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STATISTICS
AND DATA
ANALYSIS
FOR THE
BEHAVIORAL
SCIENCES

DANA S. DUNN

STATISTICS AND DATA ANALYSIS FOR THE BEHAVIORAL SCIENCES

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Moravian College



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STATISTICS AND DATA ANALYSIS FOR THE BEHAVIORAL SCIENCES

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PREFACE

In my view statistics has no reason for existence except as a catalyst for learning and discovery.

— GEORGE BOX

This quotation serves as the guiding rationale for this book and, I hope, provides an outlook for teaching and learning about statistics. From the main content to the pedagogical aids and end-of-the-chapter exercises, this textbook fosters learning and discovery. As students learn how to perform calculations and interpret the results, they will discover new ways to think about the world around them, uncover previously unrecognized relationships among disparate variables, and make better judgments about how and why people behave the way they do.

Statistics and Data Analysis for the Behavioral Sciences teaches the theory behind statistics and the analysis of data through a practical, hands-on approach. Students will learn the “how to” side of statistics: how to select an appropriate test, how to collect data for research, how to perform statistical calculations in a step-by-step manner, how to be intelligent consumers of statistical information, and how to write up analyses and results in American Psychological Association (APA) style. Linking theory with practice will help students retain what they learn for use in future behavioral science courses, research projects, graduate school, or any career where problem solving is used. Combining statistics with data analysis leads to a practical pedagogical goal—helping students to see that both are tools for intellectual discovery that examine the world and events in it in new ways.

■ To the Student

Two events spurred me to write this book, and I want you to know that I wrote it with students foremost in my mind. First, I have taught statistics for over 12 years. In that time, I’ve come to believe that some students struggle with statistics and quantitative material simply because it is not well presented by existing textbooks. Few authors, for example, adequately translate abstract ideas into concrete terms and examples that can be easily understood. Consequently, as I wrote this book, I consciously tried to make even the most complex material as accessible as possible. I also worked to develop applications and asides that bring the material to life, helping readers to make connections between abstract statistical ideas and their concrete application in daily life.

Second, the first statistics course that I took as an undergraduate was an unmitigated disaster, really, a nightmare—it was dull, difficult, and daunting. I literally had no idea what the professor was talking about, nor did I know how to use statistics for any purpose. I lost that battle but later won the war by consciously trying to think about how statistics and the properties of data reveal themselves in everyday life. I came to appreciate the utility and even—dare I say it—the beauty of statistics. In doing so, I also vowed that when I became a professor, no student of mine would suffer the pain and intellectual doubt that I did as a first-time statistics student. Thus, I wrote this book with my unfortunate “growing” experience in mind. I never want anyone in my classes or using my book to feel the anxiety that I did and, though it is a cliché, I think that the book is better because of my trying first experience.

How can you ensure that you will do well in your statistics class? Simple: Attend classes, do the reading, do the homework, and review what you learn regularly. Indeed, it is a very good idea to reserve some meaningful period of time *each day* for studying statistics and data analysis (yes, I am quite serious). When you do not understand something mentioned in this book or during class, ask the instructor for clarification *immediately*, not later, when your uncertainty has had time to blossom into full-blown confusion (remember my first experience in a statistics class—I know whereof I speak). Remember, too, the importance of reminding yourself that *statistics is for something*. You should be able to stop at any given point in the course of performing a statistical test in order to identify what you are doing, why, and what you hope to find out by using it. If you cannot do so, then you must backtrack to the point where you last understood what you were doing and why; to proceed without such understanding is not only a waste of time, it is perilous, even foolhardy, and will not help you to comprehend the material. By the way, if you feel that you need a review of basic mathematics, Appendix A provides one, including some helpful ideas on dealing with math anxiety.

Beyond these straightforward steps, you should also take advantage of the pedagogical tools I created for this book. They are reviewed in detail in the *To the Instructor* section, and I suggest you take a look at their descriptions below. I do, however, take the time to explain these tools and their use *as they appear* in the first few chapters of the book. I urge you to take these devices seriously, to see them as complementary to and not replacements for your usual study habits. I promise you that your diligence will have a favorable payoff in the end—actual understanding, reduced anxiety, and probably a higher grade than you expected when you first began the class.

■ To the Instructor

This book was written for use in a basic, first, non-calculus-based statistics course for undergraduate students in psychology, education, sociology, or one of the other behavioral sciences. I assume little mathematical sophistication, as any statistical procedure is presented conceptually first, followed by calculations demonstrated in a step-by-step manner. Indeed, it is important for both students and instructors to remember that statistics is *not* mathematics, nor is it a subfield of mathematics (Moore, 1992).

This book has a variety of pedagogical features designed to make it appeal to instructors of statistics (as well as students) including the following:

Decision Trees. Appearing on the opening page of each chapter, these very simple flow charts identify the main characteristics of the descriptive or inferential procedures reviewed therein, guiding readers through what a given test *does* (e.g., mean comparison), *when* to use it (i.e., to what research designs does it apply), and *what* sort of data it analyzes (e.g., continuous). At the close of each chapter, readers are reminded to rely

on the decision trees in a section called “Looking forward, then back.” A special icon () prompts them to recall the features found in the decision tree(s) opening the chapters.

Key Terms and Concepts. Key terms (e.g., mean, variance) and concepts (e.g., random sampling, central limit theorem) are highlighted throughout the text to gain readers’ attention and to promote retention. An alphabetical list of key terms (including the page number where each is first cited) appears at the end of every chapter.

Marginal Notes. The reader’s attention will occasionally be drawn by marginal notes—key concepts, tips, suggestions, important points, and the like—appearing in the margins of the text. An icon  drawn from the book’s cover design identifies these brief marginal notes.

Straightforward Calculation of Descriptive and Inferential Statistics by Hand. Statistical symbols and notation are explained early in the book (chapter 1). All of the descriptive and inferential statistics in the book are presented conceptually in the context of an example, and then explained in a step-by-step manner. Each step in any calculation is numbered for ease of reference (example: [2.2.3] refers to chapter 2, formula 2, step 3). Readers who have access to a basic calculator can do any statistical procedure presented in the book. Naturally, step-by-step advice also teaches students to read, understand, and use statistical notation as well as the statistical tables presented in Appendix B. Appendix A reviews basic mathematics and algebraic manipulation for those students who need a self-paced refresher course. The second half of Appendix A discusses math anxiety, providing suggestions and references to alleviate it.

Data Boxes. Specific examples of published research or methodological issues using germane statistical procedures or concepts appear in Data Boxes throughout the text. By reading Data Boxes, students learn ways in which statistics and data analysis are tools to aid the problem solver. To quote Box, they are tools for “learning and discovery.”

Focus on Interpretation of Results and Presenting Them in Written Form. All statistical procedures conclude with a discussion of how to interpret what a result *actually* means. These discussions have two points: what the test literally concludes about some statistical relationship in the data and what it means descriptively—how did participants behave in a study, what did they do? The focus then turns to clearly communicating results in prose form. Students will learn how to put these results into words for inclusion in American Psychological Association (APA) style reports or draft articles. I used this approach successfully in a previous book (Dunn, 1999). Appendix C, which provides a brief overview of writing APA style reports, gives special emphasis to properly presenting research results and statistical information.

Statistical Power, Effect Size, and Planned and Post Hoc Comparisons. Increasingly, consideration of statistical power and effect size estimates is becoming more commonplace in psychology textbooks as well as journals. I follow this good precedent by attaching discussion of the strength of association of independent to dependent variables along with specific inferential tests (e.g., estimated omega-squared— $\hat{\omega}^2$ —is presented with the *F* ratio). In the same way, review of planned or post hoc comparisons of means are attached to discussions of particular tests. I focus on conceptually straightforward approaches for doing mean comparisons (e.g., Tukey’s Honestly Significant Difference

[HSD] test), but I also discuss the important—but often neglected—perspectives provided by contrast analysis (e.g., Rosenthal & Rosnow, 1985).

Knowledge Base Concept Checks. Periodically, readers encounter digressions within each chapter called “Knowledge Bases,” as in “students will add to their statistical knowledge base.” Any Knowledge Base provides a quick concept check for students. In lieu of a diagnostic quiz, readers can think about and then answer a few questions dealing with the key points in the chapter section they just finished reading (these exercises will obviously help pace the students’ reading of conceptually challenging material, as well). Completion of each Knowledge Base in the book will incrementally add to their knowledge base of statistical concepts and data analysis techniques. Answers to Knowledge Base questions are provided immediately after the questions.

Project Exercises. Each chapter contains a “Project Exercise,” an activity that applies or extends issues presented therein. Project Exercises are designed to give students the opportunity to think about how statistical concepts can actually be employed in research or to identify particular issues that can render data analysis useful for the design of experiments or the interpretation of behavior. On occasion, a chapter’s Project Exercise might be linked to a Data Box.

End-of-Chapter Problems. Each chapter in the text concludes with a series of problems. Most problems require traditional numerical answers, but many are designed to help students think coherently and write cogently about the properties of statistics and data. Answers to the odd-numbered problems are provided in the back of the textbook in Appendix E.

Special Appendixes. Beyond the traditional appendixes devoted a review of basic math (with suggestions about combating math anxiety; Appendix A), statistical tables (Appendix B), and answers to odd-numbered end-of-chapter problems (Appendix E), I also include three more specialized offerings. Appendix C presents guidance on writing up research in APA style, highlighting specific ways to write and cogently present statistical results. Advice on organizing a research project using statistics and data analysis is presented in Appendix D. I emphasize the importance of being organized, how to manage time, and—most importantly—how to prepare raw data for analysis in this appendix. Finally, Appendix F introduces qualitative research approaches as emerging alternatives—not foils—for the statistical analysis of data. Though by no means commonplace, such approaches are gradually being accepted as new options—really, opportunities—for researchers.

■ Supplements

Statistics and Data Analysis for the Behavioral Sciences has several supplements designed to help both instructors and students. These supplements include:

Elementary Data Analysis Using Microsoft Excel by Mehan and Warner (2000). This easy to use workbook introduces students to Microsoft Excel spreadsheets as a tool to be used in introductory statistics courses. By utilizing a familiar program such as Excel, students can concentrate more on statistical concepts and outcomes and less on the mechanics of software.

Instructor's Manual and Test Bank. The book has a detailed *Instructor's Manual* (IM) and Test Bank (TB). The IM includes syllabus outlines for one- or two-semester statistics courses, detailed chapter outlines, key terms, lecture suggestions, suggestions for classroom activities and discussions, film recommendations (where available and appropriate), and suggested readings for the instructor (i.e., articles and books containing teaching tips, exercises). The TB contains test items (i.e., multiple choice items, short essays, problems), and is also available on computer diskette for PC and Macintosh.

Dedicated Website. The book has a dedicated website (www.mhhe.com.dunn) so that potential instructors can examine a synopsis of the book, its table of contents, descriptions of the available supplements, and ordering information. Links to other sites on the Web related to statistics, data analysis, and psychology (including links to other parts of the McGraw-Hill site) are available. In addition, portions of the *Instructor's Manual* and Test Bank appear on the website and are "password" accessible to instructors who have selected the text and their students. The website also has an online SPSS guide, which is an alternative to the expensive printed guides. Beginning with computing a correlation between two variables and continuing with *t* tests, ANOVAs, and chi-square, this site will help your students understand the basics of the SPSS program.

Study Guide for Statistics and Data Analysis for the Behavioral Sciences. Instructors (or students) can order a study guide to accompany *Statistics and Data Analysis for the Behavioral Sciences*. The *Study Guide* contains a review of key terms, concepts, and practice problems designed to highlight statistical issues. Answers to any problems will be provided in the back of the *Study Guide*.



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This is the second book I have written with the McGraw-Hill College Division, and I remain convinced that the professionals who work there are rare and true. I hope our relationship is a long one. My editor and friend, Joe Terry, established the project's vision, and then developmental editor, Susan Kunchandy, helped to move it forward. Editorial director Jane Vaicunas continued to show confidence in my work. Barbara Santoro—a tireless and dedicated individual—answered all my queries, organized endless details, and provided help at every turn. Marketing manager Chris Hall provided sage advice about the book's development in its later stages. Project manager Susan Brusch steered the book (and me) skillfully through the production schedule. Wayne Harms created the book's elegant and clear design. Finally, I am grateful to copy editor, Pat Steele, for consistently improving my prose.

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READER RESPONSE

No book can satisfy every reader, but every author makes a genuine effort to try, anyway, and I am no different. I welcome your comments to this first edition of *Statistics and Data Analysis for the Behavioral Sciences*. I pledge to listen carefully to critical reactions as well as any compliments, using both to improve this book's pedagogy in the future. I encourage you to take a moment, log on to www.mhhe.com/dunn and complete the short questionnaire found on this website. Your questionnaire will be e-mailed to the publisher, who will share with me. You may also contact me directly at the Department of Psychology, Moravian College, 1200 Main Street, Bethlehem, PA 18018-6650; via e-mail: dunn@moravian.edu. I sincerely look forward to hearing from you.



CONTENTS IN BRIEF

Preface

Acknowledgments

- 1** INTRODUCTION: STATISTICS AND DATA ANALYSIS AS TOOLS FOR RESEARCHERS 3
- 2** PROCESS OF RESEARCH IN PSYCHOLOGY AND RELATED FIELDS 45
- 3** FREQUENCY DISTRIBUTIONS, GRAPHING, AND DATA DISPLAY 85
- 4** DESCRIPTIVE STATISTICS: CENTRAL TENDENCY AND VARIABILITY 133
- 5** STANDARD SCORES AND THE NORMAL DISTRIBUTION 177
- 6** CORRELATION 205
- 7** LINEAR REGRESSION 241
- 8** PROBABILITY 273
- 9** INFERENCE STATISTICS: SAMPLING DISTRIBUTIONS AND HYPOTHESIS TESTING 315
- 10** MEAN COMPARISON I: THE t TEST 365
- 11** MEAN COMPARISON II: ONE-VARIABLE ANALYSIS OF VARIANCE 411
- 12** MEAN COMPARISON III: TWO-VARIABLE ANALYSIS OF VARIANCE 459
- 13** MEAN COMPARISON IV: ONE-VARIABLE REPEATED-MEASURES ANALYSIS OF VARIANCE 499
- 14** SOME NONPARAMETRIC STATISTICS FOR CATEGORICAL AND ORDINAL DATA 523
- 15** CONCLUSION: STATISTICS AND DATA ANALYSIS IN CONTEXT 563

Appendix A: Basic Mathematics Review and Discussion of Math Anxiety A-1

Appendix B: Statistical Tables B-1

Appendix C: Writing Up Research in APA Style: Overview and Focus on Results C-1

Appendix D: Doing a Research Project Using Statistics and Data Analysis: Organization, Time Management, and Prepping Data for Analysis D-1

Appendix E: Answers to Odd-Numbered End of Chapter Problems E-1

Appendix F: Emerging Alternatives: Qualitative Research Approaches F-1

References R-1

Credits CR-1

Name Index NI-1

Subject Index SI-1



CONTENTS

Preface xix

Acknowledgments xxiv

Reader Response xxvi

1 INTRODUCTION: STATISTICS AND DATA ANALYSIS AS TOOLS FOR RESEARCHERS 3

DATA BOX 1.A: *What Is or Are Data?* 5

Tools for Inference: David L.'s Problem 5

College Choice 6

College Choice: What Would (Did) You Do? 6

Statistics Is the Science of Data, Not Mathematics 8

Statistics, Data Analysis, and the Scientific Method 9

Inductive and Deductive Reasoning 10

Populations and Samples 12

Descriptive and Inferential Statistics 16

DATA BOX 1.B: *Reactions to the David L. Problem* 18

Knowledge Base 19

Discontinuous and Continuous Variables 20

DATA BOX 1.C: *Rounding and Continuous Variables* 22

Writing About Data: Overview and Agenda 23

Scales of Measurement 24

Nominal Scales 25

Ordinal Scales 26

Interval Scales 27

Ratio Scales 28

Writing About Scales 29

Knowledge Base 31

Overview of Statistical Notation 31

What to Do When: Mathematical Rules of Priority 34

DATA BOX 1.D: *The Size of Numbers is Relative* 38

Mise en Place 39

About Calculators 39

Knowledge Base 40

PROJECT EXERCISE: *Avoiding Statisticophobia* 40

Looking Forward, Then Back 41

Summary 42

Key Terms 42

Problems 42

2 PROCESS OF RESEARCH IN PSYCHOLOGY AND RELATED FIELDS 45

The Research Loop of Experimentation: An Overview of the Research Process 45

Populations and Samples Revisited: The Role of Randomness 48

Distinguishing Random Assignment from Random Sampling 48

Some Other Randomizing Procedures 50

Sampling Error 52

Knowledge Base 53

DATA BOX 2.A: *Recognizing Randomness, Imposing Order* 54

Independent and Dependent Variables 54

Types of Dependent Measures 58

Closing or Continuing the Research Loop? 60

DATA BOX 2.B: *Variable Distinctions: Simple, Sublime, and All Too Easily Forgotten* 61

The Importance of Determining Causality 61

DATA BOX 2.C: *The "Hot Hand in Basketball" and the Misrepresentation of Randomness* 62

Operational Definitions in Behavioral Research 63

Writing Operational Definitions 64

Knowledge Base 64

Reliability and Validity 65

Reliability 66

Validity 67

Knowledge Base 69

Research Designs 70

Correlational Research 70

Experiments 72

Quasi-experiments 74

DATA BOX 2.D: *Quasi-experimentation in Action: What to Do Without Random Assignment or a Control Group* 75

Knowledge Base 76

PROJECT EXERCISE: *Using a Random Numbers Table* 77

Looking Forward, Then Back 81

Summary 81

Key Terms 82

Problems 82

3 FREQUENCY DISTRIBUTIONS, GRAPHING, AND DATA DISPLAY 85

What is a Frequency Distribution? 87

	DATA BOX 3.A: <i>Dispositional Optimism and Health: A Lot About the LOT</i>	88
	<i>Proportions and Percentages</i>	90
	<i>Grouping Frequency Distributions</i>	92
	<i>True Limits and Frequency Distributions</i>	95
	<i>Knowledge Base</i>	96
	Graphing Frequency Distributions	97
	<i>Bar Graphs</i>	98
	<i>Histograms</i>	99
	<i>Frequency Polygons</i>	100
	<i>Misrepresenting Relationships: Biased or Misleading Graphs</i>	102
	New Alternatives for Graphing Data: Exploratory Data Analysis	104
	<i>Stem and Leaf Diagrams</i>	105
	DATA BOX 3.B: <i>Biased Graphical Display—Appearances Can Be Deceiving</i>	106
	<i>Tukey's Tallies</i>	108
	<i>Knowledge Base</i>	109
	Envisioning the Shape of Distributions	111
	DATA BOX 3.C: <i>Kurtosis, or What's the Point Spread?</i>	113
	DATA BOX 3.D: <i>Elegant Information—Napoleon's Ill-fated March to Moscow</i>	114
	Percentiles and Percentile Ranks	115
	<i>Cumulative Frequency</i>	116
	<i>Cumulative Percentage</i>	117
	<i>Calculating Percentile Rank</i>	118
	<i>Reversing the Process: Finding Scores from Percentile Ranks</i>	119
	<i>Exploring Data: Calculating the Middle Percentiles and Quartiles</i>	120
	<i>Writing About Percentiles</i>	122
	<i>Knowledge Base</i>	123
	Constructing Tables and Graphs	123
	<i>Less is More: Avoiding Chartjunk and Tableclutter, and Other Suggestions</i>	124
	<i>American Psychological Association (APA) Style Guidelines for Data Display</i>	125
	PROJECT EXERCISE: <i>Discussing the Benefits of Accurate but Persuasive Data Display</i>	126
	Looking Forward, Then Back	127
	Summary	128
	Key Terms	129
	Problems	129
4	DESCRIPTIVE STATISTICS: CENTRAL TENDENCY AND VARIABILITY	133
	Why Represent Data By Central Tendency	134
	The Mean: The Behavioral Scientist's Statistic of Choice	136
	DATA BOX 4.A: <i>How Many Are There? And Where Did They Come From? Proper Use of N and n</i>	138
	<i>Calculating Means from Ungrouped and Grouped Data</i>	138
	<i>Caveat Emptor: Sensitivity to Extreme Scores</i>	140

	<i>Weighted Means: An Approach for Determining Averages of Different-Sized Groups</i>	142
	DATA BOX 4.B: <i>Self-Judgment Under Uncertainty—Being Average is Sometimes OK</i>	143
	The Median	144
	The Mode	145
	The Utility of Central Tendency	147
	<i>Shapes of Distributions and Central Tendency</i>	147
	<i>When to Use Which Measure of Central Tendency</i>	148
	<i>Writing About Central Tendency</i>	149
	Knowledge Base	150
	Understanding Variability	151
	The Range	153
	<i>The Interquartile and the Semi-Interquartile Range</i>	153
	Variance and Standard Deviation	155
	<i>Sample Variance and Standard Deviation</i>	157
	<i>Homogeneity and Heterogeneity: Understanding the Standard Deviations of Different Distributions</i>	159
	<i>Calculating Variance and Standard Deviation from a Data Array</i>	160
	<i>Population Variance and Standard Deviation</i>	161
	<i>Looking Ahead: Biased and Unbiased Estimators of Variance and Standard Deviation</i>	162
	DATA BOX 4.C: <i>Avoid Computation Frustration: Get to Know Your Calculator</i>	165
	Knowledge Base	165
	Factors Affecting Variability	166
	<i>Writing About Range, Variance, and Standard Deviation</i>	168
	DATA BOX 4.D: <i>Sample Size and Variability—The Hospital Problem</i>	169
	PROJECT EXERCISE: <i>Proving the Least Squares Principle for the Mean</i>	170
	Looking Forward, Then Back	171
	Summary	172
	Key Terms	173
	Problems	173
5	STANDARD SCORES AND THE NORMAL DISTRIBUTION	177
	DATA BOX 5.A: <i>Social Comparison Among Behavioral and Natural Scientists: How Many Peers Review Research Before Publication?</i>	179
	DATA BOX 5.B: <i>Explaining the Decline in SAT Scores: Lay Versus Statistical Accounts</i>	180
	Why Standardize Measures?	181
	<i>The z Score: A Conceptual Introduction</i>	182
	<i>Formulas for Calculating z Scores</i>	185
	The Standard Normal Distribution	186
	Standard Deviation Revisited: The Area Under the Normal Curve	187
	<i>Application: Comparing Performance on More than One Measure</i>	188
	Knowledge Base	189