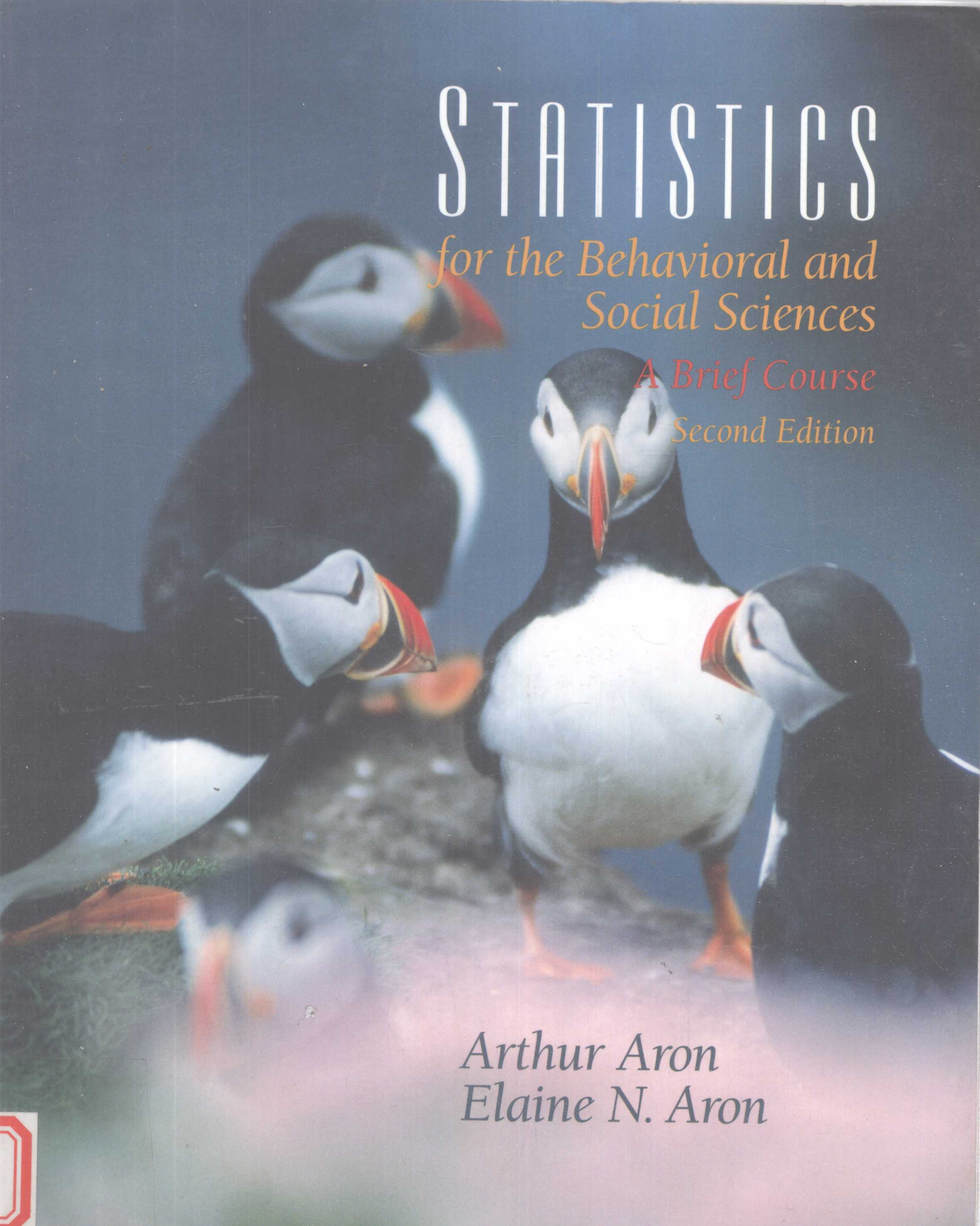

# STATISTICS

## *for the Behavioral and Social Sciences*

### *A Brief Course*

*Second Edition*

*Arthur Aron*
*Elaine N. Aron*

SECOND EDITION

# STATISTICS FOR THE BEHAVIORAL AND SOCIAL SCIENCES

## A BRIEF COURSE

Arthur Aron
Elaine N. Aron
*State University of New York at Stony Brook*


Upper Saddle River, New Jersey 07458

*Library of Congress Cataloging-in-Publication Data*

ARON, ARTHUR.
Statistics for the behavioral and social sciences : a brief course / Arthur Aron, Elaine N. Aron.—2nd ed.
p. cm.
Includes bibliographical references and index.
ISBN 0–13–026186–6
1. Social sciences—Statistical methods. 2. Social sciences—Data processing. I. Aron, Elaine. II. Title.

HA29.A745 2002
300′.1′5195—dc21

2001021906

VP, Editorial Director: *Laura Pearson*
Acquisitions Editor: *Jayme Heffler*
Editorial Assistant: *April Dawn Klemm*
Senior Managing Editor: *Mary Rottino*
Production Liaison: *Fran Russello*
Editorial/Production Supervision: *Marianne Hutchinson (Pine Tree Composition, Inc.)*
Prepress and Manufacturing Buyer: *Tricia Kenny*
Art Director: *Jayne Conte*
Cover Designer: *Bruce Kenselaar*
Director, Image Resource Center: *Melinda Lee Reo*
Manager, Rights & Permissions: *Kay Dellosa*
Image Specialist: *Beth Boyd*
Photo Researcher: *Karen Pugliano*
Senior Marketing Manager: *Sharon Cosgrove*

Credits appear on page xviii, which constitutes a continuation of the copyright page.

This book was set in 11/2 Times Roman by Pine Tree Composition, Inc.,
and was printed and bound by Von Hoffmann Press, Inc.
The cover was printed by Phoenix Color Corp.




Printed in the United States of America
10 9 8 7 6 5 4

ISBN 0-13-026186-6

Prentice-Hall International (UK) Limited, *London*
Prentice-Hall of Australia Pty. Limited, *Sydney*
Prentice-Hall Canada Inc., *Toronto*
Prentice-Hall Hispanoamericana, S.A., *Mexico*
Prentice-Hall of India Private Limited, *New Delhi*
Prentice-Hall of Japan, Inc., *Tokyo*
Pearson Education Asia Pte. Ltd., *Singapore*
Editora Prentice-Hall Do Brasil, Ltda., *Rio de Janeiro*

# Preface to the Instructor

The heart of this book was written over a summer in a small apartment near the Place Saint Ferdinand, having been outlined in nearby cafes and on walks in the Bois de Boulogne. It is based on our 35 years of experience teaching, researching, and writing. We believe that this book is as different from the conventional lot of statistics books as Paris is from Calcutta, yet still comfortable and stimulating to the long-suffering community of statistics instructors.

The approach embodied in this text has been developed over three decades of successful teaching—successful not only in the sense that students have consistently rated the course (a statistics course, remember) as a highlight of their undergraduate years but also in the sense that students come back to us years later saying, "I was light-years ahead of my fellow graduate students because of your course," or "Even though I don't do research, your course has really helped me understand statistics that I read about in my field."

In this second edition of this *Brief Course* we have tried to maintain those things about the book that were especially appreciated, while reworking the text to take into account the feedback we have received, our own experiences, and advances and changes in the field. However, before turning to the second edition, we want to reiterate some comments we made in the first edition about what we have done differently than other statistics texts.

## What We Have Done Differently

We continue to do what the best of the newer books are already doing well: emphasizing the intuitive, de-emphasizing the mathematical, and explaining everything in clear, simple language. What we have done, however, differs from these other books in nine key respects.

1. ***The definitional formulas are brought to center stage*** because they provide a concise symbolic summary of the logic of each particular procedure. All our explanations, examples, practice problems, and test bank items are based on these definitional formulas. (The amount of data to be processed in our practice problems and test items are reduced appropriately to keep computations manageable.)

Why this approach? To date, statistics texts have failed to adjust to technologic reality. What is important is not that the students learn to calculate a correlation coefficient with a large data set—computers can do that for them. What is important is that students remain constantly aware of the underlying logic of the procedure. Consider the population variance—the average of the squared deviations from the mean. This concept is immediately clear from the definitional formula (once the student is used to the symbols): Variance = $\Sigma(X - M)^2/N$. Repeatedly working problems using this formula engrains the meaning in the student's mind. In contrast, the usual computational version of this formula only obscures this meaning: Variance = $[\Sigma X^2 - (\Sigma X)^2/N]/N$. Repeatedly working problems using this formula does nothing but teach the student the difference between $\Sigma X^2$ and $(\Sigma X)^2$!

Teaching computational formulas today is an anachronism. Researchers do their statistics on computers now. At the same time, the use of statistical software makes the understanding of the basic principles, as they are symbolically expressed in the definitional formula, more important than ever.

It is a mystery to us why statistics textbooks have not changed their methods with the advent of statistical software, but we are convinced that the change is overdue. Of course, because computational formulas are both historically interesting and occasionally needed—and because some instructors may feel naked without them—we still provide them in a brief footnote wherever a computational formula would normally be introduced.

2. ***Each procedure is taught both verbally and numerically—and usually visually as well—with the same examples described in each of these ways.*** Practice exercises and test bank items, in turn, require the student to calculate results and make graphs or illustrations and also to write a short explanation in layperson's language of what the statistics mean. The chapter material completely prepares the student for these kinds of exercises and test questions.

It is our repeated experience that these different ways of expressing an idea are very important for permanently establishing a concept in a student's mind. Many students in the social and behavioral sciences are more at ease with words than with numbers. In fact, some have a positive fear of all mathematics. Writing the lay language explanation gives them an opportunity to do what they do best and, if they are having trouble, forces them to put the procedures in front of them in the verbal form they process best.

3. A main goal of any introductory statistics course in the social and behavioral sciences is to ***prepare students to read research articles.*** In fact, the way a procedure such as a *t* test or chi-square is described in a research article is often quite different from what the student expects from the standard textbook discussions. Therefore, as this book teaches a statistical method, it also gives examples of how that method is reported in the journals. The practice problems and test bank items also include excerpts from articles for the student to explain.

4. The book is ***unusually up-to-date.*** For some reason, most of the introductory statistics textbooks we have seen read as if they were written in the 1950s. The basics are still the basics, but the subtleties of the way statisticians and researchers think about those basics today has changed radically. Today, the basics are undergirded by a different appreciation of issues like effect size, power, accumulation of results

through meta-analysis; the central role of models; and a whole host of new orientations arising from the prominent role of the computer in our analyses. We are much engaged in the latest developments in theory and application of statistics. We believe this book reflects that engagement. For example, we devote an entire chapter to effect size and power, discussing how to handle situations in which assumptions are violated, we cover data transformations (this widely used approach is easily accessible to introductory students but is rarely mentioned in current introductory texts).

5. The book is written to ***capitalize on the students' motivations.*** We try to do this in two ways. First, our examples, while attempting to represent the diversity of social and behavioral science research, emphasize topics or populations that students seem to find most interesting. The first example is from a real study in which 151 students in their first week of an introductory statistics class rate how much stress they feel they are under. Also, in our examples, we continually emphasize the usefulness of statistical methods and ideas as tools in the research process, never allowing students to feel that what they are learning is theory for the sake of theory.

Second, we have tried to make the book extremely straightforward and systematic in its explanation of basic concepts so that students can have frequent "aha!" experiences. Such experiences bolster self-confidence and motivate further learning. So often textbooks constantly beat their readers over the head with just how oversimplified everything they are learning is. Instead, we try to inspire readers with the depth of what can be learned, even in an introductory course. It is really quite inspiring to *us* to see even fairly modest students glow from having mastered some concept like negative correlation, the distinction between failing to reject the null hypothesis and supporting the null hypothesis, or the idea of independence in a chi-square analysis.

6. ***The final chapter looks at advanced procedures*** without actually teaching them in detail. It explains in simple terms how to make sense out of these statistics when they are encountered in research articles. Most research articles today use methods such as hierarchical and stepwise multiple regression, factor analysis, structural equation modeling, analysis of covariance, and multivariate analysis of variance. Students completing the ordinary introductory statistics course are ill-equipped to comprehend most of the articles they must read to prepare a paper or study for a course. This chapter makes use of the basics that students have just learned to give a rudimentary understanding of these advanced procedures. It also serves as a reference guide that they can keep and use in the future when reading such articles.

7. The accompanying ***Student's Study Guide and Computer Workbook*** focuses on mastering concepts and also includes instructions and examples for working problems using a computer. Most study guides focus on plugging numbers into formulas and memorizing rules (which is consistent with the emphasis of the textbooks they accompany). For each chapter, our *Student's Study Guide and Computer Workbook* provides learning objectives, a detailed chapter outline, the chapter's formulas (with all symbols defined), and summaries of steps of conducting each procedure covered in the chapter, plus a set of self-tests, including multiple-choice, fill-in, and problem/essay questions. In addition, for each procedure covered in the chapter, the study guide furnishes a thorough outline for writing an essay explaining the procedure to a person who has never had a course in statistics.

Especially important, our *Student's Study Guide and Computer Workbook* provides the needed support for teaching students to conduct statistical analyses on the computer. First, there is a special appendix introducing the language and procedures of SPSS/for Windows. Then, in each chapter corresponding to the text chapters, there is a section showing in detail how to carry out the chapter's procedures on the

computer. (These sections include step-by-step instructions, examples, and illustrations of how each step of input and output appears on the computer screen). There are also special activities for using the computer to deepen understanding. As far as we know, no other statistics textbook package provides this much depth of explanation.

8. We have written an ***Instructor's Manual that really helps teach the course***. The *Manual* begins with a chapter summarizing what we have gleaned from our own teaching experience and the research literature on effectiveness in college teaching. The next chapter discusses alternative organizations of the course, including tables of possible schedules and a sample syllabus. Then each chapter, corresponding to the text chapters, provides full lecture outlines and **additional worked-out examples not found in the text** (in a form suitable for copying onto transparencies or for student handouts). These worked-out examples are particularly useful, as creating examples is one of the most difficult parts of preparing statistics lectures.

9. Our ***Test Bank*** **section of the** ***Instructor's Manual*** **makes preparing good exams easy.** We supply approximately 40 multiple-choice, 25 fill-in, and 10 to 12 problem/essay questions for each chapter. Considering that the emphasis of the course is so conceptual, the multiple-choice questions will be particularly useful for those of you who do not have the resources to grade essays. This supplement also includes computational answers to each textbook chapter's practice problems that are not given in the text. (The textbook provides answers to selected practice problems, including at least one example answer to an essay-type question for each chapter.)

## About this *Brief Course*

We were thrilled by the enthusiastic response of instructors and students to the first and second editions of our *Statistics for Psychology* (Aron & Aron, 1994, 1999), as well as the positive comments of reviewers, including the most encouraging evaluation in *Contemporary Psychology* (Bourgeois, 1997).

The *Brief Course* was our answer to the many requests we received from instructors and students for a textbook using our approach that is (a) more general in its focus than psychology alone and (b) shorter, to accommodate less comprehensive courses. Of course, we tried to retain all the qualities that endeared the original to our readers. At the same time, the *Brief Course* was not a cosmetic revision. The broadening of focus meant using examples from the entire range of the social and behavioral sciences, from anthropology to political science. Most important, the broadening informed the relative emphasis (and inclusion) of different topics and the tenor of the discussion of these topics. The shortening was also dramatic: This *Brief Course* is about half the length of the original, making it quite feasible to do the whole book, even in a quarter-length course.

### Influences on the Second Edition

We did the revision for the second edition in San Francisco. We hope that this has not resulted in a loss of whatever romance the first edition gained from being written in Paris. On the other hand, this edition has been leavened by some beautiful views of the Bay.

More important, this revision is enriched by our experience teaching with the first edition and by the experience and encouragement of scores of instructors who have written to us about their experiences using the book. This revision is also

informed by our own use of statistical methods. The last five years have been a very productive time for the two of us in our own research programs in personality and social psychology. (For overviews of our main research programs, see A. Aron, E. Aron, & Norman (2001) and E. Aron & A. Aron (1997). Perhaps particularly useful has been that one of us (AA) has served as associate editor for the *Journal of Personality and Social Psychology* during the last several years. This has kept us in touch with how the best researchers are using statistics (as well as how reviewers rate their colleagues' use of statistics).

### Specific Changes in the Second Edition

1. ***Writing.*** We have thoroughly reviewed every sentence, simplifying constructions and terminology wherever possible. It is hard enough to learn statistics without having to read complicated sentences.
2. ***Updating examples.*** We have replaced over 50 examples from the first edition with newer ones. This is particularly important for the sections on how to understand and evaluate research articles. The whole point of these sections is for students to see how statistics actually look when reported in current research. In reviewing the old examples and finding new ones, we were struck by quite a few subtle changes in the way statistical results are being reported. For example, five years ago interaction effects in analysis of variance were generally reported with line graphs—today they usually use bar graphs (see Chapter 10).
3. ***Adjustments to enhance pedagogy and better meet the needs of instructors using the book.*** These have been mostly small changes, but there are a great many of them. Perhaps what will seem most obvious to those who have used the first edition is that we have added a section on levels of measurement and significantly revised our chapter on correlation and regression. We have also made even more of an effort than in the first edition to use multicultural examples whenever possible.
4. ***Some changes we have not made.*** The 9 points noted earlier in this introduction remain as the central, unique features of this book. Also, except where we felt we could make a major improvement in pedagogy, we have not changed the major teaching examples in each chapter, for two reasons. First, instructors using the first edition told us that they have built their lectures around their experience using these examples and don't want to have to start from scratch with new ones. Second, these examples include tables showing all the details of computation. By keeping these examples the same, we minimize the chance of errors creeping in.

### Keep in Touch

Our goal is to do whatever we can to help you make your course a success. If you have any questions or suggestions, please write or contact us by email (**aron@psych1.psy.sunysb.edu** will do for both of us). Also, if you should find an error somewhere, for everyone's benefit, please let us know right away. When errors have come up in the past, we have had good success in getting them fixed in the very next printing.

## Acknowledgments

First and foremost, we are grateful to our students through the years, who have guided our approach to teaching by encouraging us with their appreciation for what we have done well, as well as their various means of discouraging us from persisting in what we have done not so well.

We remain grateful to all of those who helped us with the first edition of the *Brief Course* as well as to those who helped with the first and second editions of the larger book. For their very helpful input on the development of this second edition of the *Brief Course,* we want to thank Carol Pandey, L. A. Pierce College; Stephen L. Chew, Samford University; Malina Monaco, Georgia State University; Michael Biderman, University of Tennessee at Chattanooga; Dennis Jowaisas, Oklahoma City University; Rod Gillis, University of Miami; Marie A. Roman, DePaul University; Sally Radmacher, Missouri Western State College; Robert Shamansky, Simpson College; and Maria Czyzewska, Southwest Texas State University.

In addition, we want to express our appreciation to the following individuals who told us about errors in the first edition: Harley Baker, Kathy Bechstein, Doug Cornford, Hamze Dodeen, O. H. Gordon, Jeff Joireman, Dennis Jowaisas, Beth Morling, Richard Wielkiewicz, Thom Yantek, and Shuqiang Zhang. We also particularly want to acknowledge Sheryl Skaggs for her assistance in locating many of the new examples for this edition.

*Arthur Aron*
*Elaine Aron*

## Credits

# Introduction to the Student

The goal of this book is to help you *understand* statistics. We emphasize meaning and concepts, not just symbols and numbers.

This emphasis plays to your strength. Most social and behavioral science students are not lovers of mathematics but are keenly attuned to ideas. And we want to underscore the following, based on our 35 years' experience in teaching: ***We have never had a student who could do well in other college courses who could not also do well in this course.*** (However, we will admit that doing well in this course may require more work than doing well in others.)

In this introduction, we discuss why you are taking this course and how you can gain the most from it.

## Why Learn Statistics? (Besides Fulfilling a Requirement)

1. ***Understanding statistics is crucial to being able to read research results.*** In most of the social and behavioral sciences, nearly every course you take will emphasize the results of research studies, and these usually include statistics. If you do not understand the basic logic of statistics—if you cannot make sense of the jargon, the tables, and the graphs that are at the heart of any research report—your reading of research will be very superficial.
2. ***Understanding statistics is crucial to doing research yourself.*** Many students eventually go on to graduate school. Graduate study in the social and behav-

ioral sciences almost always involves *doing* research. Often learning to do research on your own is the entire focus of graduate school, and doing research almost always involves statistics. This course gives you a solid foundation in the statistics you need for doing research. Further, by mastering the basic logic and ways of thinking about statistics, you will be unusually well prepared for the advanced courses, which focus on the nitty-gritty of analyzing research results.

Many universities also offer opportunities for undergraduates to do research. The main focus of this book is understanding statistics, not using statistics. Still, you will learn the skills you need to do some of the most common statistics used in the kinds of research you are likely to do.

3. ***Understanding statistics develops your analytic and critical thinking.*** Social and behavioral science students are often most interested in people and in improving things in the practical world. This does not mean that you avoid abstractions. In fact, the students we know are exhilarated most by the almost philosophical levels of abstraction where the secrets of human experience so often seem to hide. Yet even this kind of abstraction often is grasped only superficially at first, as slogans instead of useful knowledge. Of all the courses you are likely to take in the social and behavioral sciences, this course will probably do the most to help you learn to think precisely, to evaluate information, and to apply logical analysis at a very high level.

## How to Gain the Most from This Course

There are five things we can advise:

1. ***Keep your attention on the concepts.*** Treat this course less like a math course and more like a course in logic. When you read a section of a chapter, your attention should be on grasping the principles. When working the exercises, think about why you are doing each step. If you simply try to memorize how to come up with the right numbers, you will have learned very little of use in your future studies—nor will you do very well on the tests in this course.

2. ***Be sure you know each concept before you go on to the next.*** Statistics is cumulative. Each new concept is built on the last one. Even within a chapter, if you have read a section and you do not understand it—*stop.* Reread it, rethink it, ask for help. Do whatever you need to do to grasp it. (If you think that you understand a section but are not sure, try working a practice problem on it at the end of the chapter.)

Having to read the material in this book over and over does not mean that you are stupid. Most students have to read each chapter several times. Each reading in statistics is usually much slower than that in other textbooks. Statistics reading has to be pored over with clear, calm attention for it to sink in. Allow plenty of time for this kind of reading and rereading.

3. ***Keep up.*** Again, statistics is cumulative. If you fall behind in your reading or miss lectures, the lectures you then attend will be almost meaningless. It will get harder and harder to catch up.

4. ***Study especially intensely in the first half of the course.*** It is especially important to master the material thoroughly at the start of the course. This is because everything else in statistics is built on what you learn at the start. Yet the beginning of the semester is often when students study least seriously.

If you have mastered the first half of the course—not just learned the general idea, but really know it—the second half will be easier. If you have not mastered the first half, the second half will be close to impossible.

5. ***Help each other.*** There is no better way to solidify and deepen your understanding of statistics than to try to explain it to someone having a harder time. (Of course, this explaining has to be done with patience and respect.) For those of you who are having a harder time, there is no better way to work through the difficult parts than by learning from another student who has just mastered the material.

Thus, we strongly urge you to form study teams with one to three other students. It is best if your team includes some who expect this material to come easily and some who don't. Those who learn statistics easily will really get the very most from helping others who have to struggle with it—the latter will tax the former's supposed understanding enormously. For those who fear trouble ahead, you need to work with those who do not—the blind leading the blind is no way to learn. Pick teammates who live near you so that it is easy for you to get together. Also, meet often—between each class, if possible.

## A Final Note

Believe it or not, we love teaching statistics. Time and again, we have had the wonderful experience of having beaming students come to us to say, "Professor Aron, I got a 90% on this exam. I can't believe it! Me, a 90 on a statistics exam!" Or the student who tells us, "This is actually fun. Don't tell anyone, but I'm actually enjoying . . . statistics, of all things!" We hope you will have these kinds of experiences in this course.

*Arthur Aron*
*Elaine N. Aron*

# Brief Contents

# Contents