

Psychology 405: Psychometric Theory

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Swift 315 (as if that were useful)

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1 Overview

To understand something is to know how to measure it. This leads to the study of psychological measurement. In particular, psychometrics: the assigning of numbers to observed psychological phenomena and to unobserved concepts. This includes the development and evaluation of the fit of theoretical models to empirical data. Although this can be done in the abstract, psychometrics easier to understand if done with real (or simulated) data with modern computer techniques.

Psychometrics is that area of psychology that specializes in how to measure what we talk and think about. It is how to assign numbers to observations in a way that best allows us to summarize our observations in order to advance our knowledge. Although in particular it is the study of how to measure psychological constructs, the techniques of psychometrics are applicable to most problems in measurement. The measurement of intelligence, extraversion, severity of crimes, or even batting averages in baseball are all grist for the psychometric mill. Any set of observations that are not perfect exemplars of the construct of interest is open to questions of reliability and validity and to psychometric analysis.

Although it is possible to make the study of psychometrics seem dauntingly difficult, in fact the basic concepts are straightforward. This course (and the accompanying text) is an attempt to introduce the fundamental concepts in psychometric theory so that the student will be able to understand how to apply them to real data sets of interest. It is not meant to make one an expert, but merely to instill confidence and an understanding of the fundamentals of measurement so that the student can better understand and contribute to the research enterprise.

1.1 A word of warning

To learn psychometrics is like learning a new language. It at first appears impossible but with practice one can become fluent. Unlike some material that can be learned in one reading, psychometrics (like a new language) requires reading and practicing and questioning and then doing it all again.

2 Objectives

1. To acquaint you with the fundamental vocabulary and logic of psychological measurement and behavioral assessment.
2. To develop your capacity for critical judgment of the adequacy of measures purported to assess behavior in the role of theory development.
3. To acquaint you with some of the relevant literature in personality assessment, psychometric theory and practice, and methods of observing and measuring behavior.
4. To instill in you an appreciation of and an interest in the principles and methods of psychometric theory in general and behavior assessment in particular.

5. This course is not designed to make you into an accomplished psychometrist (one who gives tests) nor is it designed to make you a skilled psychometrician (one who constructs tests), nor will it give you “hands on” experience with psychometric computer programs. Rather it is aimed to allow you to understand the fundamental theoretical issues concerning both the psychometrist and the psychometrician.
6. Because modern psychometrics and statistics may be done using open source software such as R, examples will be presented in R. Instructions for installing and using R for psychometrics are available in various parts of this syllabus.

3 Text, readings, and requirements

3.1 Text

The primary text is available on line and is still a work in progress.:

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

Other texts that are useful supplements include (but are not limited to):

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

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

3.2 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/405.syllabus.pdf>

Please note that although we are organizing the lectures through CANVAS and holding them with ZOOM, the lecture notes are all on the personality-project web site.

3.3 Requirements

1. Asking questions! If you are confused, probably at least half of your colleagues are confused as well. You are doing them (and yourself) a favor by asking questions.
2. Normally, we have two multiple choice exams. But this quarter is different and I am not yet sure what we will do.
3. A final paper applying principles of psychometrics to a question of interest to you. This should be roughly 10 pages of text, but can include more computer output. It should be a clear enough statement of the problem that I can understand it.
4. Sporadic homework will be provided. This is mainly for you to see if you understand what we are doing.
5. Familiarity with basic statistics is useful, a willingness to learn about statistics is even more useful.
6. You must be willing to use computer packages that allow for basic and advanced psychometrics. This means R (R Core Team, 2021). Current versions of SPSS and JMP do not do modern statistics.
7. This is a hands on course. You will be expected to try the various programs on simulated and real data sets.

As might be expected, most of my examples and lectures will make use of the powerful statistical system, R (R Core Team, 2021). 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 one package a great

deal and another occasionally. The R packages are *psych* (Revelle, 2021) and *lavaan* (Rosseel, 2012). R can be downloaded from <https://cran.r-project.org>. Once installed packages can be downloaded from the CRAN server. To get the latest, bleeding edge version of the *psych* package, you can install it from my repository using the `install.packages` command.

3.4 Evaluation

1. Homework assignments will be given weekly. These are your benefit and will be graded on a completed, not completed basis.
2. Students will be expected to write a short paper demonstrating the use of psychometrics applied to their particular research interests.

3.5 Accessibility

Any student requesting accommodations related to a disability or other condition is required to register with AccessibleNU (accessiblenu@northwestern.edu; 847-467-5530) and provide me with an accommodation notification from AccessibleNU, preferably within the first two weeks of class. All information will remain confidential.

3.6 Office Hours

Tuesdays (and most Thursdays) from 2-5. If we were to be meeting physically, Swift Hall 315. Otherwise I am available for “office hours” by Zoom. With any luck, we might actually see each other eventually.

4 Privacy considerations

This class or portions of this class will be recorded by me for educational purposes. These recordings will be shared only with students enrolled in the course and will be deleted at the end of the end of the Spring Quarter, 2021 course. I hope to have these recordings available in CANVAS so that you can review the materials.

4.1 Recording of Class Sessions by Students

Unauthorized student recording is prohibited. Faculty should not grant individual requests for students to record class sessions. Students requesting the use of assistive technology as an accommodation should direct such requests to AccessibleNU.

As part of our communication to students, all instructors have been asked to include the following statement on all Syllabi for Spring Quarter, 2021 classes:

Unauthorized student recording of classroom or other academic activities (including advising sessions or office hours) is prohibited. Unauthorized recording is unethical and may also be a violation of University policy and state law. Students requesting the use of assistive technology as an accommodation should contact AccessibleNU. Unauthorized use of classroom recordings – including distributing or posting them – is also prohibited. Under the University’s Copyright Policy, faculty own the copyright to instructional materials – including those resources created specifically for the purposes of instruction, such as syllabi, lectures and lecture notes, and presentations. Students cannot copy, reproduce, display, or distribute these materials. Students who engage in unauthorized recording, unauthorized use of a recording, or unauthorized distribution of instructional materials will be referred to the appropriate University office for follow-up.

5 Comments about remote instruction and learning

We have been doing this for a year now. We do not necessarily enjoy it, but we are coping. We are in this together and must help each other learn how to teach, study, and learn remotely. The first rule is to stay healthy, both physically and psychologically. Don't be afraid of asking for help from each other and from me as we go along.

I am going to try various techniques such as break out groups so you can have short conversations about what you are understanding and not understanding and then come back as a group to ask those questions. Some of what I will try will work, some will not. It is up to all of us to figure out the best way of doing this.

I hope eventually to see all of you in person, and not just as an image on a screen.

6 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 May 17, 2021

6.1 News of changes

6.2 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 Homework #1 with answers |
| 2 a | Models of Measurement | Metric properties and the problems of scale | Chapter 3: The problems of scale | Using R for statistics and an even shorter guide to R |
| 2b | Variance and Covariance | Correlation and Regression (Part 1) | Chapter 4: Correlation 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 and even more | Multiple Correlations (Chapter 5) | Applications of correlations Problem set 3 |
| 4a | Latent variable models | Factor Analysis | Constructs, Components, and Factors (Chapter 6) | Factor Analysis (How To) |
| 4 b | | Even more fa | | Homework set 4 |
| 5a | Reliability | Reliability Theory | Reliability (Chapter 7) α to ω Supplement to α to ω | Omega Analysis (How To) Homework set 5 |
| 6 a | Item Response Theory | Item Response Theory | Item Response Theory (Chapter 8) | Factor approaches to IRT see section 7 Homework set 6 |
| 6 b | Validity | Validity Validity of SAPA methods | Predicting the Persome That takes the BISCUIT | Homework set 7 |
| 7 | Scale Construction | scale construction | That takes the BISCUIT | scoring scales Homework set 7 |
| | Confirmatory analysis | efa vs. cfa | more on validity | |
| 8 | Structural Equation Modeling | sem vs. cfa continued Goodness of fit | sem chapters 3, 4, 5, 6 | Factor analysis and sem |
| 9 | Other approaches | Further topics Review of 405 | | Final Project |

This table and the entire syllabus is being converted from HTML to L^AT_EX. The original version is [here](#)

6.3 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.

References

- Jöreskog, K. G. and Sörbom, D. (1999). *LISREL 8: Structural equation modeling with the SIMPLIS command language*. Scientific Software International, Lincolnwood.
- Loehlin, J. C. and Beaujean, A. (2017). *Latent variable models: an introduction to factor, path, and structural equation analysis*. Routledge, Mahwah, N.J., 5th edition.
- R Core Team (2021). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.
- Raykov, T. and Marcoulides, G. A. (2006). *A first course in structural equation modeling*. Lawrence Erlbaum Associates, Mahwah, N.J., 2nd edition.
- Revelle, W. (2021). **psych**: Procedures for personality and psychological research. Technical report, <https://CRAN.r-project.org/package=psych>. R package version 2.1.3.
- Revelle, W. (in prep). *An introduction to psychometric theory with applications in R*. Springer.
- Rosseel, Y. (2012). lavaan: An R package for structural equation modeling. *Journal of Statistical Software*, 48(2):1–36.