Workshop Construction and Analysis of Tests and Questionnaires

Day 2: Validity (Factor analysis)

Day 2

- Validity: Internal structure

- Factor analysis
  - Short introduction
  - Rotation (Varimax and Oblimin)
  - How to choose the number of factors/dimension?
  - How to determine what item belongs to what dimension?

- Lab: Performing factor analysis in SPSS
  - Analysing your own data
  - Additional questions
  - Extra material: Confirmatory factor analysis (CFA) in R

Material for the second day

- See

  https://github.com/ingaschwabe/Psychometrics-Workshop

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
        - 3) **Nomological network** of the construct has been specified and tested

Construct validity: Internal structure

- From the <u>description</u> of the content domain, it may appear that the construct consists of several *sub-constructs (multiple dimensions)*

- => Internal structure of a questionnaire

- The internal structure can be <u>investigated (tested)</u> through factor analysis

Questionnaires: Internal structure

Is our questionnaire unidimensional? Or are there multiple dimenions?

- For example:
  - Questionnaire about satisfaction of employees
  - 2 dimensions: 1) Atmosphere, 2) Communication within the organisation
  - -> 2 scales: 1) Atmosphere, 2) Communication

Example items of a hypothetical questionnaire measuring 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 (also referred to as subconstructs) using

Factor analysis

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 ○

Items taken from Big Five Personality Test

- The items are 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 are measuring **2** of them. Which are those?

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 *(rev)*	1 ○	2 ○	3 ○	4 ○	5 ○
7. … Makes a mess of things *(rev)*	1 ○	2 ○	3 ○	4 ○	5 ○
8. …. Often forgets to put things back in their proper place *(rev)*	1 ○	2 ○	3 ○	4 ○	5 ○
9. … Gets chores done right away	1 ○	2 ○	3 ○	4 ○	5 ○
10. … Is relaxed most of the time *(rev)*	1 ○	2 ○	3 ○	4 ○	5 ○

Items taken from Big Five Personality Test

-> by looking for 'patterns' in the data/items, you find items that are measuring the same thing.

... and that is exactly what factor analysis does!

(but then in a more systematic/mathematical way)

Goal of factor analysis

- *For questionnaire data* the goal is to

-*Subdivide the items in groups of items that each measure a subconstruct (a dimension)*

- Hence, factor analysis can *reveal the internal structure of a questionnaire*

Classical test theory and modern test theory

Classical test theory (large part of day 1 of this workshop)

- Sumscore to measure the construct / build the scale
$$X = X_1 + X_2 + \cdots + X_J$$

Modern test theory: Factor analysis (FA)

- Look for factors -> those are representative for the underlying dimensions

- Use *factorscores* instead of sumscores (not discussed in detail here)

Classical test theory vs modern test theory

- Classical test theory and using sum scores:
can only be used to *evaluate* if a number of items form one scale. Or we need to calculate multiple sumscores

- Modern test theory and using factor analysis:
    - -you can **detect** which items form together a scale
    - -you can find subconstructs (*internal structure*); this means that you build multiple (possibly correlated) scales
    - - Instead of a sumscore, you can use a so-called **factor score**

-> *So in practice, we **first** perform a FA if we don't know what items belong to what scale*

-> *If there was only classical test theory, we wouldn't know what items belong to which sclae. This is also the reason why we <u>first</u> perform a factor analysis, and then reliability analysis.*

Factor analysis in a few words

- **What are the underlying dimensions of my construct**?
  - Is my construct one-dimensional or do different items measure different sub-dimensions?

  - E.g.: **Employee satisfaction**
    - Do all items measure the same dimension of this construct or can we identify constructs (different dimensions)? (e.g. is this construct one-dimensional or multi-dimensional?)

    - E.g.: Items that measure *atmosphere* & items that measure *communication within the organization*

    Which items measure which sub-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 known which items belong to which dimension

Exploratory versus confirmatory FA

- **Confirmatory FA**

  - Use FA to check whether the <u>expected</u> subdivision of the items in groups measuring a construct holds

    *number of constructs known/expected

    *expected/known which variable measures which construct

    *knowledge/expectations about correlations between constructs

    e.g.: Based on literature or already existing (and validated) questionnaires!
    For example: NEO big 5, validated in the US, but now used in the Netherlands

Exploratory FA

- Different types:
  - **Principal component analysis (PCA)**
  - **Principal axis factoring (PAF)**

Exploratory FA: Different types

- ***Principal axis factoring (PAF)***

   -Tries to account only for variance due to the construct we are interested in (e.g., trying to "factor out" measurement error")

   => More advaned, 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 modelled: *mathematical technique*, *no statistical model used*!! This is just matrix algebra/variance decomposition

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

   => The default option in SPSS and therefore often used nonetheless
   => Sometimes pragmatically used (e.g., big data: computationally more feasible)

Factor analysis in practice

Example: Oxford Internet Surveys (OxIS)

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.

Factor analysis: Find factors

- **-> Are there groups of items that measure the same thing?**

- **-> Find factors (= dimensions) in the data**

- Every factor = representative for a dimension
  So for data obtained with the NEO Big 5 (measures 5 personality traits), an outcome of a FA could be that we have 5 dimensions

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 a factorloading

What exactly is a factorloading?

- They boil down to a correlation of an item and a factor.

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.

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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 Questions (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)

	Enjoyable escape	Instrumental efficiency	Problem generator	Social facilitator
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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.

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Interpretation:

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

29