Social Behavioral Statistics

Focusing on practical application, this textbook provides clear and concise explanations of statistical tests and techniques that students can apply in real-world situations. It has a dual emphasis: first, on doing statistics, and second, on understanding statistics, to do away with the mind-set that statistics is difficult. Procedural explanations are provided so students know how to apply particular statistical tests and techniques in practical research situations. Conceptual understanding is encouraged to ensure students know not only when and how to apply appropriate techniques but also why they are using them. Ancillary resources are available, including sample answers to exercises, teaching slides, an instructor's manual, and a test bank. Illustrative figures, real-world data, practice exercises, and software instructions make this an essential resource for mastering statistics for undergraduate and graduate students in the social and behavioral sciences.

Roberto R. Heredia is Regents Professor in the Department of Psychology and Communication at Texas A&M International University, USA. He served as Chair of the Department of Behavioral Sciences for two years and was director of a multimillion-dollar grant from the US Department of Education. He has published on bilingual memory, bilingual lexical representation, bilingual nonliteral language processing, stereotype processing, and evolutionary psychology.

Richard D. Hartley is Professor in the Department of Criminology and Criminal Justice at the University of Texas at San Antonio, USA. His research interests include decision-making practices for criminal court outcomes, empirical determinants of prosecutorial and judicial decision-making, and process and outcome evaluation. Some of this research has been funded by the National Institute of Justice, the American Statistical Association, and the Bureau of Justice Statistics.

"*Social Behavioral Statistics* is a user-friendly text designed to make statistics accessible and relatable through the use of humor and a diverse range of examples. The focus on hypothesis testing, along with guidance on using jamovi, a free open-source statistical software program, is especially useful for students interested in conducting research projects."

Deborah Koetzle, John Jay College of Criminal Justice

"This new textbook presents statistical concepts in clear, accessible language and incorporates real-world examples to foster an interactive and collaborative classroom environment. Rather than focusing on rote memorization of formulas, it emphasizes understanding the meaning and uses of statistics. The book also offers straightforward, step-by-step instructions for conducting statistical tests using jamovi, enabling students to practically apply what they've learned."

Diane Mello-Goldner, Boston University

"An arsenal of statistical tools adds focused certainty to probability estimates, which guides scientific discovery, testability of scientific hunches, and falsifiability checks to spurious truisms. Heredia and Hartley's *Social Behavioral Statistics* is a clear and practical guide to mastering statistics. They show that the intuitive scientist errs with an error of uncertainty that the statistical scientist does not."

Luis Vega, California State University

Social Behavioral Statistics

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Para Papá y Mamá

RRH

Para mi familia, Criss, Emily, y Alexander

RDH

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Preface

To the Student

We've all been through it – it is, and will always be, a part of our personal memories: the first day of class, a required class. The comforting words from the professor: *Statistics is not math; you'll like it. Work on it. It's one of those things that you'll learn to like and appreciate*. Then the same feeling again in graduate school: more required courses in statistics. And again, the comforting words from the statistics professor: *Statistics should not be intimidating, but you will have to work on it to understand it*. In fact, one of the best-known statisticians in the behavioral sciences, Jacob Cohen, about whom you'll learn, didn't have much training in formal mathematics beyond high school.

You see, our perceived fears about statistics oftentimes arise simply from our lack of understanding of, or knowledge about, the topic. And once we do understand statistics, those unfounded fears disappear, and we embrace the world of statistics – we know we have found the *Statistical Truth*! At one point, we were both one of you, fearing and dreading statistics. But now, writing this book has been one of the most, if not *the* most, gratifying experiences in our academic careers.

Our goal in this book is to simplify the learning process so that you can enjoy and understand the statistical universe surrounding you and all of us. Our overall purpose is to simplify the language of statistics and do away with the mind-set that statistics is difficult and that you are not good at math. To do this, we simplify the mathematical computations to a minimum and emphasize intuition, critical thinking, and problem-solving strategies. We use short sentences and paragraphs, and we repeat information tactically to better allow you to process the information fast and efficiently. We provide just enough detail to get our point across. If anything, at times, we might sound repetitive. Repetition, in addition to other learning strategies, such as creating mental images, mental elaboration, paraphrasing, and self-testing, increases retention, remembering, and long-term learning.

Much of the technical language and notation used to describe statistical strategies is simplified. At the same time, consideration has been given to those of you who may wish to use this book as a reference or guide in your future work. We keep notation to a minimum to provide appropriate context and simplify the learning process. However, statistical notation deemed crucial to simplifying complex formulas, and that is standard in the social and behavioral sciences literature, is emphasized.

You will notice that we include topics that are often given extended coverage in more advanced texts. A key objective is to describe and explain some of the more complex statistical procedures in a simplified and conceptual fashion. We make extensive use of easy-to-follow

examples drawn from the social, educational, criminological, and psychological sciences in an effort to make this book student-friendly and interesting to those of you majoring in these disciplines and to provide you with opportunities to relate statistical tests to issues you are likely to encounter during the research process.

Critical thinking and understanding are essential in the social and behavioral sciences, and we are confident that we emphasize such vital cognitive and learning processes. Learning about, and practicing, statistical techniques is the best way to become more adept at doing statistics. We believe that practice leads to perfection!

It is our hope that after completing this course, you will be confident and comfortable tackling advanced courses and readings in statistical inference. And you can always drop us a line at rheredia@tamiu.edu or richard.hartley@utsa.edu to let us know how we are doing.

To the Instructor

Thank you for selecting our book! We hope you enjoy using it as much as we enjoyed writing it. Our book is straight to the point. You'll first notice our intense preference for definitional formulas as opposed to computational ones. Computational formulas, in our view, are an excellent source for a frontal lobe workout. At the end, however, computational formulas are moot in relation to the conceptual understanding of statistical principles.

You will also notice our intense emphasis on the hypothesis-testing process. As we entertained the possibility of authoring this book, we were surprised that very few introductory textbooks follow this approach. This approach introduces students not only to applying statistical principles but also to the experimental method of testing viable hypotheses. For this, we are thankful to Arthur Aron. For one of us, he was a mentor and instructor in graduate school, and his coauthored book *Statistics for the Behavioral and Social Sciences: A Brief Course* has been the book of choice for the last twenty years.

To simplify the learning process, the computations of examples are described, both symbolically and verbally, step-by-step. They are simple, clear, and, most important of all, based on the social and behavioral empirical and theoretical literature. Our overall purpose was to include statistical examples that are easy to understand and related to current events. Most important, we present statistical examples that make sense and to which students can relate.

There is a dual level of statistical coverage. The first level consists of elementary tests and techniques, especially those concerned with undergraduates most interested in an applied field. Our goal is for this population of students to develop a general understanding of basic statistical principles so that they become critical consumers of science. In the event that they become interested in the research process, they will have adequate statistical tools for a good start.

The second level of statistical coverage is directly relevant for students who want to take on more significant research projects, such as senior or master's theses. You'll find advanced topics like the index of qualitative variation and mean absolute deviation in Chapter 4, effect size and statistical power in Chapter 7, the Sandler *A*-test in Chapter 8, multiple comparisons and factorial designs in Chapter 9, and simple and multiple regression in Chapter 11.

Instructors with different interests in how the subject matter of this course ought to be taught have the flexibility of choosing which statistical topics to include in their lectures and examinations and which to exclude. This is considered to be a flexibility option available to anyone using this book in their particular course. Different sections of chapters may be omitted, therefore, if instructors want only to convey basic principles and provide an overview of what statistics is and can do.

We are huge fans of free and open source software (FOSS). We grew up using Unix/Windows SAS, Unix/Windows SPSS, and Stata. These are excellent statistical software apps. But, there are equally good and even better FOSS programs for our students to use anytime and anywhere and that are *free, as in free beer*! In fact, some advanced statistical procedures, such as linear mixed models, are easier to carry out and interpret in jamovi or JASP-stats than those traditional ones mentioned earlier.

Out of the different existing FOSS apps (jamovi, JASP-stats, GNU PSPP, Statistics Open for All [SOFA], and R), we selected jamovi for its user-friendliness and extensive support community. Jamovi is a full-fledged statistical app widely accepted by the scientific community, and we are proud to count ourselves as part of this community. Additionally, unlike other introductory books, we introduce students to statistical power and effect size using specific modules in jamovi and G*Power, *the* FOSS app for power analysis. An instructor's manual, slide presentations, a test bank for each chapter, and answers to practice exercises are available at www.cambridge.org/heredia.

Finally, pictures are worth a thousand words and, we know, are more conducive to superior learning. We take advantage of this highly replicated effect and provide just the right number of figures to facilitate students' short- and long-term learning.

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We acknowledge, first, students from our Basic Statistics for Psychology course, whose curiosity and feedback have been a valuable resource and inspiration. Special thanks to our dear student Ezra Vela, who read every chapter and provided us with lots of feedback, and to Evelyn García – the best stats tutor we ever had – for her diligent and excellent feedback on chapter questions and answers. We thank Ana Lee Paz, our colleague and friend, who was able to capture our love for those furry, four-legged family members in *Moquis Contante* (Mokis the counting dog!) for the book's cover. Finally, we offer thanks to our dear friend and colleague, stats guru Luis A. Vega, for his unwavering support and invaluable feedback on *tough* statistical principles.

We also thank our students and colleagues who had to put up with us while we were preoccupied making sense of our lectures and discussions as we were very involved in the writing process. Most of the figures (graphs) were created using Datagraph. We are thankful to the Datagraph folks for their support and their quick responses.

We have deep gratitude for several individuals who were critical to seeing this book through to completion, including David Repetto, from Cambridge University Press (CUP), for his confidence in and support of our book and, also from CUP, Jane Adams and Rowan Groat, who were instrumental in many ways, from facilitating reviews of chapters to producing tables, figures, and other materials that have made these chapters much more digestible for students. Finally, writing this book was made possible by a Texas A&M International University Faculty Development Leave to RRH for fall 2020.

Organization of the Book

This book provides the fundamentals of statistics for students in the social and behavioral science disciplines. The book has a dual emphasis. One emphasis is on *doing statistics*. This means that nuts-and-bolts procedural explanations are provided so that students know how to apply particular statistical tests and techniques in practical research situations. The second emphasis is on *understanding statistics*. This means that we are most interested in students' conceptual understanding of statistical procedures and their knowing when and how to apply the appropriate statistical techniques as they analyze data. Both doing and understanding are emphasized here.

Content Overview

Chapter 1 explores the link between the research process and theory and the role of statistics in scientific discovery. Discrete and continuous variables, the building blocks of methodology, take center stage with clear and elaborate examples and their applicability to levels or scales of measurement and measures of central tendency.

Chapter 2 discusses the different graphic techniques for describing data. These include bar graphs, histograms, frequency polygons, and shapes and patterns of distributions.

Chapter 3 examines measures of central tendency and their correspondence to normality and skewness.

Chapter 4 examines measures of variability. These measures depict the extent to which scores in a distribution are spread out or clustered together. Thus both the points around which scores focus and how they are distributed around these points compose the subject matter of this chapter.

Chapter 5 examines the normal distribution, its relationship to z-scores, and its applicability to probability theory and statistical inference.

Chapter 6 examines the process of statistical decision rules and hypothesis testing. It introduces the student to the hypothesis-testing process and to the relevance of the standard error in reaching statistical conclusions about whether to accept or reject a working hypothesis. Type I and Type II errors, along with the types of statistical tests researchers apply in testing hypotheses, are presented; the latter include one-tailed or directional tests versus two-tailed or nondirectional tests.

Chapter 7 introduces students to statistical power and effect size in hypothesis testing. Guidelines for interpretation of effect size, along with other sources of increasing statistical power, are provided. Point estimation and interval estimation and their relationship to population parameter estimates and the hypothesis-testing process are considered.

Chapter 8 examines the *t*-test and its assumptions as it applies to mean comparison between samples and populations and experimental designs, such as between-subjects, within-subjects, and matched designs. Measures of variability are reintroduced in relation to biased and unbiased estimates and the estimated standard error of the mean.

Chapter 9 introduces students to one-way or one-factor analysis of variance (ANOVA) and factorial designs. Although we provide step-by-step calculation demonstrations, we place greater emphasis on conceptual understanding than on computation, especially for factorial designs and multifactor ANOVA.

Chapter 10 examines the correlation or association between variables. The correlation coefficient, which measures the degree and direction of an association, is discussed, as are some of the issues regarding applying and interpreting correlations. The chapter also outlines the many different measures of association but focuses on Pearson's *r*.

Chapter 11 introduces students to bivariate regression and multiple regression. The chapter also introduces students to the importance of linear relationships and how linearity can be used to make predictions on one variable from the knowledge of another variable or multiple variables. Calculations are kept to a minimum. Interpretation and conceptual understanding of critical concepts in regression are emphasized.

Chapter 12 presents several popular distribution-free statistical tests that are commonly used in the social and behavioral sciences. The chapter provides an explanation of goodness-of-fit statistical tests, which are often referred to as chi-square tests. Chi-square tests have few restrictive assumptions underlying their application and are used for data that violate one or more of the formal assumptions regarding the use of parametric statistics.