# Empirical Research Methods

## Introduction, basic concepts

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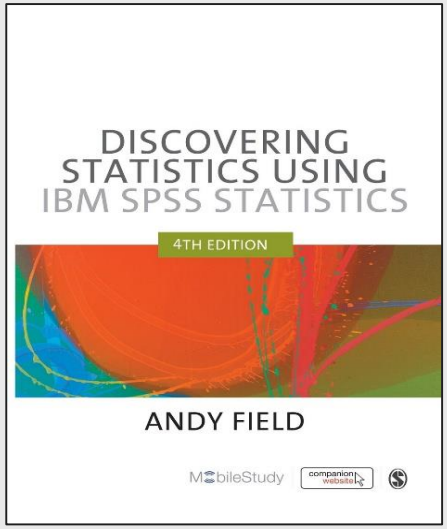
# Literature

We won‘t work with a specific textbook, but rather with our **collection of online resources** in the wiki.

However, if you would like to use a book additionally, I can recommend these (optional!):


- Language: German
- PDF for free (in the uni network): Link

- Language: English
- Hands-on, with lots of humor



# Empirical research methods

**What we will learn in this course:**

- What are empirical research methods?
- Why do we need research and scientific approaches?
- What are the basic concepts of empirical research?

# “Empirical”?

“Empirical evidence, also known as sensory experience, is the information received by means of the senses, particularly by **observation and documentation of patterns and behavior through experimentation**. The term comes from the Greek word for experience, ἐμπειρία (*empeiría*).”

(**Empirical evidence.** In *Wikipedia*. Retrieved September 13, 2018, from https://en.wikipedia.org/wiki/Empirical_evidence)

# An example

You observe the following:

“If I don‘t get my coffee in the morning, I do not feel productive during the day“

→ Does coffee really increase mental performance?

# An example

Assuming that there is a question* you would like to answer, e.g.

- Does coffee increase mental performance?
- Are tablets helpful for mathematics learning?
- Is collaborative learning more effective than individual learning?

→ Do research!

* Research questions are usually derived based on prior work of other researchers or theoretical considerations, and not everyday observations.

# Steps in Research

## Research question and hypotheses

1. Formulate your **research question**: “Does coffee increase mental performance?”

2. Formulate your null and alternative **hypothesis**:

   - **Null hypothesis / H0 (stating no difference, no relationship)**

     → $M_C = M_W$ (The mean performance after drinking coffee is the same as the mean performance after drinking water)

   - **Alternative hypothesis / H1 (stating a difference, a relationship):**

     $M_C > M_W$ (The mean performance after drinking coffee is higher than the mean performance after drinking water) — directional hypothesis

     $M_C < M_W$ (The mean performance after drinking coffee is lower than the mean performance after drinking water) — directional hypothesis

     Or: $M_C \neq M_W$ (The mean performance after drinking coffee is different from the mean performance after drinking water — non-directional hypothesis

3. Test your hypothesis by collecting data

# Variables: IV and DV

- What exactly are you investigating? What are relevant aspects of your research question*?
  - Coffee consumption

    → **Independent variable / IV** (will be manipulated in the experiment)
  - Mental performance

    → **Dependent variable / DV** (will be measured in the experiment)
- Caution!

  Do you really measure what you want to measure? How do you define “coffee consumption“ and “mental performance“?

  → **Operationalization** of variables

* “Does coffee increase mental performance?”

# Control and confounding variables

- Many factors can influence mental performance. But for our experiment, we are specifically interested in the effect of coffee

→ We vary only this one aspect and keep the others as standardized as possible

- **Control variables**: Factors that potentially have an impact should be controlled
  - In our example: E.g., breakfast, amount of sleep, …
- **Confounding variables**: Other random factors that cannot be controlled
  - In our example: E.g., bad weather, noisy construction site nearby

# Variables: Levels of measurement / scale levels

| | Possible relations and operations* | Example |
|---|---|---|
| Nominal scale | = / ≠<br>Equality / inequality | Study subject (Computer Science ≠ Psychology ≠ Education) |
| Ordinal scale | > / <<br>Greater / smaller (ranking, sorting) | University degrees (Bachelor < Master < PhD) |
| Interval scale | + / -<br>Intervals between values are meaningful and equal | Temperature in °C |
| Ratio scale | × / ÷<br>Meaningful zero value | Number of credit points (0-120); Temperature in K |

*Each higher scale level has all the features from the lower scale level(s)

# Collecting data: Sample vs. population

- Choose your target group, e.g. students aged 20-30 years

→ But: You cannot investigate all participants with these features

→ From the **population** of all students aged 20-30, you **randomly** select an **acceptably large** number: the **sample**

- …Sample?

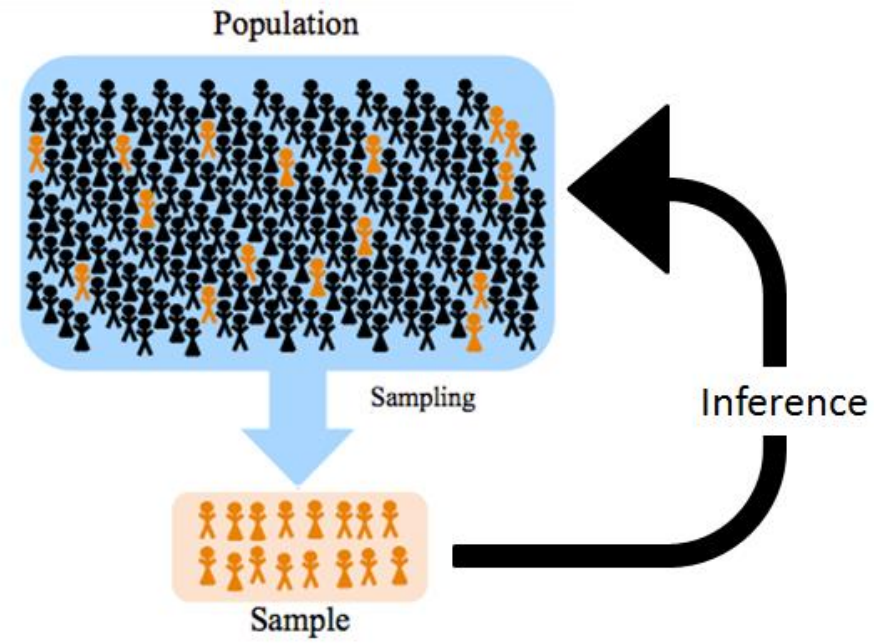
→ Consists of **research participants / subjects**

- …Randomly?

→ Random selection to represent the population well

- …acceptably large?

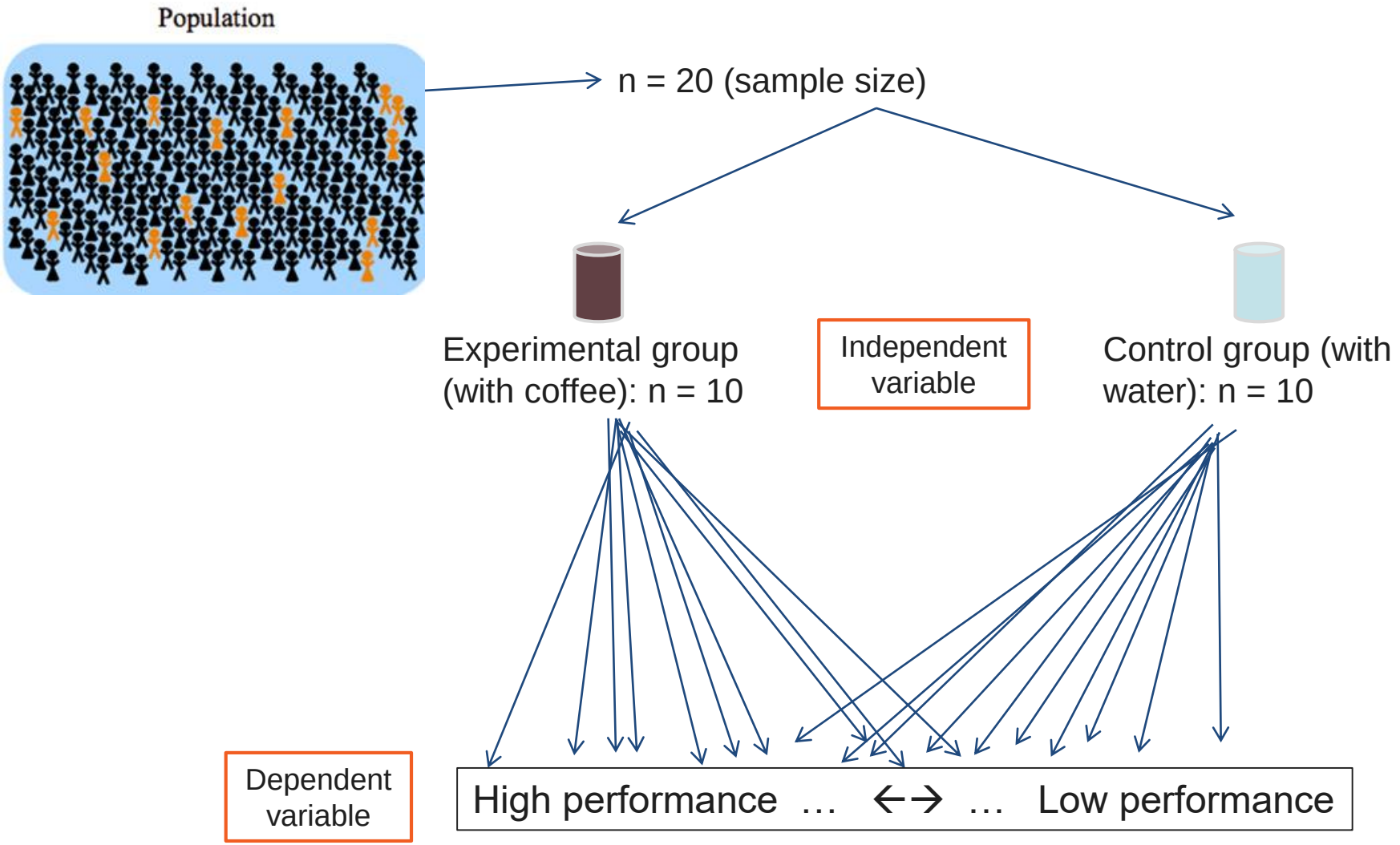
→ Can be calculated



# Collecting data: Lab vs. field

| Example for lab experiment | Example for field experiment |
| --- | --- |
| Participants are invited to the university at 8 a.m.<br><br>They receive exactly 200 ml of coffee (vs. water).<br><br>25 minutes later, they take part in a performance test, while an EEG is recorded. | Participants are instructed to start their daily routine at home with coffee (vs. water).<br><br>After a short break, they are supposed to complete a performance test on their private laptops at home. |

# Testing hypotheses



# Testing hypotheses

- Select the appropriate statistical test

(in this case: t-test might fit*)

- Take the decision:
  - Reject the H0 (→ support for the H1)
  - OR: Keep the H0

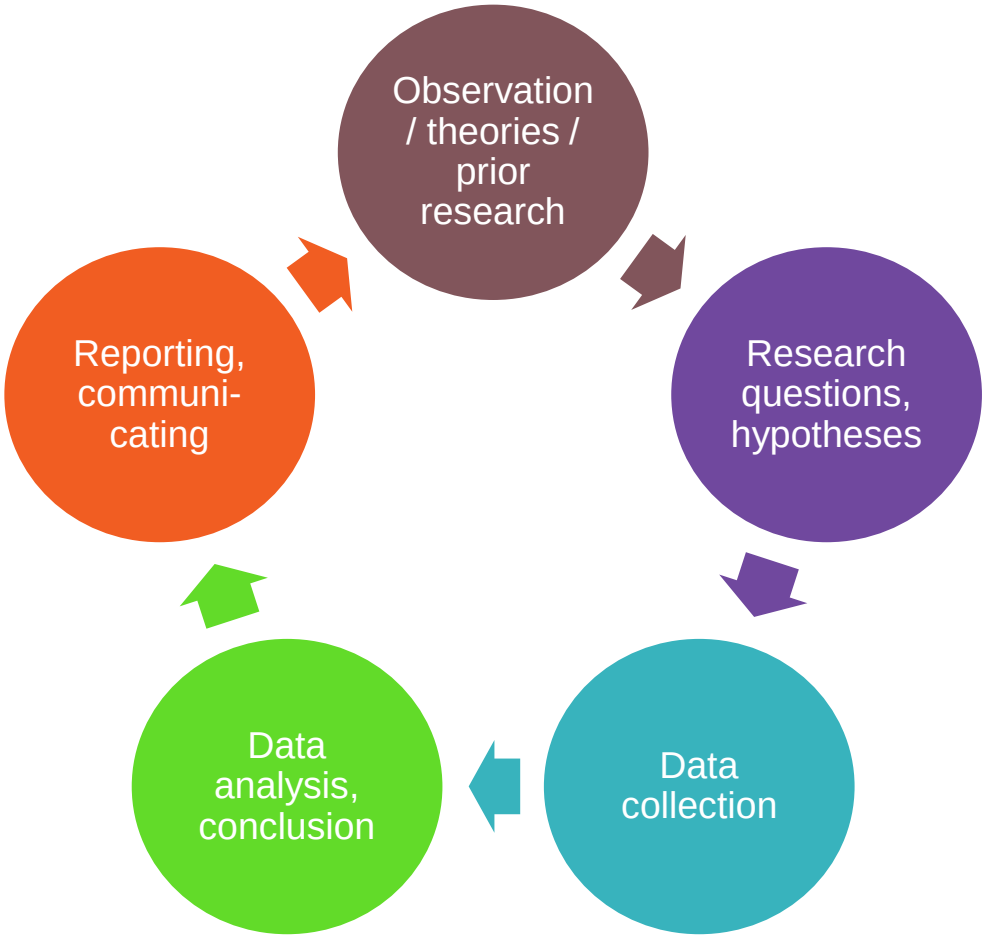
* Don’t worry, you will learn about this later.

# Generating further research questions

- Based on the findings, usually, follow-up questions can be derived…
  - Does it matter how much coffee you drink?
  - Do milk and sugar play a role?
  - …

→ The research questions and topics become more concrete and refined

# The research cycle



# QUESTIONS?

# THANK YOU FOR YOUR ATTENTION!