“In describing a dataset through a selected model, and fitting a set of data into a confirmatory model, three related issues need scrutiny. They include the measurement, distributional and structural properties of data obtained in applied educational, epidemiological and psychosocial research.”

- Rowe, 2005
An Introduction - The Structures within Structural Equation Modeling (SEM)
Sivakumar Alagumalai, School of Education, UofA

Testing trust dimensionality in relationship performance of firms
Dr Christopher J. Medlin, Adelaide Business School, UofA

Applying a single level path analysis to examine factors that could impact South Australian students’ learning and attitudes towards Physics
Dr Francisco Ben, Tabor Adelaide
What is NEEDED:

**Approximations to the real world**

- No clear differentiation between IV and DV
- Relationship of Xs to each other needs scrutiny
- Not all Xs affect Y directly
- Multilevel effects (direct, indirect, interactions, ...)
- Error needs careful examination and articulation
Structural Equation Models

Combine three concepts

Latent variables
  • Pearson (1904), psychometrics
  • Factor analysis model

Path analysis
  • Wright (1934), biometrics
  • Technique to analyze systems of relations

Simultaneous regression models
  • Econometrics
  • Epidemiology
Also known as:

- Covariance structure models
- Latent variable models
- “LISREL” models
- Structural Equations with Latent Variables
What can you do with SEM?

• Latent and Observed Variables
• Multiple indicators of same concept
• Measurement error
• Restrictions on model parameters
• Test complex RQs
  • Direct and Indirect effects
  • Interactions (incl. enhancer/suppressor effects)
  • Reciprocal relations
• Tests of model fit (flexibility)
SEM is a combination of

**Measurement model** (part of the model that relates the latent variables to the observed variables; factor analytic part)

**Path analysis** [Structure/Distribution] (Regression between variables; Only path model exists between the measured variables)
Great scrutiny needed to account for the measurement, distributional and structural properties of obtained data.

Run the risk of generating biased and misleading estimates and inferences.
The unfriendly BUT IMPORTANT bits!!!

Notations, Equations and Mathematics …
Putting all together:

Trust in Individuals

people are helpful (x1)

people can be trusted (x2)

people are Fair (x3)

\[ \begin{align*}
\lambda_1 \xi + \delta_1 \\
1 \xi_1 + \delta_1 \\
2 \xi_2 + \delta_2 \\
\frac{3}{1} \xi_3 + \delta_3 \\
\end{align*} \]

\[ \begin{bmatrix}
VAR(\xi_1) \\
VAR(\delta_2) \\
0 \\
VAR(\delta_3)
\end{bmatrix} \]

The Factorial Invariance Study: 1999

[Special Invitation Address at the Harvard University “Brain and Learning Conference”, 10-13 Nov 2004, Cambridge, MA. Boston.]
Physics problem solving

• Ability to recall facts / concepts / formulae
• Translation skills (problem statement)
• One-step problem solving process
• Two-step problem solving processes
• Related problem solving process (metacognition etc..)
Related processes and skills of the problem solving dimension

Non-interactive skills

Interactive skills (correlated)
One-factor model

Two-factor model

Three-factor model

Four-factor model
Two-factor hierarchical model

Four-factor hierarchical model
Two-factor nested model

Four-factor nested model
Multiple Indicators and Multiple Causes (MIMIC) model

Cause-Effect (CE) model
<table>
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<tr>
<th>Model</th>
<th>1F</th>
<th>2F</th>
<th>3F</th>
<th>4F</th>
<th>2FH</th>
<th>4FH</th>
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Note: $N = 655$
1F - One-factor Model
2F - Two-factor Model
3F - Three-factor Model
4F - Four-factor model
2FH - Two-factor-hierarchical Model
4FH - Four-factor-hierarchical Model
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<tr>
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</tbody>
</table>

Note: N = 655
2FN - Two-factor Nested Model  
3FN - Three-factor Nested Model  
4FN - Four-factor Nested Model  
MI - MIMIC Model  
CE - Cause-Effect Model
When it fits!
Testing Structural Invariance of the Achievement Goal Questionnaire in American, Chinese, and Dutch College Students

Huaping Sun¹ and Diley Hernandez²

Abstract
This study investigates the structural invariance of the Achievement Goal Questionnaire (AGQ) in American, Chinese, and Dutch college students. Using confirmatory factor analyses (CFA), the authors found evidence for the four-factor structure of achievement goals in all three samples. Subsequent multigroup CFAs supported structural invariance of the AGQ across the samples.

The Brazilian TCBQ responses fit closely to the original TCBQ five-factor structure.

**Figure.** Structural equation model of the effects of covariates on the factors measured by the TCBQ. Note. Only the estimates that were statistically significant are shown. * p < .05, *** p < .001. The values shown are the statistically significant effects of covariates.
When it fits sometimes!
Past studies attempted to test this dimensional taxonomy or structure, using exploratory factor analysis (EFA) and confirmatory factor analysis (CFA), yielding diverse results.

- de Groot et al., found a six-factor dimensional structure similar to that of the U.S. model
- Lemos et al., found an eight-syndrome dimensional structure
- Lambert et al., found that the data did not fit well with the U.S. model
- O’Keene et al., found a seven-factor structure
HOMICIDE, STRUCTURAL FACTORS, AND THE RACIAL INVARIANCE ASSUMPTION*  

GRAHAM C. OUSEY

A primary implication is that the current versions of many structural theories need revision in order to account for observed race differences in the effects of structural factors and to explain fully the gaps.
Since its construction and subsequent validation for English speaking adults, the DERS has been translated into several languages and applied to community samples and psychiatric patients. Although the DERS has shown good psychometric properties when measuring both adults’ and adolescents’ ER difficulties, some doubts remain about its internal structure.

However, Marín et al. (2012) failed to replicate the original six-factor structure in Mexican adolescents using both CFA and principal component analysis (PCA) and instead proposed a shorter four-factor model, in which the Impulse and Strategies items were either integrated into the remaining dimensions or removed.

1. Item analysis and reliability
Classic item analysis was carried out. The aim of this analysis was to evaluate how the measures of each of the abilities are assigned to each intelligence scale, using the correlation between each ability measure and each intelligence scale (Nunnally, 1978). This correlation is used to determine whether an item – ability – belongs to the intelligence scale it has been assigned to, to a different one, or whether it should be eliminated in subsequent analyses.

2. Comparison of models: confirmatory factor analysis
The next step in the data analysis involved establishing different structural models, which corresponded to the four theoretical models.

More experimental, construct validity and predictive studies are needed to establish the true usefulness of the theory of multiple intelligences.
Results suggest an absence of structural invariance in Gardner’s tasks. Exploratory analyses suggest a three-factor structure for individuals with higher performance levels and a two-factor structure for individuals with lower performance levels.
Multigroup CFA results concerning metric and scalar invariance suggested partial strict invariance for the SF-36, but only weak invariance for the KDCS. Structural invariance was not supported.

A number of studies have investigated the PWB Scales factor structure in diverse populations. The results of these studies have been controversial, suggesting the existence of a variety of alternative models, different for structures (linear and hierarchical) and item loadings.

In this invariance model the same factor structure (i.e. the same pattern of fixed and free factor loadings) was specified for each group, and no equality constraints were imposed on model parameters across samples.

Although the obtained results provided a preliminary support for cross-cultural structural invariance of the PWB Scales (a self-report measure), further investigations are required to ensure its generalizability and applicability.
Implications for factor/scale – scores and thus inference & reporting.
This study reports on the evaluation of the Assessment Literacy Inventory utility using 582 in-service teachers through employing the Rasch model and confirmatory factor analysis. The results indicate that the Assessment Literacy Inventory works well at the item level. However, the Assessment Literacy Inventory seven-factor structure, based on the Standards for Teacher Competence in Educational Assessment of Students, poses challenges against newer psychometric techniques.
Researchers are now recognizing the importance of establishing measurement invariance prior to testing or exploring substantively interesting hypotheses about group differences.

structural model (i.e., invariance of factor variances and covariances and factor means)

Researchers have recognized the relationship between CFA-based tests of measurement invariance and differential item functioning defined by item response theory.

Although CFA treats the relationship between an underlying construct and item responses as a linear function and item response theory (IRT) analyses assume a logistic function, item loadings and intercepts in CFA provide similar information as do the item discrimination and item location parameters in IRT. There is no parameter in IRT analogous to the uniqueness provided in CFA, but the standard error functions associated with trait level provide similar information.

Another difference between IRT and CFA approaches is the fact that in IRT, discrimination and location parameters are estimated and tested for group differences simultaneously, although CFA approaches usually involve the test of metric and scalar invariance in separate analytic steps.
An issue which seems to be ignored by most of the literature on measurement equivalence is the degree to which lack of measurement equivalence across groups translates into diminished reliability and validity in groups.

Great scrutiny needed to account for the measurement, distributional and structural properties of obtained data.

Run the risk of generating biased and misleading estimates and inferences.

Rowe, K. (2005). p. 16
Software and Codes:

AMOS (SPSS)
EQS
MPLUS
LISREL
R / R+
Essentially, all models are wrong, but some are useful.

(George E. P. Box)
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Applying a single level path analysis to examine factors that could impact South Australian students’ learning and attitudes towards Physics
Dr Francisco Ben, Tabor Adelaide
Workshop - 2.5 hours

RASCH Measurement Models: Does your questionnaire/test measure up?

Date/Time: Thursday, 21 July 2016 - 9.30am-12.00pm
Venue: Kevin Marjoribanks SMaRTE Classroom (Level 8, Nexus Building)

As places are limited (25 seats), please register at http://education.adelaide.edu.au/research/seminars/
## 2016 Special Seminar Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Time</th>
<th>Presenters &amp; Abstract</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 April 2016</td>
<td>12.00pm-1.00pm</td>
<td>Register Nearly' Best Test/ Questionnaire Design: Considerations and Current Innovations</td>
</tr>
<tr>
<td>20 May 2016</td>
<td>12.00pm-1.00pm</td>
<td>Register Path &amp; Structural Equation Models</td>
</tr>
<tr>
<td>23 Sept 2016</td>
<td>11.00am-12.00pm</td>
<td>Register Multilevel Models</td>
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<tr>
<td>25 Nov 2016</td>
<td>11.00am-12.00pm</td>
<td>Register Advanced Quantitative Models</td>
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### Workshops 2.5 hours

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<tr>
<td>21 July 2016</td>
<td>9.30am-12.00pm</td>
<td>Register RASCH Measurement Models</td>
</tr>
<tr>
<td>6 Oct 2016</td>
<td>10.00am-12.30pm</td>
<td>Register Path models &amp; SEM</td>
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TMERG:
Transdisciplinary Measurement and Evaluation Research Group

FEATURED ITEM

FEATURED COLLECTION
Welcome to TMERG Seminar #1: 5 Nov 2015
An important element of research is questionnaire/test design. Examination of underlying constructs of the questionnaire/test, and its validation are...

RECENTLY ADDED ITEMS

TMERG_Seminar1_5_Nov2015_ChristopherSchapel

TMERG_Seminar1_4_Nov2015_PatrickKorbel

View All Items

http://omeka.ersa.edu.au/tmerg/
Transdisciplinary Measurement and Evaluation Research Group

Thank You