Digital Module 23: Multidimensional Item Response Theory Graphics

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Available in the ITEMS Portal at https://ncme.elevate.commpartners.com

Module Overview

In this digital ITEMS module, Dr. Terry Ackerman and Dr. Qing Xie cover the underlying theory and application of *multidimensional item response theory* models from a visual perspective. They begin the module with a brief review of how to interpret evidence of dimensionality of test data. They then examine the basic characteristics of unidimensional IRT models and how these concepts change when the IRT model is expanded to two dimensions. This leads to a more in-depth discussion of how unidimensional item characteristic curves change in two-dimensional models and can be represented as a surface, as a contour plot, or collectively as a set of vectors. They then expanded this to the test level where test characteristic curves become test characteristic surfaces and with accompanying contours. They include additional discussions on how to compute information and represent it in terms of "clamshell", number, or centroid plots. The module includes audio-narrated slides as well as the usual package of the usual package of curated resources, a glossary, data activities, and quiz questions with diagnostic feedback.

Key words: *centroid plot, clamshell plot, contour plot, item information curve, item information surface, multidimensional item response theory, MIRT, response surface, RShiny, test characteristic curve, test characteristic surface, vector*

Prerequisite Knowledge

This ITEMS module assumes no prior knowledge of multidimensional item response theory graphics. However, it is probably helpful to have a working knowledge of foundational assessment and statistical concepts such as:

- being familiar with the underpinnings of classical test theory and its applications to assessment
- understanding the underlying theory, applications, and estimation of unidimensional models
- having graduate-level course experience in multivariate statistics, including factor analysis, principal component analysis, and multiple regression
- having some practical experience in programming in *R*

The following NCME ITEMS modules may serve as a useful introduction to the prerequisite knowledge:

- Print Module 07 (Harris; Comparison of 1-, 2-, and 3-parameter IRT models)
- Print Module 21 (Ackerman, Gierl, & Walker; Using MIRT to evaluate educational and psychological tests)
- Digital Module 08 (Yoo & Hambleton; Foundations of operational item analysis)
- Digital Module 19 (Wang & Thompson; Foundations of IRT estimation)

These modules and others are available for free in the ITEMS portal.

Learning Objectives

Upon completion of this ITEMS module, learners should be able to:

- Evaluate the dimensionality of dichotomous response data
- Extend the concepts and modeling of unidimensional IRT to two dimensions
- Graphically illustrate and explain how items and tests can be represented in a two-dimensional latent ability space
- Explain and represent item and test information for the two-dimensional compensatory model
- Understand how to evaluate scores scale consistency in a two-dimension test

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Module Structure

The digital module is divided into the following sections, which can be reviewed sequentially or independently [*approximate completion times in parentheses*].

- Module Introduction [*5* minutes]
- Section 1: Evaluate the Dimensionality of Response Data [10 minutes]
- Section 2: Extend basic concepts from UIRT to MIRT [15 minutes]
- Section 3: Plots for 2-D Items and Tests [30 minutes]
- Section 4: Representing Test Information for 2-D Data [20 minutes]
- Section 5: Examining Score Scale Consistency with Centroid Plots [10 minutes]
- Section 6: Creating MIRT plots in RShiny [20 minutes]
- Section 7: Data Activities [15 minutes]

In the portal site, you can also find a video version of the core content as well as a handout with all core slides along with other materials.

Module Components

This ITEMS module includes the following components, which are delivered within a web-delivered unified design shell that is compatible across platforms (i.e., laptops, desktops, tablets, cell phones) and was created with modern course development software (*Articulate 360*):

- integrated content slides that provide a structured walk-through of the content
- interactive data activities with diagnostic feedback
- sample data, syntax file, and access to a RShiny package
- data-based activities with video solutions
- glossary of key terms
- supplementary digital resources

Additional materials may be added over time so check back periodically!-

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Instructors

Terry Ackerman, *University of Iowa*

After receiving his Ph.D., Dr. Ackerman worked for five years as a psychometrician at ACT where one of his primary responsibilities involved working on an Office of Naval Research grant that focused on multidimensional item response theory (MIRT) and its potential applications to standardized tests. Given his strong interest and passion for teaching, he then left ACT and went to the University of Illinois at Urbana-Champaign where he taught graduate courses in statistics and testing and measurement. During that time, Dr. Ackerman was fortunate to have great colleagues and mentors at Illinois including Dr. William Stout, Dr. Rod McDonald, and Dr. Larry Hubert. His research continued to focus on MIRT and expanded to include differential item and test functioning. After 10 years at Illinois he moved to the University of North Carolina at Greensboro where, as a department chair, he helped build a strong program in educational testing and measurement and developed a strong internship program. He chaired and sat on several technical advisory committees for several testing companies including the American Institute for Certified Public Accountants (AICPA), Measured Progress, the College Board, ETS, and the Defense Advisory Committee, which oversaw the testing for the U.S. military. During his 17 years as a professor, chair, and associate dean, Dr. Ackerman was elected to serve as the president of the National Council on Measurement in Education (NCME) and the Psychometric Society. In 2016, he briefly returned to ACT as the company's first Lindquist Chair before moving to the University of Iowa as a Distinguished Visiting Professor.

Qing Xie, *University of Iowa*

Qing Xie received her Ph.D. in Educational Measurement and Statistics and M.S. in Statistics from the University of Iowa. During her graduate study, she worked as a Research Assistant (RA) in the Psychometric Research Department at ACT for about five years, where she provided psychometric and statistical support on operational tasks for large-scale assessments and worked both independently and collaboratively on multiple quantitative research projects. Later, she was a RA at the Iowa Testing Programs, University of Iowa and an Associate Psychometrician at ETS. She now works at the Center for Drug Evaluation and Research at the U.S. Food and Drug Administration.

Instructional Design Team

Jonathan Lehrfeld, *Educational Testing Service (ETS)*

Jon is a Psychometrician at ETS. He provides operational support on K-12 assessments and pursues research interests in scaling and equating and in issues in English language proficiency assessments. Prior to this, he worked at Council for Aid to Education as Psychometrician and Associate Director of Measurement Science. Jon received his Ph.D. in psychometrics and quantitative psychology from Fordham University in 2016. His dissertation focused on integrating propensity score methods with structural equation modeling.

André A. Rupp, *Mindful Measurement*

André A. Rupp is the coauthor and coeditor of two award-winning interdisciplinary books entitled Diagnostic Measurement: Theory, Methods, and Applications (2010) and The Handbook of Cognition and Assessment: Frameworks, Methodologies, and Applications (2016) and has just published the Handbook of Automated Scoring: Theory into Practice (2020). His research synthesis- and framework-oriented work has appeared in a wide variety of prestigious peer-reviewed journals. Among other things, he is passionate about improving processes for interdisciplinary collaborations during the development and implementation of scoring solutions for digitally delivered assessments. Consequently, he is very excited to serve as the associate editor/lead instructional designer of the ITEMS portal for NCME whose mission is to provide free digital resources to support self-directed learning and professional development.