Investigating Dimensionality
by means of
Mokken Analysis
and
Confirmatory Factor Analysis

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with
Mokken Analysis
and CFA

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Investigating Dimensionality

Most common methods:

- Principal Component Analysis (PCA)
- Exploratory Factor Analysis (EFA)
- Confirmatory Factor Analysis (CFA)

Less common methods:

- DIMTEST (Stout, Nandakumar, Junker, Chang, & Steidinger, 1992)
- DETECT (Zhang & Stout, 1999)
- Mokken Analysis (Mokken, 1971; Sijtsma & Molenaar, 2002)

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Mokken Analysis

A lot of favorable properties:

- has been around for some time
  (Mokken, 1971; Sijtsma & Molenaar, 2002)
- in the framework of nonparametric item response theory
- can be applied to dichotomous or polytomous (ordinal) data
- empirically testable assumptions

But hardly ever used:

- still rather unknown (except in the Netherlands)
- sounds complicated – item response functions of unknown form?
- results not easily comparable to "standard research"
- no (commonly known) benchmarks for model fit

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Mokken Analysis

Has already been used conjointly with PCA:

- unsurprisingly, by researchers from the Netherlands
  (Wismeijer, Sijtsma, van Assen, & Vingerhoets, 2008)
- combined use was found to be beneficial
  in terms of these methods complementing each other

Can also be used conjointly with CFA:

- CFA offers well-established benchmarks to assess the fit of factor models (e.g., Hu & Bentler, 1999)
- can make results comparable to prior research
- Mokken Analysis offers an "additional dimension" over (exploratory/confirmatory) factor analysis

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Mokken Analysis

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- based on the Monotone Homogeneity Model (MHM; Mokken & Lewis, 1982; Sijtsma & Molenaar, 2002)
- assumptions:
  - unidimensional latent trait(s)
  - monotonicity
  - local independence of responses

- Mokken Analysis can be used to select items to scales in order to satisfy the MHM
- by calculating scalability coefficients
  - H_{ij} for item pairs
  - H_i for single items in relation to their common scale
  - H for the complete scale

- and using an automated item selection procedure

Automated Item Selection Procedure

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1. select the two items to form a scale
   - that have the highest pairwise scalability coefficient H_{ij}
   - which has to be higher than a user-specified minimum value c (scalability criterion)
2. from the remaining items, select the item
   - that correlates positively with all items already in the scale
   - that has a pairwise scalability coefficient $H_{ij} > c$ with all items in the scale
   - that maximizes the scale's scalability coefficient H
3. repeat step 2 until no item satisfies these conditions
4. start at step 1 to construct a second/third/... scale

- repeat this procedure for increasing scalability criteria c
- resulting in an increasing number of more and more clear-cut scales (and more unscalable items)
- thereby revealing the dimensionality of the questionnaire

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Attitudes Toward Suicide Scale (Eskin, 2004)
measures different factors (EFA):
- *acceptability of suicide*
- suicide as a *sign of mental illness*
- the belief that persons who commit suicide will be *punished after death*
- the opinion that suicidal people should *communicate their problems*
- the intention to *hide past suicidal behavior*
- the opinion that suicide should be *discussed and reported openly* among friends or in the news

and maybe
- the view of *suicide as a solution* to one's problems

as found by another study using EFA (Eskin, Voracek, Stieger, & Altinyazar, 2011).

Attitudes Toward Suicide

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Practical/clinical relevance

Especially the factor *acceptability of suicide* is important for suicide prevention, as higher acceptability ...

- moderates the relationship between hopelessness and suicidal ideation (in men; Gibb, Andover, & Beach, 2006)
- is linked to increased planning of suicidal actions in adolescents (Joe, Romer, & Jamieson, 2007)
- may be associated with higher suicide rates (Salander Renberg, Hjelmeland, & Koposov, 2008)

- although findings remain debated (Beautrais, Horwood, & Fergusson, 2004; Salander Renberg et al., 2008)

6 or 7 Factors?

To resolve this issue:

- Mokken Scaling
  - to investigate dimensionality non-parametrically
  - using R 2.14.1 (R Development Core Team, 2011)
  - and package *mokken* Version 2.6 (van der Ark, 2007)
- CFA
  - to quantify the fit of the models
  - using lavaan Version 0.4–10 (Rosseel, 2011)
  - and MPlus 6.1 (Muthén & Muthén, 2008)

Sample:

- $N = 571$ German-speaking volunteers (41% men)
- subjects with missings omitted
- mean age 30 years ($SD = 12.8$ years)

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$c = .00$ to $.05$

1. Someone who has gone bankrupt has the right to kill him/herself.
2. Someone who is tired of living has the right to kill him/herself.
3. Someone who dishonored his/her family has the right to kill him/herself.
4. Someone suffering from an incurable illness has the right to kill him/herself.
5. Suicide can be a solution to some problems.
6. Suicide can be the only way out of life's problems.
7. People have the right to kill themselves.
8. Killing oneself by committing suicide is a right behavior.
9. People who attempt suicide are mentally ill.
10. People who kill themselves by committing suicide are mentally ill.
11. People who think and plan suicide are mentally ill.
12. People who attempt suicide are going to be punished in the other world.
13. People who kill themselves are going to be punished in the other world.
14. People who think and plan suicide are going to be punished in the other world.
15. People who kill themselves by committing suicide are sinful.
16. There is a life after death.
17. A person who [. . .] plans suicide should tell [. . .] friends [. . .]
18. People should tell their psychological problems to their friends.
19. Young people should tell their psychological problems to their parents.
20. A young person who thinks and plans suicide should tell this to his/her parents.
21. Families whose daughter/son attempts suicide should hide this from their neighbors.
22. Families who lose a daughter/son from suicide should hide this from their neighbors.
23. Suicide news should be written openly in the newspapers.
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- 3 scales to begin with

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$c = .10$ to $.15$

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- 4 scales now (*open reporting* of suicides splits off)

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$c = .20$

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22. Families who lose a daughter/son from suicide should hide this from their neighbors.
23. Suicide news should be written openly in the newspapers.
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- 4 scales, all are combinations of the six-factor solution (Eskin, 2004)
- scale *open reporting* not a seperate scale here (unstable scale?)

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16. There is a life after death.
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18. People should tell their psychological problems to their friends.
19. Young people should tell their psychological problems to their parents.
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21. Families whose daughter/son attempts suicide should hide this from their neighbors.
22. Families who lose a daughter/son from suicide should hide this from their neighbors.
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$c = .30$

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22. Families who lose a daughter/son from suicide should hide this from their neighbors.
23. Suicide news should be written openly in the newspapers.
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▶ matches the six-factor solution found by Eskin (2004)
▶ except for item 16 (unscalable)

$c = .35$ to $.45$

1. Someone who has gone bankrupt has the right to kill him/herself.
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4. Someone suffering from an incurable illness has the right to kill him/herself.
5. Suicide can be a solution to some problems.
6. Suicide can be the only way out of life's problems.
7. People have the right to kill themselves.
8. Killing oneself by committing suicide is a right behavior.
9. People who attempt suicide are mentally ill.
10. People who kill themselves by committing suicide are mentally ill.
11. People who think and plan suicide are mentally ill.
12. People who attempt suicide are going to be punished in the other world.
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14. People who think and plan suicide are going to be punished in the other world.
15. People who kill themselves by committing suicide are sinful.
16. There is a life after death.
17. A person who [...] plans suicide should tell [...] friends [...]
18. People should tell their psychological problems to their friends.
19. Young people should tell their psychological problems to their parents.
20. A young person who thinks and plans suicide should tell this to his/her parents.
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22. Families who lose a daughter/son from suicide should hide this from their neighbors.
23. Suicide news should be written openly in the newspapers.
24. The matter of suicide should be discussed openly among friends.

▶ factor *open reporting* of suicide is dropped

$c = .50$

1. Someone who has gone bankrupt has the right to kill him/herself.
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3. Someone who dishonored his/her family has the right to kill him/herself.
4. Someone suffering from an incurable illness has the right to kill him/herself.
5. Suicide can be a solution to some problems.
6. Suicide can be the only way out of life's problems.
7. People have the right to kill themselves.
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22. Families who lose a daughter/son from suicide should hide this from their neighbors.
23. Suicide news should be written openly in the newspapers.
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▶ matches the seven-factor solution found by Eskin et al. (2011)
▶ except for excluded items

Slide (top-left)

$c = .55$

1.	Someone who has gone bankrupt has the right to kill him/herself.
2.	Someone who is tired of living has the right to kill him/herself.
3.	Someone who dishonored his/her family has the right to kill him/herself.
4.	Someone suffering from an incurable illness has the right to kill him/herself.
5.	Suicide can be a solution to some problems.
6.	Suicide can be the only way out of life's problems.
7.	People have the right to kill themselves.
8.	Killing oneself by committing suicide is a right behavior.
9.	People who attempt suicide are mentally ill.
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- additional item dropped
- but scales remain essentially unchanged

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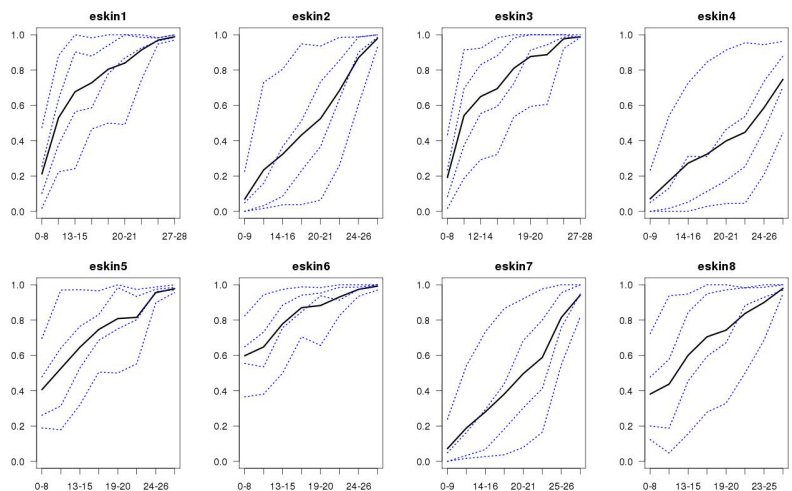## Dimensionality

Dimensionality revealed by:

- increasing the scalability criterion c
- watching how the scales develop
- to reveal dimensionality of the questionnaire

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Assumption of Monotonicity

For acceptability (including the the two "solution"-items 5 and 6):

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Assumption of Monotonicity

Violations of monotonicity only very minor:

- no significant violations scales *acceptability of suicide*, *suicide as a sign of mental illness*, and *hiding suicidal behavior*
- one violation for each of the items 14, 18, and 24 (significant at $\alpha = 5\%$, but based on 40 pairwise comparisons each)
- two violations for item 17 (based on 60 pairwise comparisons).

- number of violations appears negligible
- does not impair the ordering of respondents on the latent trait, i.e., the respective attitude (Wismeijer et al., 2008)

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Confirmatory Factor Analysis

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#	No. of Factors	Items excluded	Split	TLI	CFI	RMSEA	SRMR
1	7	-	no	.881	.901	.082[.077,.087]	.071(.068)
2	6	-	no	.885	.902	.081[.076,.085]	.064(.061)
3	6	16	no	.888	.905	.083[.078,.088]	.062(.060)
4	6	16,17,23,24	yes	.917	.932	.081[.075,.086]	.054(.052)

Note. Split = Splitting the factor *suicide as a solution* from the factor *acceptability of suicide* (yes or no); TLI = Tucker-Lewis index; CFI = comparative fit index; RMSEA = root-mean-square error of approximation; SRMR = standardized root-mean-square residual (lavaan/Mplus); numbers in brackets are 95% confidence intervals for the RMSEA.

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Regarding the attitudes toward suicide scale:

- both (six- and seven-) factor structures from prior research found with Mokken Analysis
- seven-factor solution results from split of the acceptability scale
- suicide as a solution to one's problems:
  - may be regarded as a facet of acceptability
  - or may be treated as a seperate construct (for clear-cut factor structure)

- hence: six- / seven-factor solution found in prior research maybe due to different importance of this aspect in the two samples

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- one factor weak (open reporting of suicides, items 23 and 24)
  - item 23: open reporting in the news (copycat / Werther effects vs. Papageno effect)
  - item 24: open discussion among friends (experienced as a relief, usually)
- better not use this factor

Regarding methodology:

- factor structure revealed by Mokken Analysis
- "additional dimension" when increasing scalability criterion c
- allows deeper insights into dimensionality of the scale

- fit of resulting models can be judged by CFA benchmarks
- and compared to prior research

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Advantages of Mokken Analysis:

- drops unscalable items automatically
- produces scales (not only data transformations; Wismeijer et al., 2008)
- assumptions empirically testable
- reveals additional insights by increasing the scalability criterion c
- very intuitive

Advantages of CFA:

- fit can be judged easily
- well-established benchmarks
- results comparable to prior research

$\Rightarrow$ combining both methods combines all advantages

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Outlook

- using the methodology on other questionnaires,
  to construct scales with a more clear-cut factorial structure

- using Mokken Analysis and CFA in cross-validation studies

- making Mokken Analysis more popular?

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Thank you.

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