

SIXTH EDITION

# Statistics for the Behavioral and Social Sciences

A Brief Course

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# Preface to the Instructor

The heart of this text 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 many years of experience in teaching, researching, and writing. We believe that it is still as different from the conventional lot of statistics texts as Paris is from Pompeii, yet still comfortable and stimulating to the long-suffering community of statistics instructors.

Our approach was developed over 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 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 sixth edition of this *Brief Course* we have tried to maintain those things about the course that have been especially appreciated, while reworking the text to take into account the feedback we have received, our own ongoing teaching experiences, and advances and changes in the field. We of course have continued to focus on simplifying exposition and have done our usual updating of content, examples, and so on, plus making a host of minor adjustments to make the book more effective. For several chapters, our examples are now even more engaging, which we hope will further increase student interest and learning.

## New to this Edition

As we undertook the challenge to update and refresh the sixth edition of our text, some of the major changes include:

- We have added learning objectives that tie to each section and summary point in each chapter. This allows students to identify and track their understanding of key concepts.
- New, recent examples that illustrate each statistical procedure in actual research articles.
- More subsections, or “chunking” of information to help your students better absorb and retain statistical concepts and their applications throughout this course.
- Appendix E, A Closer Look at the Logic and Language of Behavioral and Social Sciences Research, formerly Web Chapter 1. We have updated this chapter (and include it now in with the main text, making it more

easily available), which helps students to understand and evaluate the research contexts in which statistical methods are applied.

- Chapter 12, A Closer Look at Advanced Statistical Procedures in Research Articles, formerly Web Chapter 2 (and also previously not included in the main text), which helps students to make sense of advanced statistical procedures that they will commonly encounter in research articles. This chapter has been updated to reflect current techniques, such as more recent procedures for conducting mediation analyses and the basic ideas of Bayesian methods.

In addition to the new components of our text, we also want to reiterate some comments we made in the first edition about how this book from the beginning has been quite different from other statistics texts.

## What We Do Differently

As different as this course is, it has from the start also done what the best of the statistics texts of the last few years have been already doing well: emphasizing the intuitive, deemphasizing the mathematical, and explaining everything in direct, simple language. But what we have done continues to go beyond even the best of the current lot in eight 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? Even in 2018 most statistics texts have still not faced technological realities. What is important is not that the students learn to calculate a correlation coefficient by hand with a large data set—programs like SPSS can do this in an instant with just a few mouse clicks. What is important is that students work problems in a way that keeps them constantly aware of the underlying logic of what they are doing. 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): the population variance =  $[\sum(X - M)^2]/N$ . Repeatedly working problems using this formula ingrains the *meaning* in

the student's mind. In contrast, the usual computational version of this formula only obscures this meaning: the population variance =  $[\sum X^2 - (\sum X)^2/N]/N$ . Repeatedly working problems using this computational formula does nothing but teaches the student the difference between  $\sum X^2$  and  $(\sum X)^2$ !

Teaching these tired computational formulas today is an anachronism—at least 40 years out of date! Researchers do their statistics on computers, and 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. Students still need to work lots of problems by hand to learn the material. But they need to work them using the definitional formulas that reinforce the concepts, not using the antiquated computational formulas that obscure them. Not since the era when Eisenhower was U.S. president have those computational formulas made some sense as time-savers for researchers who had to work with large data sets by hand. But they were always poor teaching tools. (Because some instructors may feel naked without them, we still provide the computational formulas, usually in a brief footnote, at the point in the chapter where they would traditionally have been introduced.)

2. *Each procedure is taught both verbally and numerically—and usually visually as well.* In fact, when we introduce every formula, it has attached to it a concise statement of the formula in words. (The major formulas with their verbal descriptions are also repeated in Appendix D.) Typically, each example lays out the procedures in worked-out formulas, in words (often with a list of steps), and usually illustrated with easy-to-grasp figures. Practice problems and test bank items, in turn, require the student to calculate results, write a short explanation in layperson's language of what they have done, and make a sketch (for example, of the distributions involved in a  $t$  test). The course material completely prepares the student for these kinds of practice problems and test questions.

It is our repeated experience that these different ways of expressing an idea are crucial for permanently establishing a concept in a student's mind. Many students in the behavioral and social sciences are more at ease with words than with numbers. In fact, many of even the brightest students have a strong fear of all mathematics. Writing the formula in words and providing the lay-language explanation give them an opportunity to do what they do best.

3. A main goal of any introductory statistics course in the behavioral and social sciences is to *prepare students to read research articles*. 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 course teaches a statistical method, it also gives examples of how that method is reported in recent journal articles. And we don't just leave it there. The practice problems and test bank items also include excerpts from journal articles for the student to explain.

4. The book is *unusually up-to-date*. For some reason, most introductory statistics textbooks read as if they were written in the 1950s. The basics are still the basics, but statisticians and researchers think far more subtly about those basics now. Today, the basics are undergirded by a new appreciation of issues such as effect size, power, the accumulation of results through meta-analysis, the critical role of models, and a whole host of new orientations arising from the central role of the computer in statistical analyses. We are much engaged in the latest developments in statistical theory and application, and this book reflects that engagement. For example, we devote an entire early chapter to effect size and power and then return to these topics as we teach each technique. Furthermore, we discuss how to handle situations in which assumptions are violated, and we cover data transformations (this widely used approach is easily accessible to introductory students but is rarely mentioned in current introductory texts).
5. *We capitalize on the students' motivations.* We do this in two ways. First, our examples, while attempting to represent the diversity of behavioral and social sciences research, emphasize topics or populations that students seem to find most interesting. The very first example is from a real study in which students in their first week of an introductory statistics class rate how much stress they feel they are under. Also, our examples 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 worked to make the course 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. It is quite inspiring to *us* to see even fairly modest students glow from having mastered some concept like negative correlation or the distinction between failing to reject the null hypothesis and supporting the null hypothesis. At the same time, we do not constantly remind them how greatly oversimplified we have made things, as some textbooks do.

6. *We emphasize statistical methods as a living, growing field of research.* Each chapter includes a "Bringing Statistics to Life" feature about famous statisticians or interesting sidelights about the field. The goal is for

students to see statistical methods as human efforts to make sense out of the jumble of numbers generated by a research study; to see that statistics are not “given” by nature, not infallible, not perfect descriptions of the events they try to describe, but rather constitute a language that is constantly improving through the careful thought of those who use it. We hope that this orientation will help them maintain a questioning, alert attitude as students and later as professionals.

7. *We include a chapter-length appendix (Appendix E) that provides an overview of the logic and language of the research process in behavioral and social sciences.* Statistical methods are tools used in the research process. Students will find the statistical procedures in this course easier to understand if they appreciate the context in which they are typically used. This chapter outlines the pros and cons of numerous common research designs and also introduces students to the important topics of reliability and validity.
8. *We include a chapter (Chapter 12) that 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 multilevel modeling, mediation, factor analysis, structural equation modeling, analysis of covariance, or multivariate analysis of variance. Students completing an ordinary introductory statistics course are ill-equipped to comprehend most of the articles they must read to prepare a paper or study a course topic in further depth. This chapter makes use of the basics that students have just learned (along with extensive excerpts from recent research articles) to give a rudimentary understanding of these advanced procedures. This chapter also serves as a reference guide that students can use in the future when reading such articles.
9. *We include a chapter (Chapter 13) that helps students learn how to apply statistical methods in their own research projects.* The topics covered include: determining the type of statistical test to use; determining statistical power and required sample size; gathering the data for a study; screening data before analysis; implementing a systematic analysis plan; and writing up the study results. The chapter helps students to understand the broader application of the statistical principles and tests that they learned in prior chapters.

## Support Materials for Instructors

This book is also different from most others in the amount of support materials for instructors (and in this edition we have further strengthened the instructor’s resource materials to make the course easier than ever to teach).

### INSTRUCTOR’S MANUAL (ISBN 9780205989126)

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. A lecture outline is provided for each chapter, along with teaching examples (beyond those in the text) that can be easily incorporated into your lectures. The manual also includes computational answers to each chapter’s Set 2 practice problems. (The text provides answers to the Set 1 practice problems at the back of the book, including at least one example answer to an essay-type question for each chapter.)

### TEST BANK (ISBN 9780205989126)

Our *Test Bank section of the Instructor’s Manual makes preparing good exams easy*. We supply approximately 40 multiple-choice, 25 fill-in, and 10–12 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.

### POWERPOINT SLIDES (ISBN 9780205989140)

A set of customizable ADA-compliant PowerPoint slides is now available for each chapter. Together with the Instructor’s Manual, you now have a wealth of resources that with minimal time will help you to prepare and deliver a stellar lecture, every single class.

## About this *Brief Course*

We have been thrilled by the enthusiastic response of instructors and students to the six editions of our *Statistics for Psychology* (Aron & Aron, 1994, 1999, 2003; Aron, Aron, & Coups, 2006, 2009; Aron, Coups, & Aron, 2013), as well as the positive comments of reviewers, including most encouraging evaluations from early on in *Contemporary Psychology* (Bourgeois, 1997) and *Psychology Learning and Teaching* (Shevlin, 2005).

This *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 behavioral and social 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 substantially briefer than the original, making it quite feasible to cover the whole text even in a quarter-length course.

## 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 send us an e-mail (Arthur.Aron@stonybrook.edu will do for all 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 usually been able to fix them in the very next printing.

## Acknowledgments

First and foremost, we are grateful to our students through the years, who have shaped our approach to teaching by

rewarding us with their appreciation for what we have done well, as well as their various means of extinguishing what we have done not so well. We also much appreciate all those instructors who have sent us their ideas and encouragement.

We remain grateful to all of those who helped us with the first five editions of this book, as well as to those who helped with the first six editions of the larger book (*Statistics for Psychology*). We thank the many people at Pearson who guided and supported us through the revision process for this sixth edition of the *Brief Course*.

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# 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. Many behavioral and social science students are not lovers of mathematics but are keenly attuned to ideas. And we want to underscore the following, based on our collective many decades of experience in teaching: *We have never had a student who could do well in other university 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, Other Than to Fulfill a Requirement?

1. ***Understanding statistics is crucial to being able to read research articles.*** In most of the behavioral and social 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. We also recommend that you take a course on how to design and evaluate good research. We have, however, added an appendix (Appendix E) which provides an overview of the logic and language of the research process in behavioral and social sciences. Also, we have included a chapter (Chapter 12) which helps you understand the basics of the most common more advanced procedures you may run into when reading research, without actually teaching them in detail.
2. ***Understanding statistics is crucial to doing your own research.*** Many students eventually go on to graduate school. Graduate study in the behavioral and social sciences almost always involves *doing* research. In fact, learning to do research on your own is often 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 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 course is understanding statistics, not using statistics. Still, you will learn the basics you need to analyze the results of the kinds of research you are likely to do. And in Chapter 13, Applying Statistical Methods in Your Own Research Project, you will learn some practical advice and tips for using what you learn in this text for analyzing the results of your own research.

3. ***Understanding statistics develops your analytic and critical thinking.*** Behavioral and social 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 behavioral and social 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. Moreover, you will find that these skills will also help you to evaluate media reports of behavioral and social sciences research, which are becoming increasingly common.

## 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. There are short “How are you doing?”

self-tests at the end of each main chapter section. Be sure you do them. And if you are having trouble answering a question—or even if you can answer it but aren't sure you really understand it—stop. Reread the section, rethink it, ask for help. Do whatever you need to do to grasp it. Don't go on to the next section until you are completely confident you have gotten this one. If you are not sure, and you've already done the "How are you doing?" questions, take a look at the "Example Worked-Out Problems" toward the end of the chapter, or try working a practice problem on this material from the end of the chapter. The answers to the Set 1 practice problems are given in Appendix B at the end of the book, so you will be able to check your work.

Having to read the material in this text over and over does not mean that you are stupid. Most students have to read each chapter several times. And 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. Everything else you learn in statistics is built on what you learn at the start. Yet the beginning of the semester is often when students study least.

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 a lot 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 groups with one to three other students. It is best if your group includes some who expect this material to come easily and some who don't. Those who learn statistics easily will get the very most from helping others who struggle with it—the latter will tax the former's supposed understanding enormously. 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 group members 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, 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 very much hope you will have these kinds of experiences in this course.

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