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A Review of *Bayesian Item Response Modeling: Theory and Applications*

Prathiba Natesan
University of North Texas

J.-P. Fox. *Bayesian Item Response Modeling: Theory and Applications*. New York, NY: Springer, 2010. 314 pp., $69.95 (Hardcover). ISBN: 978-1-4419-0741-7.

The primary reason Bayesian methods have become increasingly sought after in educational statistics is their flexibility in evaluating complex models. Bayesian estimation of item response models has been argued to be more advantageous than marginalized maximum likelihood or maximum likelihood because of their ability to estimate parameters for complex data structures, such as hierarchical data or data that violate the basic assumptions of item response theory (IRT), success with smaller samples, no parameter drift, and parameter estimation in extreme response patterns (Albert, 1992; Fox, 2010; Lord, 1986; Swaminathan & Gifford, 1982). Other practical reasons for their increased use include the advent of powerful estimation methods such as Markov chain Monte Carlo (MCMC; Albert, 1992; Patz & Junker, 1999) and the availability of open-access software programs such as R and BUGS that facilitate MCMC estimation. As a result, there is prolific growth in the number of published articles that use Bayesian estimation. This in turn has created a real need for a comprehensive source of information on Bayesian approaches to IRT.

Some other, relatively isolated, works on the topic exist. The classic book, *Item response theory: Parameter estimation techniques* by Baker and Kim (2004) addressed Bayesian estimation in only one chapter. The recently published *Explanatory item response models: A generalized linear and nonlinear approach* edited by De Boeck and Wilson (2004) provided some examples of Bayesian estimation of item response models. However, this text emphasized the formulation of IRT models as generalized linear and nonlinear models and not Bayesian estimation procedures. A psychometrician or an advanced student of psychometrics did not have a comprehensive guide that focused on the Bayesian estimation of all aspects of IRT in detail along with some practical

Correspondence should be directed to Prathiba.natesan@unt.edu.

examples. Fortunately, Fox's (2010) new book, *Bayesian item response modeling: Theory and applications* fits the bill.

After a very brief introduction to IRT models, this clearly written and well-presented book dives right into the Bayesian estimation of IRT models. The reader is expected to have some prior knowledge in IRT, say equivalent to Embretson and Reise (2000) or Hambleton, Swaminathan, and Rogers (1991). The book begins with a brief introduction to Bayesian estimation and proceeds to discuss some basic elements of Bayesian statistics such as priors, MCMC methods, and residual analysis. There is also discussion about the use of Bayesian methods for various aspects of IRT such as item dependence and person fit index. The technical presentation of the Bayesian technique is adequately rigorous but not as mathematically complex as the Baker and Kim text, making it a good read for researchers with some advanced mathematical training. Fox, being an expert in multilevel item response models, does not miss the opportunity to introduce multilevel models and variations including random item effects models and response time models. Compelling evidence showing the advantages and the ease of Bayesian methods in estimating such complex models is presented in the book. All the models are demonstrated using real-world data examples (TIMMS, Cito, etc.) and program codes in WINBUGS and SPlus (only some of which are available on the author's website) which is one more desirable feature. The book also presents a few MCMC sampling schemes for those interested in writing their own Gibbs samplers. The exercises at the end of each chapter help emphasize the concepts introduced in the chapter.

There are some concepts I wish were addressed more in detail for someone without any prior knowledge about Bayesian estimation, such as the effect of different priors, suggested length of chains to run, the concepts of burn-in, thinning and autocorrelation, and convergence statistics/diagnostics. These have been discussed briefly in the text, but not adequately enough to equip a self-study in Bayesian estimation with deeper understanding to aid decisions regarding these concepts in one's own research. A reader with no knowledge in Bayesian methods would benefit from Gelman, Carlin, Stern, and Rubin (2004) as a supplemental text. The author might consider adding the solutions to at least some problems as an appendix in the second edition or on his website so the self-study can check his or her understanding of the concepts. Illustration of how to write one's own Gibbs sampler using the MCMC schemes presented would have been helpful as well, although the instructions in these MCMC schemes are quite useful for someone with good experience in computer programming.

There are few books that can elucidate statistical concepts in the social sciences well and still retain their mathematical rigor. Jean-Paul Fox has certainly managed to accomplish this daunting task. The book is well suited as a course text for advanced or higher level courses in psychometrics. In sum, the book is an excellent presentation that will serve as a "must-read" for any research on Bayesian IRT models.

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