

Psychology 454: Psychological Measurement

An introduction to latent variable modeling

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September 25, 2024

1 Objectives

To understand the fundamental concepts in latent variable modeling in order to make you a better consumer and producer of latent variable models in your research.

To understand how to evaluate the quality of models when applied to data by understanding various sources of variability of goodness of fit tests.

To learn how to apply these concepts to real data sets using a variety of standard statistical packages (e.g., R, Mx, MPlus)

2 Text, readings, and requirements

2.1 Text

Loehlin, J. C. and Alexander Beaujean Latent Variable Models (5th ed). Routledge. 2017

Revelle, W. (in preparation) An introduction to psychometric theory with applications in R. Springer. Draft chapters available at <https://personality-project.org/r/book>.

Revelle, W. (in preparation) Adventures in Latent Variable Modeling using R. Draft chapters available at <https://personality-project.org/r/book>.

2.2 Readings

Multiple web based readings including, but not limited to the ones listed in the references. This list will be added to throughout the quarter.

Syllabus and handouts available at <https://personality-project.org/courses/454/454.syllabus.pdf>

2.3 Requirements

Some basic knowledge of psychometric theory (to be reviewed in week 1). This course is a natural sequel to [Psychology 405: Psychometric Theory](#). Some of the web readings will be taken from the 405 syllabus.

Familiarity with matrix algebra (to be reviewed in week 1)

Willingness to use computer packages that allow for structural equation modeling. These can either be downloaded to your computer (e.g, the open source packages R, and Mx) or run if you have a license to the proprietary program MPlus. Willingness to ask questions and add to the class discussion.

2.4 Evaluation

Homework assignments will be given weekly. These are your benefit and will be graded on a completed, not completed basis.

Students will be expected to write a short paper demonstrating the use of structural equation techniques applied to their particular research interests. They will also be asked to present their use of latent variable models in short (15-30 minute) presentations in the last few weeks of the course.

This is a hands on course. You will be expected to try the various programs on simulated and real data sets.

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

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, 2023)	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
8b	longitudinal Categorical Multilevel analysis	From Yves Rosseel Multilevel tutorial (Revelle and Wilt, 2019)	longitudinal sem categorical sem multilevel.pdf	
9	Critiques of SEM Other latent models	Freedman Freedman (1987) Cliff (Cliff, 1983) Loehlin, Chapter 7 IRT as categorical response model	Critiques and warnings Item Response Theory	
10	Summary of Latent Variable models		Review of SEM	

4 Detailed Notes

4.1 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](#))

4.2 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](#).

4.3 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 [latent variable](#) analysis by David Kenny

4.4 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](#)

4.5 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](#).

4.6 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.

4.7 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).

4.8 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

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