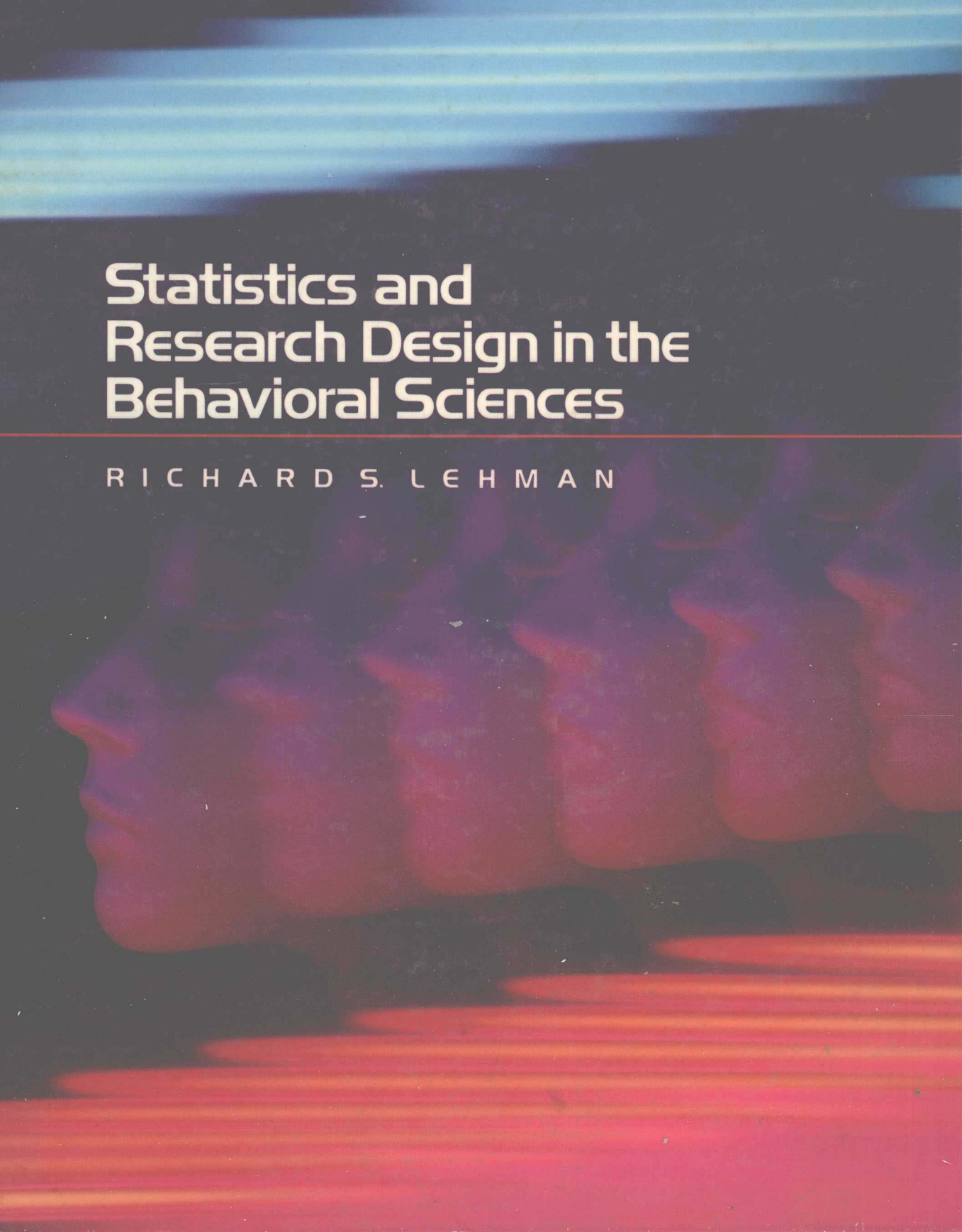
Statistics and Research Design in the Behavioral Sciences

RICHARD S. LEHMAN



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Compositor: Asco Trade Typesetting Ltd., Hong Kong
Cover Photo: © 1988 Larry Hamill
Signing Representative: Jim Brace Thompson

Credits appear on page 562.

Printed in the United States of America 18

1 2 3 4 5 6 7 8 9 10—95 94 93 92 91

Library of Congress Cataloging-in-Publication Data

Lehman, Richard S.
Statistics and research design in the behavioral sciences / Richard S. Lehman.
p. cm.
Includes bibliographical references and index.
ISBN 0-534-13878-0
1. Psychology—Statistical methods. 2. Psychology—Research—Methodology.
I. Title.
BF39.L34 1991
150'.72—dc20 90-36704

PREFACE

Many years ago, when I was finishing graduate school and interviewing for faculty positions, I was often asked whether I would prefer to teach a course in statistics or one in research methods. I have always had trouble answering that question, because to me the two topics are so completely intertwined as to make their separation difficult and confusing to students. In the traditional curriculum, the "methods" course presents ways to set up research, and the "statistics" course addresses how to analyze the data that come from research. Why not, I wondered, just have a single course that teaches students both how to ask questions by using good research design and how to answer questions by using the appropriate statistics? Fortunately, I found a faculty position that didn't force me to decide between the two courses, and I have been teaching a single combined course for 25 years.

I've always had to use two texts to teach my combined course, because no single book has adequately presented research methods and statistics. I hope that *Statistics and Research Design in the Behavioral Sciences* addresses that problem. Here you will find all of the usual topics from the "methods" course, as well as all those from the "statistics" course. They are combined into a single volume in a way that makes sense to me and to my students. Presenting the complementary topics of research design and analysis together helps students learn that the research enterprise is a unified undertaking and that it is not separate processes of collecting data and then analyzing them.

Features

- Research methods and statistics are developed together. The emphasis is on how each method addresses certain kinds of research questions and how the statistics help answer those questions. In every case, the logic of a particular method is discussed first, and then the appropriate analysis is presented conceptually and computationally.
- The mechanics of doing research—from getting ideas to analyzing data to interpreting and presenting the results—are developed in an integrated way.
- Classical experimental designs are developed in a logical progression, from the simplest single-sample procedure through complex analysis of variance designs, showing how the different designs are interrelated.
- Survey research, quasi-experiments, and other research strategies are covered, and their strengths and weaknesses outlined.
- Measurement theory is developed carefully and its relationship to both research questions and statistical answers is clarified.
- Analysis of variance is presented thoroughly, because it is the most widely

used general research strategy in the behavioral sciences. One-way designs, both between and within subjects, and two-factor designs (between subjects, within subjects, and mixed) are given full treatment. Follow-up tests are given for all ANOVA computations.

- The anxiety with which many students approach the design and statistics course is directly addressed. The writing is relaxed, informal, and nonmathematical in style. In addition, many of the illustrations use sets of actual data addressing nontrivial questions, supplied by my colleagues. Each researcher is introduced by a short biography so that students are exposed to real research workers in a personal way.

Organization

The book is arranged in four major sections. Part One begins with a discussion of the nature of research and theory in the behavioral sciences. Chapters 2–4 are devoted to research methods, measurement theory and procedures, and ways of controlling and manipulating variables. The underlying theme in Part One is how to ask questions by establishing the setting in which data can be collected.

Part Two introduces univariate and bivariate descriptive statistics. These statistics are presented as ways of finding answers, in data, to the questions posed by virtue of the research design. Graphic methods are presented first, and then the usual univariate descriptive statistics are given careful treatment. Correlation and regression are developed as descriptive methods for two variables.

When the classical experimental designs are developed in Part Three, they are shown to provide a structured way of posing questions and analyzing data. The presentation of experimental design begins with single-group studies, progresses through single-factor experiments, and concludes with the full treatment of factorial designs.

Part Four presents alternative ways of carrying out research. The treatment of categorical data is covered fully here. In addition, research using single subjects, quasi-experiments, case studies, surveys, and archival and small-N research are discussed.

Order of Presentation

Anyone who writes a textbook must choose an order for the topics; the users must then decide whether to use the author's order or provide their own. Some parts of this book offer flexibility in reordering the material, while others are more rigidly ordered. Chapters 1–4 are written cumulatively, so that each chapter depends critically upon previous material. Similarly, the univariate descriptive statistics (Chapters 5–8) are developed cumulatively. But the correlation and regression material, presented here as bivariate descriptive statistics (Chapters 9 and 10), could easily be studied out of sequence.

The classical design material (Part Three) is tightly integrated, and most instructors will probably want to teach this unit in the order presented, with one exception. The one-way within-subjects design (Chapter 17) is presented *before*

the between-subjects factorial experiment (Chapters 18 and 19). This nonstandard ordering permits complete development of the single-factor experimental design in all of its guises *before* the factorial is introduced. The order of those chapters can easily be changed to put the between-subjects factorial in its customary place—before the first repeated-measures design.

The final two chapters are self-contained and may easily be moved. Some instructors may wish to introduce the material on other research methods (Chapter 22) earlier, perhaps following Chapters 1–4, so that all of the methods material is together. Similarly, the Chi-square topics in Chapter 21 can easily be moved from their present position to anywhere after the development of inferential logic in Chapters 12 and 13.

Some Pedagogical Matters

The book is intended for a 5- or 6-credit one-semester course, or for a two-quarter or a two-semester sequence in research methods and statistics. It presupposes no background in mathematics beyond high school algebra and geometry and does not rely upon any content prerequisite. It can profitably be used by students who have had only an introductory course in psychology.

Nearly every chapter includes exercises. Solutions to roughly half of the exercises are provided at the back of the book, and a supplementary answer book provides the rest. Since I believe that students don't really understand a set of data and its analysis if they can't describe it, many of the exercises ask that the results be communicated in written form, often using the American Psychological Association format.

This book recognizes that most statistical arithmetic is done by computer in the "real" research world. But it is not a computer-dependent text. No computer is necessary for any of the material, except for some optional exercises, and no computer output is pictured. Complete computations are given and illustrated for all statistics. Statistical materials are always first presented conceptually and then the computations are illustrated. In this way, instructors who choose to have their students use computers may omit the hand calculations with no loss of continuity.

For the student with access to a computer, there are numerous computer-based exercises. Some of them merely ask that the student repeat a previous analysis using a computer. Others, though, use the computer to expand on illustrations and concepts. No particular computer program is assumed by these optional exercises, and no instruction in computer use is offered.

The book offers somewhat more statistical coverage than is the norm for an undergraduate first course. Among the more unusual topics covered are tests for correlations, variances, medians, and proportions. Also slightly unusual are the extensive treatments given to within-subjects and mixed-factorial designs and to follow-up tests for every analysis of variance design. In addition, the chapter on regression offers careful development of residuals and the logic of r^2, as well as a brief conceptual introduction to multiple regression. Although no detail is provided on multiple regression, the student is introduced to the concept and may be motivated to further explore it on an available computer program.

Acknowledgments

I want to recognize assistance from several sources. First, Franklin & Marshall College, through its sabbatical leave program, made it possible for me to accomplish the bulk of the actual writing free of many academic duties. Alan Levine helped me plot several distribution forms. N. John Castellan Jr. advised me on some of the materials in Chapter 21. My departmental colleagues Chuck Stewart, Don Tyrrell, Tim Hubbard, Ed Hass, John Campbell, and Fred Owens all provided data sets.

I want to thank three authors for setting good examples of clear, readable, technical writing: Donald Knuth, Geoffrey Keppel, and David Howell. All have written beautiful expositions of difficult material—in computer science and in statistics. They offer proof that despite difficult subject matter, writing can still be understandable, graceful, and, yes, even humorous. In addition, the late Richard V. Andree taught me more about good writing in a one-page handout than any number of courses could have. If the writing in this book rises above the stuffy prose that's common in this kind of material, those men are due some of the credit.

Over the years, my family has learned to understand the writer in the house. My wife, Jean, has endured late hours, no weekends, abbreviated summer vacations, scant help in her studio, and endless uncompleted home repairs, all in the name of progress on The Book. My daughter, Barbara, has grown from a child, drawing with flowchart templates while I was writing an early simulation book, to a young adult, complaining that this book comes a semester too late for her to use it as a text. I very much appreciate their love, tolerance, and support.

Several reviewers of early versions of the manuscript helped to shape it in various ways. I especially want to thank Cole Barton, Davidson College, University of California, San Francisco; Fred Fidura, SUNY, Geneseo; Timothy Goldsmith, University of New Mexico; Donald Kendrick, Middle Tennessee State University; Willard Larkin, University of Maryland, College Park; Lee Sechrest, University of Arizona; Kirk Smith, Bowling Green State University; and Michael Wogalter, Rensselaer Polytechnic Institute. I wish I could blame them for inadequacies in the book, but those are my responsibility, sometimes because I ignored their advice. Ken King at Wadsworth recognized the worth of this project (if not its original expression) and he, together with production editor Donna Linden, worked hard to help me bring it into shape. Thank you.

Richard Lehman
Lancaster, PA

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PART ONE

Some Research Fundamentals

Psychology is the science that studies behavior. It seeks to understand why we behave as we do and why others behave as they do. It asks questions about behavior in an attempt to understand and explain it. And it seeks answers to its questions by conducting research. In broader terms, science is the process of asking questions and answering them. This book is about that process as it is used in psychology.

Doing research—the process of asking and answering questions—relies on certain skills. Among those skills are the understanding of and the ability to use a variety of research methods and techniques. Many of those methods and techniques are statistical—they allow us to describe research results and to make inferences about similar behavior in similar situations.

In Part One of this book, we begin the study of research methods in psychology by looking at some fundamental considerations. Chapter 1 discusses the nature of science and scientific research. Chapter 2 introduces most of the common research strategies in psychology and discusses some of the mechanics of actually doing research. Then Chapter 3 discusses measurement, which is a fundamental for all research.