Current Topics in Human–Computer Interaction

Research Approaches in HCI

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

Summer Semester ’24

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

RWTH AACHEN UNIVERSITY

Three Approaches to HCI Research

Test

Empirical science

Observe

Ethnography

Make

Engineering & Design

CHAPTER 6

Engineering & Design

RWTH AACHEN UNIVERSITY

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]

RWTH AACHEN UNIVERSITY

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

RWTH AACHEN UNIVERSITY

Three Approaches to HCI Research

Test

Empirical science

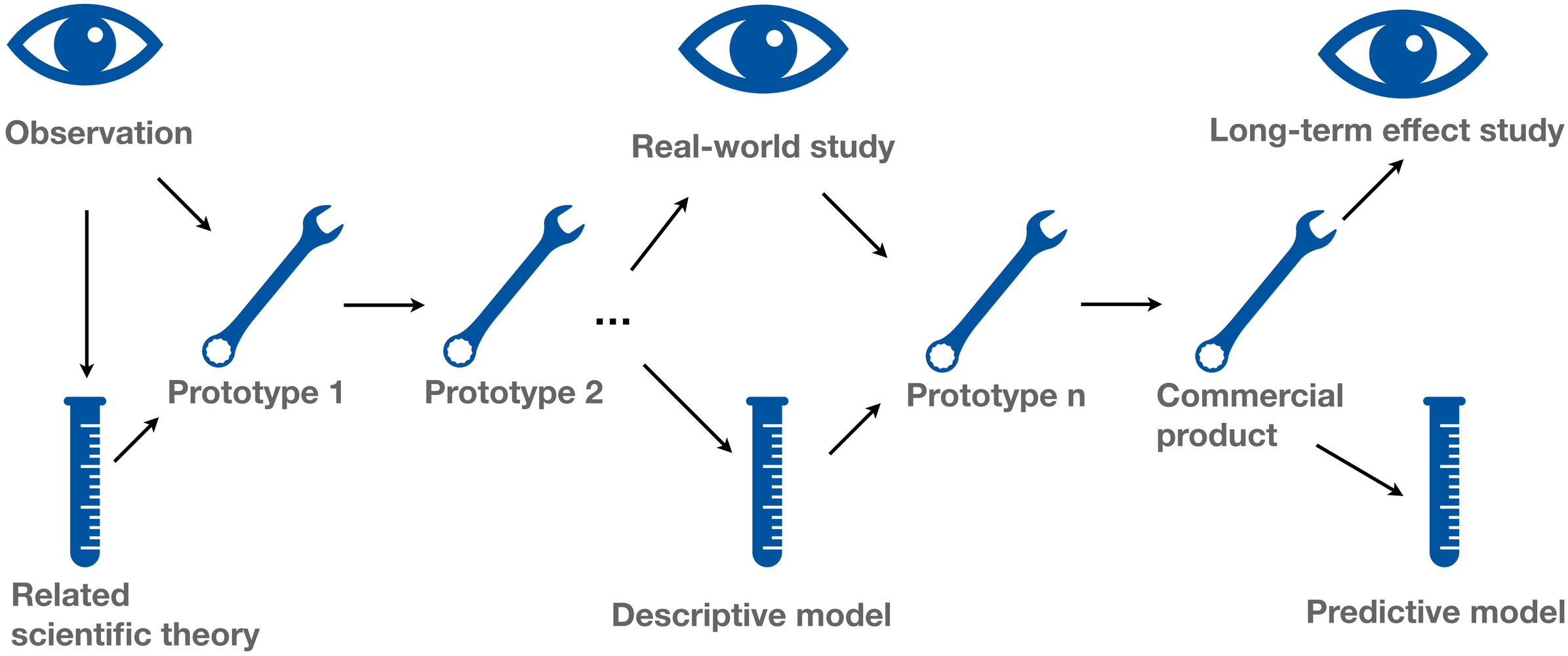
Observe

Ethnography

Make

Engineering & Design

The Messy Truth



RWTH AACHEN UNIVERSITY

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]

RWTH AACHEN UNIVERSITY

CHAPTER 7

Experimental Research

RWTH AACHEN UNIVERSITY

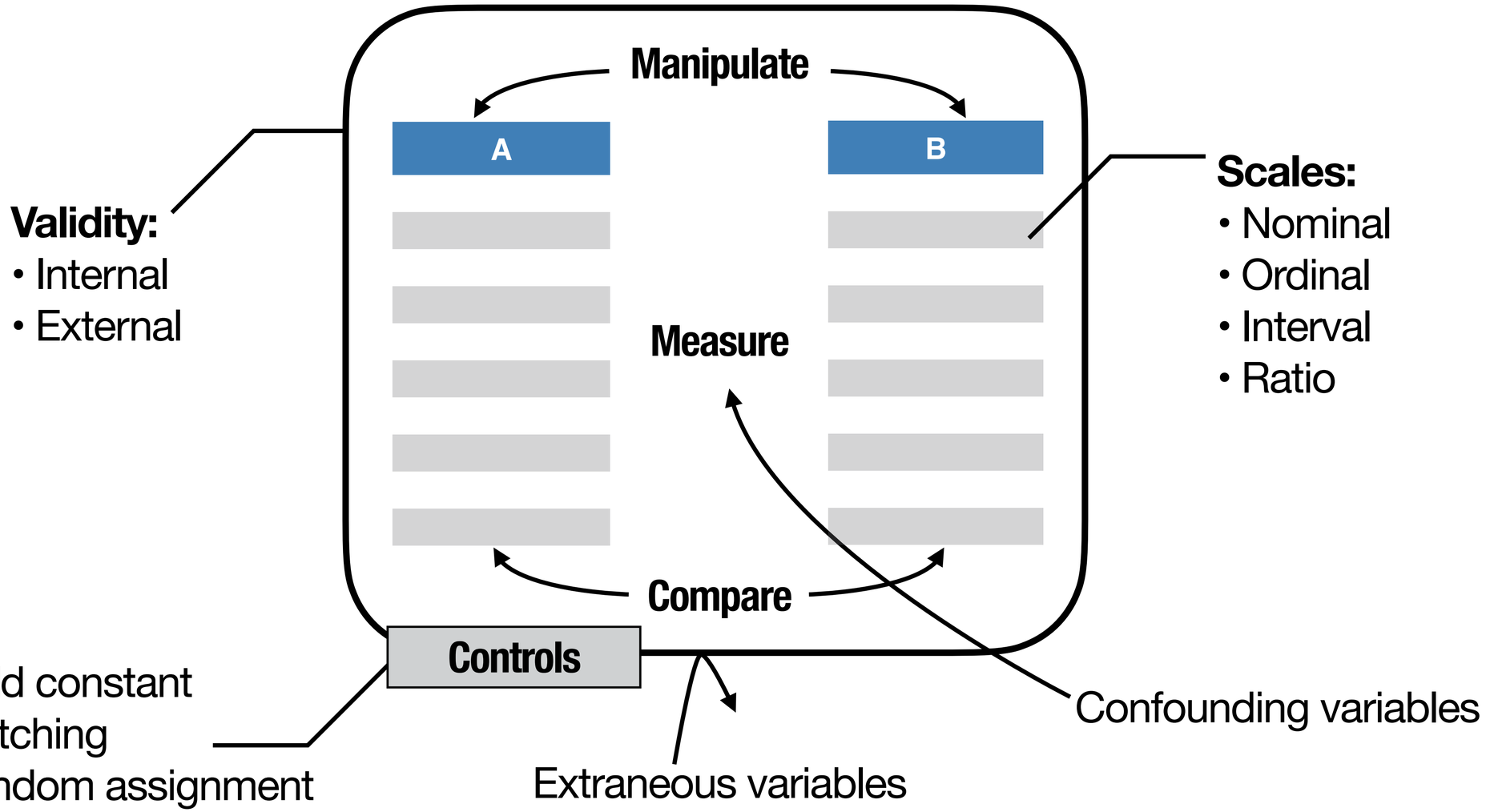
In-class Exercise: Operationalization

- **Research Question:**
  “Young participants will have 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.”

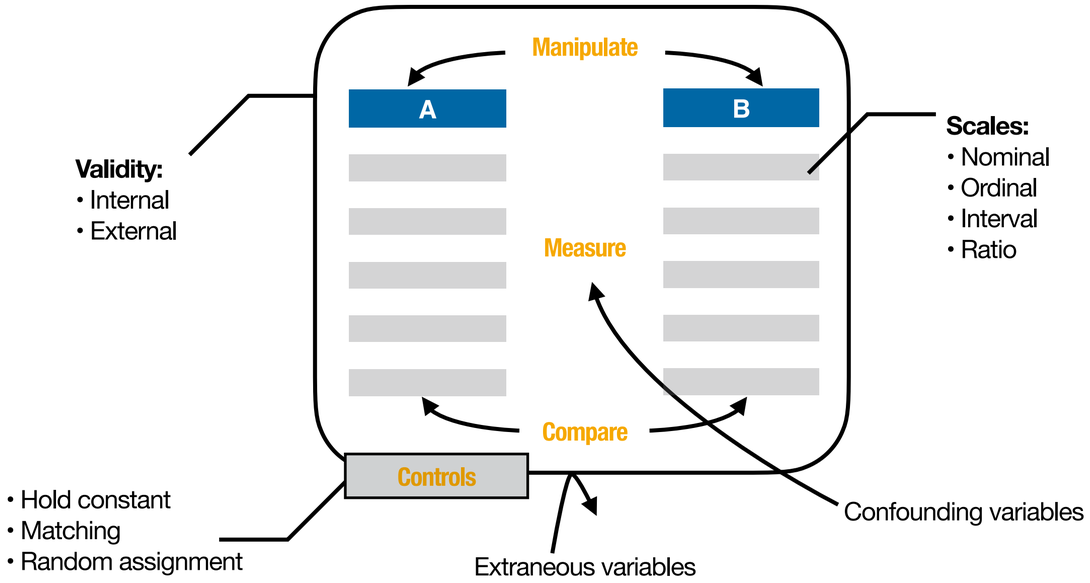
Basic Elements of Experimental Studies



RWTH AACHEN UNIVERSITY

Basic Elements of Experimental Studies

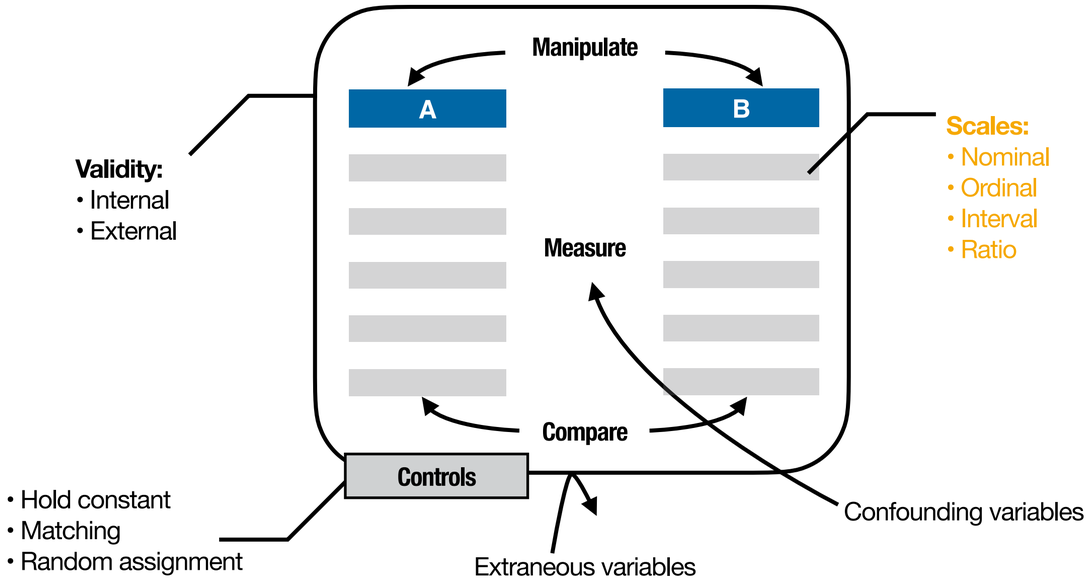
- **Manipulate** the value of the independent variable to create treatment conditions.
- **Measure** the value of the dependent variable in each treatment condition
- **Compare** the values between treatment conditions.
  Consistent differences between treatments are evidence of causality.
- **Control** 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., keyboard type (IV), 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)

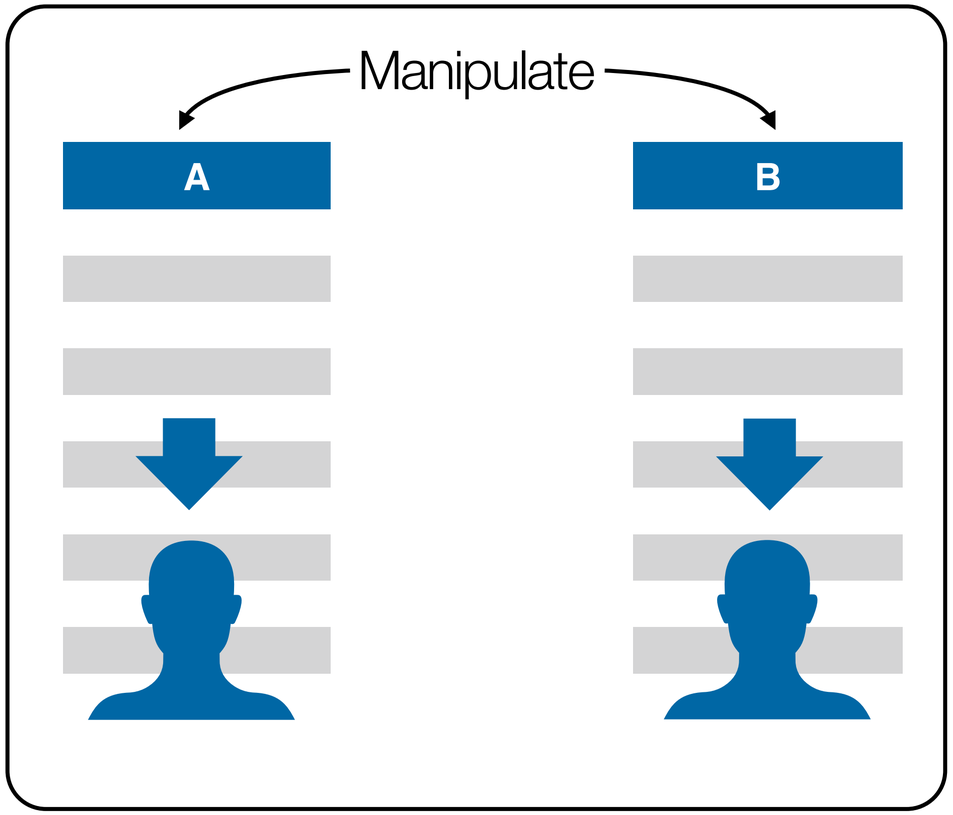


Basic Experimental Designs

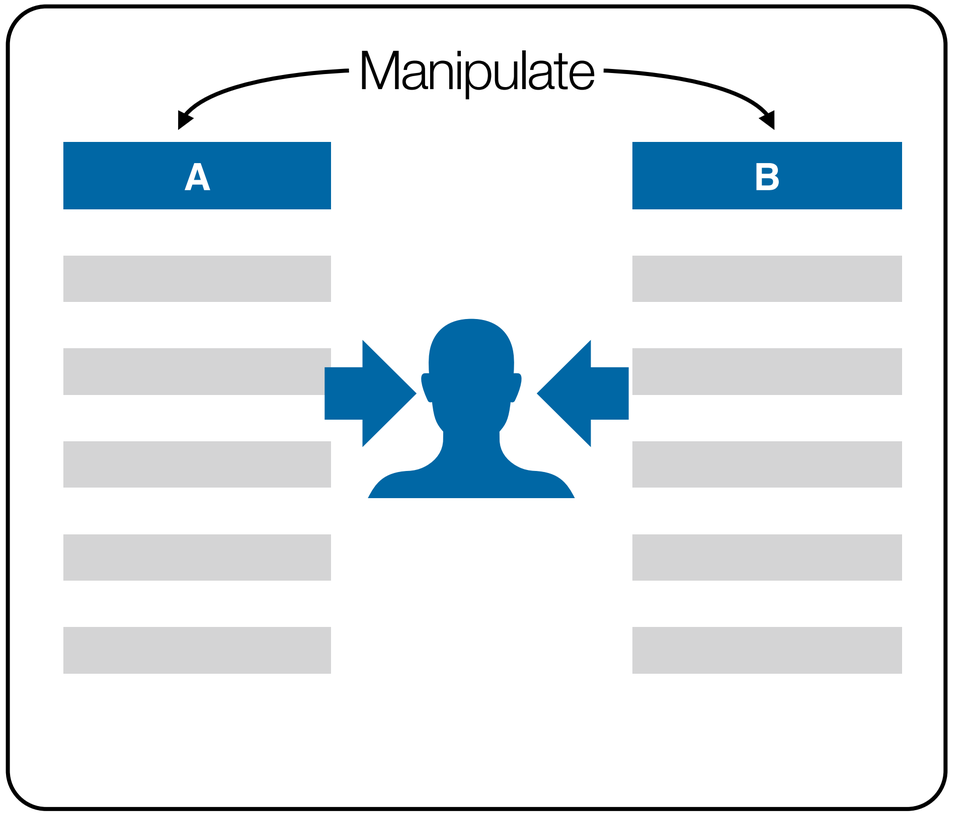
- **Between-groups design**
  - Each subject only does one variant of the experiment
  - There are at least 2 groups to isolate effect of manipulation:
    - **Treatment group** and **control group**
    - **Advantage:** no practice effects across variants
    - Good for tasks that are simple and involve 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

RWTH AACHEN UNIVERSITY

Basic Experimental Designs



Between-groups design



Within-groups design

RWTH AACHEN UNIVERSITY

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)

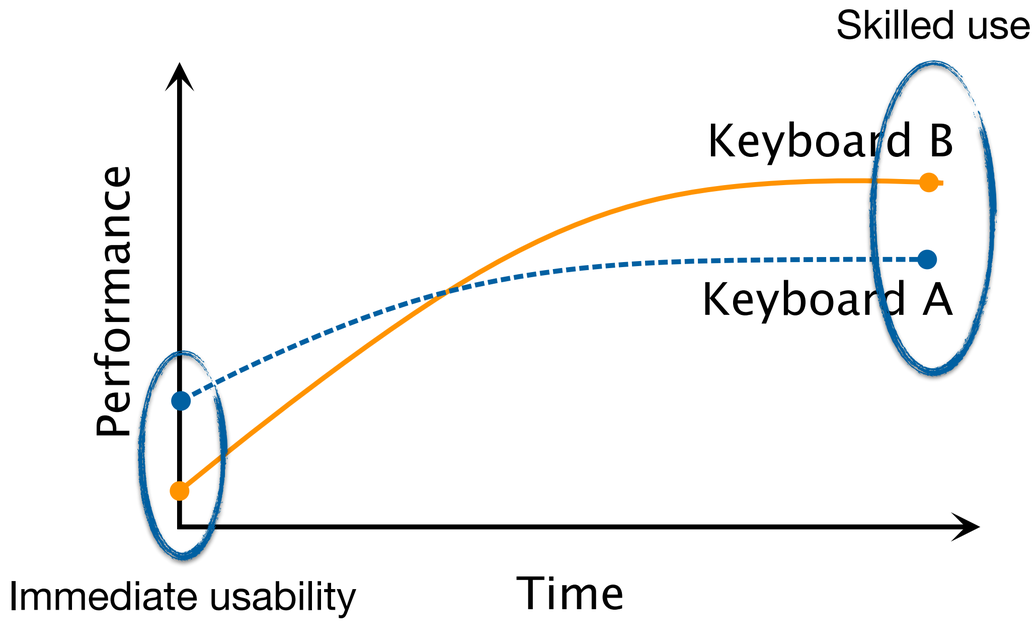
- Latin Square is a compromise:
  - Each condition appears at each ordinal position
  - Each condition precedes and follows each other condition exactly once
  - Only *n* permutations
  - Example: six treatments (A, B, C, D, E, F)

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

RWTH AACHEN UNIVERSITY

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

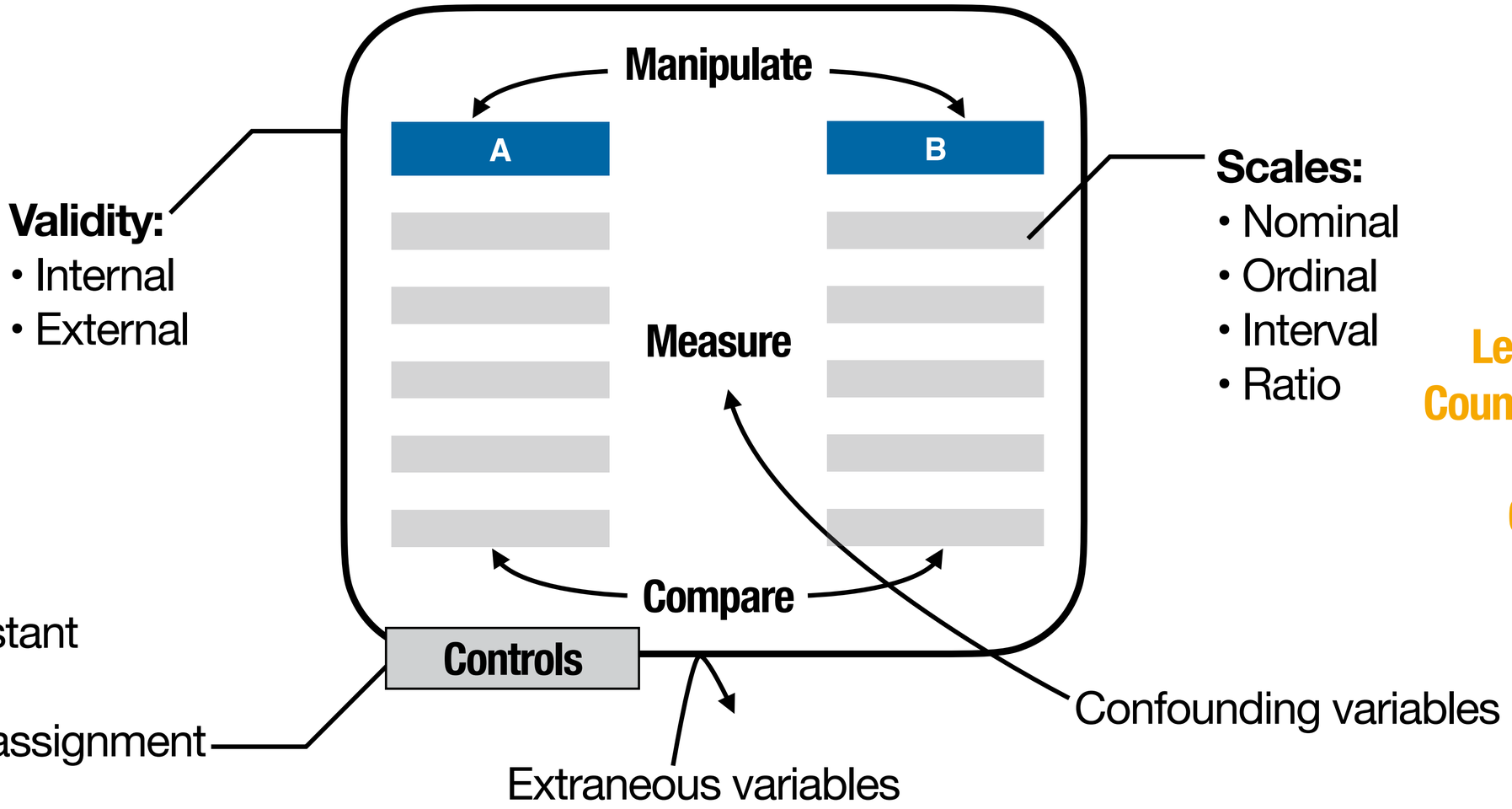
- Describe one reason to choose a
  - **Within-groups design**
  - **Between-groups design**

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

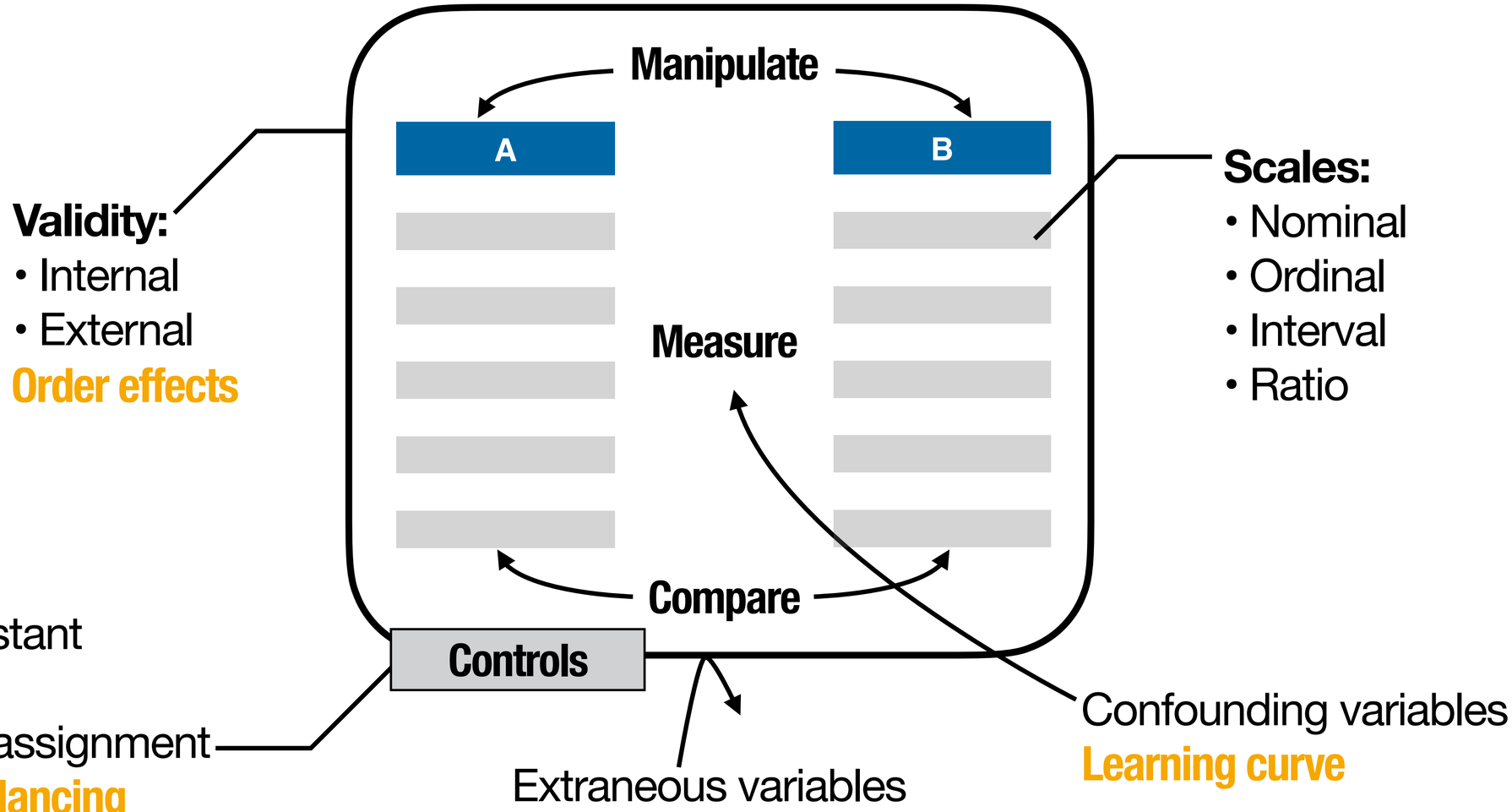
RWTH AACHEN UNIVERSITY

In-class Exercise: Basics of Experimental Studies



RWTH AACHEN UNIVERSITY

In-class Exercise: Basics of Experimental Studies



RWTH AACHEN UNIVERSITY

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

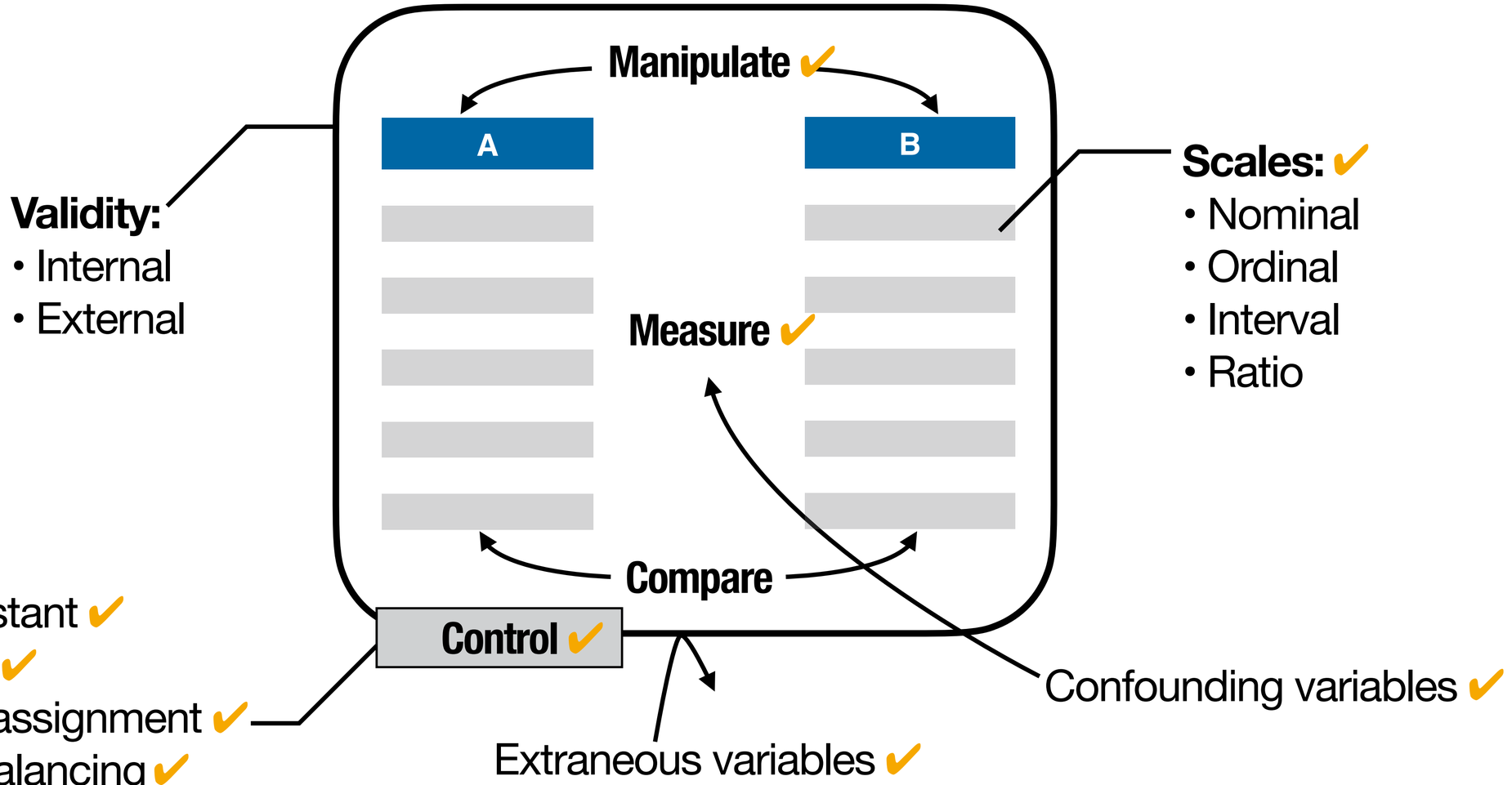
RWTH AACHEN UNIVERSITY

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

RWTH AACHEN UNIVERSITY

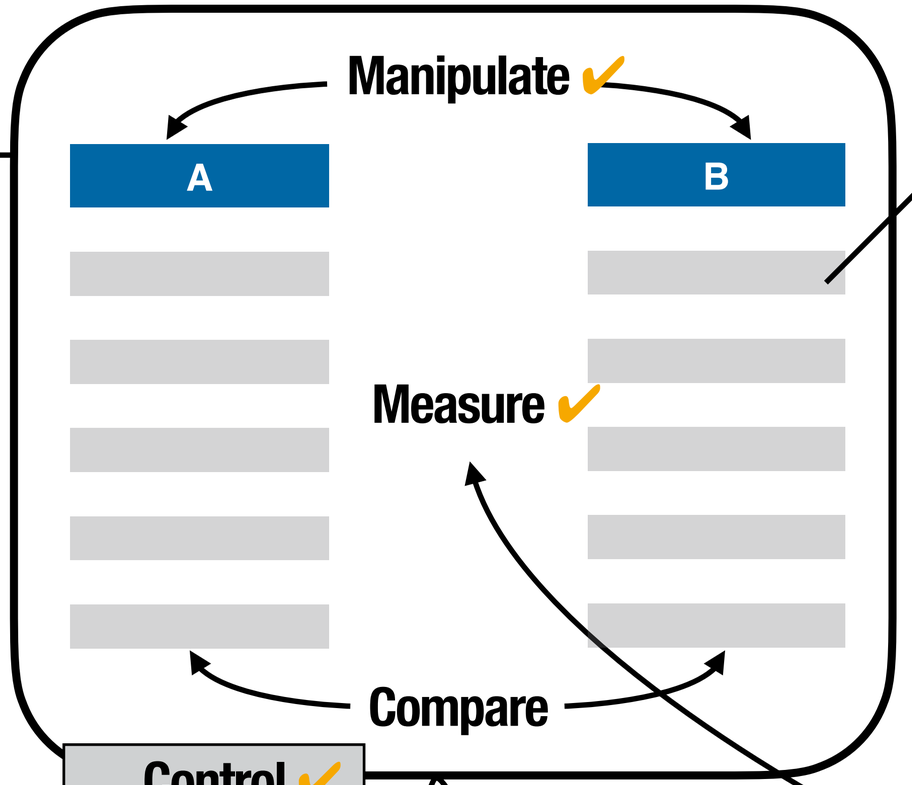
Basic Elements of Experimental Studies



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

RWTH AACHEN UNIVERSITY

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 ✔

RWTH AACHEN UNIVERSITY

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

RWTH AACHEN UNIVERSITY

Dealing with Extraneous Variables

Include them as IVs ⇒ too many experimental conditions!

Leave as random

⇒ Reflects variation in natural use

⇒ ↑ External validity

⟷

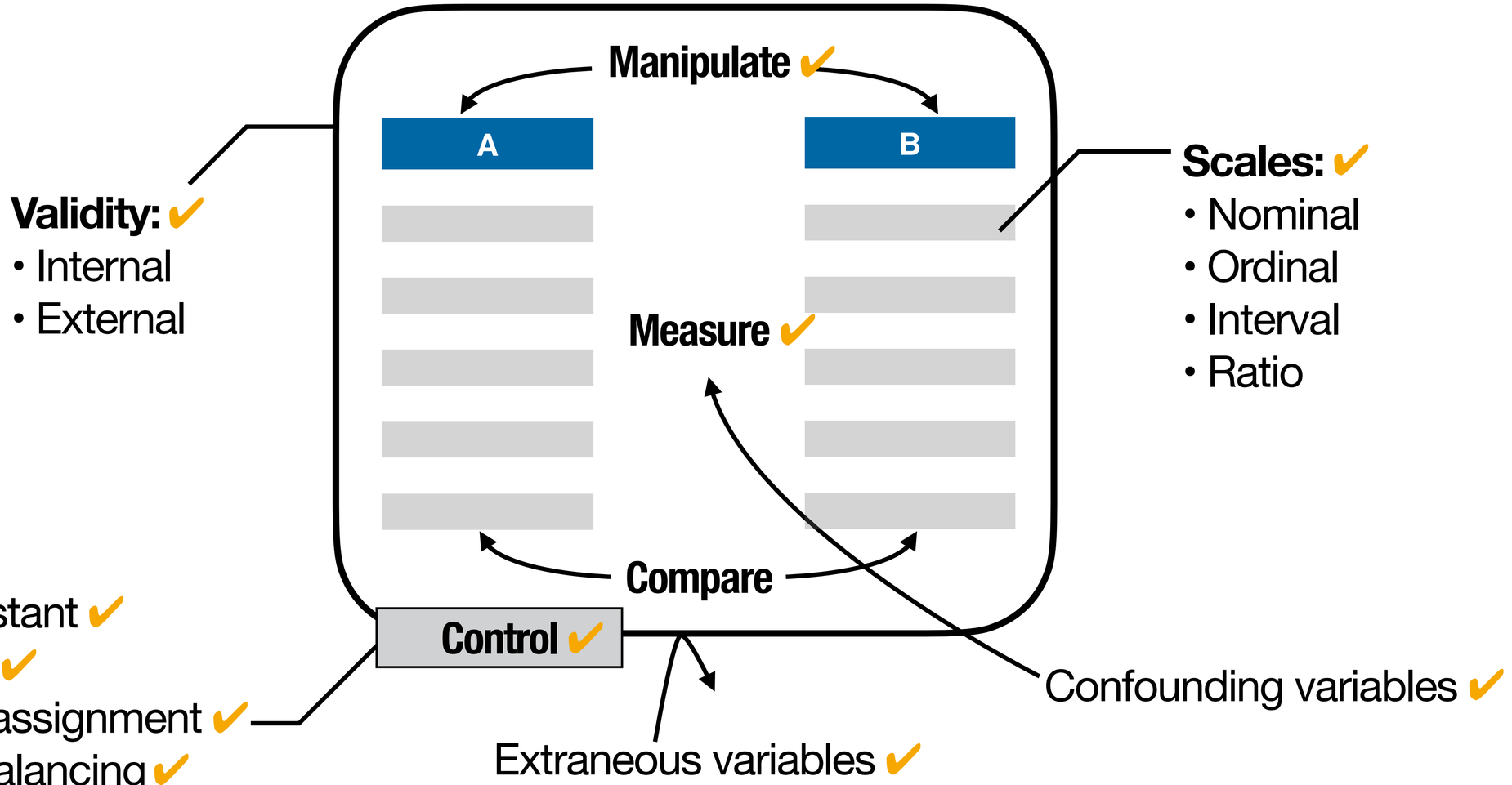
Control

⇒ Higher confidence to infer causality in the results

⇒ ↑ Internal validity

RWTH AACHEN UNIVERSITY

Basic Elements of Experimental Studies



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

RWTH AACHEN UNIVERSITY

What's next?

- Next lecture on **May 28th**
  ➡ No lectures for the next three weeks (due to Student Representative Council, CHI, excursion week…)
- Official start of Mini HCI Project **this week**
  - Complete and upload Milestone 1 by Tuesday, **May 7, 18:00**

KW 18	KW 19	KW 20	KW 21	KW 22	KW 23	KW 24	KW 25	KW 26	KW 27	KW 28
M1: Research Topic	**M2:** Research Plan			**M3**: Conducting Research		**M4**: Data analysis			**M5**: Prepare Presentation	

RWTH AACHEN UNIVERSITY

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. DOI=10.1145/1978942.1979137 http://doi.acm.org/10.1145/1978942.1979137

- Barry Brown and Eric Laurier. 2012. The normal natural troubles of driving with GPS. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12). ACM, New York, NY, USA, 1621-1630. DOI=10.1145/2207676.2208285 http://doi.acm.org/10.1145/2207676.2208285

- Moira Burke, Cameron Marlow, and Thomas Lento. 2010. Social network activity and social well-being. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10). ACM, New York, NY, USA, 1909-1912. DOI=10.1145/1753326.1753613 http://doi.acm.org/10.1145/1753326.1753613

- Mathieu Nancel, Julie Wagner, Emmanuel Pietriga, Olivier Chapuis, and Wendy Mackay. 2011. Mid-air pan-and-zoom on wall-sized displays. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 177-186. DOI=10.1145/1978942.1978969 http://doi.acm.org/10.1145/1978942.1978969

- L. Amaya Becvar and James D. Hollan. 2007. Transparency and technology appropriation: social impacts of a video blogging system in dental hygiene clinical instruction. In Proceedings of the 2007 international ACM conference on Supporting group work (GROUP '07). ACM, New York, NY, USA, 311-320. DOI=10.1145/1316624.1316672 http://doi.acm.org/10.1145/1316624.1316672

- Chris Harrison, Desney Tan, and Dan Morris. 2010. Skinput: appropriating the body as an input surface. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10). ACM, New York, NY, USA, 453-462. DOI=10.1145/1753326.1753394 http://doi.acm.org/10.1145/1753326.1753394

RWTH AACHEN UNIVERSITY