

Psychology 405: Psychometric Theory

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

This is the abbreviated form of the syllabus, The full syllabus is at <https://personality-project.org/courses/405/405.syllabus.pdf>

Current version of June 2, 2025

1.1 News of changes

April 9: Specified the date of the midterm to be April 28th

April 14 Updated the correlation/regression slides to discuss the effect of sequential ordering of predictors.
Updated the linear Algebra slides to change `setCor` to `lmCor`.

April 15: Updated the [factor analysis](#) slides

April 21: Updated the [factor analysis](#) slides again. Updated the Rpkgpsych package to 2.4.5 `packageDate(psych)` of 2025-04-20

April 30: Updated the [Reliability Theory](#) slides.

May 5: Even more updates to the [Reliability Theory](#) slides.

May 7: Updated the [IRT](#) slides

May 12: Serious updates to the [validity](#) slides.

May 14: Serious updates to the [scale construction](#) slides.

May 18: We will continue the discussion of [scale construction](#) and review the logic of Synthetic Aperture Personality Assessment (SAPA) as presented in talk to Kellogg in 2020 [Validity of SAPA methods](#) .

May 19: Added a recent chapter with Kayla Garner on [scale construction](#) .

May 20: Added notes on [personality taxonomies](#)

May 28: Updated the notes on [introduction to sem](#) Updated the notes on [comparing efa to cfa to sem](#) Finally, updated [more ways of measuring](#)

June 2: Updated the review notes: [course review](#); Added the [Hofmann et al. \(2025\)](#) article to the supplementary readings.

1.2 Assignments as a table

Week	Topic	Lecture Notes	Readings	Homework/ R help
1 a	Correlational and Experimental Psychology	Overview	Chapter 1: the role of measurement	Getting started with R
1b		Theory of Data	Chapter 2: Theory of Data	Appendix A: Using R
2 a	Models of Measurement	Metric properties and the problems of scale	Chapter 3: The problems of scale	Homework #1 with answers
2b		Correlation and Regression (Part 1)	Chapter 4: Correlation	Using R for statistics and an even shorter guide to R
			Francis Galton & Charles Spearman	Simple Regression problems #2
				More problems
3a	Variance and Covariance	Correlation and Regression (Part2)	Review of linear/matrix algebra (Appendix E)	
3b		Linear algebra More on correlations and regression	Multiple Correlations (Chapter 5)	Applications of correlations
4a	Latent variable models	Factor Analysis	Constructs, Components, and Factors (Chapter 6)	Problem set 3
5 a		Even more fa	latent variables = Easter Bunnies?	Factor Analysis (How To)
				Homework set 4
5 a	Midterm Reliability	Reliability Theory	Reliability (Chapter 7) α to ω Supplement to α to ω	sample questions
5b				Omega Analysis (How To)
				Homework set 5
				Problems
6 a	Item Response Theory	Item Response Theory	Item Response Theory (Chapter 8)	Factor approaches to IRT see section 7
6 b	Validity	Validity Validity of SAPA methods Validity- another look	Predicting the Persome That takes the BISCUIT fishing nets	Homework set 6
7	Scale Construction	scale construction	Revelle & Garner (2022)	scoring scales
	Confirmatory analysis	personality taxonomies efa vs. cfa	scale construction more on validity	Homework set 7
8	Structural Equation Modeling	sem vs. cfa continued	sem chapters 3, 4,	Factor analysis and sem
		Goodness of fit	5, 6	
9	Other approaches	Further topics Review of 405		Final Project

This table and the entire syllabus has been converted from HTML to L^AT_EX.

2 Detailed Notes

2.1 Week 1

Introduction to psychological measurement. Some historical readings are well worth reading. e.g., [Cattell \(1893\)](#) discusses why we are not doing science if we are not concerned with measurement.

[Cronbach \(1957\)](#) was an unanswered plea to unify the two disciplines of scientific psychology.

The Howto's use R and the *psych* package will introduce to some of the ways to analyze psychometric data that we will do.

1. <https://personality-project.org/r/psych/intro.pdf> Overview I
2. <http://personality-project.org/r/psych/overview.pdf> Overview II
3. <https://personality-project.org/r/psych/HowTo/factor.pdf> Factor analysis
4. <http://personality-project.org/r/psych/HowTo/omega.pdf> omega
5. <http://personality-project.org/r/psych/HowTo/scoring.pdf> Scoring scales

2.2 Week 2

The problem of the quality of our scales runs through many of the inferences we make from our data.

Review of linear/matrix algebra ([Appendix E](#))

2.3 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 <https://personality-project.org/courses/405/405-efa.pdf>.

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.

2.4 Week 4

Perhaps the fundamental issue of latent variable analysis is why use latent variables. The classic development of latent variable analysis was ([Spearman, 1904](#)) with the development of what has come to be called “Exploratory Factor Analysis”. While a useful descriptive technique to describe the “common” part of variables, EFA can be made a testable technique using “Confirmatory Factor Analysis” which is the root of most SEM packages. See [EFA/CFA](#) for an overview of PCA, EFA, and then the basics of CFA. [EFA/CFA – psych, sem and lavaan](#).

The problem of hierarchical representations of data. Many people claim a “general factor” of personality in analogy to the ‘g’ factor of ability. This has been disputed ([Revelle and Wilt, 2013](#)). See also [A general factor of personality?](#) talk given at an “Experts Meeting” on personality structure. Also see [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 Week 7

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

2.8 Week 8

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 hand column). [R and LISREL lecture notes](#)

For a very good discussion of latent change estimation in R see [Ghisletta and McArdle, \(2014\)](#) ([Ghisletta and McArdle, 2012](#)). Also see the lecture notes from Yves Rosseel [Modeling change with lavaan](#)

For an example of modeling change in cognitive ability and depression to examine the temporal sequencing of the effects, look at [Aichele et al. \(2018\)](#).

An excellent set of lecture notes on testing for invariance comes from [Tutorial on measurement invariance](#) Kate Xu.

A recent paper on the power of items versus facets versus traits ([Hofmann et al., 2025](#)).

2.9 Week 10

[Course review](#)

2.10 Software

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

2.11 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.

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