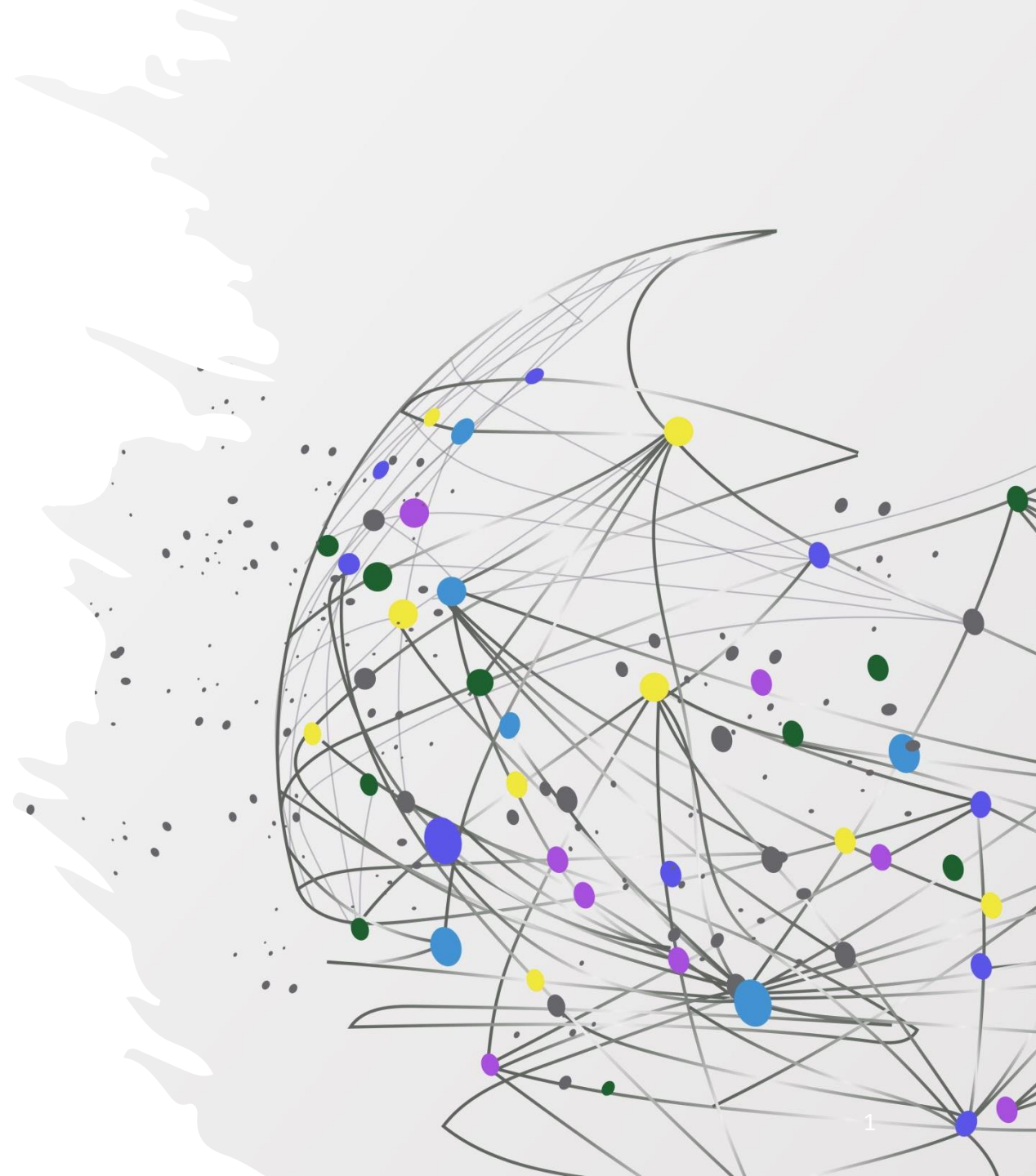


# Workshop Construction and Analysis of Tests & Questionnaires

**Day 2:** Validity (Factor analysis)

**Part I:** Introduction to factor analysis



# Day 2: welcome & short introduction

- Welcome to day 2 of the workshop construction & analysis of test and questionnaires! 😊
- Today is about validity in general and more specifically about **factor analysis**
- In case you want me to speed up and/or discuss a certain topic in more general, **please let me know** (and I'll try to improvise)

# Who am I, who are you?

- Inga Schwabe, dep. of methodology & statistics
- I teach psychometrics & structural equation modelling & do research in (applied) psychometrics, behavioral genetics & data science methods
- When I'm not teaching or doing research, I enjoy rock climbing and renovating my old house
- I live in Tilburg with my partner, 2 sons & 3 chickens
- What about you and your experiences and expectations?
  - What is your research about + Are you at the moment (or planning to) use questionnaires?
  - Any expectations or wishes for lectures and/or lab session for today?



# Day 2

- Theory: Factor analysis (10 – *approx.* 12.30?)
- Short introduction
  - Rotation (Varimax and Oblimin)
  - How to choose the number of factors/dimensions?
  - How to determine what item belongs to what dimension?
- Lab: Performing factor analysis in SPSS  
(*officially starts at 12.45, **but what works for you?*** )
  - Assignment to practice factor analysis in SPSS
  - Also possible: Analyzing your own data (if applicable)
  - Additional questions
  - Extra material: Confirmatory factor analysis (CFA) in R

# Material for the second day

- See

<https://github.com/ingaschwabe/Psychometrics-Workshop-2024>

*Includes these slides, material for the lab session but also extra material*

# Validity: two kinds

- Validity is often divided into two types:
- **Construct validity**
  - To what extent is the 'hypothetical construct' responsible for questionnaire scores?
  - In other words: Do we measure the (underlying) construct well?
- **Criterion validity**
  - Relationship test scores & external criterion outside of the questionnaire
  - How well does a test predict behavior or performance outside of the situation? (criterion in present, past or future)
  - For example: Test scores of (potential) employees & actual performance

# Construct validity

- Today, we will concentrate on **construct** validity (NL: begripsvaliditeit)
- Definition
  - *Construct validity is used to indicate if a scale/questionnaire measures the (underlying) construct well*
  - A scale has good construct validity if
    - 1) **Content domain** of the construct is covered
    - 2) **Internal structure** has been checked <- **Factor analysis**
    - 3) **Nomological network** of the construct has been specified and tested

# Construct validity:

## Internal structure

- The construct may consist of several *sub-constructs* (**multiple dimensions**) – e.g., say our questionnaire measures the construct ‘healthy behavior’ this might consist of two dimensions: **Exercising** & **Diet**
- => also referred to as ‘internal structure’ of a questionnaire
- This internal structure can be investigated (tested) through **factor analysis**



# Questionnaires: Internal structure

Is our questionnaire unidimensional?  
Or can we distinguish multiple dimensions?

For example:  
Questionnaire **about satisfaction of employees:**

- **2 dimensions:**
  - 1) **Atmosphere,**
  - 2) **Communication within the organization**
- -> 2 scales: (and two resulting sum scores!)
  - 1) Atmosphere (for example 10 items that together measure atmosphere)
  - 2) Communication (for example 15 items that together measure communication)

# Example items of a hypothetical questionnaire measuring the satisfaction of employees

I totally agree    I agree    Neutral    I disagree    I totally disagree

I feel good at work.

My colleagues and me, we are working together,  
it is not competitive.

Scale that measures atmosphere (2 example items)

The communication between the team of  
managers and accountants is good.

The accountants communicate well with the  
production management.

Scale that measures communication (2 example items)

We can find these dimensions (sometimes also referred to as subconstructs) using

## **Factor analysis**

# What does factor analysis do?

## Example to illustrate this (in a simple way)

- Following slides: Example items taken from the NEO big five which measures 5 different personality traits:

*Extraversion, Agreeableness, Neuroticism, Conscientiousness & Openness to new experiences*

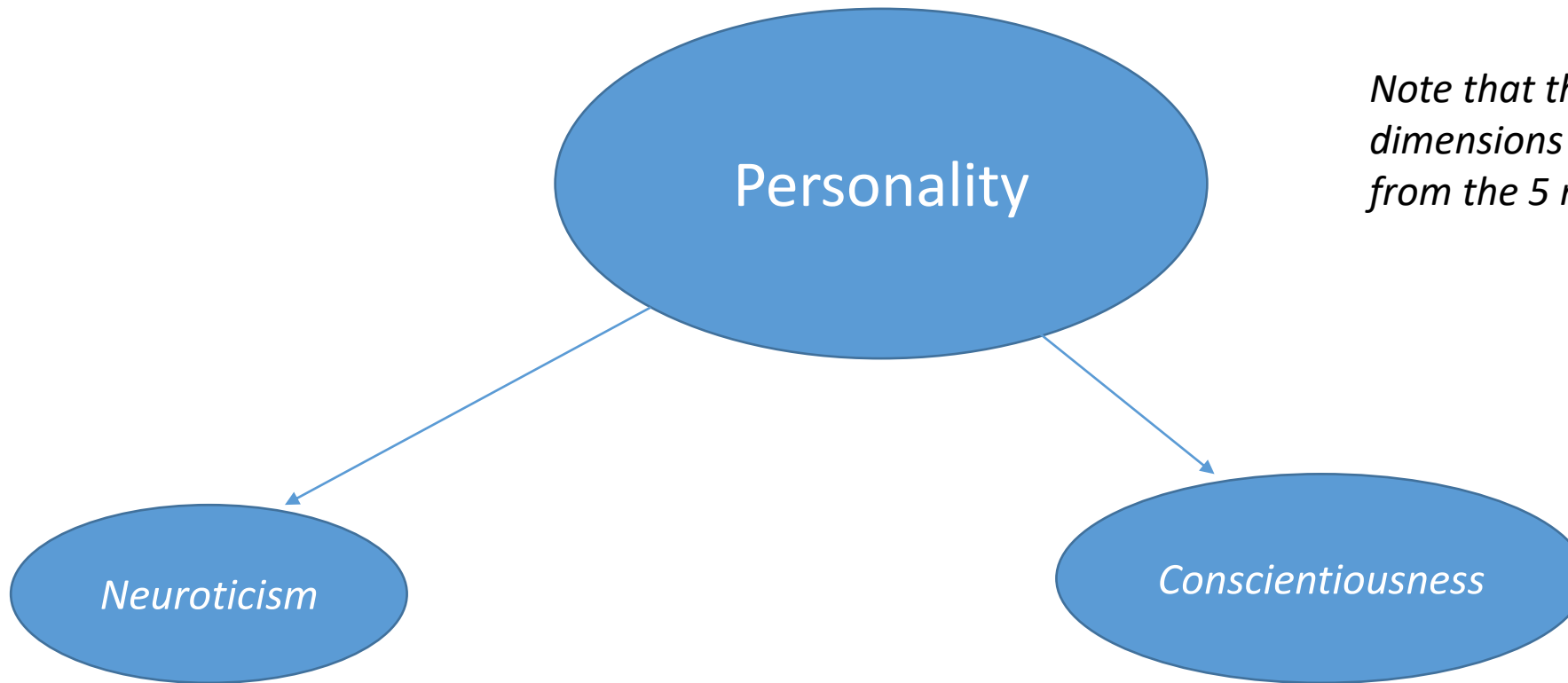
- So, the NEO big 5 assumes that there are **5** different dimensions
- The items on the following slide measuring **2** of them: **Neuroticism & Conscientiousness**

## I see myself as someone who ...

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree
1. ... Worries about things	1 ○	2 ○	3 ○	4 ○	5 ○
2. ... Pays attention to details	1 ○	2 ○	3 ○	4 ○	5 ○
3. ... Follows a schedule	1 ○	2 ○	3 ○	4 ○	5 ○
4. ... Gets stressed out easily	1 ○	2 ○	3 ○	4 ○	5 ○
5. ... Is easily disturbed	1 ○	2 ○	3 ○	4 ○	5 ○
6. ... Seldom feels blue	1 ○	2 ○	3 ○	4 ○	5 ○
7. ... Makes a mess of things	1 ○	2 ○	3 ○	4 ○	5 ○
8. .... Often forgets to put things back in their proper place	1 ○	2 ○	3 ○	4 ○	5 ○
9. ... Gets chores done right away	1 ○	2 ○	3 ○	4 ○	5 ○
10. ... Is relaxed most of the time	1 ○	2 ○	3 ○	4 ○	5 ○

## I see myself as someone who ...

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5. ... Is easily disturbed	1 ○	2 ○	3 ○	4 ○	5 ○
6. ... Seldom feels blue ( <i>rev</i> )	1 ○	2 ○	3 ○	4 ○	5 ○
7. ... Makes a mess of things ( <i>rev</i> )	1 ○	2 ○	3 ○	4 ○	5 ○
8. .... Often forgets to put things back in their proper place ( <i>rev</i> )	1 ○	2 ○	3 ○	4 ○	5 ○
9. ... Gets chores done right away	1 ○	2 ○	3 ○	4 ○	5 ○
10. ... Is relaxed most of the time ( <i>rev</i> )	1 ○	2 ○	3 ○	4 ○	5 ○



*Note that these are only 2 dimensions (taken as an example) from the 5 measured by the Neo big 5*

- Item 1** ("Worries about things")
- Item 4** ("Gets stressed out easily")
- Item 5** ("Is easily disturbed")
- Item 6** ("Seldom feels blue" (contra indicative))
- Item 10** ("Is relaxed most of the time") (contra indicative)

Items measure **together** the dimension **neuroticism**.

- Item 2** ("Pays attention to the details")
- Item 3** ("Follows a schedule")
- Item 7** ("Makes a mess of things") (contra indicative)
- Item 8** ("Often forgets to put things back to their proper place") (contra indicative)
- Item 9** ("Gets chores done right away") (contra indicative)

Items measure **together** the dimension **conscientiousness**.

Internal structure =>  
patterns & groups of items

By looking at the content of the item, we can order them into different groups of items that measure different dimensions of our construct.

So this says something about the internal structure of our questionnaire.



- -> by looking for patterns in our data (grouping of items) we can find items that measure the same dimension.

... and – simply put- this is actually exactly what a factor analysis does!

(but then on a more systematic/mathematical way 😊 - and using actual data 😊)

Summarized,

Factor analysis  
answers two  
questions:



**1) How many dimensions are there?**  
(here 2, but we can determine this based on FA – more later)

**2) Which items measure what dimension?**

# Exploratory versus confirmatory FA

- **Exploratory** Factor Analysis (FA)

- **Use FA to subdivide the items in groups that each measure a construct**
  - *Number of dimensions unknown/not tested before\**
  - *Not known which items belong to which dimension\**

*\*Note: you will probably have an idea about it based on literature and/or the way you developed your questionnaire... Important is that this has not been statistically tested yet.*

# Exploratory versus confirmatory FA

- **Confirmatory FA**

- Use FA to check whether the **expected** internal structure holds
  - *number of dimensions known/expected, for example, based on earlier research that has already performed a factor analysis using the exact same questionnaire \*Based on that, we have very concrete expectations on the number of dimensions and what items belong to which dimension*
  - *Usually the case when we use an existing questionnaire that has already been validated using a different sample (e.g., the neo big 5 has been validated in the US already, but not in the Netherlands – with Dutch respondents)*

# Exploratory FA

- Principal component analysis (PCA) (strictly speaking not FA!)
- Factor analysis

# PCA v.s. factor analysis

- ***Factor analysis***

- Tries to account only for variance (indiv. differences in scores on questionnaire) due to the construct we are interested in (e.g., “factor out” measurement error”)

- => More advanced, and from a theoretical point of view, usually the *better* option

- ***Principal component analysis (PCA)***

- Does not make a distinction between different sources of variance, also measurement error is modeled: *mathematical technique, no statistical model used!!* This is “just” matrix algebra/variance decomposition

- Rather used to summarize data (e.g., big data applications – genetics, etc.)

- => The default option in SPSS and therefore often used nonetheless

- => Sometimes pragmatically used (e.g., big data: computationally more feasible)

*How does factor analysis  
work exactly?*

# How do we know what item(s) belong to what dimension? -> **Factorloadings**

- First some background:
  - Factor analysis tries to find patterns in the data, in other words: it tries to find set of items that **correlate strongly with each other**
  - So, for example if items 1,2,3 and 4 correlate very highly with each other, probably these items **measure the same thing**, so they might **underlie the same dimension**
  - And this information is expressed in **factorloadings**



# What exactly is a factorloading?

- Boils down to a **correlation of an item and a factor (= dimension)**

So, for example, let's say we have 2 factors and we only look at item 1, then for this item, we get:

- Correlation with factor 1 (dimension 1) = 0.3
- Correlation with factor 2 (dimension 2) = 0.7

And these numbers, 0.3 & 0.7 are referred to as **factorloadings**.

# This is still abstract, so let's use a real example

*Disagree (1) – Agree (5)*

V1. Going online helps me escape from things I would rather not deal with.

V2. Going online helps me pass the time when I am bored or have nothing to do.

V3. When I am online I don't feel lonely.

V4. I just enjoy being online to see what comes up.

V5. Going online is an efficient means for finding information.

V6. The Internet makes life easier.

V7. The Internet helps me save time.

V8. It is difficult to delete personal information once it is online.

V9. The Internet is frustrating to work with.

V10. There is too much immoral material online.

V11. Dealing with email takes up too much time.

V12. People can find personal information about me online.

V13. Going online allows me to keep in touch with people.

V14. It is easier for me to meet people online than in person.

- Questionnaire about **internet use** with **14 Items/statements** (see left side)

-Assume that we have 4 dimensions  
***(we will learn later how we can determine this number ourselves)***

**Which items belong to which dimension?**  
**-> Use factor analysis**

# In practice:

- Data in SPSS
- SPSS -> Run factor analysis
- SPSS Output: **Table with factorloadings** (amongst other output)
- For every item: a loading on all factors (all dimensions)
- And we can use this output to determine which “items load on which factor” (formal statistical terminology). Or in other words: which items belong to which scale (applied way of putting it)



	Enjoyable escape	Instrumental efficiency	Problem generator	Social facilitator
Going online helps me escape from things I would rather not deal with.	0.4882			
Going online helps me pass the time when I am bored or have nothing to do.	0.4443			
When I am online I don't feel lonely.	0.4121			
I just enjoy being online to see what comes up.	0.4034	0.2136		
Going online is an efficient means for finding information.		0.6808		
The internet makes life easier.		0.4661		
The internet helps me save time.		0.3799		0.2877
It is difficult to delete personal information once it is online.			0.501	
The internet is frustrating to work with.			0.535	0.2427
There is too much immoral material online.			0.4624	
Dealing with email takes up too much time.	0.288		0.4518	
People can find personal information about me online.				0.7254
Going online allows me to keep in touch with people.				0.3861
It is easier for me to meet people online than in person.	0.3186			0.3254
Eigenvalues	2.66	1.86	1.66	1.53

Notes: N = 1,448. Loadings

less than 0.20 have been left blank.

\*white spaces = loadings below .2 are not shown (see also the note under the table)



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## Interpretation:

**Factorloading** is the correlation between the *item* and the *factor*



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# Part 2 of today: Factor analysis in practice

- How does this work in practice?
- Part 2: Factor analysis in practice
- Now: 5 minutes break and/or time for questions