

# Psychology 454: Psychological Measurement

## An introduction to latent variable modeling

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## 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 and the need to *compare* models rather than merely accepting or rejecting them.

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

## 2 Text, readings, and requirements

### 2.1 Text

Loehlin, J. C. Latent Variable Models (4th ed). Lawrence Erlbaum Associates, Mahwah, N.J. 2004 (suggested)

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

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

### 2.2 Readings

Multiple web based readings including, but not limited to those found on the web based syllabus: available at <http://personality-project.org/revelle/syllabi/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, which includes three latent variable packages, *lavaan*, *sem*, and *OpenMx*), run on the Social Science Computer Cluster (e.g., Lisrel or Prelis), or ones for which you have a license (e.g., EQS). The examples will be primarily from *psych* (Revelle, 2010), *lavaan* (Rosseel, 2010) and *sem* (Fox, 2009).

Willingness to ask questions and add to the class discussion.

## 2.4 Evaluation

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

Students will be expected to write a short paper  $\approx 10-12$  pages demonstrating the use of structural equation techniques applied to their particular research interests.

## 3 Outline (to be added to frequently - keep checking)

<sup>1</sup>

Week	Topic	Reading	Lecture Notes	Homework
1	Review Correlation/Regression Reliability Matrix Algebra	Loehlin Chapter 1	Correlation and Regression Matrix Algebra Introduction to R Using the SSCC inverse of a matrix. factor analysis.	Problem set 1 Exercises from Loehlin 1-12 (page 32-34)
2	Basic Model fitting lecture notes	Loehlin Chapter 2	Path models Model fitting Using R	Problem set 2 from web
3	Simple models Simulating structural data. (lecture notes)	Loehlin Chapter 3	OLS/WLS/MLE Simulating structural data	Problem set 3
4	Exploratory FA psych for sem	Loehlin Chapter 5 Hierarchical factor models	EFA/CFA lecture notes	Problem set 4
5	EFA (continued) Exploring real data (today's notes)	Loehlin Chapter 6	EFA/CFA continued examining items	Problem set 5
6	CFA Change Examining change(notes) More LISREL (notes)	Loehlin Chapter 4 R and LISREL	R and LISREL	Problem set 6
7		Loehlin Chapter Scale and Item quality	Problems with Items Types of structures Item characteristics more on skew	Problem set 7
8	Goodness of Fit Evaluating Alternatives	Loehlin Chapter 7 Comparing models	lecture notes. more latent models lavaan	Problem set 8
9	Goodness of Fit Evaluating Alternatives	Loehlin Chapter 7 general factor of personality? Steps of analysis	errors in modeling. real data.	Problem set 9

<sup>1</sup>Last modified February 22, 2011

## 4 Detailed Notes

### 4.1 Week 1

Introduction to latent variables

Review of correlation, regression, and classical reliability theory

Review of matrix algebra ([Appendix 1](#)) See also John Fox's [review of matrices](#).

### 4.2 Week 2

Application of matrix algebra to pattern and structure Finding the [inverse of a matrix](#).

### 4.3 Week 3

No class on Monday (MLK day)

Structural models and goodness of fit tests. 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.

### 4.4 Week 4

No class on Wednesday, January 26th (SPSP conference)

[Analysis of hierarchical factor models](#) using hierarchical and bifactor solutions. The lecture notes for week 4 are [here](#).

### 4.5 Week 5

Exploratory and confirmatory factor analysis, continued. [Lecture notes for week 5](#).

### 4.6 Week 6

Comparing sem in [R and LISREL](#). Consideration of goodness of fit tests ([Barrett et al., 2007](#)) ([Barrett, 2007](#)) (Click on Issue 5 in the left hand column). [R and LISREL lecture notes](#).

### 4.7 Week 7

Most personality and affective measures are made up of items rather than scales. Thus, we need to examine the problem of [scale and item quality](#). [Item characteristics lecture notes](#).

### 4.8 Week 8

What happens if we misspecify a model? What happens if we do not include the right variables or do not include the right paths. [Comparing models](#). [Comparing models lecture notes](#).

## 4.9 Week 9

What do the various goodness of fit statistics measuring. (The notes and readings are the same as last week, but have been updated) [Comparing models](#). [Comparing models lecture notes](#).

## 4.10 Week 10

No class on Monday, March 7th. Final Review

# 5 Computer advice; particularly for R

The [R tutorial](#) gives a short introduction to the use of R.

1. Install R on your computer.
  - (a) With your browser, go to CRAN <http://cran.r-project.org/>
  - (b) Choose the appropriate operating system (PC, Mac, Linux)
  - (c) Follow the instructions to download the most recent version (2.12.1) as a “universal binary” file (Mac) or “base” files for Windows.
2. From CRAN (for Macs or PCs)
  - From the Packages and Data menu (Mac) Packages menu (PCs) select: “Package Installer”
  - Location is a CRAN binary file
  - Get list (the query box can be set to psych)
  - Choose psych
  - Install selected
3. Download other suggested packages using the “Psychometrics” task view
  - `install.packages("ctv")`
  - `library("ctv")`
  - `install.views("Psychometrics")`
  - wait for a few minutes!
4. Alternatively, install a few key packages
  - `mvtnorm` (used in psych for polychoric, tetrachoric correlations)
  - `GPArotation` (used in psych for factor analysis rotations)
  - `sem` (We will use this for sem analysis)
  - `lavaan` (We will also use this one)
5. (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:
  - e.g., `library(psych)` or `library(sem)`
  - 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 as well as an overview of their functionality.
- `objects("package:psych")` will list the functions available in a package (in this case, `psych`).

## 5.1 Using the Social Science Computer Cluster

1. Get an **account** and then to log in as a remote user.
2. Log on to the system using SSH (see the “**how to**” for doing this)
3. upload the appropriate batch command file using a **sftp connection**.
4. Issue a batch command (e.g., `lisrel8 infile outfile`)
5. sftp the outfile back to your desktop
6. repeat (3-5) until satisfied

## 5.2 Student versions of LISREL

If you don't want to use the SSCC, you can download a **student version** of LISREL from Scientific Software for either a PC or a (non intel) Mac.

## 5.3 R for SPSS/SAS users

A very thorough document designed to help users of SPSS or SAS understand the joys of R is available from Bob Muenchen ([Muenchen, 2009](#)) at the University of Tennessee [R for SAS and SPSS – pdf version](#) or [R for SAS and SPSS – html version](#)

# 6 References

## References

- Barrett, P. (2007). Structural equation modelling: Adjudging model fit. *Personality and Individual Differences*, 42(5):815–824.
- Fox, J. (2009). *sem: Structural Equation Models*. R package version 0.9-15.
- Muenchen, R. A. (2009). *R for SAS and SPSS Users*. Springer.
- Revelle, W. (2010). *psych: Procedures for Personality and Psychological Research*. Northwestern University, Evanston, 1.0-92 edition. R package version 1.0-92.
- Rosseel, Y. (2010). *lavaan: Latent Variable Analysis*. R package version 0.4-3.
- Bollen, K.A. (2002) Latent variables in psychology and the social sciences. Annual Review of Psychology.**
- Barratt, P. (2007) Structural equation modeling: Adjudging model fit. *Personality and Individual Differences*, 815-824. (Available for NU accounts at <http://www.sciencedirect.com/science/journal/01918869>)
- Loehlin, J. C. (2004) *Latent Variable Models* (4th ed). Lawrence Erlbaum Associates, Mahwah, N.J.
- Rakov, T. & Marcoulides, G.A. (2006), *A first course in structural equation modeling*, 2nd Edition; Mahwah, N.J.; Erlbaum