Measurement, Scaling, and Dimensional Analysis
2020 ICPSR Summer Program
Daily, 1:00–3:00 p.m.

Professor: Adam Enders
Office Hours: Daily, 3:00–4:00 p.m. (or by appointment)
Email: see Canvas

Teaching Assistant: Tyler Girard
Office Hours: Daily, 11:00 a.m–12:30 p.m. (or by appointment)
Email: see Canvas

Course Description

Though scientists working in all manner of disciplines and methodological traditions recognize measurement as a fundamental and crucial step of the scientific process, the topic is rarely given formal attention in core graduate courses beyond a cursory treatment of the concepts of reliability and validity. The central goal of this course is to aid social scientists in better measuring the phenomena they are interested in by developing a broad toolkit of methods useful for such purposes.

We will begin by discussing some basics of measurement, as well as a theory of data that can be used to aid researchers in determining the most appropriate and useful “scaling” methodologies to apply to their data. From here, we will engage psychometric philosophies of measurement, which will eventually introduce participants to basic unidimensional scaling models, such as the summated rating model and item response theory. The assessment and “reduction” of dimensionality via principal components and factor analysis will round out the second core section of the course. Finally, we will consider a host of methodologies useful for representing substantively interesting characteristics of data in multiple dimensions, and, in particular, providing spatial, or geometric, visualizations of those characteristics. These methodologies include various formulations of multidimensional scaling, correspondence analysis, and cluster analysis.

Course Prerequisites & Software Considerations

Participants should be familiar, and comfortable, with basic descriptive statistics and linear models (i.e., OLS regression). Familiarity with matrix algebra and maximum likelihood estimation will serve participants well, but is not strictly required for participation or necessary for participants to understand course material. I recommend sitting in on the first couple weeks of the “Mathematics for Social Scientists II” workshop if you have no familiarity with matrix algebra.
Most software programs include routines for executing most of the techniques we will discuss in class, though none is perfect. In an effort to keep the focus of course on the substantive material, code to execute all analyses in the R statistical computing environment will be made available to participants.

Course Materials

There is no required textbook for this course. This is partially because much of the material we will be exploring can be learned from more accessible (i.e., free!) journal articles. The class schedule below provides a lengthy list of such articles, organized by topic. The lack of a textbook is also due to the fact that there really is no single text that addresses all of the topics we will be considering, at least not in the way we will be covering them.

Those caveats aside, there are a few excellent textbooks that cover several of the topics we will be addressing. In order of utility to this course, by my estimation, starting with most useful:


Canonical topic-specific texts that are useful for diving in on certain methodologies:


Inexpensive Sage “little green books” that I think are useful across several topics (others noted under specific topics below):


**Course Requirements**

Though the ICPSR Summer Program is most concerned with providing participants with the practical tools necessary to aid their own research, formal evaluations of course performance will be made at the end of the session. Depending on how the course unfolds, 4-5 assignments designed to provide participants an opportunity to apply the methodologies discussed in class will be administered.

Participants who are required to obtain, or are otherwise expecting, a formal letter grade must complete all assignments and alert the teaching assistant that they are requesting a letter grade. Other participants are encouraged to complete and submit the assignments, though no letter grade will be administered upon completion of the course. Assignments will be graded primarily for effort and completion.

**Disclaimer on Intellectual Property**

By participating in this course, you agree not to record, reproduce, distribute, make derivative use of, or display publicly any of the content provided on this website, unless the use is permitted by law or by licenses explicitly granted to you by the copyright holders.

In other words, please respect that the course is unique and takes considerable effort to execute. We ask participants to refrain from sharing course content with other participants or colleagues not enrolled in the course.
Class Schedule

Basics of Data and Measurement

I. Data Theory & “Scaling”

Jacoby. Chapter 3.
McIver and Carmines. Chapter 1.

II. Dimensionality

Jacoby. Chapter 4.

III. Measurement

Jacoby. Chapters 1 & 2.

Measurement Theory & Unidimensional Scaling

I. Classical Test Theory & Reliability

Mair. Chapter 1.
Desjardins and Bulut. Chapter 2.
II. The Summated Rating Model

McIver and Carmines. Chapter 3.

Jacoby. Pages 38-41.


Applications:


Many papers that have “scales” or “indexes”...by which they usually mean the SRM

III. Guttman and Mokken Scaling


McIver and Carmines. Chapters 4 & 5.

Applications:


**IV. Item Response Theory**


Mair. Chapter 4.

Desjardins and Bulut. Chapters 5-8.


Applications:


**V. The Unfolding Model**

McIver and Carmines. Chapter 6.


Applications:


Assessing (and Reducing) Dimensionality

I. Singular Value Decomposition and the Biplot

Mair. Chapter 10.


Applications:


II. Principal Components Analysis

Mair. Chapter 6.

Vehkalahti and Bartholomew. Chapter 13.

Everitt and Hothorn. Chapter 3.

Weller and Romney. Chapter 3.

Wickens. Chapter 9.


Applications:


III. Common (“Exploratory”) Factor Analysis
**IV. Confirmatory Factor Analysis**


Mair. Chapter 2.

Vehkalahti and Bartholomew. Chapter 16.

Desjardins and Bulut. Chapter 4.

Everitt and Hothorn. Chapter 7.


Applications:

Countless examples in all disciplines!


V. Measurement Invariance & Differential Item Functioning


Mair. Chapter 4.

Desjardins and Bulut. Chapter 11.


Applications:


VI. Multiple Correspondence Analysis & Nonlinear PCA

Mair. Chapter 8.
Weller and Romney. Chapters 5-8.


Applications:


**Multidimensional Scaling & Correspondence Analysis**

I. Classical Multidimensional Scaling


Borg and Groenen. Chapters 2, 3, 8, 9, 11-13.

Armstrong II et al. Pages 103-128.

Mair. Chapter 9.

Vehkalahti and Bartholomew. Chapter 14.

Everitt and Hothorn. Chapter 4.


Applications:


II. Weighted Multidimensional Scaling

Borg and Groenen. Chapter 22.

Armstrong II et al. Pages 132-143.


Applications:


III. Multidimensional Unfolding

Armstrong II et al. Chapter 5.

Borg and Groenen. Chapter 14.

Applications:

[https://voteview.com/](https://voteview.com/)


IV. The Vector Unfolding Model (MDPREF)
Applications:


V. Cluster Analysis

Mair. Chapter 12.

Vehkalahti and Bartholomew. Chapter 17.

Everitt and Hothorn. Chapter 6.

Applications:


VI. Correspondence Analysis


Applications:
