Digital Module 06: Posterior Predictive Model Checking

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

Module Overview

Drawing valid inferences from modern measurement models is contingent upon a good fit of the data to the model. Violations of model-data fit have numerous consequences, limiting the usefulness and applicability of the model. As Bayesian estimation is becoming more common, understanding the Bayesian approaches for evaluating model-data fit models is critical. In this instructional module, Allison Ames and Aaron Myers provide an overview of Posterior Predictive Model Checking (PPMC), the most common Bayesian model-data fit approach. Specifically, they review the conceptual foundation of Bayesian inference as well as PPMC and walk through the computational steps of PPMC using real-life data examples from simple linear regression and item response theory (IRT) analysis. They provide guidance for how to interpret PPMC results and discuss how to implement PPMC for other model(s) and data. The digital module contains sample data, SAS code, diagnostic quiz questions, data-based activities, curated resources, and a glossary.

Key words: Bayesian inference, Simple linear regression, Item response theory (IRT), Model-data fit, Posterior Predictive Model Checking (PPMC), Bayes' theorem, Yen's Q3

Prerequisite Knowledge

This ITEMS module assumes no prior knowledge of PPMC. However, to get the most out of this module, it might be beneficial to have a basic understanding of:

- Bayesian inference, including familiarity with the concepts of prior and posterior distributions - technical details are not required
- Simple linear regression along with associated model assumptions
- Unidimensional IRT models such as the 1-, 2-, or 3-parameter logistic models along with associated model assumptions

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

- Module 40: An NCME instructional module on IRT item-fit analysis (Ames & Penfield, 2015)
- Module 27: Markov chain Monte Carlo Methods for item response theory models (Kim & Bolt, 2007)

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:

- Explain the rationale behind PPMC for linear regression and IRT models
- Articulate how descriptive statistics (e.g., minimum, mean) and traditional fit statistics for linear regression (e.g., Breusch-Pagan statistic) are used in PPMC
- Articulate how summary statistics (e.g., total score frequency distributions) and traditional item fit statistics for IRT (e.g., difficulty and discrimination indices, Yen's Q_3) are used in PPMC
- Interpret graphical and statistical output to evaluate the fit of linear regression and IRT models
- Apply the PPMC approach in commonly available statistical software such as SAS

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 [*10 Minutes*]
- Section 1: Conceptual Foundations [*20 Minutes*]
- Section 2: PPMC for Linear Regression [*20 Minutes*]
- Section 3: PPMC for IRT [*40 Minutes*]
- Section 4: Linear Regression Data Activity [*30 Minutes*]
- Section 5: IRT Data Activity [*30 Minutes*]
- Section 6: Quizzes [*20 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 with suitable voice-over
- embedded didactic videos to demonstrate software implementations
- interactive quiz questions with diagnostic feedback
- data activity sample data, sample SAS code, and annotated solutions
- glossary of key terms
- supplementary digital resources

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

Content Developers

Allison Ames, *Assistant professor at the University of Arkansas*

Allison is an assistant professor in the Educational Statistics and Research Methods program in the Department of Rehabilitation, Human Resources and Communication Disorders, Research Methodology, and Counseling at the University of Arkansas. There, she teaches courses in educational statistics, including a course on Bayesian inference. Allison received her Ph.D. from the University of North Carolina at Greensboro. Her research interests include Bayesian item response theory, with an emphasis on prior specification; model-data fit; and models for response processes. Her research has been published in prominent peer-reviewed journals. She enjoyed collaborating on this project with a graduate student, senior faculty member, and the Instructional Design Team.

Aaron Myers, *Graduate Assistant at the University of Arkansas*

Aaron is a doctoral student in the Educational Statistics and Research Methods program at the University of Arkansas. His research interests include Bayesian inference, data mining, multidimensional item response theory, and multilevel modeling. Aaron previously received his M.A. in Quantitative Psychology from James Madison University. He currently serves as a graduate assistant where he teaches introductory statistics and works in a statistical consulting lab.

Instructional Design Team

André A. Rupp, *Research Director at the Educational Testing Service (ETS)*

André is a research director in the psychometrics, statistics, and data sciences area at ETS. He is the co-author and co-editor 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); he is currently working on the *Handbook of Automated Scoring*. 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.

Xi Lu, *Doctoral Candidate at Florida State University*

Xi is a doctoral candidate in the Instructional Systems and Learning Technologies program at Florida State University. Her current research interest focuses on designing and developing optimal learning supports to facilitate STEM learning in digital interactive environments. She also works as a research assistant with Dr. Val Shute on an NSF project targeted at designing various learning supports for a 2D physics game called *Physics Playground* to help middle school kids learn physics. Before coming to FSU, Xi taught Chinese for six years in Monterey Bay, California.
