FOURTH EDITION

BEHAVIORAL RESEARCH AND ANALYSIS

An Introduction to Statistics Within the Context of Experimental Design

MAX VERCRUYSSEN • HAL W. HENDRICK

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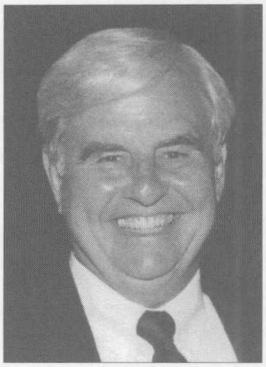
In Memoriam



Hal W. Hendrick
1933–2011
Creator and Co-Author of This Book
International Ergonomics Expert

On May 13, 2011, while editing the page proofs of this fourth edition, the book's founder and co-author peacefully took his last breath. During his gallant 18-month battle with cancer he was able to meet and say goodbye to friends and relatives. He was disappointed not to be able to see this book in its final published form but was satisfied to know his last piece of scholarly work was completed. Professor Hendrick touched the lives of many and will be dearly missed. However, his memory and inspiration live on in those who still picture his constant smile, hear his frequent laughter, and remember his giving nature, friendly demeanor, nurturing collaborations, and gentle kindness. His author biography in this book relates some of his great achievements but he was much more on a personal level as a husband, father, grandfather, university professor and dean, international professional organization leader, consultant, expert witness, mentor, and friend to many. His individual successes were usually a result of his expending a lot of energy inspiring everyone around him to be the best they could be. He was a remarkable leader who profoundly changed the lives of many. Farewell and thank you …

Preface

This book was created by Dr. Hendrick (1981) before Dr. Vercruyssen joined him in writing the second edition (1989) and then became the lead author for the third edition (1990) and this one (2012). Its primary use was for graduate students in the behavioral sciences and education as a component of the training for completing a thesis. However, it has recently been expanded to a broader audience including undergraduates.

Since publication of the first edition of this text in 1981, we have received many suggestions and comments from readers for improving this book. Nearly all reader suggestions and some new ideas have been included in the current edition. We hope you find this revised edition useful and that you will send us comments for changes in the next edition.

PURPOSE AND AUDIENCE

As with the previous editions, the purpose of this book is to present an overview of statistical methods within the context of fundamental topics relevant to career professionals, including experimental design, data collection, data analysis, interpretation of results, and communication of findings. We envision this text as being particularly useful in four types of applications: first, as the introductory text in research-oriented statistical methods courses in the behavioral sciences, the natural sciences, education, engineering, business, and multidisciplinary applied fields; second, as a companion in advanced research methods or content-oriented experimental courses in these same disciplines; third, as a text to introduce graduate and honor undergraduate students to experimental research, statistical tools, and scientific communications (e.g., theses, refereed publications, research proposals, research presentations); and finally, as a resource for purposes of review and refamiliarization for professionals in a variety of research fields.

Because readers of this text are likely to be users rather than producers of statistical equations, the emphasis has been placed on explaining statistical procedures and interpreting obtained results without discussing the derivation of equations or history of the method. Probability theory is scarcely mentioned in the appendices; this is not a purpose of this text. Also, the mathematical demands are minimal—no college-level mathematics background is required or assumed. We want this text to become a single resource that will assist students and seasoned professionals in conducting scientific research and reporting it to the scientific community.

ORIGIN AND UNIQUENESS

The authors realized while teaching courses in experimental psychology and research methodologies that although the students had taken prerequisite courses in statistics and research methods, their actual knowledge of the basics of research design and statistical analyses varied greatly and was generally poorer than expected. In looking for a comprehensive text that could be used to bring the students up to speed, none was found totally suitable. The books either reviewed the basics of behavioral research and experimental design but provided only cursory coverage of statistical methods or they provided comprehensive coverage of statistical methods with very little coverage of the research context within which these methods are used. Nowhere could we find a resource that provided the methodology, statistics, and coverage of communication skills, so we set out to write our own.

Graduate students using this text in research or statistics courses required for degrees in psychology, communications, systems management, neuroscience, safety science, kinesiology and sport

sciences, engineering, and human factors have preferred this book to widely utilized conventional texts because presenting statistical methods within the context of research design made the methods much more meaningful and easier to remember. This appeared to be of benefit from both motivational and learning standpoints. We found that when students are assigned experiments at the beginning of a course, for which they must collect and analyze data and formally write the results of their study, they have a specific purpose for learning the contents of this book and the whole learning process is facilitated. Therefore, we strongly recommend that readers have an experiment planned (e.g., thesis, dissertation, term project) before starting this text.

TEXT ORGANIZATION

Chapter 1 contains a general review of scientific research, including various approaches to empirical investigations. Chapters 2 and 3 provide an overview of descriptive statistics (univariate and bivariate). Chapter 4 presents statistical hypotheses testing, basic simple experimental designs, and commonly used parametric and nonparametric tests. Chapter 5 introduces simple univariate analysis of variance (ANOVA). Chapter 6 differentiates multifactor univariate ANOVA designs (between, within, and mixed). Chapter 7 prepares the reader for planning, conducting, and reporting a behavioral research study. Each chapter in the body now contains relevant keywords, chapter summaries, keyword definitions, and end of chapter exercises (with answers).

Appendix A includes statistical reference tables. Appendix B contains a glossary to facilitate access to information on statistical terms, symbols, and equations. Appendix C contains statistical equations.

Acknowledgments

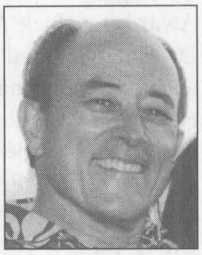
Over the years, many individuals have contributed to the continued development of this book. Students in the authors' classes continue to make helpful comments each semester, but over the years major efforts have come from graduate students George Brogmus, J.C. Edwards, Gretchen Greatorex, Tina Mihaly, Olu Olofinboba, Sara Reynolds, and Kim Siu. Desktop publishing support was provided by Michelle Agustin and Gia Macabeo-Shahn. We especially appreciate assistance provided by high school student Nani Vercruyssen who helped change the wording so this book is more understandable to entry-level students and by doctoral student Yasuhiro Ueyama who made suggestions for wording that made this book easier for beginning researchers whose native language is not English. Mia Vercruyssen, a technical writer, provided valuable revisions to this edition.

We are grateful to the Literary Executor of the late Sir Ronald A. Fisher, F.R.S.; to Dr. Frank Yates, F.R.S.; and to the Longman Group Ltd., London for permission to reprint Tables C, D, and E in Appendix A from *Statistical Tables for Biology, Agriculture and Medical Research* (6th ed., 1974). Of course, we are also grateful to those who first introduced us to the field of statistics: Paul A. Games (MV), Thomas Pyle (MV), Robert Perloff (HWH), and Ben Winer (HWH). Thank you for supporting continued development of this instructional tool.

Max Vercruyssen
Honolulu, Hawaii

Hal W. Hendrick
Denver, Colorado

About the Authors

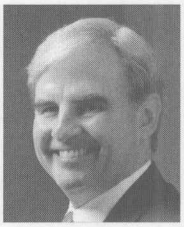


Max Vercruyssen, PhD, is the director of Hawaii Academy, a private school for lifetime fitness, gymnastics, and human sciences, where he also serves as chair of the research department and as head coach of the school's elite-level trampoline gymnastics teams.

Dr. Vercruyssen holds a bachelor's degree in experimental psychology; master's degrees in experimental and physiological psychology, exercise and sport sciences, and public health; a PhD in neuromuscular control, and pursued postdoctoral training to earn advanced certificates in ergonomics and gerontology. Most of his advanced statistics training was under Paul A. Games (Pennsylvania State University) and as required for experimental psychology, biostatistics, and longitudinal studies of aging.

At the University of Southern California (USC), Dr. Vercruyssen served as assistant professor of human factors and ergonomics, director of the Human Factors Laboratory, and codirector of the Laboratory of Attention and Motor Performance in the Andrus Gerontology Center. He also helped develop the university's ergonomics graduate degree programs and mentored the first ergonomics majors in safety science. At the University of Hawaii, he was an associate professor in psychology, gerontology, and geriatric medicine.

During the 1990s, Dr. Vercruyssen was also a research associate at the University of Minnesota's Center for Transportation Research, Institute of Intelligent Transportation Systems, and a distinguished fellow of gerontechnology at the Technical University of Eindhoven, Netherlands. Dr. Vercruyssen has authored or coauthored over 200 refereed publications and presented papers at international scientific and technical conferences. Nine years of his university appointments involved teaching experimental research and statistics courses and mentoring thesis students (the practical need that resulted in developing this book). His students have received national research awards and his athletes have held many national and world championship titles. His current challenge is to make required statistics training palatable for students who may not enjoy or want to study mathematics—even those with statistophobia—as well as for those with great ambitions for academic achievement.



Hal W. Hendrick, PhD, was emeritus professor of human factors and ergonomics at the University of Southern California. He held a BA in psychology from Ohio Wesleyan University, an MS in human factors, and a PhD in industrial psychology from Purdue University. Dr. Hendrick studied statistics and experimental design with APA Past President Professor Robert Perloff and Professor Ben Winer, the "guru" of behavioral research and analysis of his time. For six years, Dr. Hendrick developed and taught a course in statistics and experimental design at the United States Air Force Academy and for 19 years, a similar graduate-level course at USC.

Dr. Hendrick was a past chair of USC's Human Factors Department, former executive director of the university's Institute of Safety and Systems Management, and a former college dean at the University of Denver. He was a certified professional ergonomist, a diplomate of the American Board of Forensic Examiners, and a fellow of the American Psychological Society, the Human Factors and Ergonomics Society (HFES), the International Ergonomics Association (IEA), the American College of Forensic Examiners, and a charter member and fellow of the Association

for Psychological Science. He was a past president of the Human Factors and Ergonomics Society, the International Ergonomics Association, the Foundation for Professional Ergonomics, and was a founding member and past president of the Board of Certification in Profession Ergonomics.

Dr. Hendrick was a recipient of USC's highest award for teaching excellence, the IEA Distinguished Service Award, the HFES Arnold M. Small President's Distinguished Service Award, the Jack A. Kraft Innovator Award, and the Alexander C. Williams, Jr. Design Award. Dr. Hendrick had over 45 years of experience as a human factors and ergonomics and industrial and organizational psychologist practitioner, educator, program administrator, and consultant. He was the author or coauthor of over 200 professional publications and three textbooks, and has edited or coedited 10 books, including the *Handbook of Human Factors and Ergonomics Methods* (CRC Press, 2005). Dr. Hendrick conceptualized and initiated the human factors subdiscipline of macroergonomics. He held a regular commission in the U.S. Air Force (Lt. Col., USAF ret).

Contents