

The Oxford Handbook of QUANTITATIVE

METHODS VOLUME 1 FOUNDATIONS





YCHOLOGY

Editor-in-Chief PETER E. NATHAN

# The Oxford Handbook of Quantitative Methods

Edited by

Todd D. Little

VOLUME 1: FOUNDATIONS





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An undertaking of this scope calls for handbook editors and chapter authors who are established scholars in the areas about which they write. Many of the

nation's and world's most productive and best-respected psychologists have agreed to edit *Library* handbooks or write authoritative chapters in their areas of expertise.

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Peter E. Nathan Editor-in-Chief Oxford Library of Psychology

# ABOUT THE EDITOR

#### Todd D. Little

Todd D. Little, Ph.D., is a Professor of Psychology, Director of the Quantitative training program, Director of the undergraduate Social and Behavioral Sciences Methodology minor, and a member of the Developmental training program. Since 2010, Todd has been Director of the Center for Research Methods and Data Analysis (CRMDA) at Kansas University. Little is internationally recognized for his quantitative work on various aspects of applied SEM (e.g., indicator selection, parceling, modeling developmental processes) as well as his substantive developmental research (e.g., action-control processes and motivation, coping, and self-regulation). In 2001, Little was elected to membership in the Society for Multivariate Experimental Psychology. In 2009, he was elected President of APA's Division 5 (Evaluation, Measurement, and Statistics) and in 2010 was elected Fellow of the division. In 2012, he was elected Fellow in the Association for Psychological Science. He founded, organizes, and teaches in the internationally renowned KU "Stats Camps" each June (see crmda.KU.edu for details of the summer training programs). Little has edited five books related to methodology including The Oxford Handbook of Quantitative Methods and the Guilford Handbook of Developmental Research Methods (with Brett Laursen and Noel Card). Little has been principal investigator or co-principal investigator on more than 15 grants and contracts, statistical consultant on more than 60 grants and he has guided the development of more than 10 different measurement tools.

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CHAPTER

1

# Introduction

Todd D. Little

#### **Abstract**

In this introductory chapter to The Oxford Handbook of Quantitative Methods, I provide an overview of the two volumes. More specifically, I describe the rationale and motivation for the selected topics that are presented in volumes. I also list out my instructions to the chapter authors and then describe how the chapters fit together into thematic groupings. I also extend my sincerest gratitude to the persons who assisted me along the way, as no work this comprehensive can be done without the considerable help and assistance of many persons. I conclude with how pleased I am with the quality and comprehensiveness of the chapters that are included.

Key Words: Overview; Quantitative Methods; Methodology; Statistics

#### Oxford Introduction

Handbooks provide a crucial venue to communicate the current state of the field. They also provide a one-stop source for learning and reviewing current best practices in a field. The Oxford Handbook of Quantitative Methods serves both of these functions. The field of quantitative methods is quite broad, as you can probably imagine. I have tried to be thorough in my selection of topics to be covered. As with any handbook of this magnitude, some topics were all set to have a contribution submitted, only to have some unforeseen hindrance preclude its inclusion at the last minute (e.g., graphical representations of data, ecological inference, history of quantitative methods). Some topics overlap with others and may not have found their way to become a separate chapter, but their fundamental elements are found in parts of other chapters.

This handbook is one of many that Oxford University Press (OUP) is assembling but will be the capstone methodology handbook. As many of you know, OUP is building a comprehensive and

synthetic Library of Handbooks covering the field of psychology (the Editor-in-Chief of the library is Peter Nathan, University of Iowa Foundation Distinguished Professor of Psychology and Public Health). The library comprises handbooks in the truest sense of the word: books that summarize and synthesize a topic, define the current scholarship, and set the agenda for future research. Each handbook is published as a bound book, and it will also be developed for electronic delivery. In this format, the content will be integrated across topics and available as a fully integrated electronic library. I think the idea of a comprehensive electronic library is very forward-thinking. This format is a very attractive opportunity to have a fully comprehensive and upto-date handbook of methods in our field. Hence, I agreed to take on the role of editor of The Oxford Handbook of Quantitative Methods.

I am very pleased with the quality of the work that each author provided. As per my request to the contributing authors, each chapter is meant to be both accessible and comprehensive; nearly all the authors were very responsive to my requests. The guidelines I asked authors to consider were:

- Handbook chapters should be comprehensive and authoritative; readers will rely heavily on these chapters, particularly when they move to the online format.
- Handbook chapters should present not only the strengths of the topic covered but also any limitations.
- Handbook chapters should make all assumptions underlying the topic explicit.
- Regarding citations, handbook chapters should cover the historical origins as well as the recent renditions of a given key topic.
- Handbook chapters should not present onesided views on any debate; rather, they should report the issues and present the arguments—both pro and con. Authors can direct readers to other platforms where a position piece is presented.
- To facilitate the online linkages, handbook chapters should point to other online resources related to the topic presented.
- Every element of every formula presented must be explicitly explained; assume no knowledge of how to read formulae.
- Examples, examples, and, when in doubt, provide an example! Concrete examples are absolutely critical to communicate quantitative content.
- Avoid jargon and acronyms. Please spell out acronyms, and if you use jargon, please remind the reader of the meaning or definition of the jargon every three to four times it is used; similarly, if you use an acronym, then remind the reader of what it means every three to four times it is used.
- Use active voice, and do not shy away from the use of I/me or we/us. Channel how you lecture on the topic. It will create a crisp and enjoyable read.
- Do not start a sentence with "This" followed by a verb. The referent to "this" must be restated because of the ambiguity this creates. This *general guideline* should be followed as a rule!

Authors, like editors, have preferences and habits, so you will find places, chapters, and so on where some of my admonitions were not followed. But the quality of the product that each chapter provides is nonetheless uncompromised. We have established a Wiki-based resource page for the handbook, which can be found at crmda. KU.edu/oxford. Each author has been asked to maintain and upload materials to

support his or her chapter contribution. At the top of that page is a link that encourages you to offer comments and suggestions on the topics and coverage of the handbook. These comments will be reviewed and integrated into future editions of this handbook. I encourage you, therefore, to take advantage of this opportunity to help shape the directions and content coverage of this handbook.

Statistical software has blossomed with the advent of hardware that provides the necessary speed and memory and programming languages coupled with numerical algorithms that are more efficient and optimized than yesteryear. These software advances have allowed many of the advances in modern statistics to become accessible to the typical end-user. Modern missing data algorithms and Bayesian estimation procedures, for example, have been the beneficiaries of these advances. Of course, some of the software developments have included simplified interfaces with slick graphic user interfaces. The critical options are usually prefilled with default settings. These latter two aspects of advancing software are unfortunate because they lead to mindless applications of the statistical techniques. I would prefer that options not be set as default but, rather, have the software prompt the user to make a choice (and give good help for what each choice means). I would prefer that a complete script of the GUI choices and the order in which steps were taken be automatically saved and displayed.

I have organized the handbook by starting with some basics. It begins with the philosophical underpinnings associated with science and quantitative methods (Haig, Chapter 2, Volume 1) followed by a discussion of how to construct theories and models so that they can be tested empirically and the best model selected (Jaccard, Chapter 5, Volume 1). I then turn to an enlightened discussion of ethics in the conduct of quantitative research (Rosnow & Rosenbloom, Chapter 3, Volume 1) and related issues when quantitative methods are applied in special populations (Widaman, Early, & Conger, Chapter 4, Volume 1). Harlow (Chapter 6, Volume 1) follows with an encompassing and impassioned discussion of teaching quantitative methods.

The theme in the next grouping of chapters centers on measurement issues. First, the late McDonald (Chapter 17, Volume 1) provides a thorough overview of Modern Test Theory. De Ayala (Chapter 8, Volume 1) adds a detailed discussion of Item Response Theory as an essential measurement and analysis tool. After these principles

of measurement are discussed, the principles and practices surrounding survey design and measure development are presented (Spector, Chapter 9, Volume 1). Kingston and Kramer (Chapter 10, Volume 1) further this discussion in the context of high-stakes testing.

A next grouping of chapters covers various design issues. Kelley (Chapter 11, Volume 1) begins this section by covering issues of power, effect size, and sample size planning. Hallberg, Wing, Wong, and Cook (Chapter 12, Volume 1) then address key experimental designs for causal inference: the gold standard randomized clinical trials (RCT) design and the underutilized regression discontinuity design. Some key quasi-experimental procedures for comparing groups are discussed in Steiner and Cooks' (Chapter 13, Volume 1) chapter on using matching and propensity scores. Finally, Van Zandt and Townsend (Chapter 14, Volume 1) provide a detailed discussion of the designs for and analyses of response time experiments. I put observational methods (Ostrov & Hart, Chapter 15, Volume 1), epidemiological methods (Bard, Rodgers, & Mueller, Chapter 16, Volume 1), and program evaluation (Figueredo, Olderbak, & Schlomer, Chapter 17, Volume 1) in with these chapters because they address more collection and design issues, although the discussion of program evaluation also addresses the unique analysis and presentation issues.

I have a stellar group of chapters related to estimation issues. Yuan and Schuster (Chapter 18, Volume 1) provide an overview of statistical estimation method; Erceg-Hurn, Wilcox, and Keselman (Chapter 19, Volume 1) provide a nice complement with a focus on robust estimation techniques. Bayesian statistical estimation methods are thoroughly reviewed in the Kaplan and Depaoli (Chapter 20, Volume 1) contribution. The details of mathematical modeling are synthesized in this section by Cavagnaro, Myung, and Pitt (Chapter 21, Volume 1). This section is completed by Johnson (Chapter 22, Volume 1), who discusses the many issues and nuances involved in conducting Monte Carlo simulations to address the whatwould-happen-if questions that we often need to answer.

The foundational techniques for the statistical analysis of quantitative data start with a detailed overview of the traditional methods that have marked social and behavioral sciences (i.e., the General Linear Model; Thompson, Chapter 2, Volume 2). Coxe, West, and Aiken (Chapter 3,

Volume 2) then extend the General Linear Model to discuss the Generalized Linear Model. This discussion is easily followed by Woods (Chapter 4, Volume 2), who synthesizes the various techniques of analyzing categorical data. After the chapter on configural frequency analysis by Von Eye, Mun, Mair and von Weber (Chapter 5, Volume 5), I then segway into nonparametric techniques (Buskirk, Tomazic, & Willoughby, Chapter 6, Volume 2) and the more specialized techniques of correspondence analysis (Greenacre, Chapter 7, Volume 2) and spatial analysis (Anselin, Murry, & Rey, Chapter 8, Volume 2). This section is capped with chapters dedicated to special areas of research—namely, techniques and issues related to the analysis of imaging data (e.g., fMRI; Price, Chapter 9, Volume 2). The closely aligned worlds of behavior genetics (i.e., twin studies; Blokland, Mosing, Verweij, & Medland, Chapter 10, Volume 2) and genes (Medland, Chapter 11, Volume 2) follows.

The foundations of multivariate techniques are grouped beginning with Ding's (Chapter 12, Volume 2) presentation of multidimensional scaling and Brown's (Chapter 13, Volume 2) summary of the foundations of latent variable measurement models. Hox layers in the multilevel issues as handled in both the manifest regression framework and the latent variable work of structural equation modeling. McArdle and Kadlec (Chapter 15, Volume 2) detail, in broad terms, different structural equation models and their utility. MacKinnon, Kisbu-Sakarya, and Gottschall (Chapter 16, Volume 2) address the many new developments in mediation analysis, while Marsh, Hau, Wen, and Nagengast (Chapter 17, Volume 2) do the same for analyses of moderation.

The next group of chapters focuses on repeated measures and longitudinal designs. It begins with a chapter I co-wrote with Wu and Selig and provides a general overview of longitudinal models (Wu, Selig, & Little, Chapter 18, Volume 2). Deboeck (Chapter 19, Volume 2) takes things further into the burgeoning world of dynamical systems and continuous-time models for longitudinal data. Relatedly, Walls (Chapter 20, Volume 2) provides an overview of designs for doing intensive longitudinal collection and analysis designs. The wonderful world of dynamic-factor models (a multivariate model for single-subject data) is presented by Ram, Brose, and Molenaar (Chapter 21, Volume 2). Wei (Chapter 22, Volume 2) covers all the issues of traditional time-series models and Peterson (Chapter 23,