Measurement, Scaling, and Dimensional Analysis

2021 ICPSR Summer Program
Daily, Asynchronous

Professor: Adam Enders
Office Hours: Daily, 1:00–3:00 p.m. (or by appointment) on Zoom
Email: see Canvas

Teaching Assistant: Tyler Girard
Office Hours: Daily, 10:00 a.m–12:00 p.m. (or by appointment) on Slack
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.

Class Meetings

Lectures will be delivered asynchronously. This strategy is designed to offer participants maximum flexibility in when and how they learn the material, and account for the fact that many participants are not located in the Eastern Standard Time zone. That said, both the instructor and TA will hold office hours every day, which will allow for face-to-face interaction and provide opportunities for participants to ask questions. We will also hold weekly lab sessions in the evening, where participants will be able to work through additional practice problems with guidance from the instructor and TA.

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 statistical analysis platforms 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 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. Five assignments designed to provide participants an opportunity to apply the methodologies discussed in class will be administered.

Participants who are required to obtain, or who 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.

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, and also because there really is no single text that addresses all of the topics we will be considering.

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:

Mair, Patrick. 2018. *Modern Psychometrics with R.* Springer.

The Wiley Handbook of Psychometric Testing, 2 Volume Set: A Multidisciplinary Reference on Survey, Scale and Test Development. 2018. Eds. Paul Irwing, Tom Booth, and David J. Hughes. Wiley-Blackwell.

Vehkalahti, Kimmo and David J. Bartholomew. 2019. *Multivariate Analysis for the Behavioral Sciences (Second Edition).* Chapman and Hall/CRC Press.

Armstrong II, David A., Ryan Bakker, Royce Carroll, Christopher Hare, Keith T. Poole, and Howard Rosenthal. 2014. *Analyzing Spatial Models of Choice and Judgment with R.* Chapman and Hall/CRC Press.

Desjardins, Christopher D. and Okan Bulut. 2018. *Handbook of Educational Measurement and Psychometrics Using R.* Chapman and Hall/CRC Press.

Everitt, Brian and Torsten Hothorn. 2011. *An Introduction to Applied Multivariate Analysis with R.* Springer.

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

Borg, Ingwer and Patrick Groenen. 2005. *Modern Multidimensional Scaling: Theory and Applications (Second Edition).* Springer.

Mulaik, Stanley A. 2009. *Foundations of Factor Analysis (Second Edition).* Chapman and Hall/CRC Press.

Greenacre, Michael. 2016. *Correspondence Analysis in Practice.* Chapman and Hall/CRC Press.

Wickens, Thomas D. 1995. *The Geometry of Multivariate Statistics.* Lawrence Erlbaum.

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

Jacoby, William G. 1991. *Data Theory and Dimensional Analysis.* Sage.

McIver, John and Edward G. Carmines. 1981. *Unidimensional Scaling.* Sage.

Weller, Susan C. and A. Kimball Romney. 1990. *Metric Scaling: Correspondence Analysis.* Sage.

Tentative Schedule

Week 1

Data Theory and dimensionality

Measurement and optimal scaling

Classical test theory

Reliability

Summated rating model ("Likert scaling")

Week 2

Nonparametric item response theory (or "Mokken scaling")

Parametric item response theory

Unidimensional unfolding (brief)

Differential item functioning

SVD and eigendecomposition

Biplots

Week 3

Principal components analysis

Exploratory factor analysis

PCA and EFA with categorical variables

Confirmatory factor analysis

Measurement invariance

Week 4

Metric multidimensional scaling

Nonmetric multidimensional scaling

MDS extensions (weighted MDS, unfolding)

Correspondence analysis

Cluster analysis

Readings By Topic

Basics of Data and Measurement

I. Data Theory & "Scaling"

Jacoby. Chapter 3.

McIver and Carmines. Chapter 1.

The Wiley Handbook of Psychometric Testing. Chapter 28.

Young, F.W. 1984. "Scaling." *Annual Review of Psychology* 35: 55-60.

II. Dimensionality

Jacoby. Chapter 4.

Weisberg, Herbert F. 1974. "Dimensionland: An Excursion into Spaces." *American Journal of Political Science* 18: 743-776.

III. Measurement

Jacoby. Chapters 1 & 2.

Stevens, S. S. 1946. "On the Theory of Scales of Measurement." *Science* 103: 677-680.

Jacoby, William G. 1999. "Levels of Measurement and Political Research: An Optimistic View." *American Journal of Political Science* 43: 271-301.

Young, Forrest W. 1981. "Quantitative Analysis of Qualitative Data." *Psychometrika* 46: 357-388.

Measurement Theory & Unidimensional Scaling

I. Classical Test Theory & Reliability

The Wiley Handbook of Psychometric Testing. Chapters 2 & 23.

Mair. Chapter 1.

Desjardins and Bulut. Chapter 2.

Sijtsma, Klaas. 2009. "On the Use, Misuse, and the Very Limited Usefulness of Cronbach's Alpha." *Psychometrika* 74: 107-120.

Traub, Ross E. 1997. "Classical Test Theory in Historical Perspective." *Educational Measures: Issues and Practice* Winter 1997: 9-14.

DeVellis, Robert F. 2006. "Classical Test Theory." *Medical Care* 44: S50-S59.

II. The Summated Rating Model

McIver and Carmines. Chapter 3.

Jacoby. Pages 38-41.

Spector, Paul E. 1992. *Summated Rating Scale Construction*. New York: Sage.

Carifio, James and Rocco J. Perla. 2007. "Ten Common Misunderstandings, Misconceptions, Persistent Myths and Urban Legends about Likert Scales and Likert Response Formats and their Antidotes." *Journal of Social Sciences* 3(3): 106-116.

Applications:

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

Lupton, Robert N., Steven M. Smallpage, and Adam M. Enders. 2020. "Values and Political Predispositions in the Age of Polarization: Examining the Relationship between Partisanship and Ideology in the United States, 1988–2012." *British Journal of Political Science* 50(1): 241-260.

Ansolabehere, Stephen, Jonathan Rodden, and James M. Snyder, Jr. 2008. "The Strength of Issues: Using Multiple Measures to Gauge Preference Stability, Ideological Constraint, and Issue Voting." *American Political Science Review* 102: 215-232.

III. Guttman and Mokken Scaling

Van Schuur, Wijbrandt H. 2011. *Ordinal Item Response Theory: Mokken Scale Analysis*. Sage.

Van Schuur, Wijbrandt H. 2003. "Mokken Scale Analysis: Between the Guttman Scale and Parametric Item Response Theory." *Political Analysis* 11: 139-163.

Van der Ark, L. Andries. 2007. "Mokken Scale Analysis in R." *Journal of Statistical Software* 20(11).

Sijtsma, Klaas, and L. Andries van der Ark. 2017. "A Tutorial on How to do a Mokken Scale Analysis on Your Test and Questionnaire Data." *British Journal of Mathematical and Statistical Psychology* 70: 137-158.

McIver and Carmines. Chapters 4 & 5.

Applications:

Girard, Tyler. 2021. "Reconciling the Theoretical and Empirical Study of International Norms: A New Approach to Measurement." *American Political Science Review* 115(1): 331-338.

Mondak, Jeffery J. and Mary R. Anderson. 2004. "The Knowledge Gap: A Reexamination of Gender-Based Differences in Political Knowledge." *Journal of Politics* 66: 492-512.

Cingranelli, David L. and David L. Richards. 1999. "Measuring the Level, Pattern, and Sequence of Government Respect for Physical Integrity Rights." *International Studies Quarterly* 43: 407-417.

Jacoby, William G. 1995. "The Structure of Ideological Thinking in the American Electorate." *American Journal of Political Science* 39: 314-335.

IV. Item Response Theory

The Wiley Handbook of Psychometric Testing. Chapters 2 & 15.

Mair. Chapter 4.

Desjardins and Bulut. Chapters 5-8.

Hambleton, Ronald K., Hariharan Swaminathan, and H. Jane Rogers. 1991. *Fundamentals of Item Response Theory.* Newbury Park: Sage.

Rizopoulos, Dimitris. 2006. "`ltm`: An R Package for Latent Variable Modeling and Item Response Theory Analyses." *Journal of Statistical Software* 17(5).

Thissen, D., and L. Steinberg. 1986. "A Taxonomy of Item Response Models." *Psychometrika* 51: 567-577.

Applications:

Meijers, Maurits J. and Andrej Zaslove. 2021. "Measuring Populism in Political Parties: Appraisal of a New Approach." *Comparative Political Studies* 54(2): 372-407.

Tausanovitch, Chris and Christopher Warshaw. 2014. "Representation in Municipal Government." *American Political Science Review* 108: 605-641.

Bafumi, Joseph and Michael C. Herron. 2010. "Leapfrog Representation and Extremism: A Study of American Voters and Their Members in Congress." *American Political Science Review* 104: 519-542.

V. The Unfolding Model

McIver and Carmines. Chapter 6.

van Schuur, Wijbrandt H. 1992. "Nonparametric Unidimensional Unfolding for Multicategory Data." *Political Analysis* 4: 41-74.

Poole, Keith T. 2004. *Spatial Models of Parliamentary Voting.* Cambridge, UK: Cambridge University Press.

Applications:

Jacoby, William G. and Saundra K. Schneider. 2009. "A New Measure of Policy Spending Priorities in the American States." *Political Analysis* 17: 1-24.

Martin, Andrew D. and Kevin M. Quinn. 2001. "Dynamic Ideal Point Estimation via Markov Chain Monte Carlo for the U.S. Supreme Court, 1953-1999." *Political Analysis* 10: 134-153.

Assessing (and Reducing) Dimensionality

I. Singular Value Decomposition and the Biplot

Mair. Chapter 10.

Martin, Carla D., and Mason A. Porter. 2012. "The Extraordinary SVD." *American Mathematical Monthly* 119(10): 838-851.

Greenacre, Michael. 2012. "Biplots: The Joy of the Singular Value Decomposition." *Wiley Interdisciplinary Reviews: Computational Statistics* 4: 399-406.

Gabriel, K.R. 1971. "The Biplot Graphic Display of Matrices with Application to Principal Components Analysis." *Biometrics* 58: 453-467.

Applications:

Porter, Mason A., Peter J. Mucha, M. E. J. Newman, and Casey M. Warmbrand. 2005. "A Network Analysis of Committees in the U.S. House of Representatives." *Proceedings of the National Academy of Sciences of the United States of America* 102: 7057-7062.

Poole, Keith T. and Howard Rosenthal. 1997. *Congress: A Political-Economic History of Roll Call Voting.* Oxford University Press.

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.

Dunteman, George H. 1989. *Principal Components Analysis*. Sage.

Applications:

Stoll, Heather. 2010. "Elite-Level Conflict Salience and Dimensionality in Western Europe: Concepts and Empirical Findings." *West European Politics* 33: 445-73.

Ura, Joseph Daniel and Patrick C. Wohlfarth. 2010. "An Appeal to the People: Public Opinion and Congressional Support for the Supreme Court." *Journal of Politics* 72: 939-956.

III. Common ("Exploratory") Factor Analysis

The Wiley Handbook of Psychometric Testing. Chapters 8, 10, & 11.

Mair. Chapter 2.

Vehkalahti and Bartholomew. Chapter 15.

Desjardins and Bulut. Chapter 4.

Everitt and Hothorn. Chapter 5.

Wickens. Chapter 9.

Mulaik, Stanley A. 2009. *Foundations of Factor Analysis (Second Edition)*. Chapman and Hall/CRC Press.

Kim, Jae-On and Charles W. Mueller. 1978. *Introduction to Factor Analysis*. Sage.

Henson, Robin K., and J. Kyle Roberts. 2006. "Use of Exploratory Factor Analysis in Published Research: Common Errors and Some Comment on Improved Practice." *Educational and Psychological Measurement* 66: 393-416.

Van Schuur, Wijbrandt H. and Henk A. L. Kiers. 1994. "Why Factor Analysis is Often the Incorrect Model for Analyzing Bipolar Concepts and What Model to Use Instead." *Applied Psychological Measurement* 18: 97-110.

Applications:

Joseph E. Uscinski, Michelle Seelig, Casey Klofstad, John Funchion, Caleb Everett, Stephan Wuchty, Kamal Premaratne, and Manohar Murthi. Forthcoming. "American Politics in Two Dimensions: Partisan and Ideological Identities versus Anti-Establishment Orientations." *American Journal of Political Science*.

Gibson, James L., Gregory A. Caldeira, and Lester Kenyatta Spence. 2003. "Measuring Attitudes toward the United States Supreme Court." *American Journal of Political Science* 47: 354-367.

Marcus, George E. 1988. "The Structure of Emotional Response: 1984 Presidential Candidates." *American Political Science Review* 82: 737-761.

Stimson, James A. 1975. "Belief Systems: Constraint, Complexity, and the 1972 Election." *American Journal of Political Science* 19: 393-417.

IV. Confirmatory Factor Analysis

The Wiley Handbook of Psychometric Testing. Chapter 26.

Mair. Chapter 2.

Vehkalahti and Bartholomew. Chapter 16.

Desjardins and Bulut. Chapter 4.

Everitt and Hothorn. Chapter 7.

Bollen, Kenneth A. 1989. *Structural Equations with Latent Variables*. Wiley.

Schumacker, Randall and Richard Lomax. 2015. *A Beginner's Guide to Structural Equation Modeling*. Routledge.

Applications:

Countless examples in all disciplines!

Armaly, Miles T. and Adam M. Enders. Forthcoming. "'Why Me?' The Role of Perceived Victimhood in American Politics." *Political Behavior*.

Swami, Viren, David Barron, Laura Weis, Martin Voracek, Stefan Stieger, and Adrian Furnham. 2017. "An Examination of the Factorial and Convergent Validity of Four Measures of Conspiracist Ideation, with Recommendations for Researchers." *PLoS ONE* 12(2): e0172617.

V. Measurement Invariance & Differential Item Functioning

The Wiley Handbook of Psychometric Testing. 2018. Chapters 26 & 27.

Mair. Chapter 4.

Desjardins and Bulut. Chapter 11.

Crane, Paul K., Laura E. Gibbons, Lance Jolley, and Gerald van Belle. 2006. "Differential Item Functioning Analysis With Ordinal Logistic Regression Techniques." *Medical Care* 44(11): S115-S123.

Choi, Seung W., Laura E. Gibbons, and Paul K. Crane. 2011."*lordif*: An R Package for Detecting Differential Item Functioning Using Iterative Hybrid Ordinal Logistic Regression/Item Response Theory and Monte Carlo Simulations." *Journal of Statistical Software* 38(8): 1-30.

Chun, Seokjoon, Stephen Stark, Eun Sook Kim, and Oleksandr S. Chernyshenko. 2016. "MIMIC Methods for Detecting DIF Among Multiple Groups: Exploring a New Sequential-Free Baseline Procedure." *Applied Psychological Measurement* 40(7): 486-499.

Applications:

Enders, Adam M. 2021. "A Matter of Principle? On the Relationship Between Racial Resentment and Ideology." *Political Behavior* 43(2): 561-584.

Pérez, Efrén O., and Marc J. Hetherington. 2014. "Authoritarianism in Black and White: Testing the Cross-Racial Validity of the Child Rearing Scale." *Political Analysis* 22: 398-412.

VI. Multiple Correspondence Analysis & Nonlinear PCA

Mair. Chapter 8.

Weller and Romney. Chapters 5-8.

Greenacre, Michael. 2016. *Correspondence Analysis in Practice*. Chapman and Hall/CRC Press.

Mori, Yuichi, Masahiro Kuroda, and Naomichi Makino. 2016. *Nonlinear Principal Component Analysis and Its Applications*. Springer.

Takane, Yoshio and Jan de Leeuw. 1987. "On the Relationship Between Item Response Theory and Factor Analysis of Discretized Variables." *Psychometrika* 52(3): 393-408.

Applications:

Barberá, Pablo, John T. Jost, Jonathan Nagler, Joshua A. Tucker, and Richard Bonneau. 2015. "Tweeting From Left to Right: Is Online Political Communication More Than an Echo Chamber?" *Psychological Science* 26(10): 1531-1542.

Blasius, Jörg, and Victor Thiessen. 2001. "Methodological Artifacts in Measures of Political Efficacy and Trust: A Multiple Correspondence Analysis." *Political Analysis* 9(1): 1-20.

Multidimensional Scaling & Correspondence Analysis

I. Classical Multidimensional Scaling

The Wiley Handbook of Psychometric Testing. Chapter 14.

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.

Kruskal, Joseph B. and Myron Wish. 1978. *Multidimensional Scaling.* Sage.

MacCallum, R.C. 1974. "Relations Between Factor Analysis and Multidimensional Scaling." *Psychological Bulletin* 81: 505-516.

Rabinowitz, George B. 1975. "An Introduction to Nonmetric Multidimensional Scaling." *American Journal of Political Science* 19: 343-390.

Jacoby, William G., and David A. Armstrong II. 2014. "Bootstrap Confidence Regions for Multidimensional Scaling Solutions." *American Journal of Political Science* 58(1): 264-278.

Applications:

> Enders, Adam M., Joseph E. Uscinski, Casey Klofstad, and Justin Stoler. 2020. "The Different Forms of COVID-19 Misinformation and Their Consequences." *The Harvard Kennedy School (HKS) Misinformation Review.*
>
> Enders, Adam M., Joseph E. Uscinski, Michelle Seelig, Casey Klofstad, John Funchion, Caleb Everett, Stephan Wuchty, Kamal Premaratne, and Manohar Murthi. Forthcoming. "Do Conspiracy Beliefs Form a Belief System? Examining the Structure and Organization of Conspiracy Beliefs." *Journal of Social and Political Psychology.*
>
> Bowen, Daniel C. and Zachary Greene. 2014. "Should We Measure Professionalism with an Index? A Note on Theory and Practice in State Legislative Professionalism Research." *State Politics & Policy Quarterly* 14(3): 277-296.
>
> Schwartz, Shalom H. and Wolfgang Bilsky. 1987. "Toward A Universal Psychological Structure of Human Values." *Journal of Personality and Social Psychology* 53: 550-562.

II. Weighted Multidimensional Scaling

Borg and Groenen. Chapter 22.

Armstrong II et al. Pages 132-143.

Arabie, Phipps; J. Douglas Carroll; Wayne S. DeSarbo. 1987. *Three-Way Scaling and Clustering.* Sage.

Applications:

> Jacoby, William G. 1986. "Levels of Conceptualization and Reliance on the Liberal-Conservative Continuum." *Journal of Politics* 48: 423-432.

Marcus, George E., David Tabb, and John L. Sullivan. 1974. "The Application of Individual Differences Scaling to the Measurement of Political Ideologies." *American Journal of Political Science* 18: 405-420.

III. Multidimensional Unfolding

Armstrong II et al. Chapter 5.

Borg and Groenen. Chapter 14.

Applications:

`https://voteview.com/`

Hare, Christopher, Tzu-Ping Liu, and Robert N. Lupton. 2018. "What Ordered Optimal Classification Reveals About Ideological Structure, Cleavages, and Polarization in the American Mass Public." *Public Choice* 176(1-2): 57-78.

Clinton, Joshua D. 2012. "Using Roll Call Estimates to Test Models of Politics." *Annual Review of Political Science* 15: 79-99.

Rabinowitz, George B. 1978. "On the Nature of Political Issues: Insights from a Spatial Analysis." *American Journal of Political Science* 22: 793-817.

IV. The Vector Unfolding Model (MDPREF)

Weller and Romney. Pages 44-54.

Borg and Groenen. Chapter 16.

Applications:

Jacoby, William G. 2019. "A Directional Model of Candidate Evaluations in the 2016 Presidential Election." *Electoral Studies* 61: 102029.

Searing, Donald D., William G. Jacoby, and Andrew H. Tyner. 2019. "The Endurance of Politicians? Values Over Four Decades: A Panel Study." *American Political Science Review* 113(1): 226-241.

Jacoby, William G. 2014. "Is There a Culture War? Conflicting Value Structures in American Public Opinion." *American Political Science Review* 108: 754-771.

V. Cluster Analysis

Mair. Chapter 12.

Vehkalahti and Bartholomew. Chapter 17.

Everitt and Hothorn. Chapter 6.

Applications:

Wolfson, Murray, Zagros Madjd-Sadjadi, and Patrick James. 2004. "Identifying National Types: A Cluster Analysis of Politics, Economics, and Conflict." *Journal of Peace Research* 41(5): 607-623.

Conger, Kimberly H., Rosalyn Cooperman, Gregory Shufeldt, Geoffrey C. Layman, Kerem Ozan Kalkan, John C. Green, and Richard Herrera. 2019. "Group Commitment Among U.S. Party Factions: A Perspective From Democratic and Republican National Convention Delegates." *American Politics Research* 47(6): 1376-1408.

VI. Correspondence Analysis

Mair (2018). Chapter 7.

Vehkalahti and Bartholomew (2019). Chapter 14.

Greenacre, Michael. 2016. *Correspondence Analysis in Practice.* Chapman and Hall/CRC Press.

Applications:

Barbera, Pablo, John T. Jost, Jonathan Nagler, Joshua A. Tucker, and Richard Bonneau. 2015. "Tweeting From Left to Right: Is Online Political Communication More Than an Echo Chamber?" *Psychological Science* 26(10): 1531-1542.

Bonica, Adam. 2014. "Mapping the Ideological Marketplace." *American Journal of Political Science* 58(2): 367-387.

Blasius, Jörg, and Victor Thiessen. 2001. "Methodological Artifacts in Measures of Political Efficacy and Trust: A Multiple Correspondence Analysis." *Political Analysis* 9(1): 1-20.