



BOOK REVIEW

Bayesian Statistics for Beginners: A Step-by-Step Approach. Therese M. Donovan and Ruth M. Mickey. 2019. Oxford University Press, Oxford, United Kingdom. 432 pp. \$49.95 paperback. ISBN: 978-0-19-884130-2

Bayesian Statistics for Beginners was written by Therese M. Donovan and Ruth M. Mickey. Believe it or not, the authors do not consider themselves experts in Bayesian statistics. But Ruth Mickey is a statistician in the Department of Mathematics and Statistics at the University of Vermont, and Therese Donovan is a biologist with the Vermont Cooperative Fish and Wildlife Research Unit. They both have educational backgrounds in frequentist and maximum likelihood methods, and are quite honest about their experience and application of Bayesian statistics. While reading this book, I joined the authors on a learning endeavor thanks to their honesty and intellectual vulnerability. Their lack of experience with Bayesian statistics helps them to be effective communicators, especially for beginners faced with learning new statistical approaches, a daunting task for many!

Bayesian Statistics for Beginners was written to answer every question Donovan and Mickey faced during their journey into the world of everything Bayesian. Questions are answered in simple yet explanatory ways. The authors lay out a series of questions and answers and work through detailed examples to ensure the reader thoroughly understands the material.

Bayesian Statistics for Beginners is divided into 20 chapters within 6 sections, each section with 2–5 chapters. Section 1 (Basics of Probability) begins by explaining the basic concept of probability (Chapter 1) and joint, marginal, and conditional probability (Chapter 2). The book starts with basic concepts that may be review material for some readers, but the authors make no assumptions about what the reader may or may not remember. The authors approach the basic concepts by asking and answering questions the reader may have been too embarrassed to ask. In addition to the atypical format, there are an abundance of charts and graphs to help the reader visualize the concepts. Specifically, the authors use Venn diagrams to display probability scenarios in a diagrammatic form.

After covering the basics, the authors introduce Bayes' Theorem and Bayesian Inference in Section 2. Chapters 3 (Bayes' Theorem) and 4 (Bayesian Inference) explain these concepts through a series of questions, whereas chapters 5 (The Author Problem: Bayesian Inference with Two Hypotheses), 6 (The Birthday Problem: Bayesian Inference with Multiple Discrete Hypotheses), and 7 (The Portrait Problem: Bayesian Inference with Joint Likelihood) help cement these concepts by working through problems. The example problems, which focus on non-ecological topics, are interesting and often amusing. Whenever Bayes' Theorem is used, it is color-coded to illustrate the different components. Additionally, conjoint probability tables are

employed to show how the probabilities are related and calculated.

In Section 3, the authors introduce probability functions. Chapter 8 covers probability mass functions (pmf), and Chapter 9 covers probability density functions (pdf). In the chapter on pmf, Donovan and Mickey solve problems using binomial and Bernoulli distributions. In the chapter on pdf, they solve problems using a uniform distribution and a normal (Gaussian) distribution. In Section 4 (Bayesian Conjugates), each chapter contains an example problem for each commonly used conjugate: beta-binomial conjugate (Chapter 10), gamma-Poisson conjugate (Chapter 11), and normal-normal conjugate (Chapter 12). Section 5 (Markov Chain Monte Carlo) revisits the same examples used in Section 4, but this time, the authors show how to estimate the posterior distribution using Markov chain Monte Carlo (MCMC) in Chapters 13 (The Shark Attack Problem Revisited), 15 (The White House Problem Revisited), and 16 (The Maple Syrup Problem Revisited). To teach the reader how to identify issues, Chapter 14 focuses on introducing some common diagnostics for MCMC analysis.

After thoroughly covering the basics with a variety of examples, Section 6 highlights some applications of Bayes' Theory. The authors describe this process in detail and then illustrate applications step-by-step. In Chapter 17 (The Survivor Problem), Donovan and Mickey explain and demonstrate how to conduct parameter estimation for a simple linear regression using MCMC. Chapter 18 (The Survivor Problem Continued) provides a brief introduction to Bayesian model selection. Bayesian belief networks are the topic for Chapter 19. *Bayesian Statistics for Beginners* ends with Chapter 20 (The Once-ler Problem) and the presentation of decision trees and how they can aid in decision-making.

The consistency in style and presentation of each section and chapter is a definite benefit to the reader. For example, each section starts with an overview of its topics. This is particularly useful for readers that may be familiar with some topics on Bayesian statistics, and that may want to skip ahead. Also, each chapter begins with a list of terms that the reader should be able to define by the end of the chapter; this gives the reader a sneak peek at what is to come. Most of the book follows a question-and-answer format, which, although unusual for a textbook, I found helped retain my attention. Throughout each chapter, key information was accentuated by being placed in a box. The authors also cite additional resources and books, providing the reader with options to deepen their understanding of topics not covered in the book.

This book is excellent for beginners in Bayesian statistics but lacks a deeper explanation and application of the concepts. For example, the book does not include any code on how to perform the statistical analyses that are discussed, but the equations are provided to calculate statistics

manually. Although I think it is important to understand the mathematics behind the code, most scientists are not experts at statistical coding, so sample code would jumpstart their actual analyses. If you are looking for a book on understanding the basic mathematics of Bayesian statistics, then this book is for you. But if you are looking to learn how to apply Bayesian statistics to your work, you will need to seek out further resources. This book is a primer to better understand higher level books on the topic.

Although *Bayesian Statistics for Beginners* by no means addresses every aspect of Bayesian statistics, this book is a helpful introduction to the world of Bayesian statistics for a

wide range of audiences. The book thoroughly explains concepts so that a beginner should have a grasp on the concepts and be able to apply them to a variety of problems. If you are interested in starting your Bayesian journey, then *Bayesian Statistics for Beginners* is an excellent place to begin.

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