Psychology 454: Psychological Measurement
An introduction to latent variable modeling

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1 Outline (to be added to frequently – keep checking)

September 26: Updated the path analysis slides for week 2 to include the Rohrer (2018) paper and figures. Correction to the psuedo inverse of a matrix in linear algebra slides

September 28: Updated the slides for Week 2

October 3: Added a link to the Roher (2018) paper. Added a link and the Wysocki et al. (2022) paper. Fixed the link to the general factor of personality slides. Added slides discussing a recent blog post on hierarchical structure.

October 5: Added links to the LISREL data examples and to a nice set of web pages by David Kenny discussing SEM models

Added the First slides on sem which introduce sem as a way of solving simple and complex medation problems.

October 9: Finally added homework 3

October 17:Updated the slides on for the week. In particular, updated the items slides. Added the (Widaman and Revelle, 2022) article discussing how to analyze complex data using simple models..

October 19" Added the goodness of fit slides and updated the change and more change slides.

October 21: Corrected some bad links.

October 24: Added the factor invariance link

October 26: Added the advanced modeling link

October 31: Improved theIssues in inference and the latent class analysis slides.

November 2: Added slides from Yves Rosseell on longitudinal sem and categorical sem

Week	Topic	Reading	Lecture Notes	Homework
1	Review Correlation and Regression Reliability	Loehlin Chapter 1 Linear Algebra	Correlation and Regression linear algebra Introduction to R Introduction to R – appendix inverse of a matrix.	Problem set 1 Exercises from Loehlin 1-12 (page 32-34)
2	Basic Model fitting	Loehlin Chapter 2 Directed Acyclic Graphs (Rohrer, 2018)	Path models Week 2 slides n Model fitting Using R	Problem set 2
3	Simple models	Loehlin Chapter 3 statistical control Wysocki et al. (2022)	OLS/WLS/MLE EFA and hierarchical structure. why latents sem and mediation A general factor of personality?	problem set 3 homework 3
4	Exploratory FA	Loehlin Chapter 5 Hierarchical factor models	review of factor analysis factoring real data	Problem set 4
5	EFA (continued)	Loehlin Chapter 6 (Widaman and Revelle, 2022)	factoring real data continued items vs continuous measures goodness of fit change more change	Problem set 5
6	CFA Multiple Groups	Loehlin Chapter 4 testing invariances one good and one bad example of modeling complex structures MIMIC models	measurement invariance analysis and critique How to define a model Advanced modeling with Lavaan types of variables, types of models	Problem set 6
7	Goodness of Fit Evaluating Alternatives	Loehlin Chapter 7	Advanced modeling with Lavaan	Problem set 7
8		Loehlin Chapter	Issues in inference latent class analysis	Problem set 8
9	longitudinal Categorical	From Yves Rosseel	longitudinal sem categorical sem	

2 Detailed Notes

2.1 Week 1

Introduction to latent variables (405 in a week).

Review of Correlation, regression, and classical reliability theory. See also Chapter 4 on Correlation and regression as well as Chapter 5 on multiple correlation and regression.

Review of matrix algebra (Appendix A)

2.2 Week 2

Application of linear algebra to pattern and structure. Exploratory factor analysis as a basic latent variable model. Structural equations as linear algebra or as path diagrams. Directed Acyclic Graphs (DAGs) as a tool for theory construction (Rohrer, 2018). The basic logic of DAGs is to show conceptual relationships. SEMS apply linear models to these conceptual relationships.

Finding the inverse of a matrix.

2.3 Week 3

Structural models and goodness of fit tests. Barrett (2007), Examples with simulated data.

How to simulate structural data. This has been revised with a correction for two factor simulations and with a more extensive analysis of the effects of sample size on estimating parameters in the two factor

model.

Using basic sem programs to find structure and apply goodness of fit tests. Using the *sem* (Fox et al., 2013) and *lavaan* (Rosseel, 2012) packages.

Some useful data set examples from the Lisrel manual

A very nice wet of web pages discussing sem and atent variable analysis by David Kenny

2.4 Week 4

Analysis of hierarchical factor models using hierarchical and bifactor solutions. The lecture notes for week 4 are here and prior notes are prior year notes

2.5 Week 5

Exploratory and confirmatory factor analysis, continued. The lecture notes for week 5 are here.

Considering issues of using items rather than continuous measures. items vs continuous measures. Unfortunately, items have serious problems with skew.

One of the most powerful applications of sem is the analysis of change.

2.6 Week 6

Comparing three examples from the literature: a short example (Erdle et al., 2009) of how not to report factor analysis, a sem paper which which actually fails to identify the model correctly (Erdle et al., 2010) and another (Marsh et al., 2010) which systematically compares models. This last one includes a good discussion of how to do measurement invariance.

2.7 Weeks 7-9

lavaan uses many examples from the MPlus manual (`http://www.statmodel.com/ugexcerpts.shtml`. See in particular the example data sets at `http://www.statmodel.com/usersguide/chapter5.shtml`. The notes describing *lavaan* output for these examples are available here.

Comparing sem in R and LISREL (Jöreskog and Sörbom, 1999). Consideration of goodness of fit tests (Barratt et al., 2007) (Click on Issue 5 in the left had column). R and LISREL lecture notes

Commercial software for structural equation modeling: EQS Bentler (1995), LISREL (Jöreskog and Sörbom, 1999) MPlus (Muthén and Muthén, 2007).

2.8 R advice

The R tutorial gives a short introduction to the use of R.

- (Macs and PCs) For this, or any other package to work, you must activate it by either using the Package Manager or the "library" command:
  - type library(psych)
  - `sessionInfo` to make sure you have the most recent version of psych.
  - `install.packages("psych", repos="https://personality-project.org/r", type="source")` to get the latest version .
  - If loading the psych package works, function such as `describe` and `pairs.panels` should work (or at least give an error message that is NOT "could not find function").
  - entering ?psych will give a list of the functions available in the psych package.

References

Barrett, P. (2007). Structural equation modelling: Adjudging model fit. *Personality and Individual Differences*, 42(5):815–824.

Bentler, P. M. (1995). *EQS structural equations program manual*. Multivariate Software, Inc., Encino, CA.

Erdle, S., Gosling, S. D., and Potter, J. (2009). Does self-esteem account for the higher-order factors of the big five? *Journal of Research in Personality*, 43(5):921 – 922.

Erdle, S., Irwing, P., Rushton, J. P., and Park, J. (2010). The general factor of personality and its relation to self-esteem in 628,640 internet respondents. *Personality and Individual Differences*, 48(3):343–346.

Fox, J., Nie, Z., and Byrnes, J. (2013). *sem: Structural Equation Models*. R package version 3.1-3.

Jöreskog, K. G. and Sörbom, D. (1999). *LISREL 8: Structural equation modeling with the SIMPLIS command language*. Scientific Software International, Lincolnwood.

Marsh, H. W., Scalas, L. F., and Nagengast, B. (2010). Longitudinal tests of competing factor structures for the rosenberg self-esteem scale: Traits, ephemeral artifacts, and stable response styles. *Psychological Assessment*, 22(2):366 – 381.

Muthén, L. and Muthén, B. (2007). *Mplus User's Guide*. Muthén & Muthén, Los Angeles, CA, fifth edition edition.

Rohrer, J. M. (2018). Thinking clearly about correlations and causation: Graphical causal models for observational data. *Advances in Methods and Practices in Psychological Science*, 1(1):27–42.

Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, 48(2):1–36.

Widaman, K. F. and Revelle, W. (2022). Thinking thrice about sum scores, and then some more about measurement and analysis. *Behavior Research Methods*.

Wysocki, A. C., Lawson, K. M., and Rhemtulla, M. (2022). Statistical control requires causal justification. *Advances in Methods and Practices in Psychological Science*, 5(2):25152459221095823.