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 variabilty 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, EQS, Lisrel, Prelis, Amos, MPlus)

2 Text, readings, and requirements

2.1 Text

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

Revelle, W. (in preparation) An introduction to psychometric theory with applications in R. Springer. 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 the ones listed in the references. This list will be added to throughout the quarter.

Syllabus and handouts 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 linear (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), run on the Social Science Computer Cluster (e.g., MPlus), or ones that you have a license for (e.g., EQS?)

Willingness to ask questions and add to the class discussion.

As might be expected, most of my examples and lectures will make use of the powerful statistical system, R (R Core Team, 2016). This is because the open source nature of R allows us to see (if we want) how the calculations are actually done, and to add new features to existing packages. We will use two packages a great deal. The R packages *psych* (Revelle, 2016) and *lavaan* (Rosseel, 2012).

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/Regression Reliability	Loehlin Chaper 1 Correlation/Regression Reliability Linear Algebra	 Correlation and Regression Introduction to R Introduction to R – appendix Linear Algebra inverse of a matrix. Using the SSCC	Problem set 1 Exercises from Loehlin 1-12 (page 32-34)
2	Basic Model fitting	Loehlin Chaper 2	Path models Week 2 slides Model fitting – regression vs. latent variables regression/mediation/latent Using R	Problem set 2
3	Simple models	Loehlin Chapter 3	OLS/WLS/MLE Even more on regression Simulating structural data. A general factor of personality?	Problem set 3
4	Exploratory FA	Loehlin Chapter 5 Hierarchical factor models	EFA/CFA – psych, sem and lavaan	Problem set 4
5	EFA (continued)	Loehlin Chapter 6 Goodness of fit	EFA/CFA continued items vs continuous measures Item Response Models more on skew change and more on change	Problem set 5
6	CFA Multiple Groups	Loehlin Chapter 4 one good and one bad example of modeling complex structures R and LISREL models R and lavaan models	SEM = regression + reliability How to define a model analysis and critique R and LISREL models types of variables, types of models	Problem set 6
7	Goodness of Fit Evaluating Alternatives	Loehlin Chapter 7 More on change latent change Ghisletta and McArdle, 2014	Advanced modeling with Lavaan	Problem set 7
8		Loehlin Chapter		Problem set 8
10			Review of SEM	

4 Detailed Notes

4.1 Week 1

Introduction to latent variables (405 in a week).

Review of Correlation and 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 linear/matrix algebra (Appendix E)

4.2 Week 2

Application of matrix algebra to pattern and structure. Chapter 6: Exploratory factor analysis as a basic latent variable model. Finding the inverse of a matrix. For a review of factor analysis, see `http://personality-project.org/revelle/syllabi/405/405-efa.pdf`.

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.

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)
  - 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.

4.9 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

References

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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.

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Loehlin, J. C. (2004). *Latent variable models: an introduction to factor, path, and structural equation analysis*. L. Erlbaum Associates, Mahwah, N.J., 4th edition.

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.

R Core Team (2016). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

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Revelle, W. (2016). *psych: Procedures for Personality and Psychological Research*. Northwestern University, Evanston, http://cran.r-project.org/web/packages/psych/. R package version 1.6.9.

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