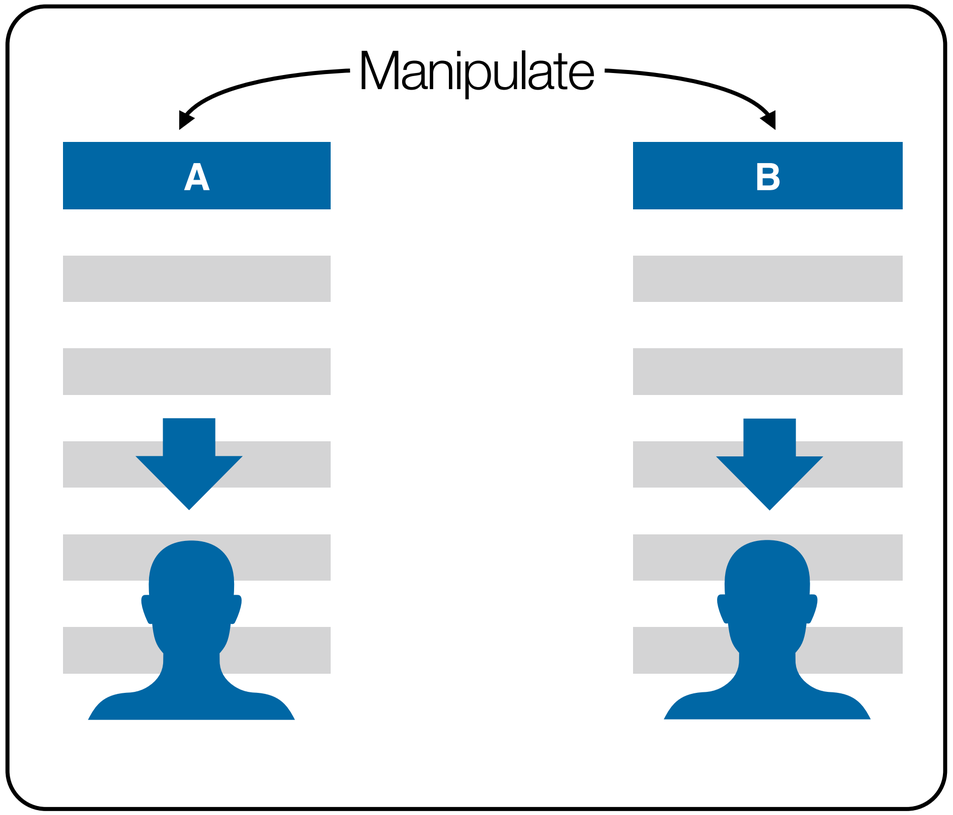
- **Nominal scale:** discrete, qualitative, categorical differences, ignoring the order
  - E.g., input techniques: mouse vs. touchscreen (IV), whether the user made an error or not (DV)
- **Ordinal scale:** sequentially ranked categories, ignoring magnitude of differences
  - E.g., size of keyboard buttons (IV), Likert (5-point) scale answers (DV)
- **Interval scale:** sequentially organized categories, all categories have the same size (possible to determine relative distances)
  - E.g., preference ranking (DV)
- **Ratio scale:** interval scale in which zero represents complete absence (possible to determine absolute distances)
  - E.g., Task completion time in seconds (DV), error rate in percent (DV)



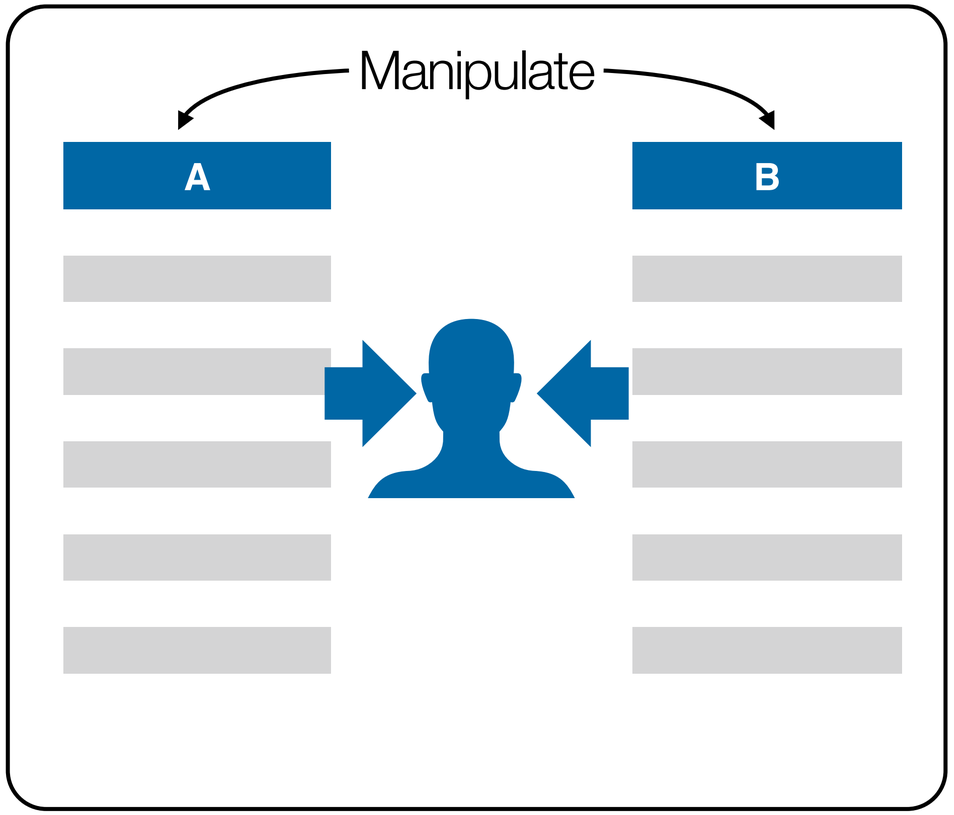
Basic Experimental Designs

- **Between-groups design**
  - Each subject only does one variant of the experiment
  - There are at least 2 groups to isolate effect of manipulation:
    - **Treatment group** and **control group**
    - **Advantage:** no practice effects across variants
    - Good for tasks that are simple and involve limited cognitive processes, e.g., tapping or visual search
    - **Disadvantage:** requires more users
- **Within-groups design**
  - Each subject does all variants of the experiment
  - **Advantage:** Fewer users required, individual differences canceled out
  - Good for complex tasks, e.g., typing, reading, composition, problem solving
  - **Disadvantage:** practice effects may occur

Basic Experimental Designs



Between-groups design



Within-groups design

Order Effects

- Within-groups design
- Behavior may be influenced by experiences that occurred earlier in the sequence
- **Carryover effects:** changes caused by the lingering aftereffects of an earlier treatment condition
  - E.g., testing the first condition causes users' fingers to hurt, degrading their performance in the second condition
- **Progressive error:** changes that are related to general experience in the study but unrelated to specific treatments
  - Practice effects and fatigue
  - E.g., the experiment takes too long overall

Counterbalancing against Order Effects

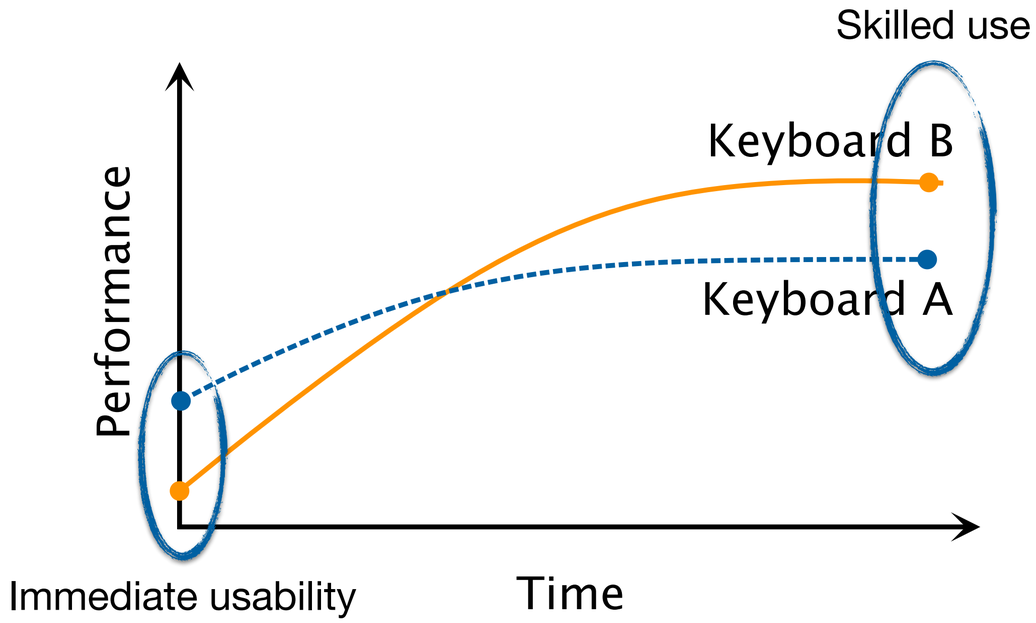
- Ideally, use every possible order of treatments with an equal number of individual participants
  (⇒ *n!* permutations)

- Latin Square is a compromise:
  - Each condition appears at each ordinal position
  - Each condition precedes and follows each other condition exactly once
  - Only *n* permutations
  - Example: six treatments (A, B, C, D, E, F)

1	A	B	F	C	E	D
2	B	C	A	D	F	E
3	C	D	B	E	A	F
4	D	E	C	F	B	A
5	E	F	D	A	C	B
6	F	A	E	B	D	C

Learning Curve

- The relationship between experience (or time) and performance
- Typically shows rapid raise at the beginning, followed by a plateau
- To reduce its effect, start measuring when the learning effect is mostly gone



In-class Exercise

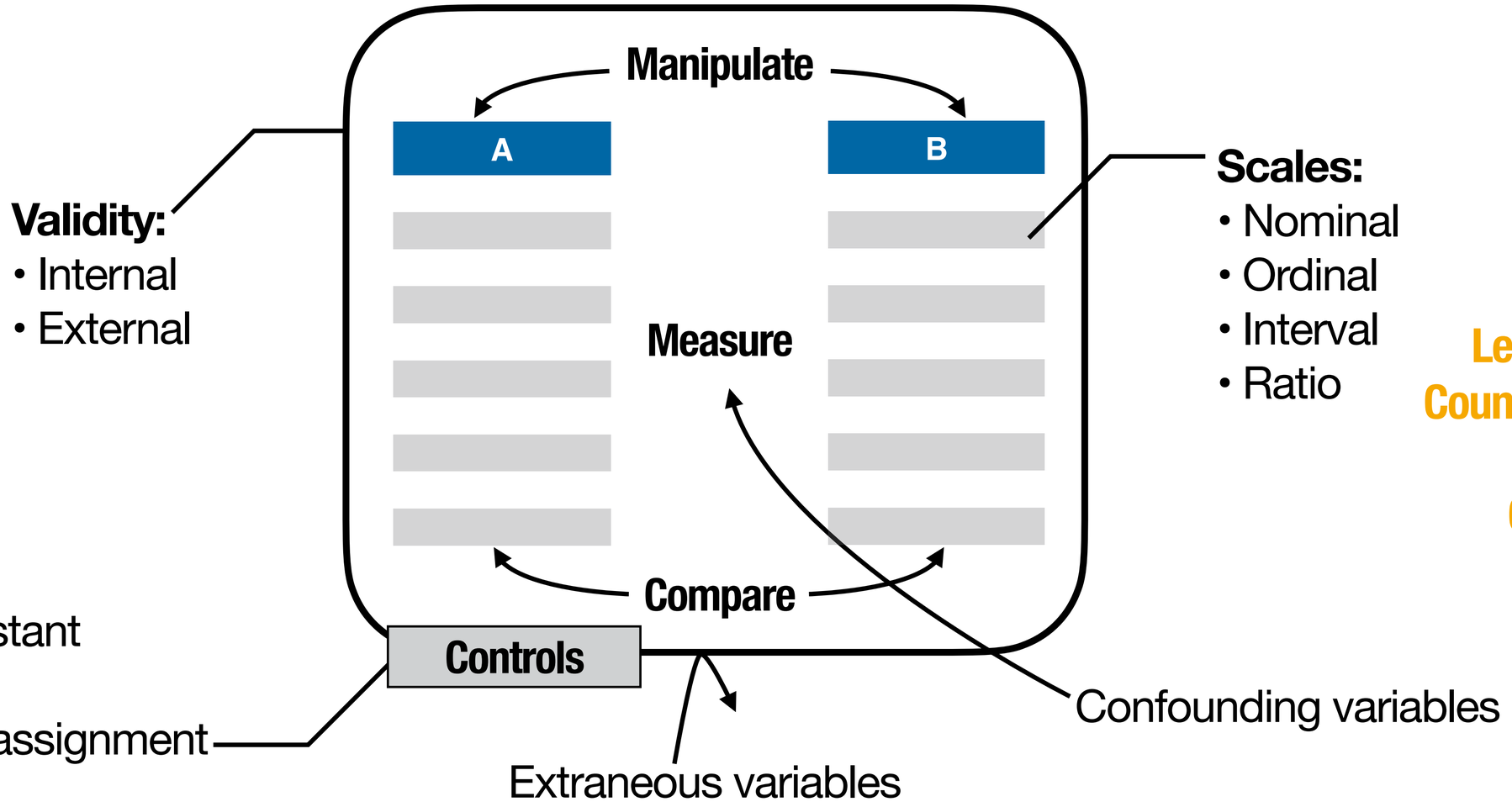
- You have designed a new keyboard layout, and you want to know how good it is
- Strategy: compare it to existing techniques

- Describe one reason to choose a
  - **Within-groups design**
  - **Between-groups design**

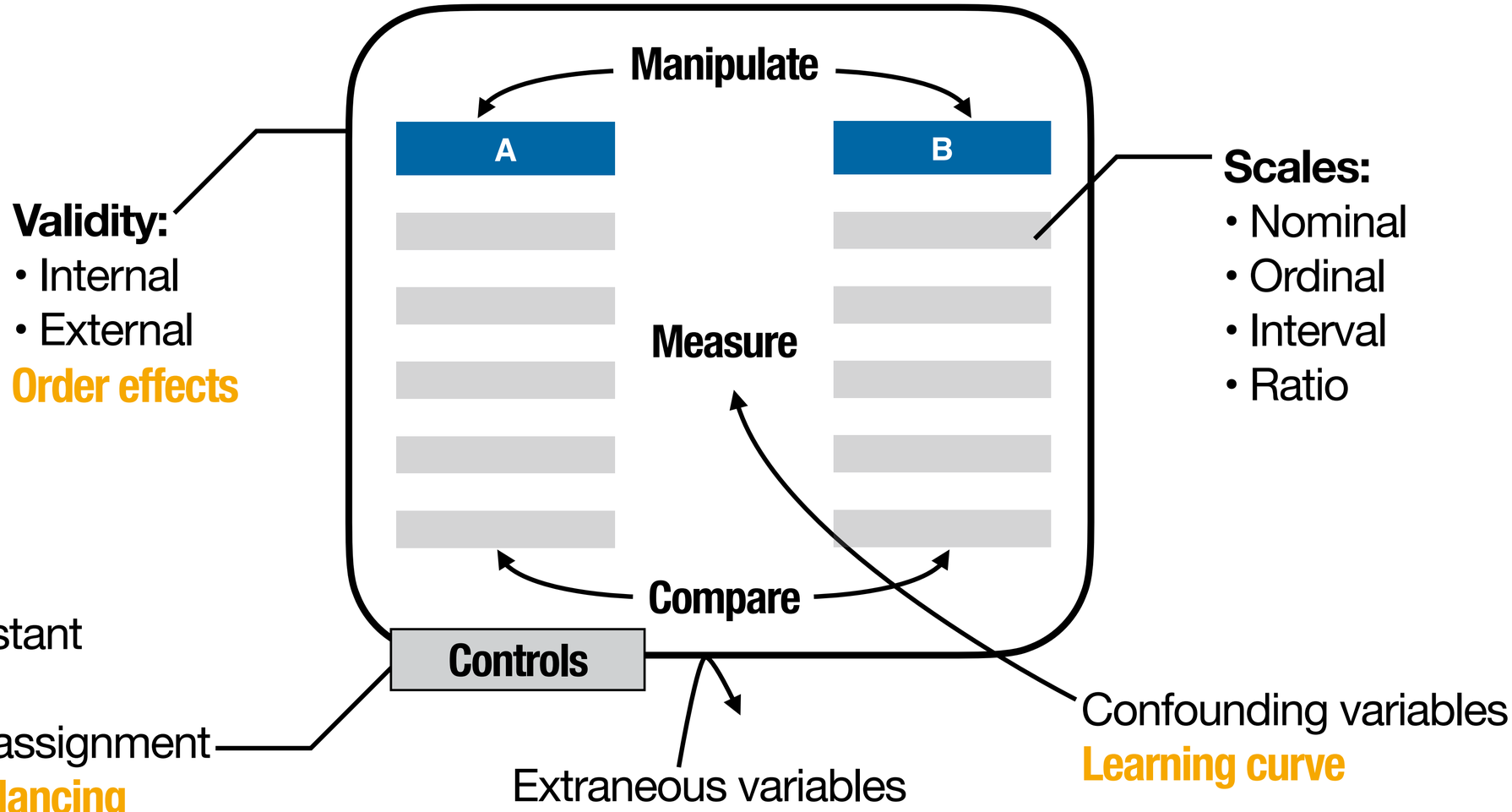
In-class Exercise

- Usually preferred: **within-group design**
  - Minimizes confounding effects from the behavioral differences between participants
- Sometimes, we need a **between-groups** design
  - E.g., when testing whether a keyboard favors users with right-handedness over those with left-handedness
  - When there are interferences between conditions, e.g., different keyboard layouts on the same hardware

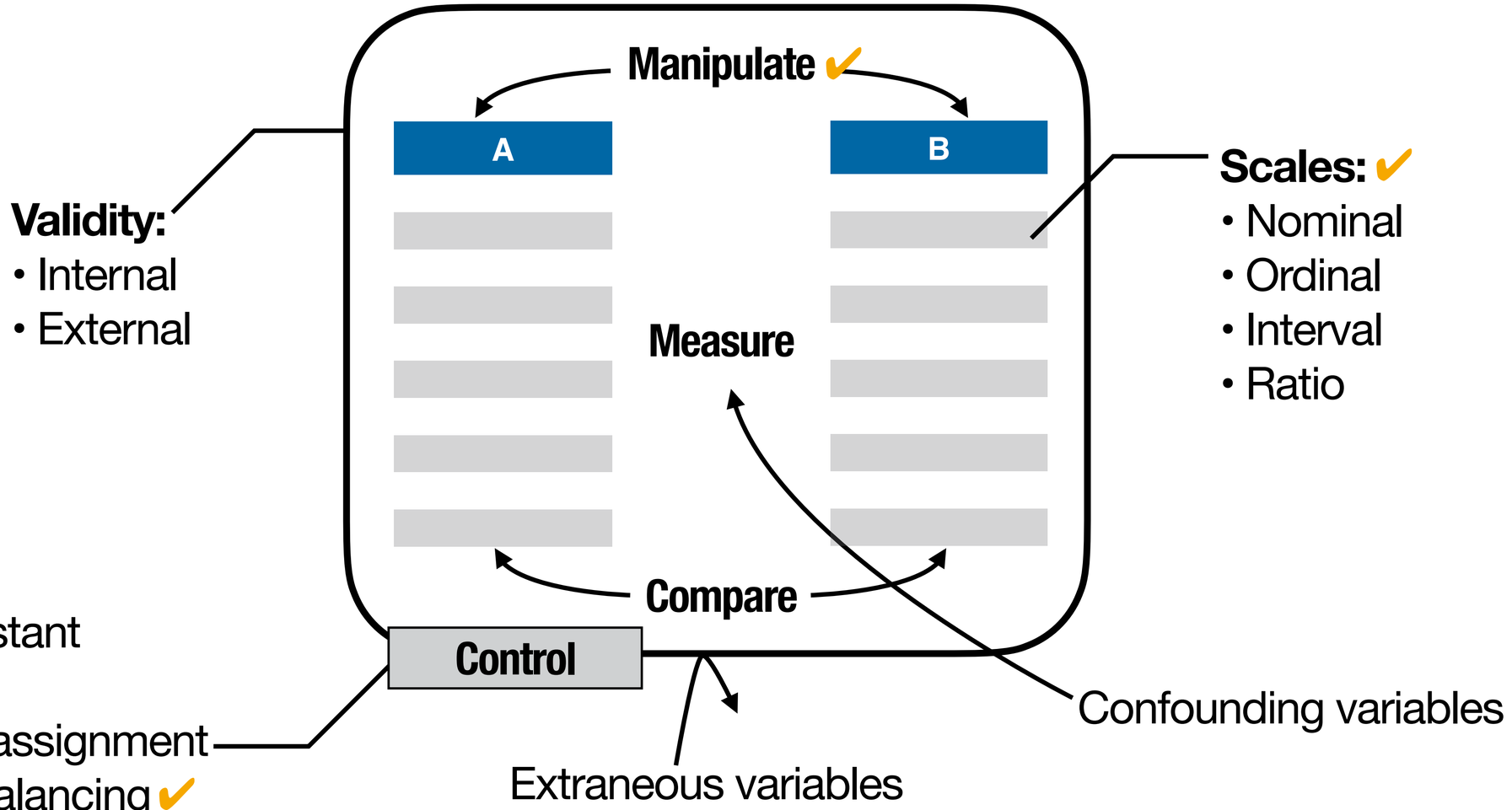
In-class Exercise: Basics of Experimental Studies



In-class Exercise: Basics of Experimental Studies

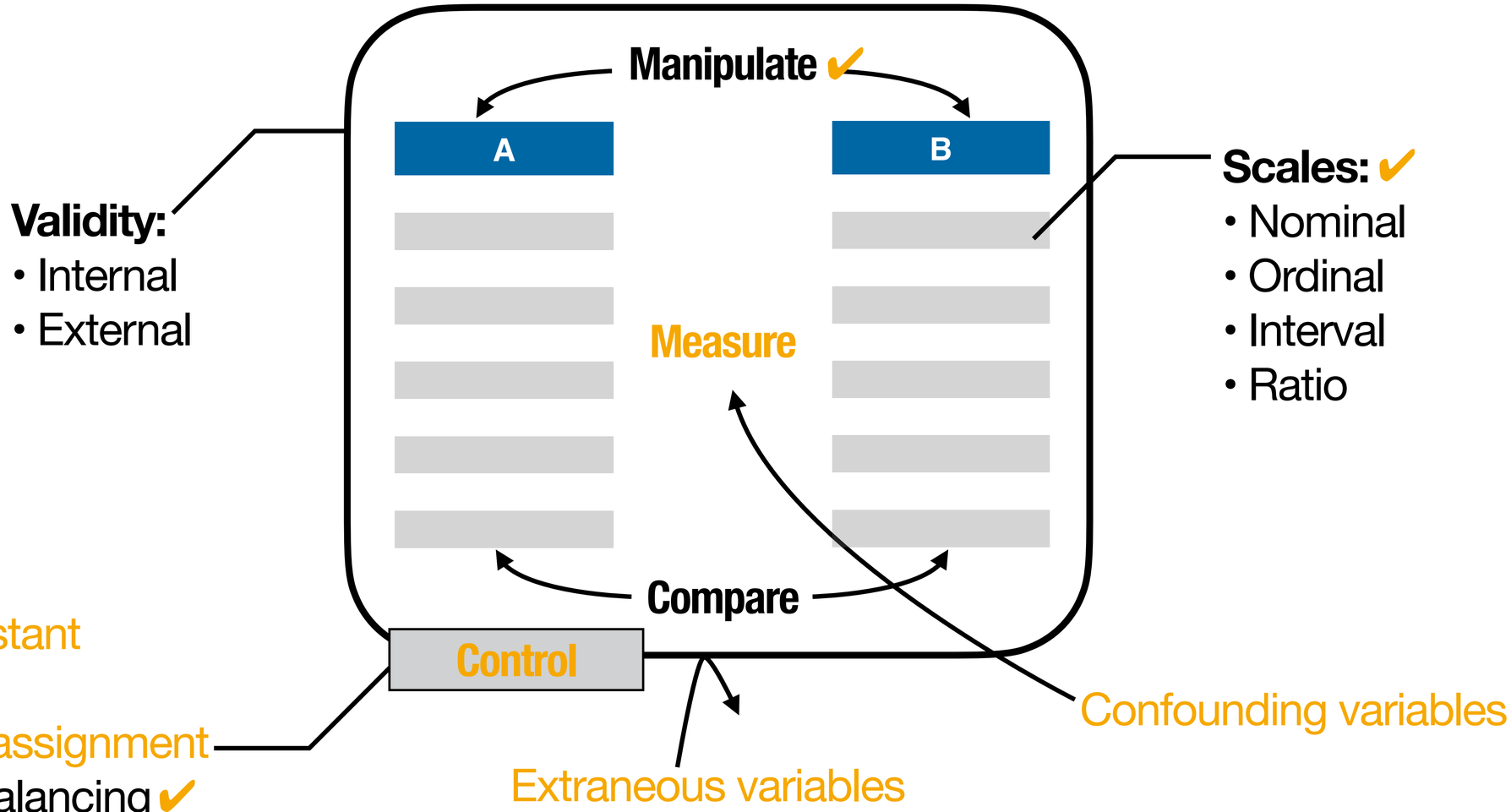


Basic Elements of Experimental Studies



- Hold constant
- Matching
- Random assignment
- Counterbalancing ✔
  - Latin Square ✔

Basic Elements of Experimental Studies



- Hold constant
- Matching
- Random assignment
- Counterbalancing ✔
  - Latin Square ✔

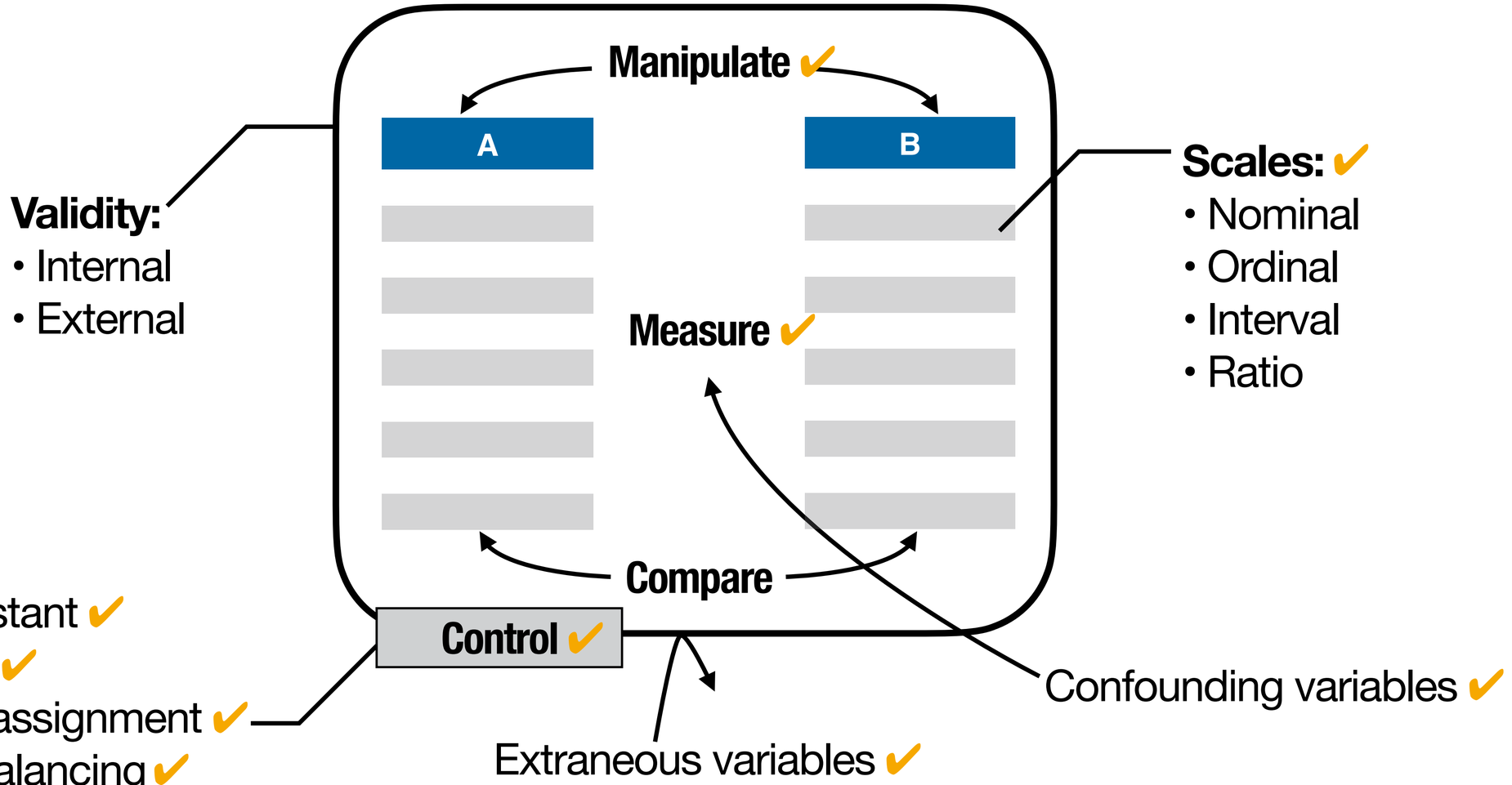
Variables

- Independent variables are **manipulated** by the researcher
- Dependent variables are **observed** for changes to assess the effect of the independent variables
- All other variables: extraneous variables
- A confounding variable is an extraneous variable that changes systematically along with IV and DVs ⇒ alternative explanation of the relationship between the two variables

Dealing with Extraneous Variables

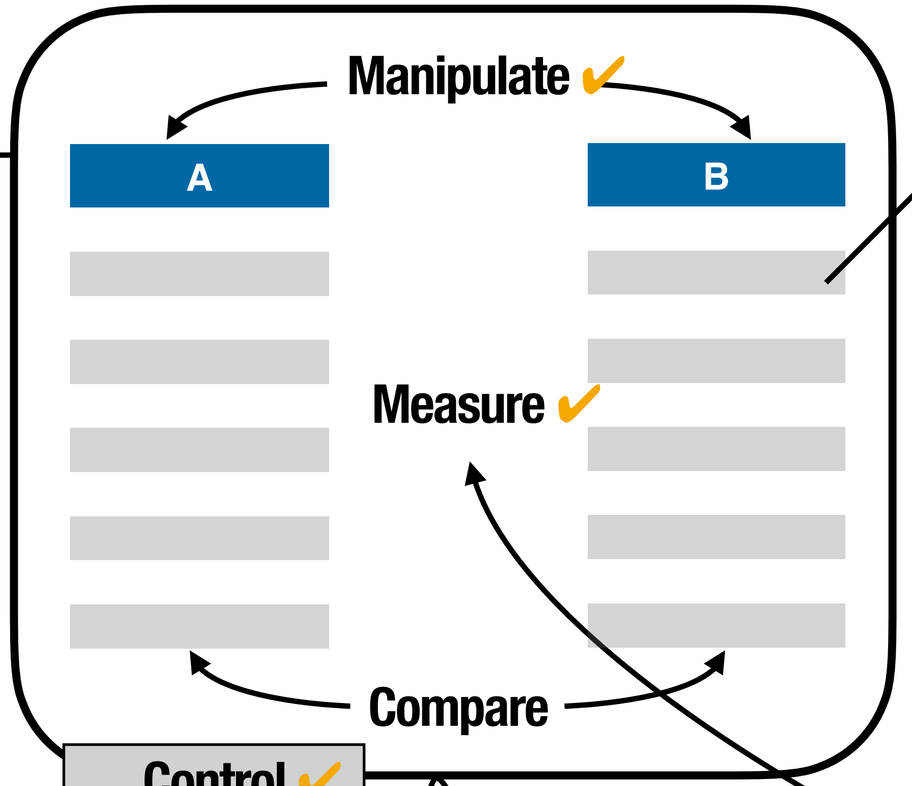
- Examples for variables that are often extraneous: Age, level of expertise
- Hold constant: select all participants to have the same value for the extraneous variable
- Match the same number of participants with each value of the extraneous variable (making it an independent variable)
- Randomly assign participants to each value of the extraneous variable

Basic Elements of Experimental Studies



- Hold constant ✔
- Matching ✔
- Random assignment ✔
- Counterbalancing ✔
  - Latin Square ✔

Basic Elements of Experimental Studies



Validity:
- Internal
- External

Scales: ✔
- Nominal
- Ordinal
- Interval
- Ratio

- Hold constant ✔
- Matching ✔
- Random assignment ✔
- Counterbalancing ✔
  - Latin Square ✔

Confounding variables ✔

Extraneous variables ✔

Validity

- A study has internal validity if it produces a single, unambiguous explanation for the relationship between two variables
  - Threats: e.g., confounding variables, experimenter bias, learning effect, Hawthorne effect (being observed causes the changes)
- External validity refers to the extent to which we can generalize the results to people, settings, times, measures, and characteristics other than those used in that study
  - Threats: e.g., generalizing across participants, interference between multiple IVs
- Always a trade-off
  ⇒ strike an appropriate balance depending on the goal of your research

Dealing with Extraneous Variables & Validity

Include them as IVs ⇒ too many experimental conditions!

Leave as random

⇒ Reflects variation in natural use

⇒ ↑ External validity

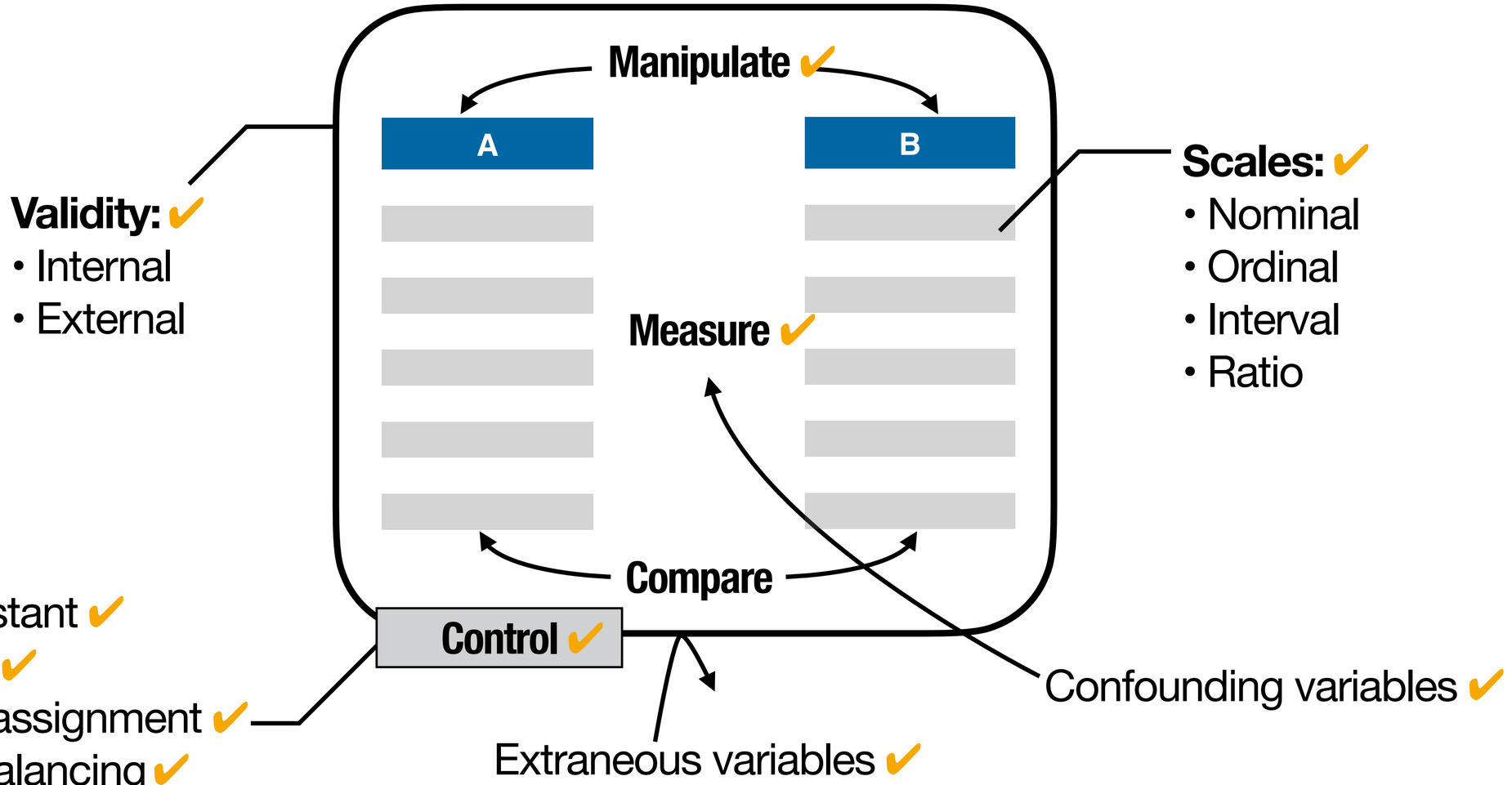
⟷

Control

⇒ Higher confidence to infer causality in the results

⇒ ↑ Internal validity

Basic Elements of Experimental Studies



- Hold constant ✔
- Matching ✔
- Random assignment ✔
- Counterbalancing ✔
  - Latin Square ✔

What's next?

- Finish Milestone 1 (Deadline today)
- Start with Milestone 2 (Deadline in two weeks)

KW 19	KW 20	KW 21	KW 22	KW 23	KW 24	KW 25	KW 26	KW 27	KW 28	KW 29	KW 30
M1: Research Topic		**M2**: Research Plan *Groups formed*	*Excursion week*	**M3**: Conduct-ing Research		**M4**: Data analysis			**M5**: Prepare Presentatio n		Project Presen-tations

Literature

- Thorsten Karrer, Moritz Wittenhagen, Leonhard Lichtschlag, Florian Heller, and Jan Borchers. 2011. Pinstripe: eyes-free continuous input on interactive clothing. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 1313-1322. https://doi.acm.org/10.1145/1978942.1979137

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