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Crash Course

Quantitative Research Papers

Quality Criteria of Research Papers in General

- The research has to come to **new findings/knowledge**.

- The results of the research have to be **generalised/generalisable findings**.

- The findings have to be generated through a **comprehensible and testable method**.

- The findings have to be **conclusive results**.

- The topic of research has to be **comprehensively/exhaustively covered**.

Structure of Quantitative Research Papers in Social Sciences

Basic structure of research papers in social sciences

1 Introduction

2 Theory & state of research

3 Research questions (& possibly hypothesised model)

4 Method

5 Results

6 Discussion

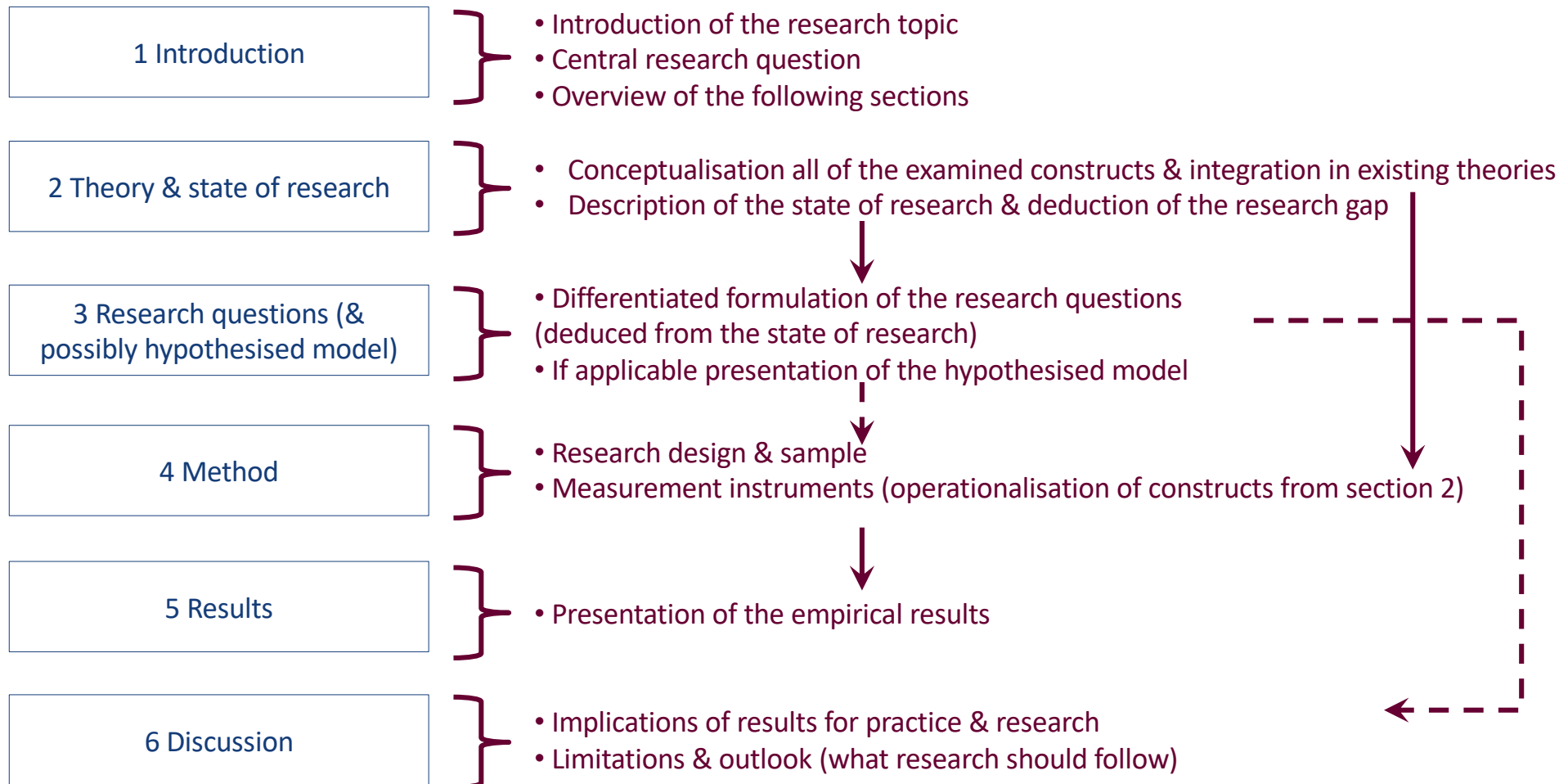**Typical structure of psychology papers**

1 Introduction
(including theory, state of research & research questions)

2 Methods

3 Results

4 Discussion

Structure of Quantitative Research Papers in Social Sciences

1 Introduction
- Introduction of the research topic
- Central research question
- Overview of the following sections

2 Theory & state of research
- Conceptualisation all of the examined constructs & integration in existing theories
- Description of the state of research & deduction of the research gap

3 Research questions (& possibly hypothesised model)
- Differentiated formulation of the research questions (deduced from the state of research)
- If applicable presentation of the hypothesised model

4 Method
- Research design & sample
- Measurement instruments (operationalisation of constructs from section 2)

5 Results
- Presentation of the empirical results

6 Discussion
- Implications of results for practice & research
- Limitations & outlook (what research should follow)

Example of a Table of Contents

Source: Godbersen, H., Dudek, B. & Ruiz Fernández, S. (2024). The Relationship Between Organizational Commitment, Commitment to Supervisor and Servant Leadership. Frontiers in Organizational Psychology, doi: 10.3389/forgp.2024.1353959.

Content

Introduction

Theory & State of Research

(Hypothesised Model &) Research Questions

Methods

Results

Discussion

- Purpose of the introduction
  - The reader should get an overview of what the research paper is about and what he or she can expect in the following sections.

- Content
  - Brief introduction into the research topic
  - Research objective/central research question(s)
  - Overview of the following sections

- Recommendation
  - Write the introduction at the end of the research project.

Source: Godbersen, H., Dudek, B. & Ruiz Fernández, S. (2024). The Relationship Between Organizational Commitment, Commitment to Supervisor and Servant Leadership. Frontiers in Organizational Psychology, doi: 10.3389/forgp.2024.1353959.
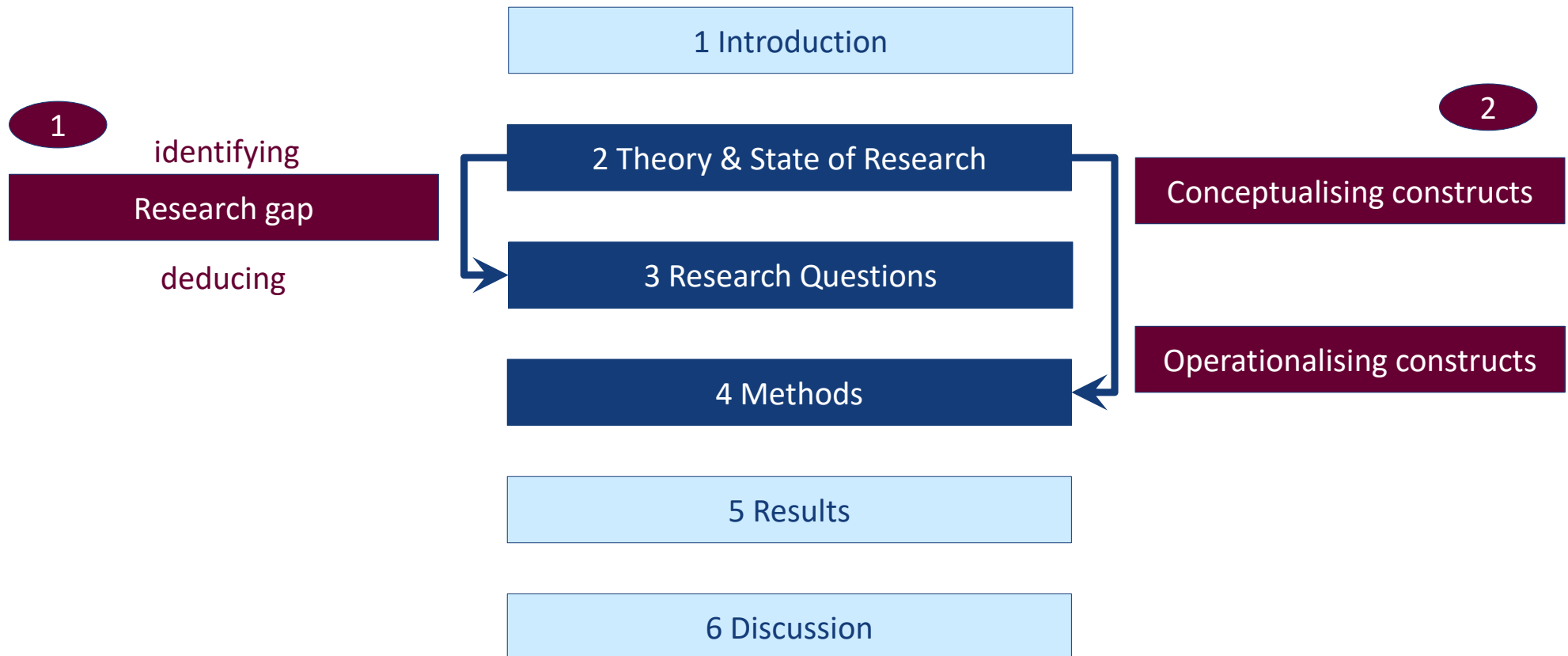
1 Introduction

Organizational commitment, commitment to supervisor and servant leadership gain popularity and relevance in both, the managerial practice and academia. Our research aims to empirically establish the relationship between the facets of these constructs. More precisely, we examine which effect the facets of servant leadership have on the facets of commitment to supervisor and which effect the facets of commitment to supervisor have on the facets of organizational commitment. To this end, we will introduce organizational commitment, commitment to supervisor and servant leadership and hypothesize their relationships, i.e., the hypothesized effects of servant leadership on commitment to supervisor and the hypothesized effects of commitment to supervisor to organizational commitment, in the following three subsections. On this basis, we will present our hypothesized model and the research questions in the fourth subsection of the introduction.

Content

Introduction

Theory & State of Research

(Hypothesised Model &) Research Questions

Methods

Results

Discussion

1 Introduction

1

identifying

Research gap

deducing

2 Theory & State of Research

3 Research Questions

4 Methods

5 Results

6 Discussion

2

Conceptualising constructs

Operationalising constructs

- Theory: Conceptualising of constructs

All of the theories / definitions that are relevant for the research topic have to be presented and backed by quotes

The own theory / definition has to be conclusively deduced from the existing theories / definitions
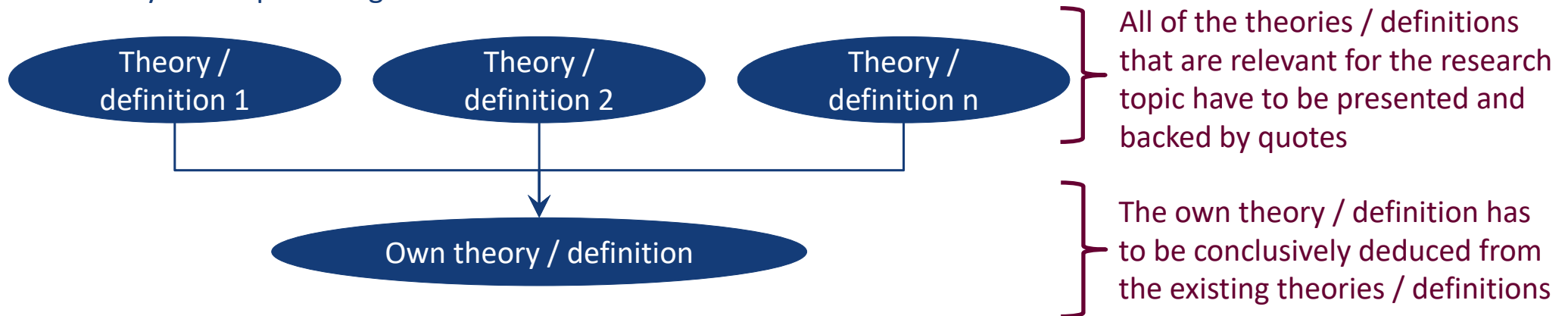
- State of Research: Antecedents, consequences & correlates of constructs
  - Antecedents ~ What causes the constructs?
  - Consequences ~ To what do the constructs lead?
  - Correlates ~ What is associated with the constructs?

- Structure

  - Normally, a sub-section should be dedicated to each construct that is examined

  - If applicable, an additionally sub-section should cover the research area

- Examples

The Relationship Between Organizational Commitment, Commitment to Supervisor and Servant Leadership
  1 Introduction
  1.1 Organisational Commitment
  1.2 Commitment to Supervisor
  1.3 Servant Leadership
  1.4 Hypothesised Model and Research Questions

Source: Godbersen, H., Dudek, B. & Ruiz Fernández, S. (2024). The Relationship Between Organizational Commitment, Commitment to Supervisor and Servant Leadership. Frontiers in Organizational Psychology, doi: 10.3389/forgp.2024.1353959.

How People Evaluate Anti-Corona Measures for Their Social Spheres: Attitude, Subjective Norm and Perceived Behavioural Control
  1 Introduction
  1.1 The Covid-19 Pandemic
  1.2 Anti-Corona Measures
  1.3 Social Spheres Affected by the Corona Pandemic
  1.4 Theory of Planned Behaviour as the Basic Structure for the Subjective Evaluation of Anti-Corona Measures
  1.5 Hypothesised Model and Research Questions

Source: Godbersen, H., Hofmann, L.A. & Ruiz-Fernández, S. (2020). How People Evaluate Anti-Corona Measures for Their Social Spheres: Attitude, Subjective Norm, and Perceived Behavioral Control. Frontiers in Psychology, doi: 10.3389/fpsyg.2020.567405.

Theory & State of Research: Citable Literature

- Citeable (academic) literature
  - Textbooks & handbooks → normally only for basic definitions
  - Articles in research journals → imperative, especially with regard to the state of research

- Normally, not citable literature
  - Popular science publications, dictionaries, internet etc.
    - Rule of thumb: "Never cite a publication you can buy at a corner shop."
  - Exceptions (internet, newspapers etc.):
    - Results of empirical studies with a transparent and reliable method
   - General development within a society, an industry, a company etc.

(1)   Search for potentially relevant sources on Google Scholar

(2)   Assess the relevance by reading the abstract

(3)   Obtain the publication

(4)   Work with the publication and integrate its contents in your research paper

(5)   Use the additional functions of Google Scholar
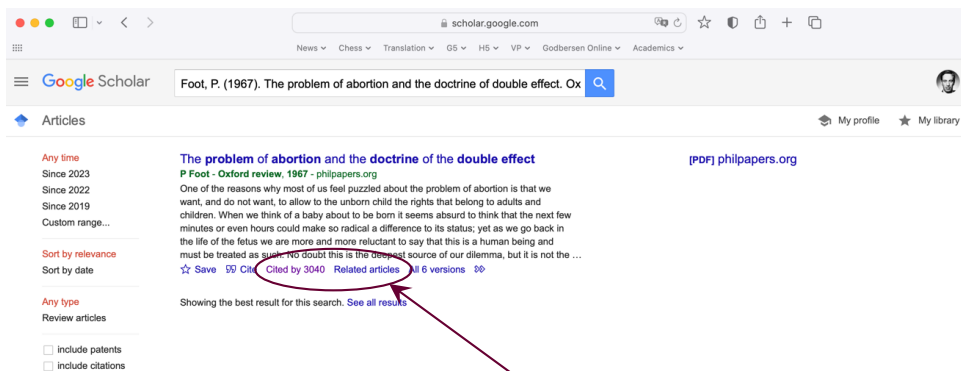
Zusatzfunktionen in GoogleScholar:
„Cited by" und „Related articles"
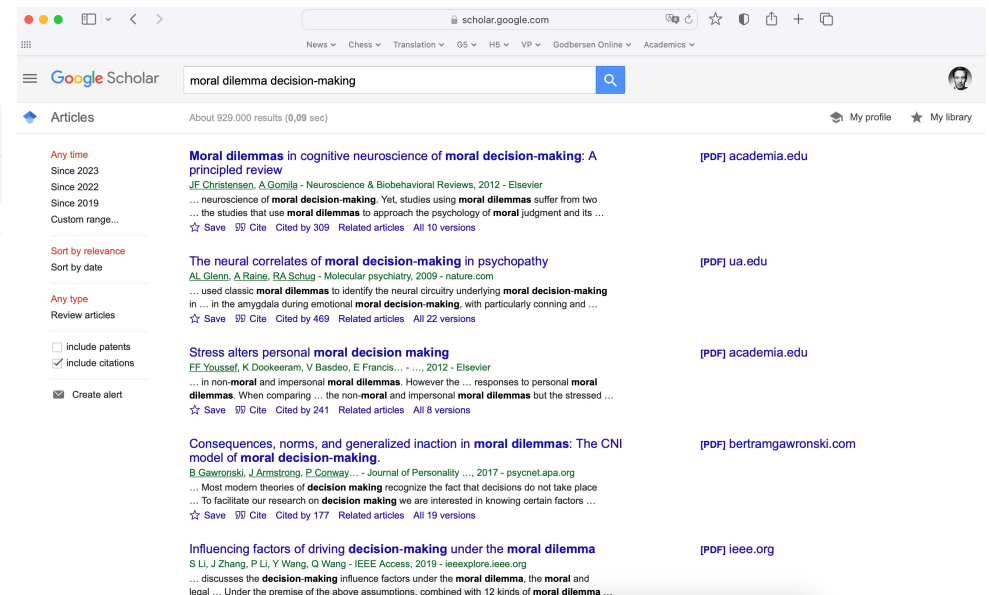
Source: Godbersen, H. (2023). Qualitative Forschung für Dummies. Wiley.

Content

Introduction

Theory & State of Research

(Hypothesised Model &) Research Questions
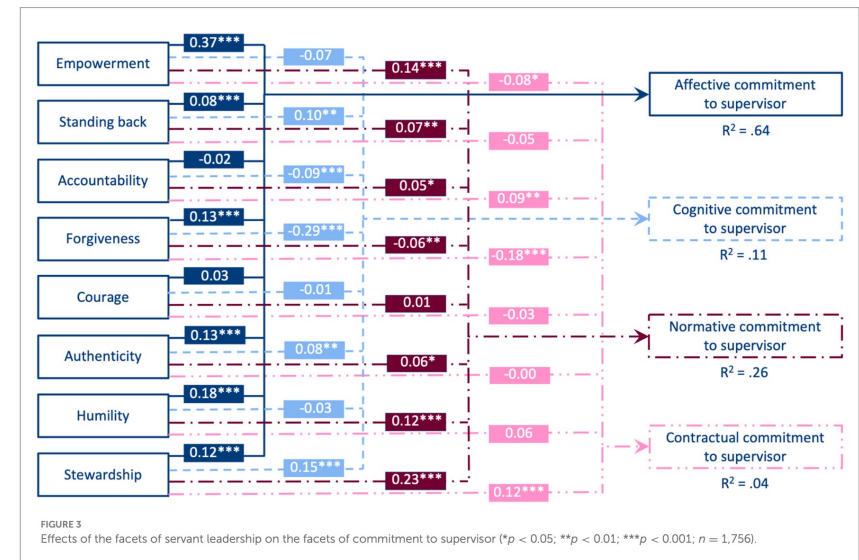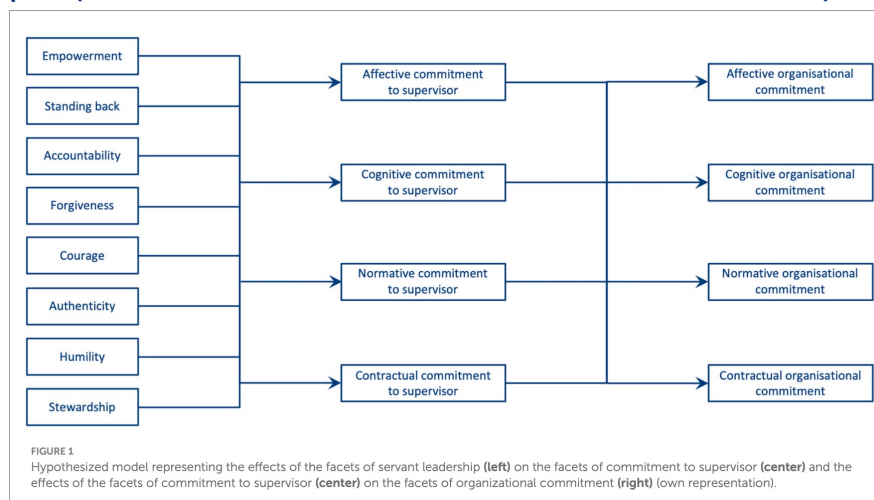
Methods

Results

Discussion

- Objective of quantitative research:
  - **Assigning numbers to empirical objects or characteristics** (compare the classical definition of measuring) to obtain a **simplified image of reality** (compare the definition of models) and, thus, **test theories**
- Research questions, hypotheses and models (theories) – simplified example:
  - Hypothesised model:

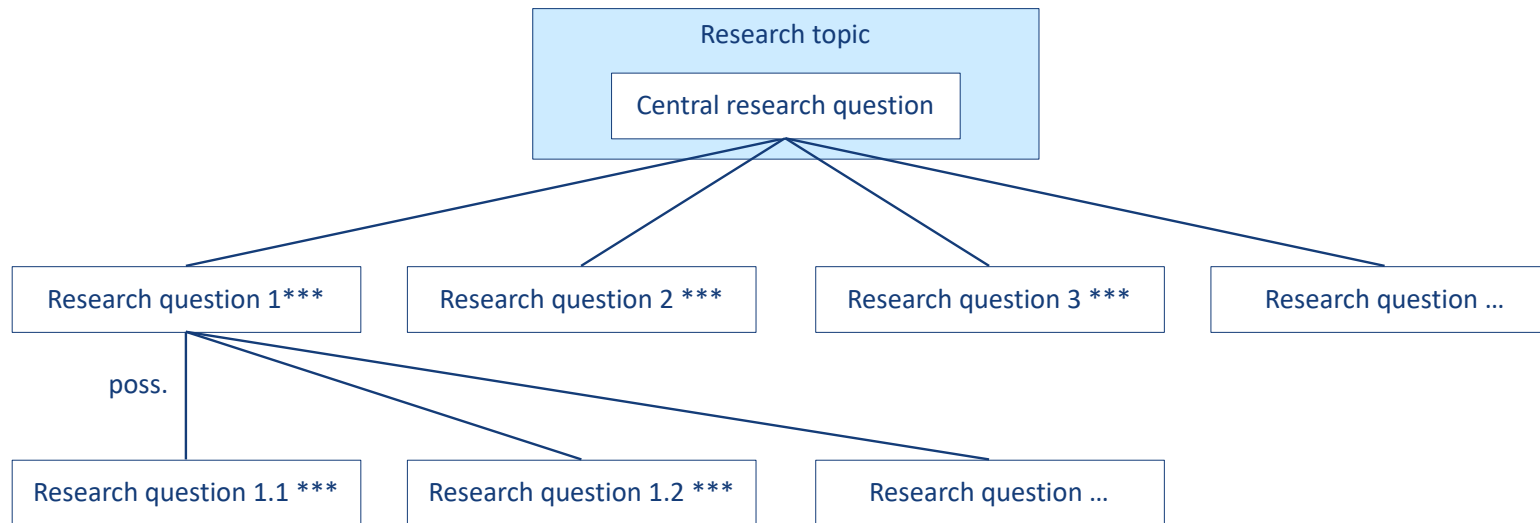| Work satisfaction | RQ1 vs. H1 → | Organisational commitment |

  - Research question RQ1:
    - Does work satisfaction have an influence on organisational commitment?
  - Hypothesis H1:
    - Work satisfaction has an influence on organisational commitment.
- Quantitative research is a "black-and-white world"/"yes-or-no world"
  - → Research questions need to be conclusively answerable
  - → Hypotheses need to be falsifiable

- **Model**: A model is a simplified image of reality.

- **Theory**: A theory consists of constructs (generalisations/abstractions of empirical objects or phenomena) & their relationships.

- **Relationship between models & theories**: Models & theories can be understood as synonyms in the academic context.

- **Recommendation for quantitative research**: If possible, a hypothesised model should be developed from theory & state of research. In the empirical part, this model should be tested ("filled with numbers") – example (Godbersen, Dudek & Ruiz Fernández, 2024):

FIGURE 1
Hypothesized model representing the effects of the facets of servant leadership (**left**) on the facets of commitment to supervisor (**center**) and the effects of the facets of commitment to supervisor (**center**) on the facets of organizational commitment (**right**) (own representation).

FIGURE 3
Effects of the facets of servant leadership on the facets of commitment to supervisor (*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; $n = 1,756$).

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                          ┌─────────────────────────────┐
                          │       Research topic        │
                          │  ┌───────────────────────┐  │
                          │  │ Central research question │
                          │  └───────────────────────┘  │
                          └─────────────────────────────┘
```

Research question 1***	Research question 2 ***	Research question 3 ***	Research question …

poss.

Research question 1.1 ***	Research question 1.2 ***	Research question …

Recommendation: Hierarchical system of research questions with one or small number of aggregated research questions and several more specific and subordinated research questions.

*** You can also use hypotheses instead of research questions

Quality criteria of research questions

- Comprehensively & conclusively deduced from theory & state of research
- Precisely defined in a differentiated way & conclusively answerable

Hypothesised Model & Research Questions: Examples
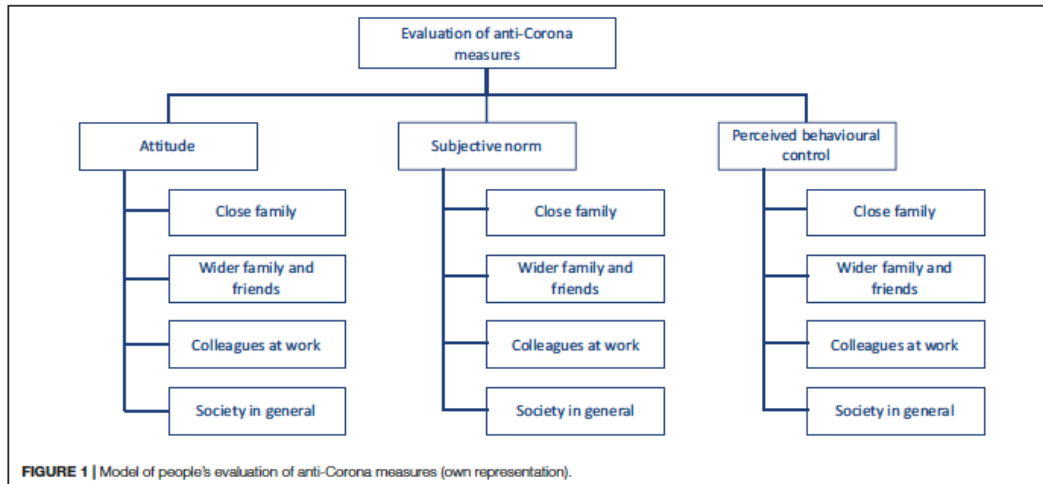
FIGURE 1 | Model of people's evaluation of anti-Corona measures (own representation).

Source: Godbersen, H., Hofmann, L.A. & Ruiz-Fernández, S. (2020). How People Evaluate Anti-Corona Measures for Their Social Spheres: Attitude, Subjective Norm, and Perceived Behavioral Control. Frontiers in Psychology, doi: 10.3389/fpsyg.2020.567405.

RQ1 (subjective relevance): Which relevance do the attitude, subjective norm, and perceived behavioral control as well as the social spheres have for the people's evaluation of anti-Corona measures?

RQ1.1: Which relevance do the attitude, subjective norm, and perceived behavioral control have for the people's evaluation of anti-Corona measures?

RQ1.2: Which relevance do the social spheres—close family, wider family and friends, colleagues at work, and society in general—have for the people's evaluation of anti-Corona measures?

RQ2 (subjective quality): How well do people evaluate anti-Corona measures—restrictions on outdoor activities, tips for hygiene and tips for mental health—with regard to their attitude, subjective norm, and perceived behavioral control as well as their social spheres?

RQ2.1: How well do people evaluate anti-Corona measures—restrictions on outdoor activities, tips for hygiene, and tips for mental health—with regard to their attitude, subjective norm, and perceived behavioral control?

RQ2.2: How well do people evaluate anti-Corona measures—restrictions on outdoor activities, tips for hygiene, and tips for mental health—with regard to their social spheres?
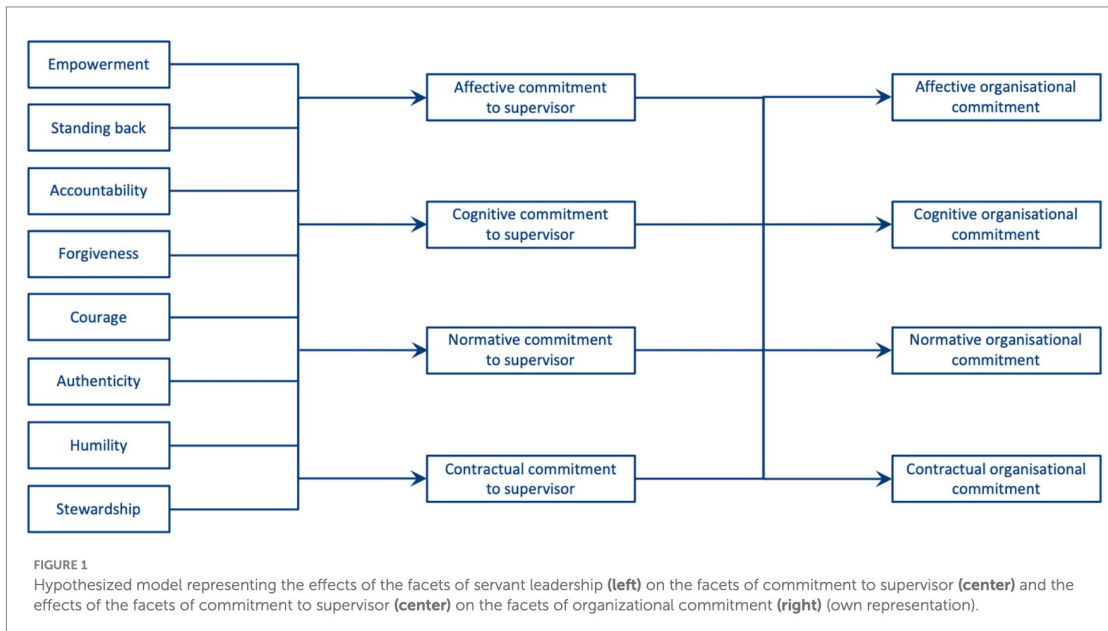
RQ2.3: How well do people evaluate anti-Corona measures—restrictions on outdoor activities, tips for hygiene, and tips for mental health—overall?

RQ3 (optimization): What is the potential of and the need for increasing the effectiveness of anti-Corona measures from the people's perspective, and with what priority should the current effectiveness of these measures be secured or increased with regard to attitude, subjective norm, and perceived behavioral control within the social spheres of people?

RQ3.1: From the people's perspective, what is the potential of and the need for increasing the effectiveness of anti-Corona measures with regard to attitude, subjective norm, and perceived behavioral control within the social spheres of people?

RQ3.2: Based on the potential of and need for increasing the effectiveness of anti-Corona measures, with which priority should the effectiveness of anti-Corona measures be secured or increased with regard to attitude, subjective norm, and perceived behavioral control within the social spheres of people?

FIGURE 1
Hypothesized model representing the effects of the facets of servant leadership **(left)** on the facets of commitment to supervisor **(center)** and the effects of the facets of commitment to supervisor **(center)** on the facets of organizational commitment **(right)** (own representation).
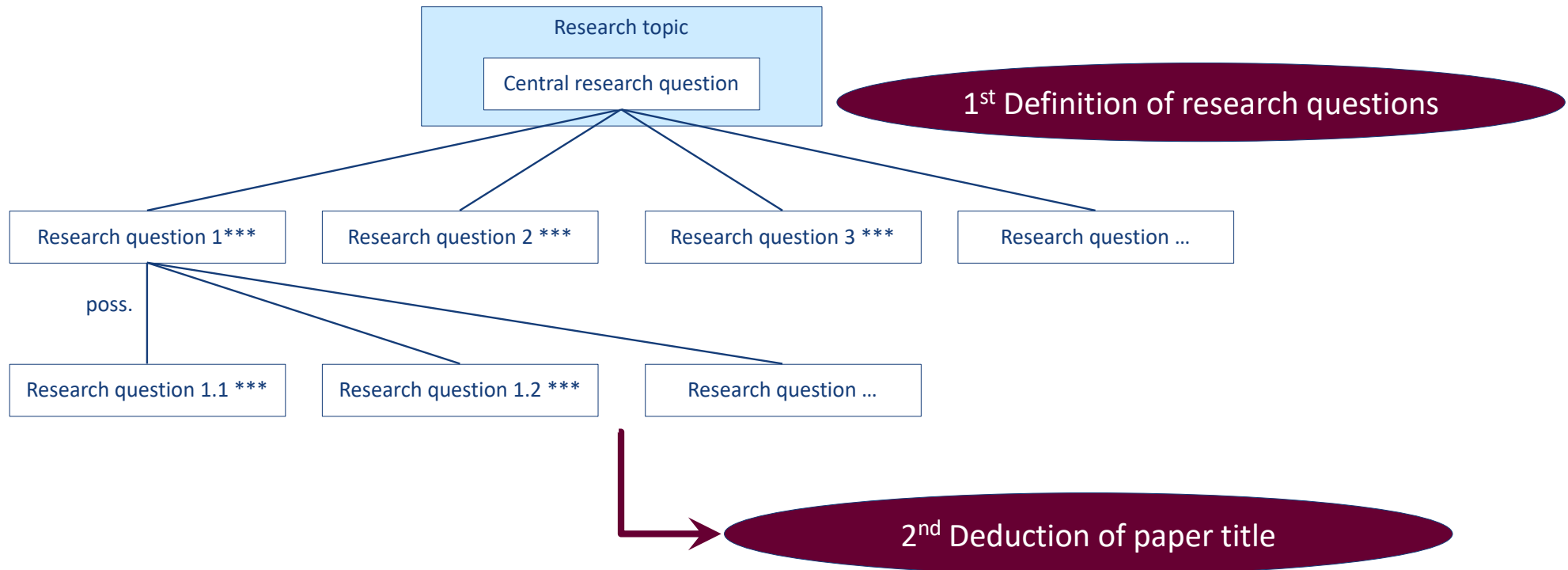
1.4 Hypothesized model and research questions

We introduced four facets of organizational commitment, i.e., affective, cognitive, normative and contractual organizational commitment, in Section 1.1. In Section 1.2, we conceptualized the same facets for commitment to supervisor and hypothesized them as antecedents of the facets of organizational commitment. In Section 1.3, we argued that the eight facets of servant leadership, i.e., empowerment, standing back, accountability, forgiveness, courage, authenticity, humility and stewardship, should be seen as determinants of the facets of commitment to supervisor. This hypothesized model is represented in Figure 1. Correspondingly, our empirical research follows two research questions:

- RQ1: Which effect do the facets of commitment to supervisor have on the facets of organizational commitment?

- RQ2: Which effect do the facets of servant leadership have on the facets of commitment to supervisor?

Source: Godbersen, H., Dudek, B. & Ruiz Fernández, S. (2024). The Relationship Between Organizational Commitment, Commitment to Supervisor and Servant Leadership. Frontiers in Organizational Psychology, doi: 10.3389/forgp.2024.1353959.
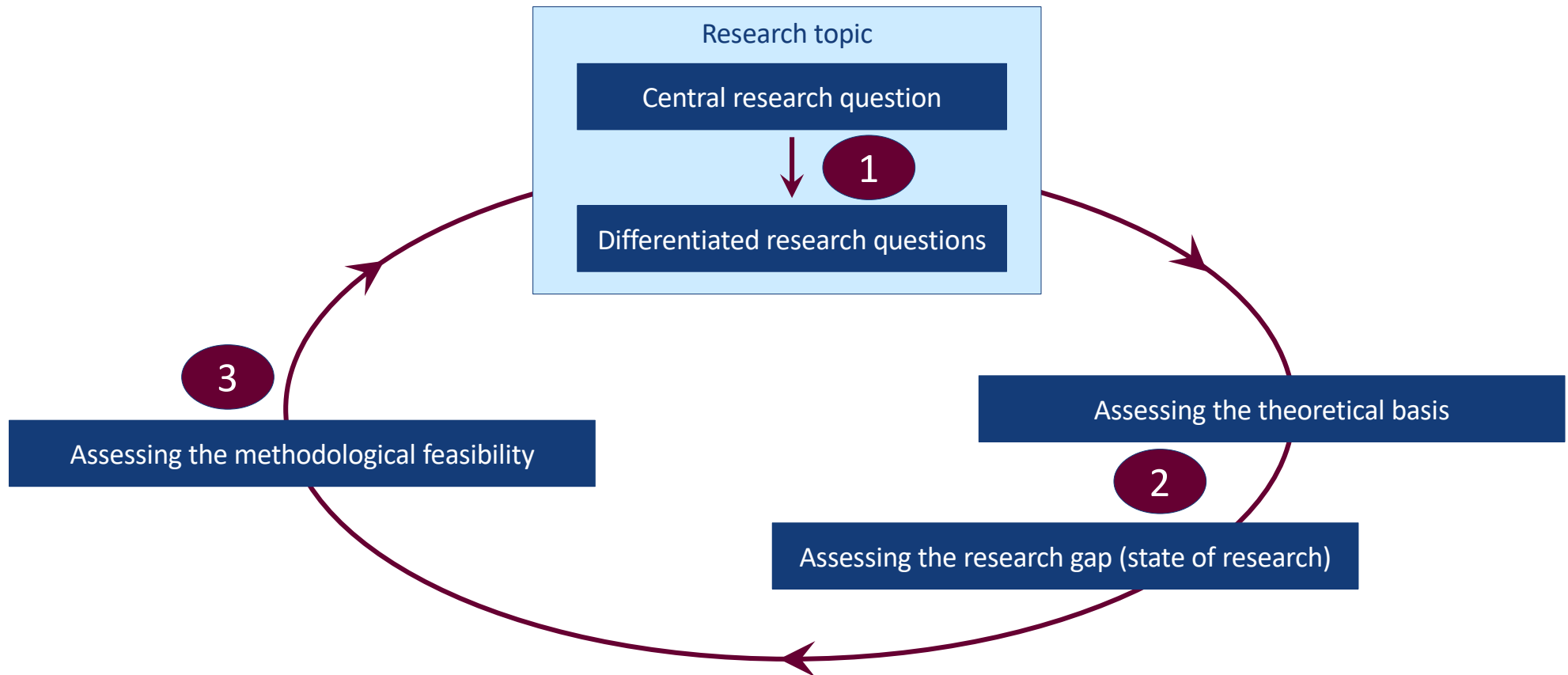
Recommendation: Defining the research questions through a circular process at the start of a research project.

Research Questions: Development

Research topic

Central research question

1st Definition of research questions

Research question 1***

Research question 2 ***

Research question 3 ***

Research question …

poss.

Research question 1.1 ***

Research question 1.2 ***

Research question …

2nd Deduction of paper title

Recommendation: Develop the research questions first – only then deduce the title of the research paper

Introduction

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(Hypothesised Model &) Research Questions

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Structure & Contents

Sample & Inductive Statistics

Scale of Measurement

Descriptive Statistics

Inferential Statistics

- Research design (1st sub-section)

  - Data collection period, data collection method (online, face-to-face etc.), recruiting of participants etc.

  - Description of sample with sample size & characteristics by sociodemographic & context variables

- Measurement instruments (2nd sub-section)

  - Questionnaire with content & scales

  - Statistical procedures

  - If applicable, quality criteria of measurement (mainly reliability)

- Please note: Experimental research may have a different structure

  - Participants / Materials (Stimuli & Apparatus) / Procedure & Design

2 Methods

The research design and measurement instruments are presented in the following two subsections.

2.1 Research design

An online questionnaire was used to collect the data between 01 September and 31 October 2023. Students of FOM University of Applied Sciences from the study centers Munich and Stuttgart recruited the participants by using a predefined quota, which is based on the employed population in Germany by gender and age groups (Statistisches Bundesamt, 2023).

The sample consists of 1,756 fully answered questionnaires. The youngest participant is 25 years of age and the oldest 64 years of age. The average age is 43.49 years (SD = 11.97). 50.00% of the sample are female, 49.83% male and 0.17% diverse. The distribution of gender and age groups within the sample roughly matches the respective distribution of the employed population in Germany, as can be seen in Table 1. This indicates a high level of representativity. However, it should be noted that the data was only collected in the areas of Munich and Stuttgart which means that the southern regions of Germany are predominantly represented in the sample.

Full-time employed participants are represented in the sample at 78.76%, whilst 21.24% of the participants are part-time employed. Of the participants, 26.42% hold personnel responsibility and 73.58% do not hold personnel responsibility. The occupations of the participants, based on the classification by the International Labour Organization (2012), are represented in Table 2. 11.22% of the participants are with their employer less than a year, 29.61% 1–5 years, 17.65% 6–10 years and 41.51% more than 10 years. The company size by employees is represented in the sample as follows: <10 employees: 6.04%; 10–49 employees: 15.77%; 50–249 employees: 15.55%; 250 or more employees: 62.64%.

2.2 Measurement instruments

Our hypothesized model, which we introduced in Section 1.4, serves as the theoretical basis of our measurement. We measured the four facets of organizational commitment with the Four-Component Model of Organizational Commitment (Gansser and Godbersen, 2023), which consists of 14 items. To measure the affective, cognitive, normative and contractual facets of commitment to supervisor, we also used the Four-Component Model of Organizational Commitment (Gansser and Godbersen, 2023), but reformulated the items so that they refer to the supervisor rather than the organization. The items of our operationalisation of organizational commitment and commitment to leader are represented in Table 3; the German items used in our questionnaire can be found in Supplementary Table S1.

Our measurement of the eight facets of servant leadership is based on the German version of the Servant Leadership Survey (Verdorfer and Peus, 2014), which is based on the Servant Leadership Survey by van Dierendonck and Nuijten (2011). The Servant Leadership Survey consists of 30 items, which are represented in Table 4. The German items we applied in our survey can be found in Supplementary Table S2.

The items of all of the constructs, i.e., facets of organizational commitment, commitment to supervisor and servant leadership, were measured on six-step scales from 1 "do not agree at all" (German: "stimme überhaupt nicht zu") to 6 "agree in full" (German: "stimme voll und ganz zu"). The analysis of our data was conducted with R (R Core Team, 2017). Partial least squares path modeling with the R-package plspm (Sanchez, 2013) forms the core of our analysis.

We determined the loadings of the items and Cronbach's alpha, Dillon-Goldstein's rho and average variance extracted for the examined constructs to test the adequacy of our measurement instruments. The respective results for organizational commitment and commitment to supervisor are represented in Table 3. All of the items load on their respective constructs above 0.60. The lowest value for Cronbach's alpha is 0.77, for Dillon-Goldstein's rho 0.85 and for average variance extracted 0.61. These results indicate a good adequacy of our measurement of the organizational commitment and commitment to supervisor facets.

The item loadings and Cronbach's alpha, Dillon-Goldstein's rho and average variance extracted for the constructs of servant leadership are represented in Table 4. All of the items load on their respective constructs above 0.60. The lowest value for Cronbach's alpha is 0.72, for Dillon-Goldstein's rho 0.84 and for average variance extracted 0.63. These results indicate a good adequacy of our measurement of the servant leadership facets.

TABLE 3 Constructs and items of organizational commitment and commitment to supervisor with loadings, Cronbach's alpha, Dillon-Goldstein's rho and average variance extracted (AVE) ($n = 1,756$).

Constructs and items	Loadings	Cronbach's alpha	Dillon-Goldstein's rho	AVE
Organizational commitment				
Affective organizational commitment		0.83	0.88	0.61
I find it pleasant to work for my employer	0.80			
I feel a personal bond to my employer	0.82			
I would personally regret if my employment with my company ended	0.86			
I can identify with my employer and its products/services	0.77			
My personal contacts to my colleagues are of importance to me	0.62			
Cognitive organizational commitment		0.80	0.87	0.63
In a way, I am bound to my employer because of the time I would have to invest to change to another employer	0.80			
I depend on my employer because there are no equivalent alternatives in the market	0.71			
I perceive a bond with my employer because my previous investment would lose its value if I changed to another employer	0.83			
I feel a bond with my manager because changing to another employer would come with switching cost	0.83			
Normative organizational commitment		0.82	0.88	0.65
It would not be fair to terminate the relationship with my employer because my employer steadily supported me	0.81			
Because of the long relationship with my employer I feel obliged to a certain considerateness	0.84			
In the relationship with my employer, I feel obliged to fairness	0.79			
Moral obligations toward my employer play a role for me	0.80			
Contractual organizational commitment		1.00	1.00	1.00
Because of my contract, I am bound to my employer	1.00			
Commitment to supervisor				

Source: Godbersen, H., Dudek, B. & Ruiz Fernández, S. (2024). The Relationship Between Organizational Commitment, Commitment to Supervisor and Servant Leadership. Frontiers in Organizational Psychology, doi: 10.3389/forgp.2024.1353959.

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- Population: Persons (or other entities) for whom the results should be valid
- Sample (essentially, the net sample is of relevance)
  - Gross sample: All persons (or other entities) that are contacted for data collection
  - Net sample: All persons (or other entities) from whom data was collected
- Complete vs. partial survey
  - Complete survey: Collecting data from all persons (or other entities) of the population
  - Partial survey: Collecting data from selected persons (or other entities) of the population
- Representative sample: A sample is representative when the distribution of attributes of the sample resembles the distribution of attributes in the population

Population
Example: Population of the United Kingdom
in the age group of 18 to under 65 years
$\rightarrow$ N = 40.5m (2023)

Gross sample
Example: n_b = 4,000

Net sample
Example: n = 2,000

- Research approaches
  - Rather exploratory designs, e.g., "principally" examining if A has an effect on B
    - → No representative sample required
    - → Rule of thumb: a sample size of at least n = 200
  - Rather "representative" designs, e.g., election polling ("What candidate (or party) would you vote for if we had a general election today?")
    - → Representative sample required
- Sampling procedures
  - Non-probability sampling
    - Convenience sampling
    - Quota sampling
    - …
  - Probability sampling / random sampling (each person or entity of of the population has the same chance to be selected into the sample)

Sample – Quota Sampling

- Procedure
  - (1) Defining the attributes of the quota
  - (2) Determining the distribution of attributes in the population
  - (3) Defining the sample size
  - (4) Determining the quotas of the sample
- Example

Age group	Population of England (2021)		Sample
	Abs.	Rel.	
20 to 29	7,102,321	23.88%	478
30 to 39	7,753,274	26.06%	521
40 to 49	7,166,966	24.09%	482
50 to 59	7,724,309	25.97%	519
Sum	29,746,870	100.00%	2,000

- Equations
  - Equation for infinite population:

$$n = \frac{z^2 \times p \times (1-p)}{\Delta p^2}$$

  - Equation for finite population:

$$n = \frac{z^2 \times p \times (1-p)}{\Delta p^2 + \dfrac{z^2 \times p \times (1-p)}{N}}$$

  - Rule of thumb: If n/N < 0.05 → you can use the equation for sampling an infinite population
- Variables
  - n = Sample size
  - N = Size of population
  - z = z-value, depends on confidence level (probability with which the values of the sample reflect the true values of the population
  - Δp = Margin of error (how many percentage points the results from the sample may differ from the true value of the population; standard: 3%)
  - p = Distribution in the sample (if no other indication, 50%)

Sample size (infinite population)

$$n = \frac{\overset{2}{z^2} \times \overset{1}{p} \times (1 - p)}{\underset{3}{\Delta p^2}}$$

(circled 4 next to n)

p (assumed distribution)	50%	
(1-p)	50%	(1)
z (confidence level = 95%)	1.96	(2)
Δp (margin of error)	3%	(3)
n (sample size)	1,067	(4)

(1) Assumption of a distribution of 50%

(2) The measured values of the sample reflect the true values of the population at a probability of 95%

(3) With a probability of 95% (2), the true values of the population are in a range of +/- 3% from the measured values (47% to 53%)

50%
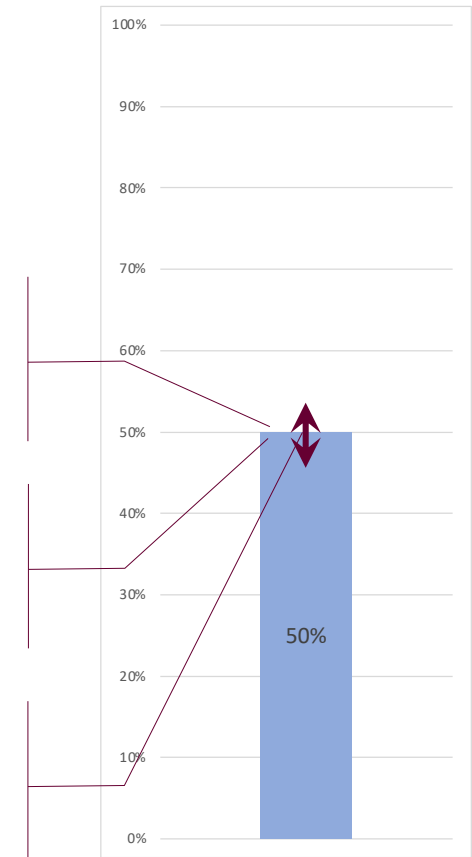
- Sample sizes can be calculated through online tools

Source: https://www.calculator.net/sample-size-calculator.html.
Accessed: 2023-08-24

- After data collection, the equation can be solved for z (or Δp) so that the level of confidence (or the margin of error) can be determined
- Inductive statistics – core question:
  - With what probability and margin of error ("range") do the results of the sample reflect the true values in the population?

$$n = \frac{z^2 \times p \times (1 - p)}{\Delta p^2}$$

$$n = \frac{z^2 \times p \times (1 - p)}{\Delta p^2 + \dfrac{z^2 \times p \times (1 - p)}{N}}$$

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Scale of Measurement

Scale of measurement		Mathematical characteristics	Characteristics of values	Example	Measure of central tendency
Categorical (dichotomous)	Nominal	$=/\neq$	Values are equal or not.	Gender	• Mode
	Ordinal	$=/\neq$; $</>$	Values are larger, smaller or equal.	Olympic ranks	• Mode • Median
Metric (continuous)	Interval	$=/\neq$; $</>$; $-$; $+$	The distance between values can be determined.	Temperature	• Mode • Median • Arithmetic mean
	Ratio	$=/\neq$; $</>$; $+/-$; $*/\div$	The distance and ratio between values can be determined.	Height	

- Nominal scale of measurement

  What gender describes you best?

Female	☐
Male	☐
Non-binary	☐

- Ordinal scale of measurement

  Please evaluate the following products by bringing them into an order from 1 (best product) to 3 (worst product).

Product A	____
Product B	____
Product C	____

- Metric scale of measurement

  How old are you in years?   ____

- Rating scale (strictly speaking an ordinal scale; can however be treated as a metric scale)

  How satisfied are you with product XY on a scale from 1 „completely dissatisfied" to 6 „completely satisfied"?

  completely dissatisfied ☐ ☐ ☐ ☐ ☐ ☐ completely satisfied

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Inferential Statistics

Deskriptive Statistics – Basic Idee

- Descriptive statistics summarises & describes a sample/dataset

- Major types of descriptive statistics
  - Frequencies
  - Measures of central tendency
  - Measures of dispersion

- Please note
  - In academic research, descriptive statistics virtually exclusively serves describing a sample through sociodemographic & context variables. With only few exceptions, a report that only covers descriptive statistics & does not apply inferential statistics does not suffice, according to academic/research standards.

Frequencies: Brief

- **Absolute frequency**
  - Number of times a value of a variable occurred

- **Relative frequency**
  - Ratio of an absolute frequency of a value to the total number of values for a variable
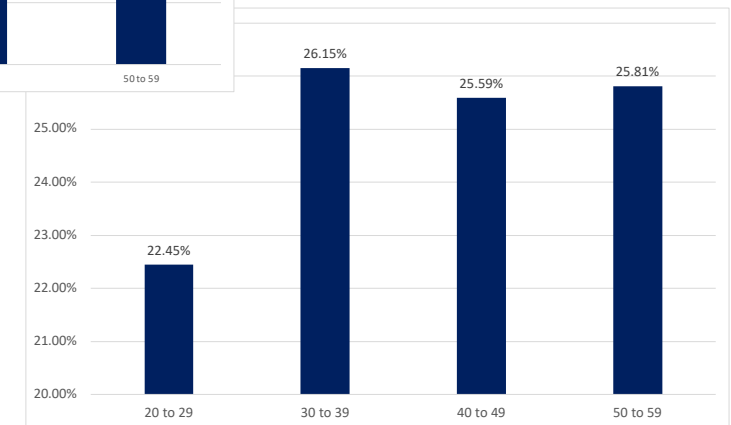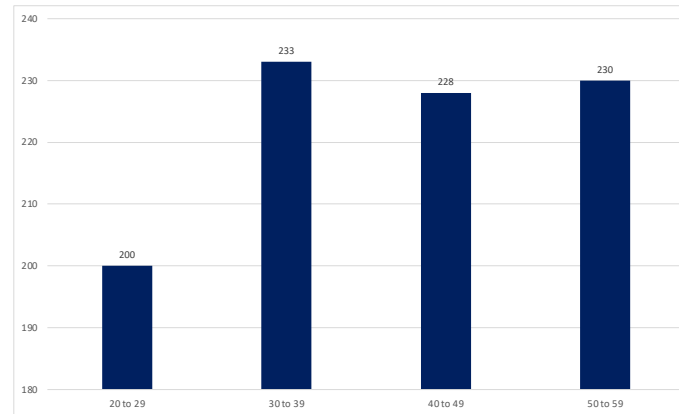
Age group	female	male	total
20 to 29	22.08%	22.84%	22.45%
30 to 39	28.35%	23.78%	26.15%
40 to 49	23.16%	28.21%	25.59%
50 to 59	26.41%	25.17%	25.81%
SUM	100.00%	100.00%	100.00%

- **Cross tabulation (contingency table)**
  - Combination of the distribution of two variables

- **Arithmetic mean**
  - Sum of all values divided by the number of all values; metric measurement level required

- **Median**
  - Value that separates the higher and lower half of a distribution; ordinal measurement level required

- **Mode**
  - Most frequent value of frequency distribution; nominal measurement level required

| Participant	Variable A	
1	23	
2	27	
3	30	
4	35	
5	40	Median
6	55	
7	60	
8	60	Mode
9	75	
Sum	405	
Arithmetic mean	45	

- Variance
  - Average squared difference of values from their arithmetic mean (please note: empirical variance→ /n; sample variance → /n-1)

$$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{\bar{x}})^2}{n}$$

- Standard deviation
  - Average difference of values from their arithmetic mean

$$\sigma = \sqrt{\sigma^2}$$

Two Normal Distributions with Different Variances

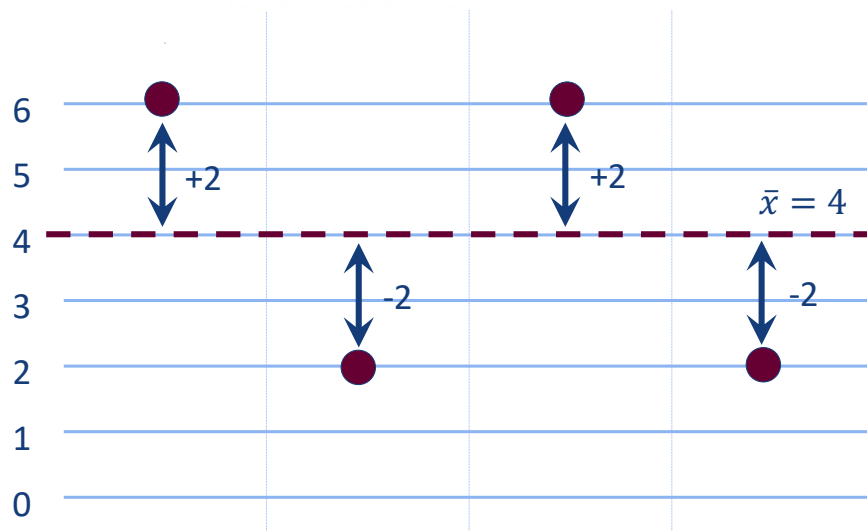Arithmetic mean of both distributions
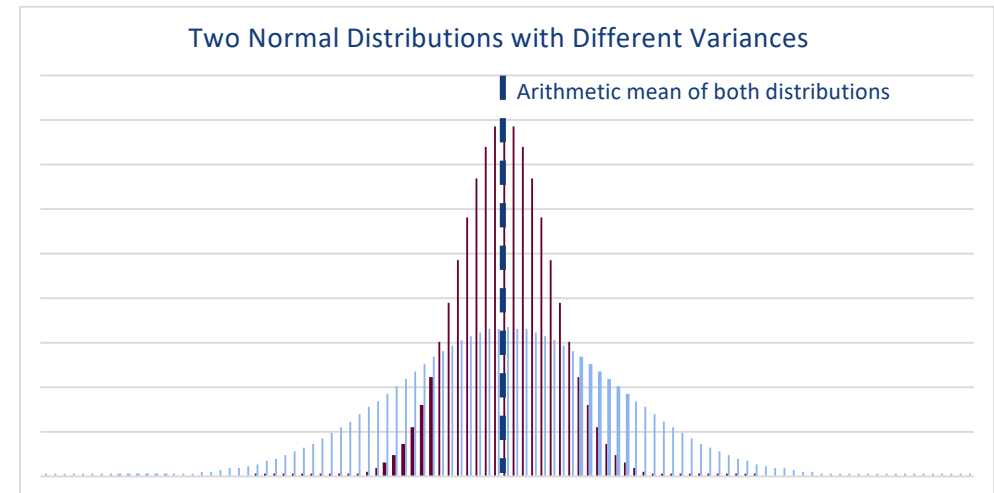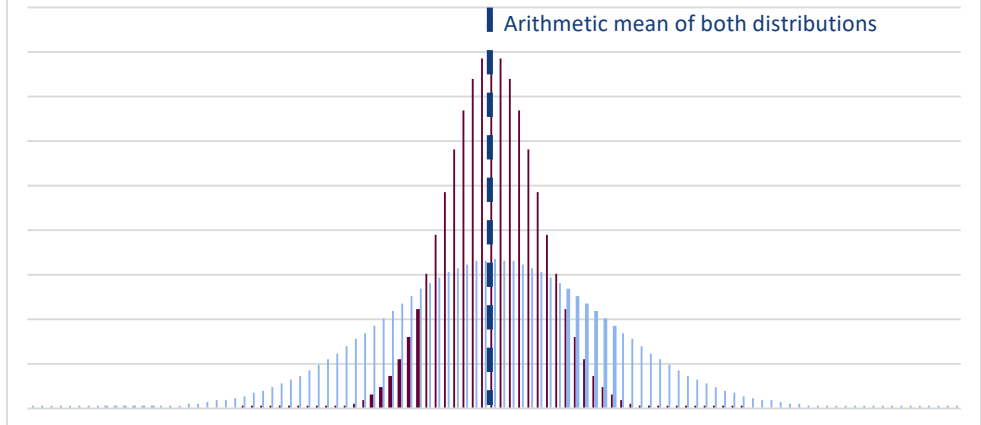
- **Measures of dispersion**

  - Variance

$$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{\bar{x}})^2}{n}$$

  - Standard deviation

$$\sigma = \sqrt{\sigma^2}$$

Two Normal Distributions with Different Variances

Arithmetic mean of both distributions

$\bar{x} = 4$

$\sum_{i=1}^{n}(x_i - \bar{\bar{x}})$ { $(+2) + (-2) + (+2) + (-2) = 0$

$\sum_{i=1}^{n}(x_i - \bar{\bar{x}})^2$ {
$(+2)^2 + (-2)^2 + (+2)^2 + (-2)^2 =$

$4 + 4 + 4 + 4 = 16$

$\sigma^2 = \frac{\sum_{i=1}^{n}(x_i - \bar{\bar{x}})^2}{n}$ { $16 / 4 = 4$

$\sigma = \sqrt{\sigma^2}$ { $\sqrt{4} = 2$

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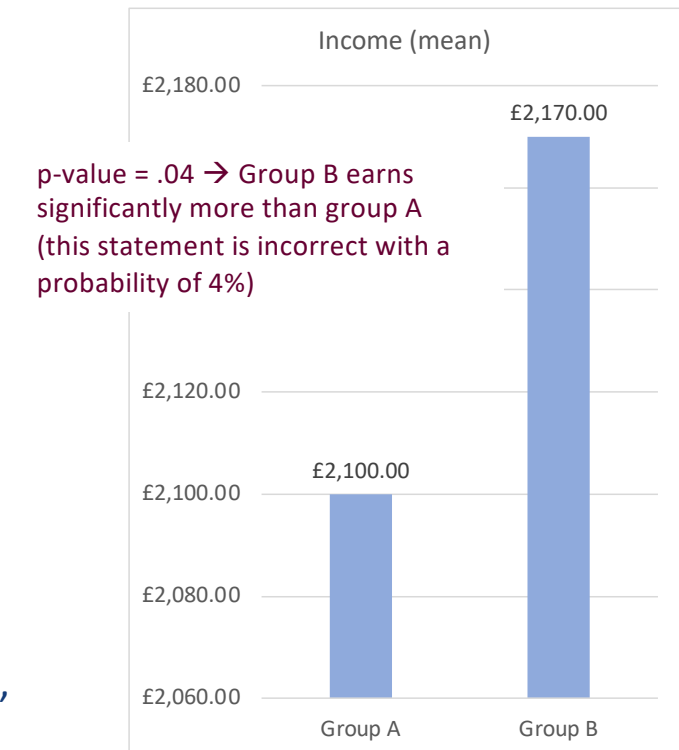
Structure & Contents

Sample & Inductive Statistics

Scale of Measurement

Descriptive Statistics

Inferential Statistics

Inferential Statistics: Principle

- Inferential statistics determines if effects are significant
  - Significant = not coincidental (common language: an effect "really" exists)
  - Non-significant = coincidental (common language: there is no effect)
- The quantitative "black and white world"
  - H1: Effect XY exists.
  - H0: Effect XY does not exist.
- „Logic" of inferential statistical procedures
  - The inferential statistical methods try to reject H0.
  - The results is the p-value with values between 0 and 1.
  - The p-value indicates the probability that H0 holds true if H0 was rejected.
- Steps of the analysis
  - (1) p-value → Significance: p < .05 = significant (higher degrees of significance at p < .01 and p < .001
  - (2) If p-value < .05: interpreting the measured values (arith. mean, frequencies etc.) → direction & strength of the effect

Income (mean)

p-value = .04 → Group B earns significantly more than group A (this statement is incorrect with a probability of 4%)

£2,180.00
£2,170.00
£2,120.00
£2,100.00
£2,080.00
£2,060.00

Group A £2,100.00
Group B £2,170.00

Scale of Measurement

Scale of measurement		Mathematical characteristics	Characteristics of values	Example	Measure of central tendency
Categorical (dichotomous)	Nominal	=/≠	Values are equal or not.	Gender	• Mode
	Ordinal	=/≠ ; </>	Values are larger, smaller or equal.	Olympic ranks	• Mode • Median
Metric (continuous)	Interval	=/≠ ; </> ; −; +	The distance between values can be determined.	Temperature	• Mode • Median • Arithmetic mean
	Ratio	=/≠ ; </> ; +/− ; */÷	The distance and ratio between values can be determined.	Height	

Inferential Statistics: Overview

Inferential Statistical Methods		Independent variable	
		categorical (dichotomous)	Metric (continuous)
Dependent variable	categorical	Chi^2 test	Discriminant analysis
	metric	t-test*** (2 groups) & Analysis of variances (≥ 3 groups)	Regression (dependence) & correlation (interdependence)

*** „Additional" tests:
- Shapiro-Wilk test
  (tests if a variable is normally distributed; precondition for t-tests at small sample sizes, n ≤ 50)
- Mann-Whitney test/Wilcoxon test
  (tests if 2 groups differ on an at least ordinally scaled variable, without requiring a normal distribution)

Exploratory Data Analysis	• Principal component analysis • Cluster analysis

- **Application**:
  - Testing the (in)dependence of two categorical (nominal) variables
- **Leading question**:
  - Is there an association of two variables with a nominal measurement level? / Are two categorical variables independent from each other?
- **Steps of the analysis**:
  1) Is the p-value < .05 (< .01, < .001)? → Significance?
  2) How do the frequencies compare?
- **Statistical Analysis („in the background")**:
  1) Calculation of the expected frequencies (e) which would indicate no difference between the variables (column sum * row sum / number of observations)
  2) Test if the observed values (h) significantly deviate from the expected values €

	Female	Male	Sum
Blue	h = 35 e = 25	h = 15 e = 25	50
Red	h = 15 e = 25	h = 35 e = 25	50
Sum	50	50	100

Chi-squared Test: Brief

- **Statistical Analysis („in the background"):**

  1) Calculation of the expected frequencies (e) which would indicate no difference between the variables (column sum * row sum / number of observations)

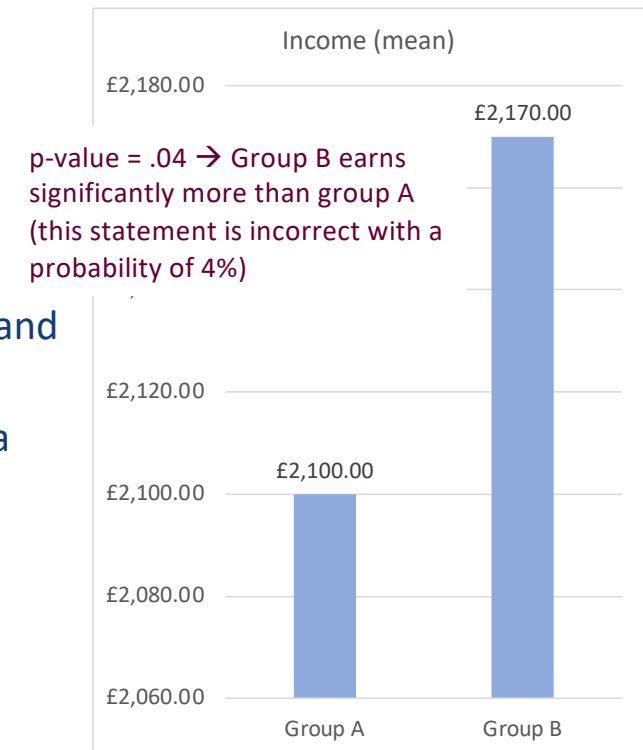 2) Test if the observed values (h) significantly deviate from the expected values

V1	Female	Male	Sum
Blue	h = 15 e = 25	h = 35 e = 25	50
Red	h = 35 e = 25	h = 15 e = 25	50
Sum	50	50	100

p-value = 0.0001447

V2	Female	Male	Sum
Bleu	h = 24 e = 25	h = 26 e = 25	50
Red	h = 26 e = 25	h = 24 e = 25	50
Sum	50	50	100

p-value = 0.8415

- **Application**:
  - Testing if a metric variable differs between two groups (independent sample t-test)
- **Leading question**:
  - Do two groups (samples) differ in a metric variable?
  - Does a categorical variable (two groups) effect a metric variable?
- **Types of t-tests**:
  - Independent sample t-test – measurements from two groups
  - Paired sample t-test – two measurement in one group (e.g., before and after)
  - One-sample t-test – comparison of a group's arithmetic mean with a fixed value
- **Steps of the analysis**:
  1) Is the p-value < .05 (< .01, < .001)? → Significance?
  2) How do the arithmetic means compare?

Income (mean)

£2,180.00

£2,170.00

p-value = .04 → Group B earns significantly more than group A (this statement is incorrect with a probability of 4%)

£2,120.00

£2,100.00

£2,100.00

£2,080.00

£2,060.00

Group A   Group B

- **Application:**
  - The ANOVA (analysis of variances) tests if the arithmetic means of three or more groups (samples) systematically differ.

- **Leading question:**
  - Do the arithmetic means of three or more groups (samples) differ in a metric variable?

- **Distinction from t-test:**
  - Whilst the t-test examines only two groups (samples), the ANOVA analyses three or more groups (samples)

- **Example:**

Independent variable

| England |
| Scotland |
| Wales |

Income
(dependent variable)
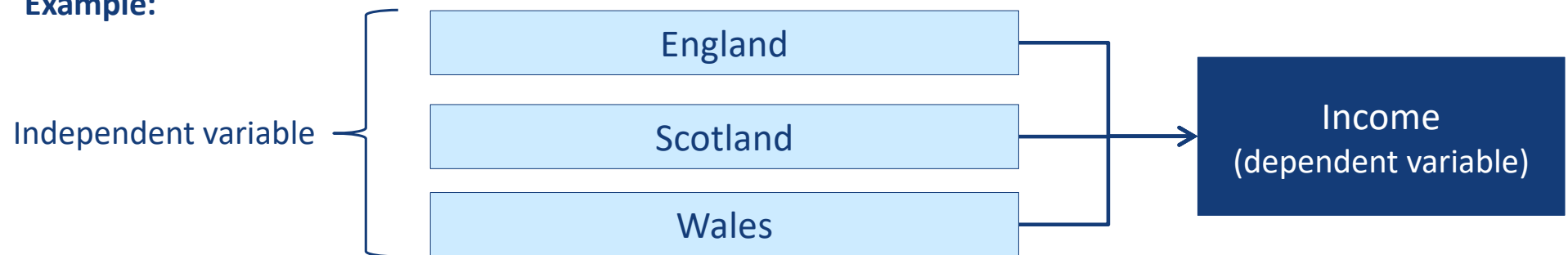
- **Application**:
  - A correlation analysis determines the linear association of two metric variables.
- **Leading question**:
  - How strong and in what direction is the linear association of two metric variables?
    → Does the value of variable A increase or decrease if the value of variable B increases or decreases (et vice versa)?
- **Steps of the analysis:**
  1) Is the p-value < .05 (< .01, < .001)? → Significance?
  2) Which value does the correlation coefficient have?
- **Possible interpretation of the correlation coefficient**:

$0 < r \leq +1.0$	Correlation in the same direction
$-1.0 \geq r < 0$	Correlation in the opposite direction

$0.0 < |r| \leq 0.2$	weak to no correlation
$0.2 < |r| \leq 0.4$	weak correlation
$0.4 < |r| \leq 0.6$	moderate correlation
$0.6 < |r| \leq 0.8$	strong correlation
$0.8 < |r| \leq 1.0$	very strong correlation

- Statistical explanation of the correlation coefficient
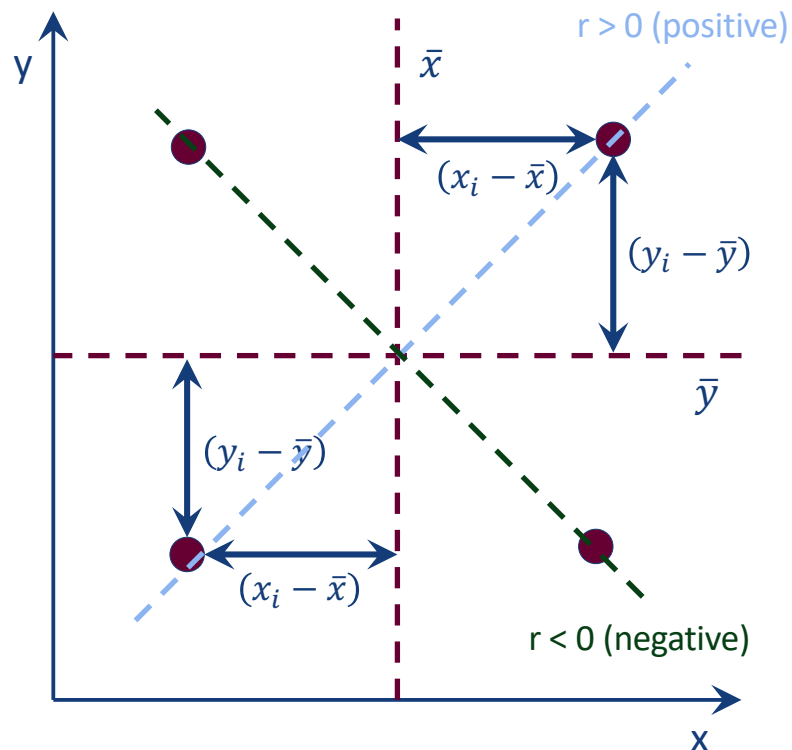
Covariance (shared dispersion of two variables):

$$\text{cov} = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})$$

Variance (dispersion of a variable):

$$\text{var} = \sigma_x = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$$

Correlation coefficient (ratio of the shared dispersion to the total dispersion):

$$r = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{var_x * var_y}}$$

Regression: Brief

- **Application:**
  - The linear regression examines the linear effect of a metric variable (simple regression) or multiple metric variables (multiple regression) on a metric variable (dependent variable).

- **Leading question:**
  - How strong is the effect of a metric variable (simple regression) or multiple metric variables (multiple regression) on another metric variable?

- **Regression model/line (result of an analysis):**
  - **y = a + b * x**
  - y: dependent variable („effect")
  - x: independent variable („cause")
  - a: y-intercept
  - b: regression coefficient ("much y increases – if x increases by one ")

- **Statistical analysis ("in the background"):**
  - The regression analysis determines a line whose squared deviations from the observed values are the least (method of least squares)


Regression: $y = a + b*x$

y

b (slope)

a (y-intercept)

x
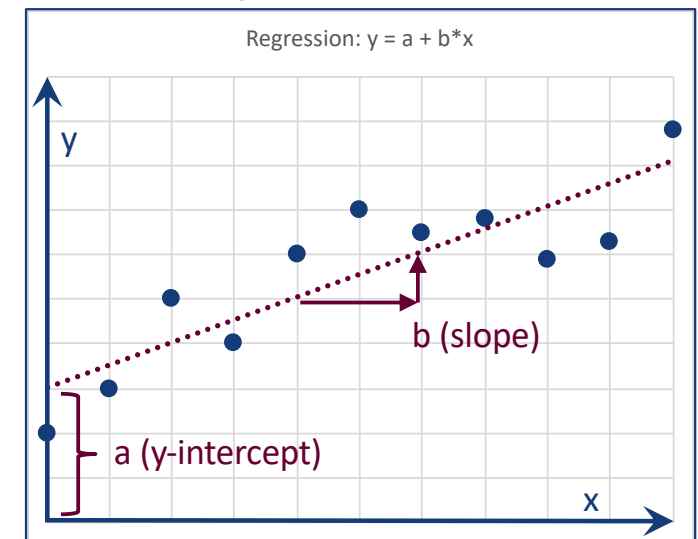
- **Steps of the analysis**:
    1) Are the p-values < .05 (< .01, < .001)?
        ➢ Does x_i significantly effects y (p-values)?
    2) How are the regression coefficients (b)?
        ➢ How strong is the effect of x_i on y?
    3) What is the value for R^2 (coefficient of determination)?
        ➢ What is the explanatory power of the regression model?
        ➢ R^2 = proportion of the variance of the dependent variable that can be explained by the independent variables
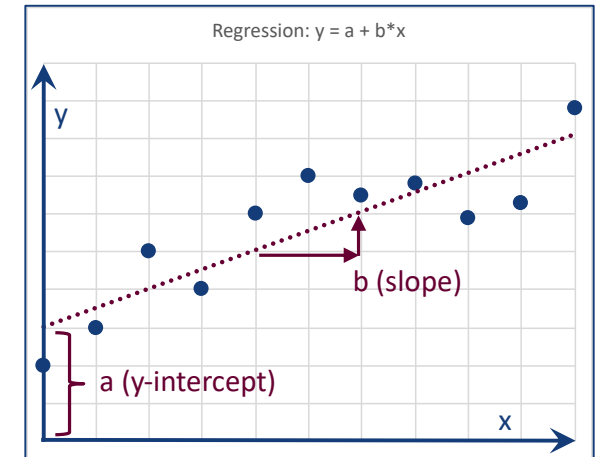
Regression: y = a + b*x

- **Please note**:
    - The regression coefficient can have positive & negative values (also compare correlation coefficient)
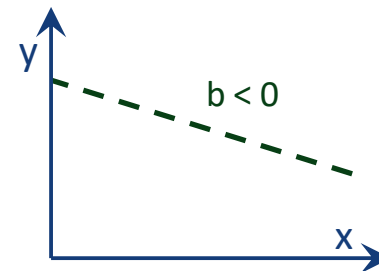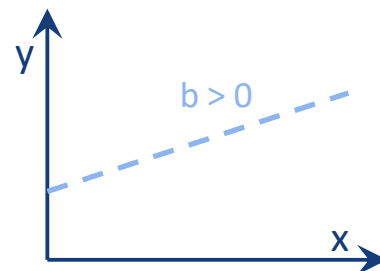
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- "Neutrally" & "objectively" reporting the results
- Normally, descriptive statistics of constructs
- Normally, inferential statistics with effect sizes, p-values & potentially additional indicators (& without further interpretation)
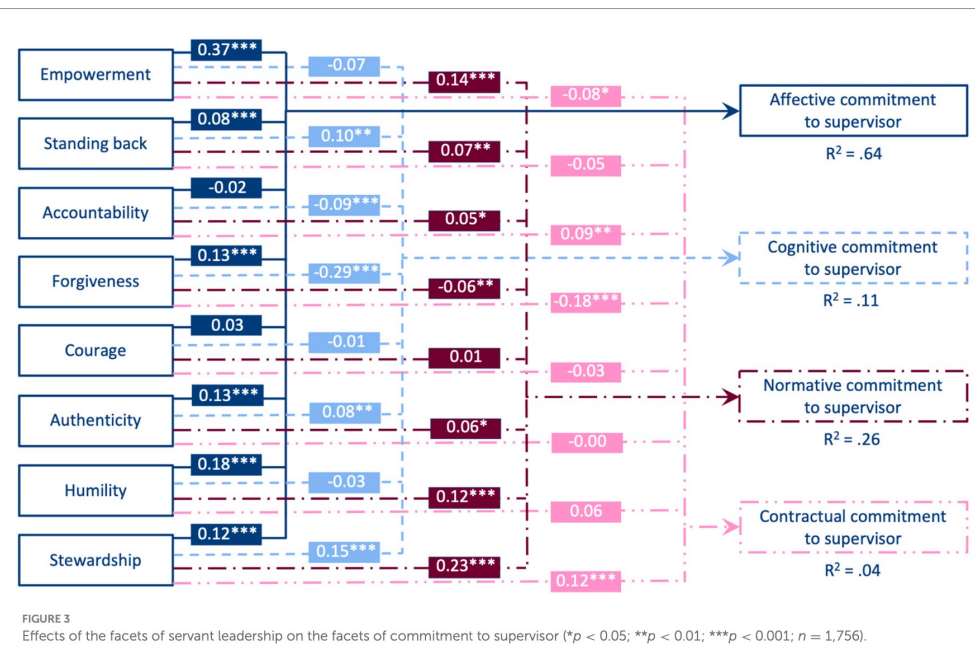

FIGURE 3
Effects of the facets of servant leadership on the facets of commitment to supervisor ($*p < 0.05$; $**p < 0.01$; $***p < 0.001$; $n = 1,756$).

TABLE 5 Descriptive statistics of the facets of organizational commitment, commitment to supervisor and servant leadership ($n = 1,756$).

Construct	Minimum	Maximum	Mean	Standard deviation	VIF
Organizational commitment					
Affective organizational commitment	1.20	6.00	4.55	1.03	
Cognitive organizational commitment	1.00	6.00	2.91	1.24	
Normative organizational commitment	1.00	6.00	3.71	1.19	
Contractual organizational commitment	1.00	6.00	4.08	1.79	
Commitment to supervisor					
Affective commitment to supervisor	1.00	6.00	4.23	1.28	1.59
Cognitive commitment to supervisor	1.00	6.00	2.93	1.20	1.21
Normative commitment to supervisor	1.00	6.00	3.81	1.16	1.79
Contractual commitment to supervisor	1.00	6.00	3.87	1.70	1.13
Servant leadership					
Empowerment	1.00	6.00	4.53	1.05	2.55
Standing back	1.00	6.00	3.91	1.17	1.70
Accountability	1.00	6.00	5.01	0.88	1.41
Forgiveness	1.00	6.00	4.33	1.26	1.35
Courage	1.00	6.00	3.86	1.26	1.30
Authenticity	1.00	6.00	3.39	1.15	1.63
Humility	1.00	6.00	4.03	1.18	2.70
Stewardship	1.00	6.00	4.09	1.17	1.69

Source: Godbersen, H., Dudek, B. & Ruiz Fernández, S. (2024). The Relationship Between Organizational Commitment, Commitment to Supervisor and Servant Leadership. Frontiers in Organizational Psychology, doi: 10.3389/forgp.2024.1353959.

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- Subsections of the discussion section
  - Implications (1st subsection)
  - Limitations & outlook (2nd subsection)

- Guiding questions when writing the discussion
  - Implications (~ interpreting the results)
    - How can the results be explained ("reasons behind the numbers")?
    - What do the results mean for academia and practice?
    - How do the results & their implications relate to findings of other researchers?
  - Limitations & Outlook
    - Which limitations does this research show?
    - What research should follow this research?

Prof. Dr. Hendrik Godbersen

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Get the basics right…

…and do the little things right.

and

Discipline & determination

or

Courage, determination, unselfishness & joyfulness in the face of adversity