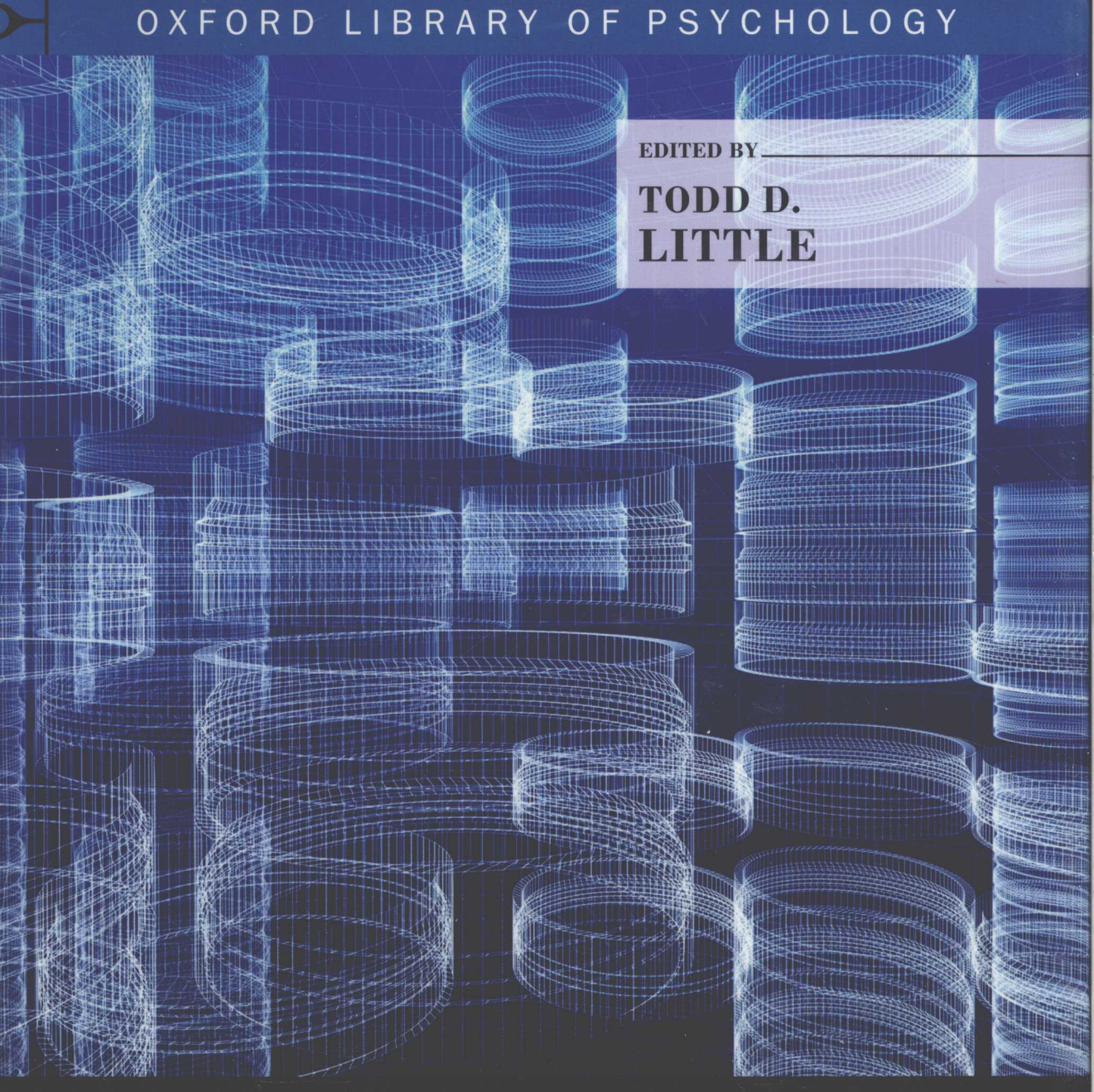


OXFORD LIBRARY OF PSYCHOLOGY

EDITED BY

**TODD D.  
LITTLE**



The Oxford Handbook of  
**QUANTITATIVE  
METHODS** **VOLUME 2**  
**STATISTICAL ANALYSIS**



OXFORD

PSYCHOLOGY

*Editor-in-Chief* PETER E. NATHAN

# The Oxford Handbook of Quantitative Methods

*Edited by*

Todd D. Little

VOLUME 2: STATISTICAL ANALYSIS



OXFORD  
UNIVERSITY PRESS

# OXFORD

UNIVERSITY PRESS

Oxford University Press, Inc., publishes works that further  
Oxford University's objective of excellence in  
research, scholarship, and education.

Oxford New York  
Auckland Cape Town Dar es Salaam Hong Kong Karachi  
Kuala Lumpur Madrid Melbourne Mexico City Nairobi  
New Delhi Shanghai Taipei Toronto

With offices in  
Argentina Austria Brazil Chile Czech Republic France Greece  
Guatemala Hungary Italy Japan Poland Portugal Singapore  
South Korea Switzerland Thailand Turkey Ukraine Vietnam

© 2013 by Oxford University Press, Inc.

Published by Oxford University Press, Inc.  
198 Madison Avenue, New York, New York 10016  
www.oup.com

Oxford is a registered trademark of Oxford University Press

All rights reserved. No part of this publication may be reproduced,  
stored in a retrieval system, or transmitted, in any form or by any means,  
electronic, mechanical, photocopying, recording, or  
otherwise, without the prior permission of Oxford University Press

Library of Congress Cataloging-in-Publication Data  
The Oxford handbook of quantitative methods / edited by Todd D. Little.  
v. cm. — (Oxford library of psychology)

ISBN 978-0-19-993487-4

ISBN 978-0-19-993489-8

1. Psychology—Statistical methods. 2. Psychology—Mathematical models. I. Little, Todd D.

BF39.O927 2012

150.72'1—dc23

2012015005

9 8 7 6 5 4 3 2 1

Printed in the United States of America  
on acid-free paper

## OXFORD LIBRARY OF PSYCHOLOGY

The *Oxford Library of Psychology*, a landmark series of handbooks, is published by Oxford University Press, one of the world's oldest and most highly respected publishers, with a tradition of publishing significant books in psychology. The ambitious goal of the *Oxford Library of Psychology* is nothing less than to span a vibrant, wide-ranging field and, in so doing, to fill a clear market need.

Encompassing a comprehensive set of handbooks, organized hierarchically, the *Library* incorporates volumes at different levels, each designed to meet a distinct need. At one level are a set of handbooks designed broadly to survey the major subfields of psychology; at another are numerous handbooks that cover important current focal research and scholarly areas of psychology in depth and detail. Planned as a reflection of the dynamism of psychology, the *Library* will grow and expand as psychology itself develops, thereby highlighting significant new research that will impact on the field. Adding to its accessibility and ease of use, the *Library* will be published in print and, later on, electronically.

The *Library* surveys psychology's principal subfields with a set of handbooks that capture the current status and future prospects of those major subdisciplines. This initial set includes handbooks of social and personality psychology, clinical psychology, counseling psychology, school psychology, educational psychology, industrial and organizational psychology, cognitive psychology, cognitive neuroscience, methods and measurements, history, neuropsychology, personality assessment, developmental psychology, and more. Each handbook undertakes to review one of psychology's major subdisciplines with breadth, comprehensiveness, and exemplary scholarship. In addition to these broadly conceived volumes, the *Library* also includes a large number of handbooks designed to explore in depth more specialized areas of scholarship and research, such as stress, health and coping, anxiety and related disorders, cognitive development, or child and adolescent assessment. In contrast to the broad coverage of the subfield handbooks, each of these latter volumes focuses on an especially productive, more highly focused line of scholarship and research. Whether at the broadest or most specific level, however, all of the *Library* handbooks offer synthetic coverage that reviews and evaluates the relevant past and present research and anticipates research in the future. Each handbook in the *Library* includes introductory and concluding chapters written by its editor to provide a roadmap to the handbook's table of contents and to offer informed anticipations of significant future developments in that field.

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.

For whom has the *Oxford Library of Psychology* been written? Because of its breadth, depth, and accessibility, the *Library* serves a diverse audience, including graduate students in psychology and their faculty mentors, scholars, researchers, and practitioners in psychology and related fields. Each will find in the *Library* the information they seek on the subfield or focal area of psychology in which they work or are interested.

Befitting its commitment to accessibility, each handbook includes a comprehensive index, as well as extensive references to help guide research. And because the *Library* was designed from its inception as an online as well as a print resource, its structure and contents will be readily and rationally searchable online. Further, once the *Library* is released online, the handbooks will be regularly and thoroughly updated.

In summary, the *Oxford Library of Psychology* will grow organically to provide a thoroughly informed perspective on the field of psychology—one that reflects both psychology's dynamism and its increasing interdisciplinarity. Once published electronically, the *Library* is also destined to become a uniquely valuable interactive tool, with extended search and browsing capabilities. As you begin to consult this handbook, we sincerely hope you will share our enthusiasm for the more than 500-year tradition of Oxford University Press for excellence, innovation, and quality, as exemplified by the *Oxford Library of Psychology*.

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](http://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.

## CONTRIBUTORS

**Leona S. Aiken**

Department of Psychology  
Arizona State University  
Tempe, AZ

**Rawni A. Anderson**

Center for Research Methods  
and Data Analysis  
University of Kansas  
Lawrence, KS

**Luc Anselin**

GeoDa Center for Geospatial Analysis  
and Computation  
School of Geographical Sciences and  
Urban Planning  
Arizona State University  
Tempe, AZ

**Amanda N. Baraldi**

Department of Psychology  
Arizona State University  
Tempe, AZ

**David E. Bard**

Department of Pediatrics  
University of Oklahoma Health Sciences  
Center  
Oklahoma City, OK

**Theodore P. Beauchaine**

Department of Psychology  
Washington State University  
Pullman, WA

**Gabriëlla A.M. Blokland**

Genetic Epidemiology Laboratory  
Queensland Institute of  
Medical Research  
School of Psychology and Centre  
for Advanced Imaging  
University of Queensland  
Brisbane, Australia

**Annette Brose**

Max Plank Institute for Human  
Development  
Berlin, Germany  
Max Plank Institute for Human Cognitive  
and Brain Sciences

**Timothy A. Brown**

Department of Psychology  
Boston University  
Boston, MA

**Trent D. Buskirk**

Department of Community Health-  
Biostatistics Division  
Saint Louis University  
Saint Louis, MO

**Noel A. Card**

Family Studies and Human Development  
University of Arizona  
Tucson, AZ

**Deborah M. Casper**

Family Studies and Human Development  
University of Arizona  
Tucson, AZ

**Daniel R. Cavagnaro**

Department of Psychology  
The Ohio State University  
Columbus, OH

**Rand D. Conger**

Department of Human and Community  
Development  
University of California at Davis  
Davis, CA

**David Cook**

Abt Associates Inc.

**Thomas D. Cook**

Institute for Policy Research  
Northwestern University  
Evanston, IL

**Stefany Coxe**

Department of Psychology  
Arizona State University  
Tempe, AZ

**R.J. de Ayala**

Department of Educational  
Psychology  
University of Nebraska Lincoln  
Lincoln, NE

- Pascal R. Deboeck**  
 Department of Psychology  
 University of Kansas  
 Lawrence, KS
- Sarah Depaoli**  
 Department of Educational Psychology  
 University of Wisconsin Madison  
 Madison, WI
- Cody S. Ding**  
 College of Education  
 University of Missouri-Saint Louis  
 Saint Louis, MO
- M. Brent Donnellan**  
 Department of Psychology  
 Michigan State University  
 East Lansing, MI
- Dawnté R. Early**  
 Department of Human and Community  
 Development  
 University of California at Davis  
 Davis, CA
- Craig K. Enders**  
 Department of Psychology  
 Arizona State University  
 Tempe, AZ
- David M. Erceg-Hurn**  
 School of Psychology  
 University of Western Australia  
 Crawley, WA, Australia
- Aurelio José Figueredo**  
 Department of Psychology  
 School of Mind, Brain, & Behavior  
 Division of Family Studies and Human  
 Development  
 College of Agriculture and Life Sciences  
 University of Arizona  
 Tucson, AZ
- Rafael Antonio Garcia**  
 Department of Psychology  
 School of Mind, Brain, & Behavior  
 University of Arizona  
 Tucson, AZ
- Amanda C. Gottschall**  
 Department of Psychology  
 Arizona State University  
 Tempe, AZ
- Michael J. Greenacre**  
 Department of Economics and Business  
 Universitat Pompeu Fabra, Barcelona  
 Barcelona, Spain
- Brian D. Haig**  
 Department of Psychology  
 University of Canterbury  
 Canterbury, New Zealand
- Kelly Hallberg**  
 Institute for Policy Research  
 Northwestern University  
 Evanston, IL
- Lisa L. Harlow**  
 Department of Psychology  
 University of Rhode Island  
 Kingston, RI
- Emily J. Hart**  
 Department of Psychology  
 University at Buffalo  
 The State University of New York  
 Buffalo, NY
- Kit-Tai Hau**  
 The Chinese University of Hong Kong  
 Hong Kong
- Joop J. Hox**  
 Department of Methodology and Statistics  
 Utrecht University  
 Utrecht, The Netherlands
- James Jaccard**  
 Department of Psychology  
 Florida International University  
 Boca Raton, FL
- Paul E. Johnson**  
 Department of Political Science  
 Kansas University  
 Lawrence, KS
- Kelly M. Kadlec**  
 Department of Psychology  
 University of Southern California  
 Los Angeles, CA
- David Kaplan**  
 Department of Educational  
 Psychology  
 University of Wisconsin-Madison  
 Madison, WI
- Ken Kelley**  
 Department of Management  
 University of Notre Dame  
 Notre Dame, IN
- Harvey J. Keselman**  
 Department of Psychology  
 University of Manitoba  
 Winnipeg, Canada



- Neal M. Kingston**  
 School of Education  
 University of Kansas  
 Lawrence, KS
- Yasemin Kisbu-Sakarya**  
 Department of Psychology  
 Arizona State University  
 Tempe, AZ
- Laura B. Kramer**  
 School of Education  
 University of Kansas  
 Lawrence, KS
- Todd D. Little**  
 Center for Research Methods and Data  
 Analysis  
 Department of Psychology  
 University of Kansas  
 Lawrence, KS
- Richard E. Lucas**  
 Department of Psychology  
 Michigan State University  
 East Lansing, MI
- David P. MacKinnon**  
 Department of Psychology  
 Arizona State University  
 Tempe, AZ
- Patrick Mair**  
 Institute for Statistics and Mathematics  
 Vienna University of Economics  
 and Business  
 Vienna, Austria
- Herbert W. Marsh**  
 Department of Education  
 University of Oxford  
 Oxford, UK
- Katherine E. Masyn**  
 Graduate School of Education  
 Harvard University  
 Cambridge, MA
- John J. McArdle**  
 Department of Psychology  
 University of Southern California  
 Los Angeles, CA
- Roderick P. McDonald<sup>†</sup>**  
 Sydney University  
 Sydney, Australia  
 Professor Emeritus  
 University of Illinois  
 at Urbana-Champaign
- Professor Emeritus  
 Macquarie University  
<sup>†</sup>April 16, 1928 – October, 29, 2011
- Sarah E. Medland**  
 Genetic Epidemiology Laboratory  
 Queensland Institute of Medical Research  
 School of Psychology  
 University of Queensland  
 Brisbane, Australia
- Peter C. M. Molenaar**  
 Department of Human Development  
 and Family Studies  
 Pennsylvania State University  
 University Park, PA
- Alexandre J.S. Morin**  
 Department of Psychology  
 University of Sherbrooke  
 Sherbrooke, Quebec, Canada
- Miriam A. Mosing**  
 Genetic Epidemiology Laboratory  
 Queensland Institute of Medical Research  
 School of Psychology  
 University of Queensland  
 Brisbane, Australia
- Keith E. Muller**  
 Department of Health Outcomes  
 and Policy  
 University of Florida  
 Gainesville, FL
- Eun-Young Mun**  
 Center of Alcohol Studies  
 Rutgers University  
 Piscataway, NJ
- Alan T. Murray**  
 GeoDa Center for Geospatial Analysis  
 and Computation  
 School of Geographical Sciences  
 and Urban Planning  
 Arizona State University  
 Tempe, AZ
- Jay I. Myung**  
 Department of Psychology  
 The Ohio State University  
 Columbus, OH
- Benjamin Nagengast**  
 Department of Education  
 Oxford University  
 Oxford, UK

**Sally Gayle Olderbak**

Department of Psychology  
School of Mind, Brain, &  
Behavior  
University of Arizona  
Tucson, AZ

**Jamie M. Ostrov**

Department of Psychology  
University at Buffalo  
The State University of New York  
Buffalo, NY

**Trond Peterson**

Department of Sociology  
University of California-Berkeley  
Berkeley, CA

**Mark A. Pitt**

Department of Psychology  
The Ohio State University  
Columbus, OH

**Larry R. Price**

College of Education and College of Science  
Texas State University-San Marcos  
San Marcos, TX

**Nilam Ram**

Department of Human Development and  
Family Studies  
Pennsylvania State University  
University Park, PA  
Max Plank Institute for Human  
Development  
Berlin, Germany

**Sergio J. Rey**

GeoDa Center for Geospatial Analysis  
and Computation  
School of Geographical Sciences and  
Urban Planning  
Arizona State University  
Tempe, AZ

**Joseph L. Rodgers**

Department of Psychology  
University of Oklahoma  
Norman, OK

**Robert Rosenthal**

Department of Psychology  
University of California, Riverside  
Riverside, CA

**Ralph L. Rosnow**

Department of Psychology  
Temple University  
Philadelphia, PA

**André A. Rupp**

Department of Measurement, Statistics,  
and Evaluation (EDMS)  
University of Maryland  
College Park, MD

**Gabriel Lee Schlomer**

Division of Family Studies and  
Human Development  
College of Agriculture and Life Sciences  
University of Arizona  
Tucson, AZ

**Christof Schuster**

Department of Psychology  
Justus-Liebig-Universität Giessen  
Giessen, Germany

**James P. Selig**

Department of Psychology  
University of New Mexico  
Albuquerque, NM

**Paul E. Spector**

Department of Psychology  
University of South Florida  
Tampa, FL

**Peter M. Steiner**

Department of Educational Psychology  
University of Wisconsin-Madison  
Madison, WI

**Carolyn Strobl**

Ludwig-Maximilians-Universität  
München Faculty of Mathematics,  
Informatics and Statistics Institute  
of Statistics  
Munich, Germany

**Bruce Thompson**

Baylor College of Medicine  
Austin, TX

**Terry T. Tomazic**

Department of Sociology and  
Criminal Justice  
Saint Louis University  
Saint Louis, MO

**James T. Townsend**

Department of Psychological and  
Brain Sciences  
Indiana University  
Bloomington, IN

**Trisha Van Zandt**

Department of Psychology  
The Ohio State University  
Columbus, OH

**Alexander von Eye**

Departments of Psychology  
Michigan State University  
East Lansing, MI  
University of Vienna  
Vienna, Austria

**Stefan von Weber**

Department of Mechanical Engineering  
Hochschule Furtwangen University  
Furtwangen im Schwarzwald, Germany

**Karin J.H. Verweij**

Genetic Epidemiology Laboratory  
Queensland Institute of Medical Research  
School of Psychology  
University of Queensland  
Brisbane, Australia

**Theodore A. Walls**

Department of Behavioral Science  
University of Rhode Island  
Kingston, RI

**Lihshing Leigh Wang**

Educational Studies Program  
University of Cincinnati  
Cincinnati, OH

**Amber S. Watts**

Center for Research Methods and Data  
Analysis and  
Lifespan Institute, Gerontology Center  
University of Kansas  
Lawrence, KS

**William W.S. Wei**

Department of Statistics  
Temple University  
Philadelphia, PA

**Zhonglin Wen**

South China Normal University

**Stephen G. West**

Department of Psychology  
Arizona State University  
Tempe, AZ

**Keith F. Widaman**

Department of Psychology  
University of California at Davis  
Davis, CA

**Rand R. Wilcox**

Department of Psychology  
University of Southern California  
Los Angeles, CA

**Lisa M. Willoughby**

Department of Psychology  
Saint Louis University  
Saint Louis, MO

**Coady Wing**

Institute for Policy Research  
Northwestern University  
Evanston, IL

**Pedro Sofio Abril Wolf**

Department of Psychology  
University of Cape Town  
Cape Town, South Africa

**Vivian Wong**

School of Education and Social Policy  
Northwestern University  
Evanston, IL

**Carol M. Woods**

Center for Research Methods and  
Data Analysis and  
Department of Psychology  
University of Kansas  
Lawrence, KS

**Wei Wu**

Center for Research Methods and  
Data Analysis and  
Department of Psychology  
University of Kansas  
Lawrence, KS

**Ke-Hai Yuan**

Department of Psychology  
University of Notre Dame  
Notre Dame, IN

## SHORT CONTENTS

Oxford Library of Psychology vii

About the Editor ix

Contributors xi

Table of Contents xvii

Chapters 1–758

Index 759

# CONTENTS

1. Introduction 1  
*Todd D. Little*
2. Overview of Traditional/Classical Statistical Approaches 7  
*Bruce Thompson*
3. Generalized Linear Models 26  
*Stefany Coxo, Stephen G. West, and Leona S. Aiken*
4. Categorical Methods 52  
*Carol M. Woods*
5. Configural Frequency Analysis 74  
*Alexander von Eye, Eun-Young Mun, Patrick Mair, and Stefan von Weber*
6. Nonparametric Statistical Techniques 106  
*Trent D. Buskirk, Lisa M. Willoughby, and Terry J. Tomazic*
7. Correspondence Analysis 142  
*Michael J. Greenacre*
8. Spatial Analysis 154  
*Luc Anselin, Alan T. Murray, and Sergio J. Rey*
9. Analysis of Imaging Data 175  
*Larry R. Price*
10. Twin Studies and Behavior Genetics 198  
*Gabriëlla A. M. Blokland, Miriam A. Mosing, Karin J. H. Verweij, and Sarah E. Medland*
11. Quantitative Analysis of Genes 219  
*Sarah E. Medland*
12. Multidimensional Scaling 235  
*Cody S. Ding*
13. Latent Variable Measurement Models 257  
*Timothy A. Brown*
14. Multilevel Regression and Multilevel Structural Equation Modeling 281  
*Joop J. Hox*
15. Structural Equation Models 295  
*John J. McArdle and Kelly M. Kadlec*

16. Developments in Mediation Analysis 338  
*David P. MacKinnon, Yasemin Kisbu-Sakarya, and Amanda C. Gottschall*
17. Moderation 361  
*Herbert W. Marsh, Kit-Tai Hau, Zhonglin Wen, Benjamin Nagengast, and Alexandre J.S. Morin*
18. Longitudinal Data Analysis 387  
*Wei Wu, James P. Selig, and Todd D. Little*
19. Dynamical Systems and Models of Continuous Time 411  
*Pascal R. Deboeck*
20. Intensive Longitudinal Data 432  
*Theodore A. Walls*
21. Dynamic Factor Analysis: Modeling Person-Specific Process 441  
*Nilam Ram, Annette Brose, and Peter C. M. Molenaar*
22. Time Series Analysis 458  
*William W.S. Wei*
23. Analyzing Event History Data 486  
*Trond Petersen*
24. Clustering and Classification 517  
*André A. Rupp*
25. Latent Class Analysis and Finite Mixture Modeling 551  
*Katherine E. Masyn*
26. Taxometrics 612  
*Theodore P. Beauchaine*
27. Missing Data Methods 635  
*Amanda N. Baraldi and Craig K. Enders*
28. Secondary Data Analysis 665  
*M. Brent Donnellan and Richard E. Lucas*
29. Data Mining 678  
*Carolin Strobl*
30. Meta-Analysis and Quantitative Research Synthesis 701  
*Noel A. Card and Deborah M. Casper*
31. Common Fallacies in Quantitative Research Methodology 718  
*Lihshing Leigh Wang, Amber S. Watts, Rawni A. Anderson, and Todd D. Little*
- Index 759



# 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 the 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 up-to-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 one-sided 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, 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](http://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 7, Volume 1) provides a thorough overview of Modern Test Theory.<sup>1</sup> 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, Garcia, & Wolf, 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 Cavagnara, 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 what-would-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). Cox, 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 2), 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 11, Volume 2) and genes (Medland, Chapter 10, 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 (Chapter 14, Volume 2) 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, Volume 2) rounds out this section with a thorough coverage of event history models.