Using Alignment optimization in establishing measurement invariance. An illustration with the value scale across countries

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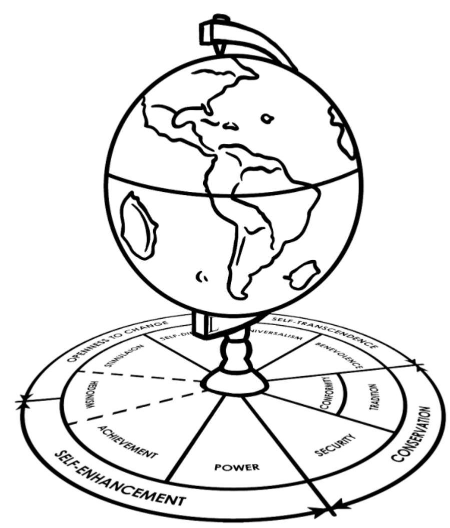


Measurement invariance
- psychometric property of a questionnaire

The questionnaire is measurement invariant
when it measures

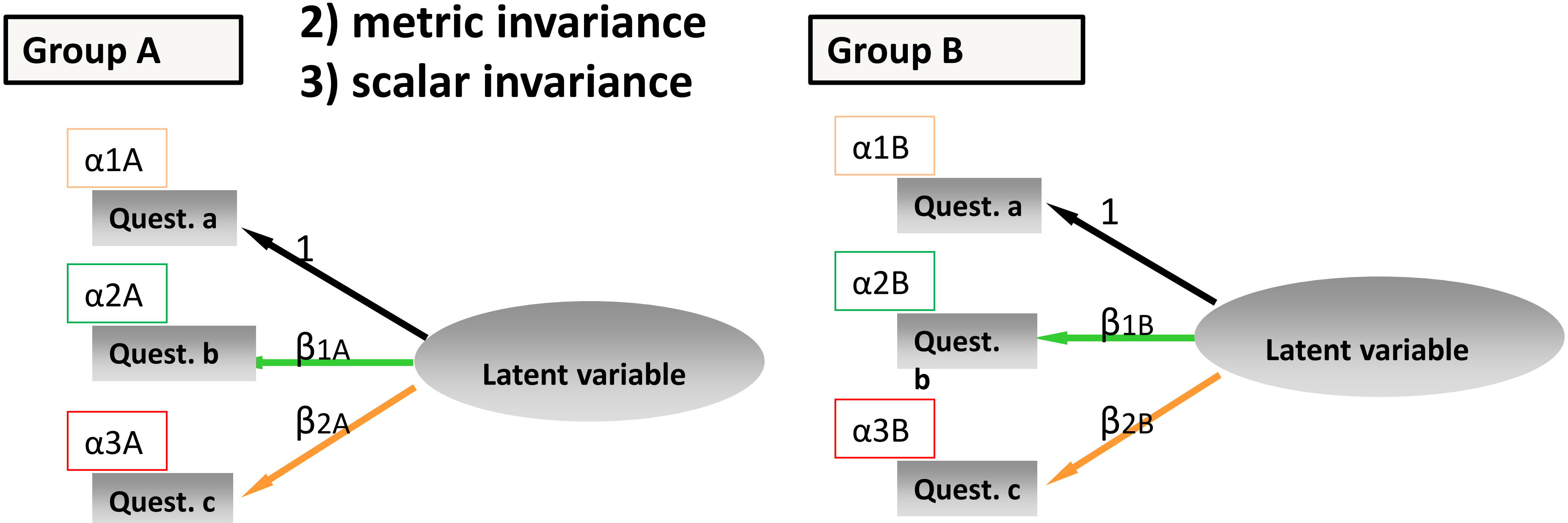
- **the same construct**
- **in the same way**
- **across different groups**, such as countries, cultures or other geographical regions, conditions of data collection or time points

Measurement invariance
is a precondition for any meaningful comparison
of means, correlates and regression coefficients
of the measured construct across groups

Most often used approach to test for measurement invariance:

1) Multigroup Confirmatory Factor Analysis - MGCFA (Bollen 1989, Jöreskog 1971)

1) configural invariance
2) metric invariance
3) scalar invariance



2) Evaluation based on differences in global model fit indices between models (Chen, 2007)

We test for measurement invariance,
because we are interested in comparability (of correlates and means)

Configural level:

- loadings and intercepts are freely estimated

BUT

all means constrained to zero

Scalar level:

- all means are estimated

BUT

- loadings and intercepts are constrained to be equal

The common problem:

The scalar model does not fit data well

= the means are estimated,

however we don't know how trustworthy they are

The Alignment optimization (Asparouhov & Muthen, 2013)
- an alternative approach in the framework of MGCFA:

The main idea of the Alignment:

→ estimating means and variances

without

→ constraining loadings and intercepts to be equal across groups

The classical MGCFA

The Alignment optimization

Configural level:

- loadings and intercepts are freely estimated
BUT
all means constrained to zero

No equality constraints on intercepts and loadings while

Estimating means

Scalar level:

- all means are estimated
BUT
- loadings and intercepts are constrained to be equal

The Alignment optimization

Estimating means

without

constraining loadings and intercepts to be equal across groups

Estimating means

taking into account

real differences in loadings and intercepts

How does it work?

The Alignment optimization

The first step

estimating of configural model with:
- free estimated intercepts and loadings,
- factor means fixed to zero,
- factor variances fixed to one

Similar to EFA

- result: a few large non-invariant parameters
and many approximately invariant rather than many medium-sized non-invariant

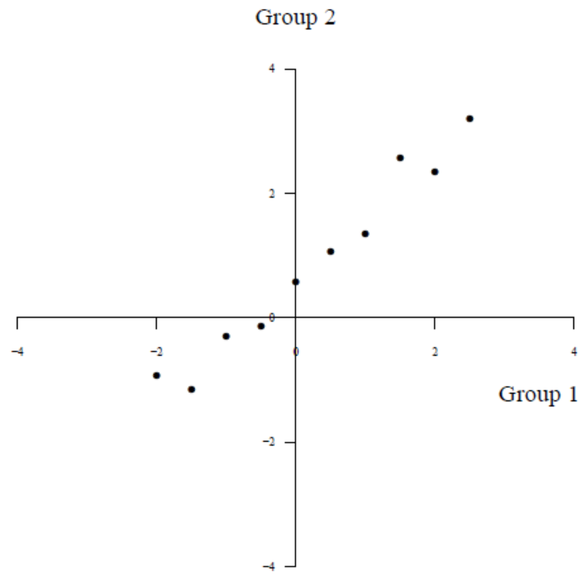
The second step = aligned model

The same model fit as the configural

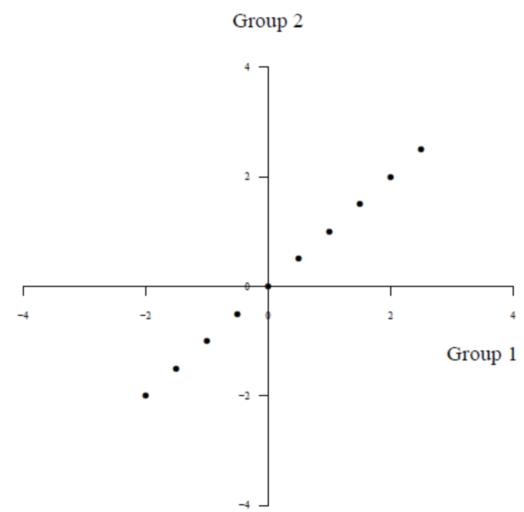
freeing the factor variances and means
and estimating them the way
that the **total amount of non-invariance is minimized**
those means and variances are chosen that minimize the number of noninvariant loadings and intercepts

= the Alignment takes into account
(1) differences in loadings and intercepts estimated in the first step
(2) while estimating factor means in the second step.

Unaligned and aligned intercepts parameters



Unaligned: Configural model (mean=0, variance=1 in both groups)



Aligned: Taking into account the group differences in means and variances

MGCFA with equality constraints

Alignment optimization

The main goal

Testing for a precondition
of meaningful means comparison
across groups

Estimating factor means
without
imposing equality constraints

The model identification

Imposing equality constraints
on loadings and intercepts

Simplicity function

Model evaluation: Possibility of means comparison

Change in model fit coefficients between
tested levels of measurement invariance.

The model fit is exactly the same
as the model fit
in configural level of MGCFA.

The means can be compared
when the global model fit coefficients
are above the cut-off criteria.

The means can be compared
when a measurement pattern
can be found in the data.

What does it mean?

Assumption
of the Alignment optimization

A „measurement pattern" can be found in data:
- there are rather little non-invariant and many invariant parameters

Mplus identifies parameters (loadings and intercept) that are non-invariant

(1) Mplus identifies the largest set of groups where a given parameter is invariant = do not differ significantly from the average value of the parameters in other groups in this set

(2) Noninvariant parameter = the parameter differs significantly from the average value of the parameter within the set of invariant groups.

Similar to modification indexes…
BUT

The modification indexes provide information about improvement of the model by introducing the **single** modification.

All non-invariant parameters in Alignment are identified **at one step**, although based only on the pairwise comparisons without taking into account the improvement of the whole model.

Assumption
of the Alignment optimization

A „measurement pattern” can be found in data:
- there are rather little non-invariant and many invariant parameters

This assumption can be tested in a convenient way in
the approximate version of the Alignment optimization

Alignment optimization in the framework of

Frequentiest approach (ML)

First step:
configural model

Bayesian approach

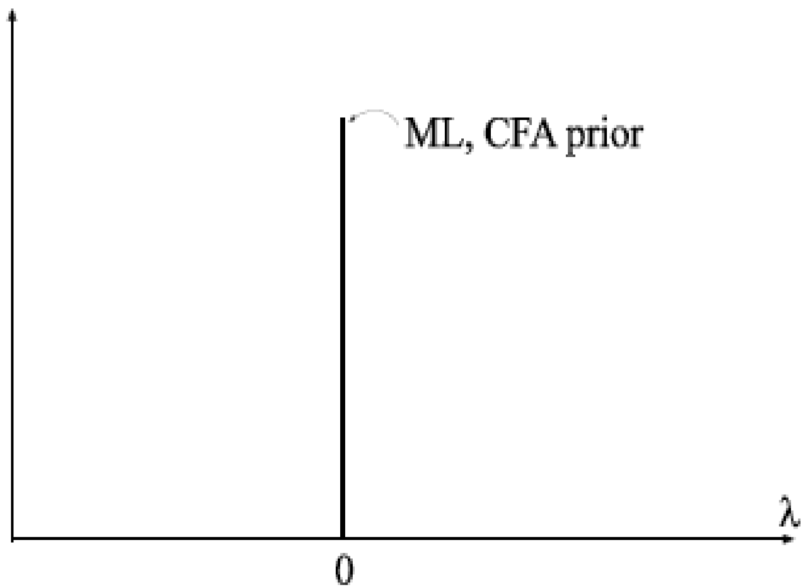
Approximate (Bayesian) approach to measurement invariance

	Frequentist exact measurement invariance	**Bayesian approximate measurement invariance**
Restrictions posed on parameters (loadings and intercepts)	Parameters are constrained to be equal	Parameters are constrained to be **approximately** equal ***(zero-mean, small-variance informative priors)***

Approximate (Bayesian) approach to measurement invariance

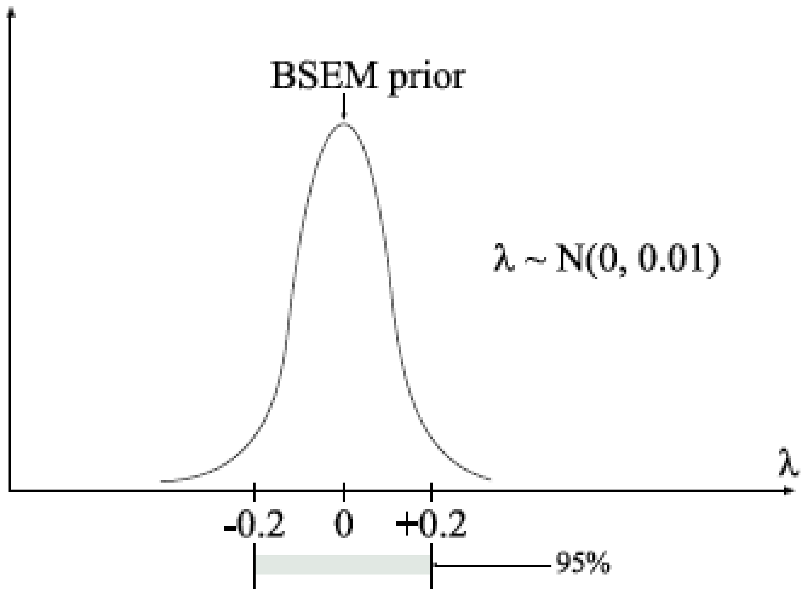
Comparison of exact and approximate approaches to MI

(Van de Schoot et al., 2013; Schmidt & Zercher 2013, Muthén & Asparouhov, 2012)



exact zero

a very strong informative prior (like a constraint in ML)
(with a mean and a variance of zero)



approximate zero

zero-mean and small-variance (.01) where 95% of the loading variation

Alignment optimization in the framework of

Frequentiest approach (ML)

First step:
configural model

Bayesian approach

two versions

First step:
non-informative priors
(similar to configural model in the frequentiest approach)

First step:
approximate scalar model
Intercepts and loadings constrained to be approximately invariant
Means and variances estimated in all groups but first

Second step:
freeing the factor variances and means
and estimating them the way that the **total amount of non-invariance is minimized**

(1) There is no need to impose the equality constraints when the parameters are anyway approximately equal
(2) The small differences in loadings and intercepts are taken into account while estimating means

Advantages of the Bayesian alignment estimation over the ML

- possibility of using binary indicator variables
- more chance for better model fit at the configural level
- more chance to resolve estimation problems
- measure of approximate measurement invariance

The advantage of the BSEM model with the alignment estimation over the BSEM without the alignment

- BSEM model without the alignment estimation is that it improves interpretability

(Asparouhov & Muthen, 2013)

The alignment estimates are obtained by minimizing the number of non-invariance items, while the BSEM estimates are obtained by minimizing the variability of the estimates across groups. The alignment estimates will be simpler to interpret as fewer non-invariant parameters will be found.

(Asparouhov & Muthen, 2013)

Limitations:
Only one latent variable

An illustration with the value scale across countries

Previous finding of values measurement invariance tests:

The disappointing result of PVQ-21 in ESS data
(Davidov, Schmidt, & Schwartz, 2008)

Only metric invariance was established for the values

Conclusion:
A cross-country comparison of means might not be meaningful

The Alignment optimization
combined with approximate measurement invariance

Results of PVQ-21 in ESS

We selected countries paticipated in all six rounds

Belgium
Denmark
Finland
Germany
Hungary
Ireland
Netherlands
Norway
Poland
Portugal
Slovenia
Spain
Sweden
Switzerland
UnitedKingdom

…and run test for measurement invariance for each value separately

Example results: Power-Achievement

Configural exact measurement invariance

CFI = .998
RMSEA = .027
SRMR = .009

Metric exact measurement invariance

CFI = .990
RMSEA = .040
SRMR = .034

Scalar exact measurement invariance

CFI = .888
RMSEA = .104
SRMR = .074

Example results: Power-Achievement

Scalar approximate measurement invariance

ppp nonsignificant → ok!

ppp = .077

95% CI = -13.1 – 92.9

CI contains zero → ok!

Conclusion:
Approximate measurement invariance is established so we proceed with the Alignment optimization

Example results: Power-Achievement

A part of Mplus output

```
APPROXIMATE MEASUREMENT INVARIANCE (NONINVARIANCE) FOR GROUPS

 Intercepts
   IPSHABT      (1) 2 (3) 4 5 6 (7) (8) (9) (10) 11 12 (13) (14) 15
   IPSUCES      1 2 (3) 4 (5) 6 7 8 9 10 11 12 13 14 15
   IMPRICH      1 (2) 3 4 5 6 7 8 9 10 11 12 (13) 14 (15)
   IPRSPOT      1 (2) 3 4 (5) (6) (7) 8 9 10 11 12 (13) 14 15

 Loadings for POAC
   IPSHABT      1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
   IPSUCES      1 2 (3) 4 5 (6) 7 8 9 10 11 12 13 14 15
   IMPRICH      1 2 3 4 5 6 7 8 9 10 11 12 13 14 (15)
   IPRSPOT      1 2 3 4 5 (6) 7 8 9 10 11 12 13 14 15
```

Non-invariant parameter in a given group in paretnthesis

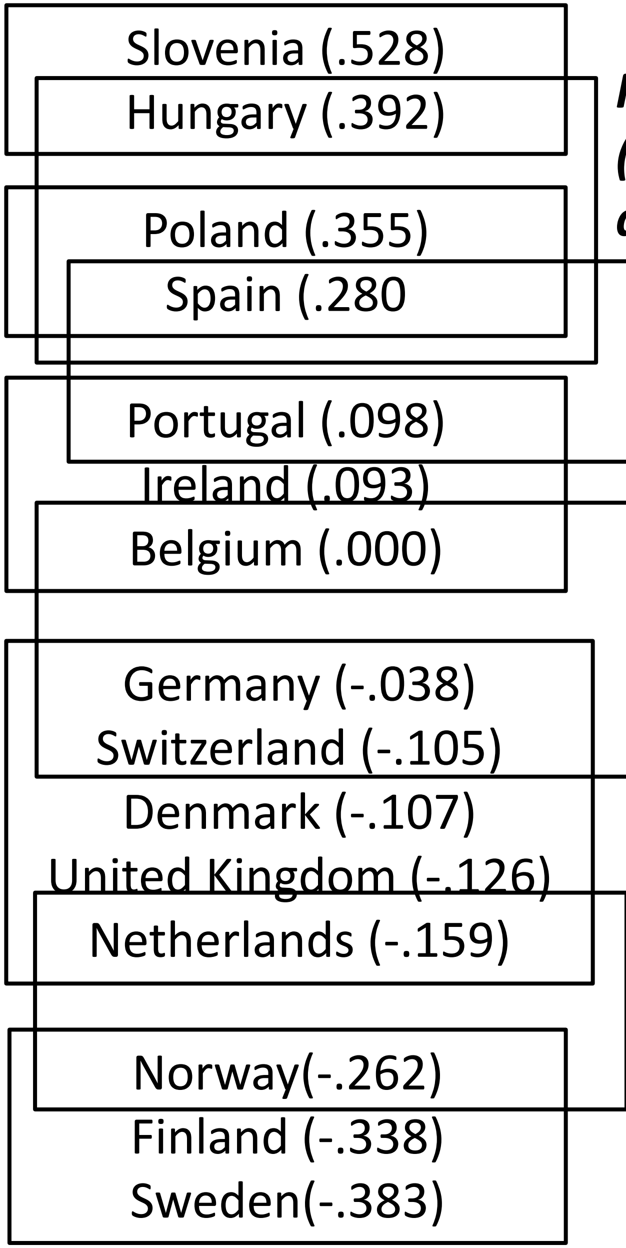
The Alignment optimization

A part of Mplus output

Ranking of country means with significant differences between countries

```
FACTOR MEAN COMPARISON AT THE 5% SIGNIFICANCE LEVEL IN DESCENDING ORDER

 Results for Factor POAC
 Ranking  Group      Value    Groups With Significantly Smaller Factor Mean
     1      15       0.528    12 5 13 9 1 3 2 4 7 10
                              11 6 14
     2       8       0.392    13 9 1 3 2 4 7 10 11 6
                              14
     3      12       0.355    13 9 1 3 2 4 7 10 11 6
                              14
     4       5       0.280    9 1 3 2 4 7 10 11 6 14
     5      13       0.098    3 2 4 7 10 11 6 14
     6       9       0.093    3 7 10 11 6 14
     7       1       0.000    4 7 10 11 6 14
     8       3      -0.038    11 6 14
     9       2      -0.105    11 6 14
    10       4      -0.107    11 6 14
    11       7      -0.126    11 6 14
    12      10      -0.159    6 14
    13      11      -0.262
    14       6      -0.338
    15      14      -0.383
```



Ranking of country means obtained in Alignment (countries located within one rectangle do not differ significantly)

The Alignment optimization

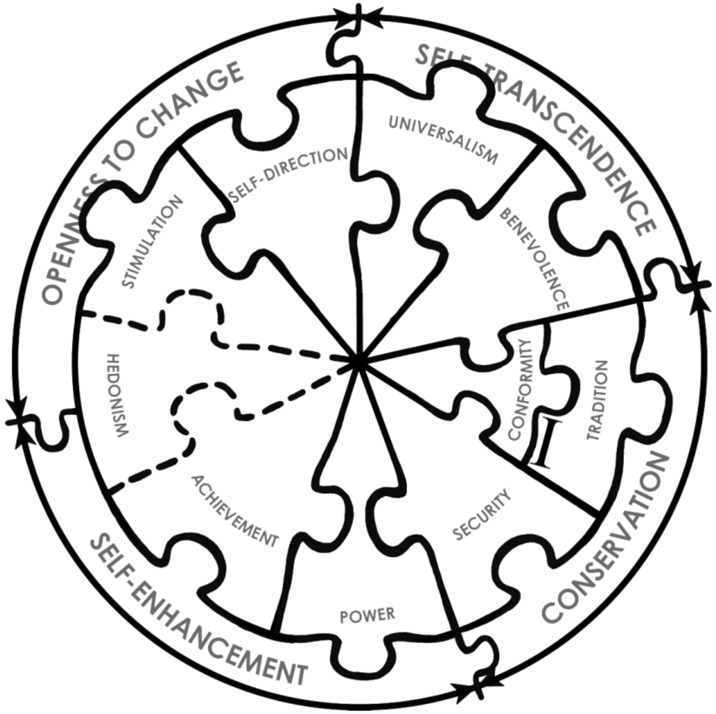
Conclusion

There is a chance and hope

to challenge the bad news

about no possibility of cross-country comparison of values

measured by PVQ-21 in ESS !



Thank you
for your attention!