

HE-06. Around the world in three statistical models.

Determining the level of measurement
invariance across countries of a PRO
instrument

PhUSE 2013 - Brussels

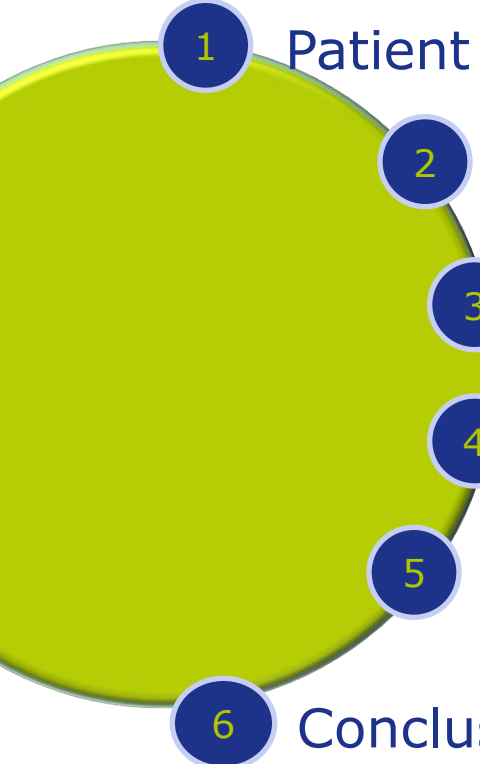
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Topics

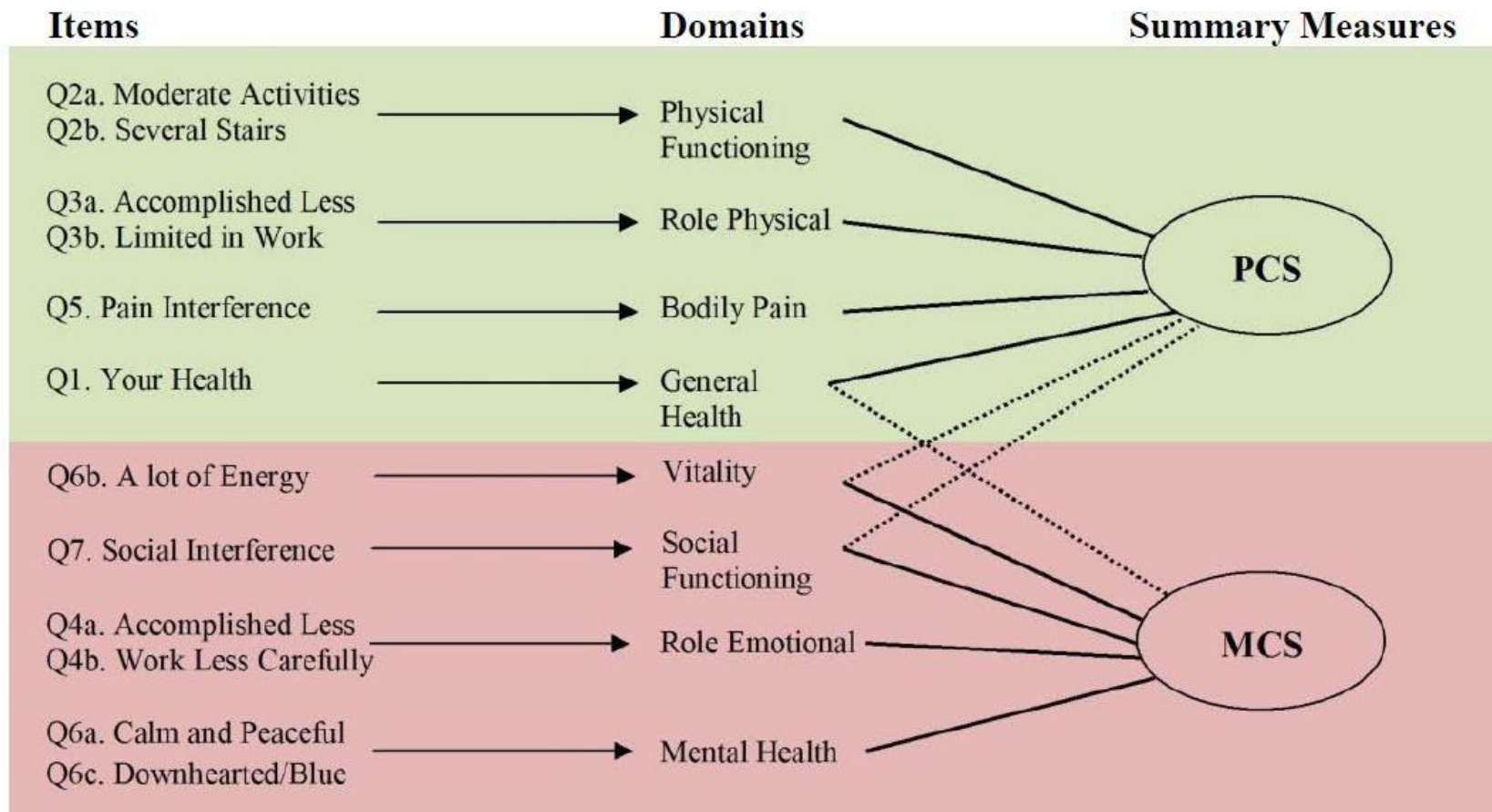
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 - 4 Statistical models to test ME/I
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PRO: measurement & analysis

- Patient Reported Outcomes (PRO)
 - Measurements of (aspects of) a patient's health status which are directly reported by the patient without any interpretation by a physician or anyone else (FDA, 2006)
 - Often relate to abstract (not observable), multi-faceted concepts (e.g. quality of life)
 - Measurement instruments consequently include multiple items (questions) to cover all aspects of the concept

PRO: measurement & analysis

- Example: the VR-12 instrument



PRO: measurement & analysis

- Factor analysis to analyze the data
 - Note: validated instruments should be analyzed according to the guidelines given by the developer of the instrument
- Exploratory Factor Analysis (EFA)
 - Extracts latent factors based on the communalities (correlations) between the variables
 - Intends to explore the data structure (how many factors are there, which items load onto which factor, are there “bad” items, etc.)
 - Sas PROC FACTOR

PRO: measurement & analysis

- Confirmatory Factor Analysis (CFA)
 - Also extracts latent factors based on the communalities (correlations) between the variables
 - But is able to impose a theoretical model on the data, and test “model fit”: how likely is it that the data were generated by this model?
 - The theoretical model specifies number of factors, factor loading structure, absence / presence of factor covariances, residual covariances, etc.
 - Sas PROC CALIS

Using PRO instruments in different countries

- Typically involves translated questionnaires
 - Is the translated questionnaire “equivalent” (comparable) to the original questionnaire: are the measurement properties preserved?
- Raises the question of measurement equivalence / invariance (ME/I)
 - Various statistical approaches:
 - Item Response Theory
 - CFA applied simultaneously within different groups (Multiple Group CFA)

Measurement equivalence/ invariance (ME/I)

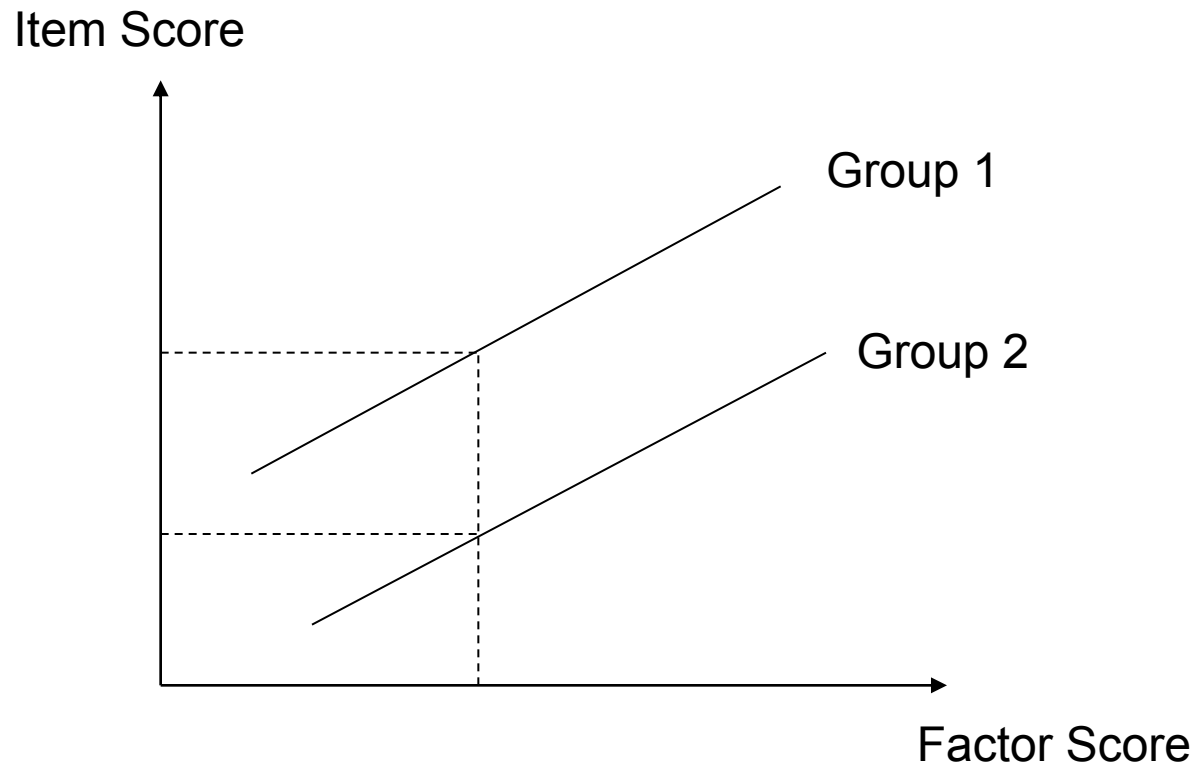
- Three levels of ME/I
 - 1. Configural equivalence
 - Same number of factors in each group? Same factor loading structure?
 - 2. Metric equivalence
 - Is the scale unit equal in each group?
 - 3. Scalar equivalence
 - Is the scale unit and the origin of the scale equal in each group?

Statistical models to test ME/I

- Each level of ME/I corresponds to a specific MGCFA model:
 - Configural equivalence
 - No across-group restrictions other than number of factors and factor loading structure
 - Metric equivalence
 - Set factor loadings equal across groups
 - Scalar equivalence
 - Set factor loadings + item intercepts equal across groups
- Moving to a higher equivalence level corresponds to adding model restrictions (setting more model parameters equal across the groups)
- Leads to statistically nested models
 - Chi-squared difference test to assess tenability of each equivalence hypothesis

Statistical models to test ME/I

- Example: metric equivalence, scalar non-equivalence (uniform DIF)



MGCFA Test: are the intercepts of the items equal across groups?

The Sas macro %measurementInvariance

- Tests the 3 models and produces:
 - Summary tables on global model fit
 - Suggested model modifications based on local model fit
- Relies on R to perform model testing (lavaan + semTools)

The Sas macro %measurementInvariance

- Example: VR-12 instrument English vs. Spanish version
- Using data available online (see paper for details)

```
DATA model;  
  INFILE CARDS;  
  LENGTH ln $ 500;  
  INPUT ln &;  
CARDS;  
pcs =~ q2a + q2b + q3a + q3b + q5 + q1 + q6b + q7  
mcs =~ q1 + q6b + q7 + q4a + q4b + q6a + q6c  
q2a ~~ q2b  
q3a ~~ q3b  
q4a ~~ q4b  
q6a ~~ q6b  
;  
RUN;
```

```
%measurementInvariance(model=model,data=lib.c12a_puf,group=C12SRVLANG,  
mi=TRUE,export_data=TRUE);
```

The Sas macro %measurementInvariance

Measurement Equivalence Testing: Results of three statistical models

Model	Chisq. (df), p	CFI	RMSEA	Incremental fit
M1. Configural Equivalence	127.246 (92), p=0.009	0.989	0.047	N.A.
M2. Metric equivalence	155.351 (105), p=0.001	0.985	0.053	M2 vs M1: p=0.009
M3. Scalar equivalence	244.097 (115), p=0.000	0.960	0.081	M3 vs M2: p=0.000
M4. Equal latent means	268.096 (117), p=0.000	0.954	0.087	M4 vs M3: p=0.000

Suggested model modifications (Modification index value > 10) for the Metric Equivalence model

Model modification	Group number	Modification Index Value	Expected Parameter Change
pcs =~ q5	1	10.033	0.244
pcs =~ q5	2	10.033	-0.244

The Sas macro %measurementInvariance

- Model modification indexes allow to modify the model for better fit
 - Moves away from a strict confirmatory approach, and becomes more exploratory. Avoid over-fitting the model.

```
DATA model;
  INFILE CARDS;
  LENGTH ln $ 500;
  INPUT ln &;
CARDS;
pcs =~ q2a + q2b + q3a + q3b + c(11,12)*q5 + q1 + q6b + q7
mcs =~ q1 + q6b + q7 + q4a + q4b + q6a + q6c
q2a ~~ q2b
q3a ~~ q3b
q4a ~~ q4b
q6a ~~ q6b
;
RUN;

%measurementInvariance(model=model,data=lib.c12a_puf,group=C12SRVLANG,
mi=TRUE);
```

The Sas macro %measurementInvariance

Measurement Equivalence Testing: Results of three statistical models

Model	Chisq. (df), p	CFI	RMSEA	Incremental fit
M1. Configural Equivalence	127.246 (92), p=0.009	0.989	0.047	N.A.
M2. Metric equivalence	144.854 (104), p=0.005	0.987	0.048	M2 vs M1: p=0.128
M3. Scalar equivalence	232.792 (114), p=0.000	0.964	0.078	M3 vs M2: p=0.000
M4. Equal latent means	257.551 (116), p=0.000	0.957	0.084	M4 vs M3: p=0.000

Suggested model modifications (Modification index value > 10) for the Scalar Equivalence model

Model modification	Group number	Modification Index Value	Expected Parameter Change
q6b ~1	1	22.436	0.21
q6b ~1	2	22.436	-0.21
q6a ~1	1	11.246	0.153
q6a ~1	2	11.246	-0.153

Conclusions

- Multiple Group CFA provides a series of tests to determine the level of measurement equivalence of an instrument
- Sas macro %measurementInvariance
 - Quickly and automatically test the level of ME/I
 - But preserves the flexibility to check which parts of the model don't fit well, and to modify the model accordingly
- This should be a useful tool for researchers who develop or validate PRO instruments that are translated for use in other countries, or that are modified in other ways (e.g. from paper to electronic questionnaires)

Future developments

- Add possibility of testing equality of residual variances
- Show fitted model parameters (factor loadings, intercepts, etc.)
- Allow use of ordinal variables
- Power analysis using Monte Carlo studies (in a separate macro)

Any questions

- Comments and suggestions are welcomed at dirk.heerwegh@businessdecision.com
- Sas Macro %measurementInvariance available from that same e-mail address
- Thanks!
- Any questions?