



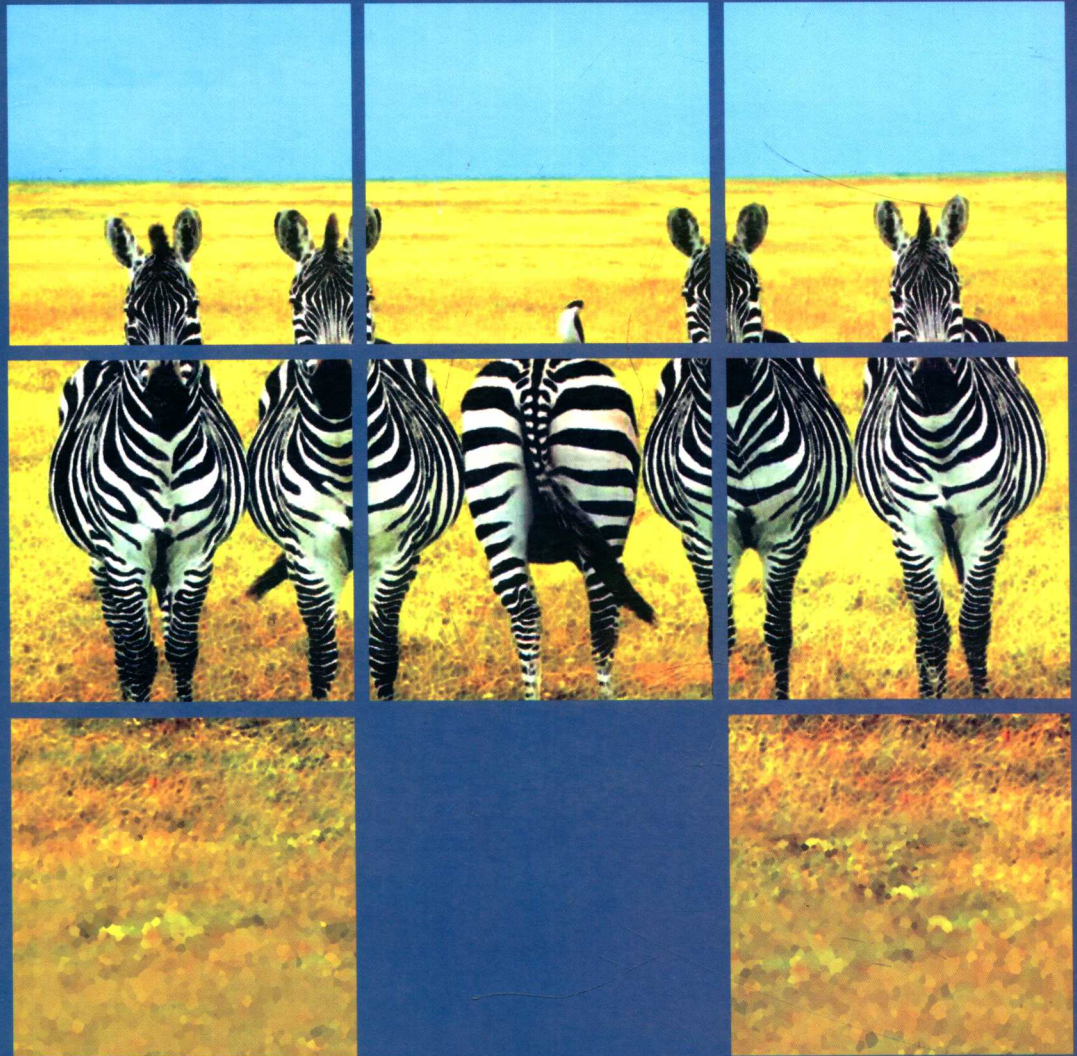
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Statistics for Psychology

心理统计

(第4版)

By Arthur Aron Elaine N. Aron Elliot Coups



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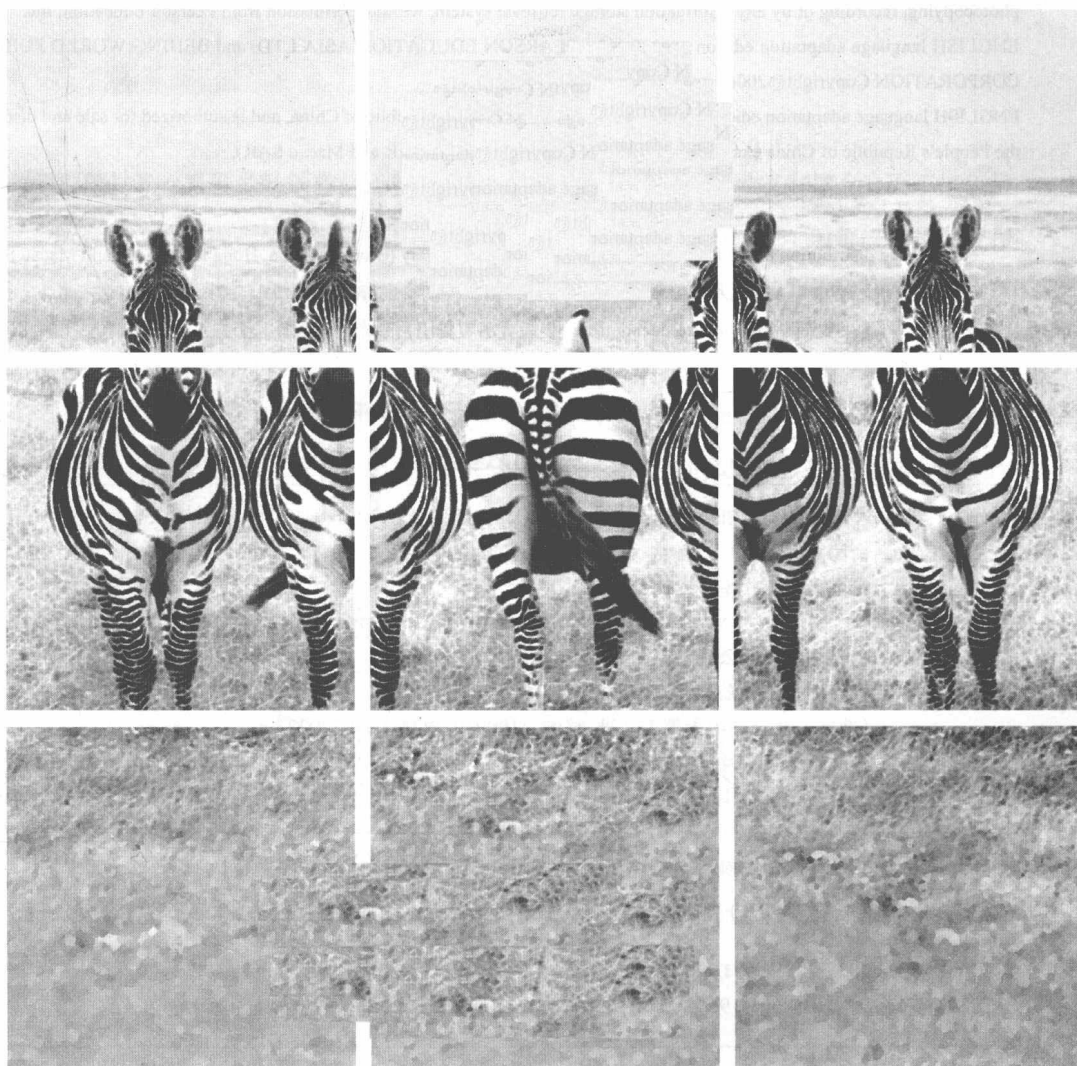
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中文导读

这本《心理统计》一直都是畅销教材。本版（第4版）强调统计基本的含义和概念，而不仅仅是符号和数字。所有的统计原理都解释得简单易懂、明了透彻。统计公式贯穿全书，对每一个统计过程的逻辑提供了简洁的符号总结。书中对于每一个统计过程都进行了言语形式和数字形式的阐述——这是建立完整统计概念结构的重要步骤。

这本心理统计教材可谓是十分与时俱进的。很多统计书的内容还停留在20世纪50年代的水平上。但是，事实上现在的统计思想已经发生了巨大的变化，不再是上个世纪中期的那些基本认识。比如，基本的假设检验就已经被统计效力、效应大小的报告所补充。此外，研究者还通过一系列研究累积起来的元分析和回归分析等相关方法来弥补假设检验的不足。在这本心理统计的第六章中，作者用了整整一章的篇幅来介绍统计显著性、效应大小和统计效力，对于学习统计的读者来说，真是莫大的帮助。

本书虽然定位为初级统计学，但却为学生读懂并撰写研究论文提供了巨大的帮助，从而填补了国内统计教材在这方面的空白。例如书中不仅在例题中提供了研究期刊学术论文中各种各样的统计量和概念，还对相应的统计方法进行了介绍，在习题中也给出相应的练习让学生进行解释。此外，每章都有专门的篇幅来讨论每种统计方法的优劣势以及最新发展，并对统计结果进行了详尽的解释和分析。研究者若能充分了解各种统计方法的优点和不足之处，就可以避免统计方法的误用，也可以减少由于滥用量化方法而导致的批评。对于需要撰写论文的研究者而言，实在是一大福音，解了他们的燃眉之急。

本书的数据大多使用真实的事例，不仅较为生动活泼，而且与现实的结合也容易激发学生对心理统计的学习兴趣。本书是一本简单易懂，并且与实际研究相结合的不可多得的统计教材。

本书中最为精彩之处在于作者对于争议性问题的处理，例如书中提到假设检验的最主要的争议是：当无法拒绝虚无假设，所得的研究结论也并非是虚无假设获得支持，而是“研究结果没有定论”。而目前主流的教科书鲜有人介绍此项争议。读者可以比较此论点与主流教科书看法的差异，对于假设检验的正确使用与误用应有更深入的了解与体会。

这本书的内容主要包括：描述统计（资料的排序，平均数、变异数、标准差和 z 分数）；推论统计（推论统计的重要概念，假设检验，样本平均数的假设检验，效应和统计效力）； t 检验（相关样本 t 检验，独立样本的 t 检验）；方差分析（方差分析的简介，方差分析的结构模式，多因素方差分析）；相关和回归（相关，预测）；非参数检验（卡方检验；非常态化总体的处理策略）；以及高级统计过程简介。最后一章还增加了以一般线性模型来概括的高级统计过程，它对多元方差分析、多元协方差分析、多元回归和因素分析等进行了概括简介，如果读者对这些高级统计过程的具体步骤感兴趣，可以寻找相关的高级统计的教材进行学习。

本书的每一章都有很多富启发性的习题，书后附有详细的答案。为激发读者的兴趣和培养心理学的研究素养，几乎每道题目都是和心理学实验主题相关的实验数据。因此，读者在做习题的过程中，也享受了一顿心理学的盛餐。此外，很多章节后面还附有SPSS操作的步骤，让读者将统计理论和具体SPSS操作融会贯通，从而加深对理论和SPSS的理解。

基于以上特点，我极力向读者推荐这本书。它将为您打开心理统计这扇神奇科学的大门，让您领略到其中的精彩纷呈。您会发现，统计不再令人望而生畏，而是让人流连忘返。

甘怡群博士后

北京大学心理系副教授

北京大学心理系心理统计课程任课教师

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 cafés and on walks in the Bois de Boulogne. It is based on our 40 years of experience teaching, researching, and writing. We believe that the result is a book 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 four 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 major, 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 read the journals in my field.”

The response to the first three editions has been overwhelming. We have received hundreds of thank-you emails and letters from instructors (and from students themselves!) from all over the world (the text has been translated into Traditional Chinese and Traditional Chinese and Spanish). Of course, we were also delighted at the outset by the enthusiastic review of the first edition in *Contemporary Psychology* (Bourgeois, 1997).

With each revision, we have tried to maintain those things about the book that have been 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. We have also added new pedagogical features to make the book even more accessible for students. However, before turning to what’s new in this latest revision, we want to reiterate what we said with the first edition about how this book from the beginning has been so different from other statistics texts.

HOW THIS BOOK WAS DRAMATICALLY DIFFERENT FROM THE START

Different as this book is, it has from the start also done what the best of the better statistics texts of the last few years have been already doing pretty well: emphasizing the intuitive, de-emphasizing the mathematical, and explaining everything in direct, simple language. But what we have done always has gone beyond these books in 10 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 practice problems and test bank items are reduced appropriately to keep computations manageable.)

Why this approach? To date, statistics texts have not faced the technological realities. What is important today is *not* that the students learn to calculate a t test with a large data set—computer programs like SPSS can do this in an instant with a few mouse clicks. What is important today 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 directly displayed in the definitional formula (once the student is used to the symbols): $\text{Variance} = [\Sigma(X - M)^2]/N$. 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: $\text{Variance} = [\Sigma X^2 - (\Sigma X)^2/N]/N$. Repeatedly working problems using this formula does nothing but teach the student the difference between ΣX^2 and $(\Sigma X)^2$!

Teaching the so-called computational formulas is an anachronism. Researchers do their statistics on computers now. At the same time, the ability to do complex statistical computations with a simple menu-driven program makes understanding of the basic principles, as they are symbolically expressed in the definitional formulas, 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. Those old computational formulas made sense as time-savers when researchers 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. Typically, each example lays out the procedures in worked-out formulas, in words (often with a list of steps), and illustrated with an easy-to-grasp figure. 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 chapter 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 establishing a concept in a student's mind. Many psychology students are more at ease with words than with numbers. In fact, some have a positive fear of all mathematics. Writing the formula in words and providing the lay-language explanation gives them an opportunity to do what they do best.

3. A main goal of any introductory statistics course in psychology is to *prepare students to read research articles*. The way a procedure such as a t test or an analysis of variance 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 current 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*. 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 effect size, power, limitations of significance testing, the accumulation of results through meta-analysis, the critical role of models, the underlying unity of difference and association statistics, the growing prominence of regression and associated methods, and a host of new developments arising from the central role of the computer in statistical analyses. We are much engaged in the latest thinking in statistical theory and application, and this book reflects that engagement. For example, we devote an entire early chapter (Chapter 6) to effect size and power and then return to these topics as we teach each technique.

5. We *capitalize on the students' motivations*. We do this in two ways. First, our examples emphasize topics or populations that students seem to find most interesting. The very first 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. Other examples emphasize clinical, organizational, social, and educational psychology while being sure to include sufficient interesting examples from cognitive, developmental, behavioral and cognitive neuroscience, and other areas to inspire students with the value of those approaches. (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 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. 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 books do. Instead, we show students, in the controversy sections in particular, how much there is for them to consider deeply, even in an introductory course.

6. We *emphasize statistical methods as a living, growing field of research*. We take the time to describe the issues, such as the upheaval about the value of significance testing. In addition, each chapter includes one or more "boxes" about famous statisticians or interesting sidelights. 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. *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 psychology research articles today use methods such as analysis of covariance, multivariate analysis of variance, hierarchical multiple regression, mediation, factor analysis, or structural equation modeling. 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 a course topic in further depth. This chapter makes use of the basics that students have just learned (along with extensive excerpts from current research

articles) to give a rudimentary understanding of these advanced procedures. This chapter also serves as a reference guide that students can keep and use in the future when reading such articles.

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, tables of possible schedules and a sample syllabus, advice on structuring exams and an example test, and more still! 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 for student handouts; also available from our website to download as Power Point slides). These lecture outlines and worked-out examples are especially useful to new instructors or those using our book for the first time, since structuring lectures and creating good examples is one of the most demanding parts of teaching the course.

9. Our *Test Bank makes preparing 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.

10. The accompanying *Student's Study Guide and SPSS Workbook* focuses on mastering concepts and also includes instructions and examples for working problems with SPSS. Most study guides concentrate 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 SPSS Workbook* provides learning objectives, 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 (a task they are frequently given in the practice problems and test bank items).

Also, our *Student's Study Guide and SPSS Workbook* goes beyond the brief SPSS sections in each text chapter to provide the needed support for teaching students to become comfortable with this program and carrying out analyses on the computer. First, there is a special appendix on getting started with SPSS. Then, in each chapter corresponding to the text chapters, there is a section showing in detail how to carry out the chapter's procedures with SPSS. (These sections include step-by-step instructions, examples, and illustrations of how each menu and each output appears on the screen.) There are also special activities for using the computer to strengthen understanding. As far as we know, no other statistics textbook package provides this much depth of explanation.

WHAT'S NEW IN THIS FOURTH EDITION

With each new edition we have worked to improve the writing, update content, and make adjustments based on our experience teaching and the wonderful input we have received from instructors using the text. In the third edition, we also focused extensively on adding important pedagogical features including "How Are You Doing?" self-tests throughout the chapters, doubling the number of practice prob-

lems, providing worked-out computational problems as examples just prior to each chapter's practice problems, and as each new formula is introduced, including a boxed concise statement of the formula in words.

With the third edition, we also developed a unique webpage available to instructors who adopt the book and their students: <http://www.prenhall.com/aron>. The webpage provides a variety of study aids, including tips on how to focus one's studying for each chapter; additional practice problems that include actual tables from the text on the web, giving the students the opportunity to use the tables to work through problems; interactive demonstrations for each chapter; an online student study guide, including practice problems, true/false questions, and fill in the blanks; a glossary of all terms from the text; flash card exercises for each chapter's key terms; and all formulas both in symbols (students can click on each symbol to find out what it is) and stated in words. In addition, the webpage supplements the text with four downloadable chapters, one on the basics of research methods, one on applying statistics in one's own research projects, one on repeated measures analysis of variance, and one on integration of statistical tests and the general linear model (which also serves as an excellent review/overview of the entire book).

In this fourth edition, we of course have continued to focus on simplifying exposition and have done our usual updating of content, examples, boxes, controversies, and so on, plus making a host of minor adjustments to make the book more effective. And we have added further pedagogical aids, such as many web links throughout the book with interactive demonstrations, separating out some sections as "Advanced Topics," and introducing most chapters with an engaging example that we carry out throughout the chapter. One major new feature is a section in each chapter showing how to carry out the chapter's procedures using SPSS. Another change is that we have simplified the analysis of variance presentation (combining the previous two chapters on one-way analysis of variance). Yet another new addition is a section on mediational analysis in Chapter 15.

However, the main focus of the present revision has been to reconceptualize the teaching of the material on correlation and regression. We had long resisted calls from instructors to move these topics to after the t test and analysis of variance, thinking that they worked best as descriptive statistics (in previous editions they came right after mean and standard deviation). Many instructors will no doubt continue to prefer to follow our original order, so we have made sure that users can still go directly from Chapter 2 to correlation and regression (now Chapters 11 and 12), and then return to Chapter 3 to begin the discussion of inferential statistics.

At the same time we want to emphasize that the reordering generated much more than a simple moving of material from one place to the other. We took advantage of the reordering to rethink how we cover the material. Correlation is now taught with a definitional formula that is even more conceptually transparent than what we had used in the past, and which does not require using standard deviations or Z scores (which had always raised complications regarding using N or $N - 1$ in their figuring). The new placement also means we can now teach significance tests and power for correlation at a much more sophisticated level. (But the rest of the chapter stands alone, so that instructors preferring to teach correlation early can simply ignore this material.) Perhaps the greatest improvement is in our treatment of regression, always a particularly difficult topic for students. We are especially pleased with our decision to focus on raw-score regression from the outset, making the whole topic much easier for students to grasp.

The most significant change brought by the fourth edition, from our point of view, is that we have added an author, Elliot Coups. The three of us have worked

remarkably well together and believe that the synergy among us and the injection of some “new blood” has resulted in a book that both maintains and builds on what has made it a success so far, yet also shines with fresh new ideas and approaches.

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 email (*Arthur.Aron@sunysb.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 deeply appreciate all those students and instructors who have sent us their ideas and encouragement.

We remain grateful to all of those who helped us with the first three editions of this book, as well as to those who helped with the three editions of the *Brief Course* version. For their very helpful input on the development of this fourth edition of *Statistics for Psychology*, we want to thank Mark Walter, Albion College; Helga Walz, University of Baltimore; Susan Nolan, Seton Hall University; Jwa K. Kim, Middle Tennessee State University; Steven Gangestad, University of New Mexico; Mark Vosvick, University of North Texas; Ann Lynn, Ithaca College; John Bechtold, Messiah College; Donald Sharpe, University of Regina; Terri-Lynn MacKay, University of Manitoba; and Jacqueline Bichsel, Penn State Harrisburg. We also want to thank Jessica Mosher of Prentice Hall, who led us through the long revision process with a combination of carrot and stick.

We particularly want to acknowledge Ayorkor Gaba, who helped us locate wonderful research article examples, Jesus Salcedo for identifying many crucial final changes to the text, Ted Whitley for his thoughtful and painstaking work on revising the *Student’s Study Guide and SPSS Workbook*, and Vincent Fortunato for valuable work on the companion website for the text.

Arthur Aron
Elaine N. Aron
Elliot J. Coups

CREDITS

Data in Tables 7–9, 7–10, 8–4, 8–5, 9–9, 9–10, 10–14, 10–15, 11–6, 11–7, 13–9, and 13–10 are based on tables in Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Copyright © 1988 by Lawrence Erlbaum Associates, Inc. Reprinted by permission.



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 psychology majors are not lovers of mathematics but are keenly attuned to ideas. And we want to underscore the following, based on our 40 years of teaching experience: *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 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 psychology research articles.* Nearly every course you will take as a psychology major will emphasize the results of research studies, and these almost always are expressed using 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 good research. In this book, we focus on the statistical methods for making sense of the data collected through research. However, we have included a downloadable chapter on the website for the book—<http://www.prenhall.com/aron>—that provides an overview of the logic and language of psychology research.)

2. *Understanding statistics is crucial to doing research yourself.* Many psychology majors eventually decide to go on to graduate school. Graduate study in psychology—even in clinical and counseling psychology and other applied areas—almost always involves *doing* research. In fact, learning to do research on your own is often the main 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 psychology programs 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 basics you need to analyze the results of the kinds of research you are likely to do. (Also, the website that accompanies this book—<http://www.prenhall.com/aron>—has a special chapter to help you with practical issues in using what you learn in this book for analyzing results of your own research.)

3. *Understanding statistics develops your analytic and critical thinking.* Psychology majors 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 psychology, this one 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. 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.)

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. 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 particularly 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 easier. If you have not mastered the first half, the second half will be close to impossible.

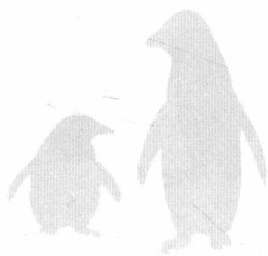
5. *Help each other.* There is no better way to solidify and deepen your understanding of statistics than to try to explain it to someone who is having a harder time. (Of course, this explaining has to be done with patience and respect.) For those of you who are having a harder time, there is no better 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 most from helping others who have to struggle with it—the latter will tax the former's supposed understanding enormously. Those who fear trouble ahead 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 hope you will have these kinds of experiences in this course.

*Arthur Aron
Elaine N. Aron
Elliot J. Coups*



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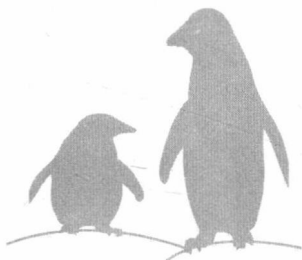
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