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社会学经典教材影印丛书

统计想象

[美] 费里斯·里奇（Ferris Ritchey）著

THE STATISTICAL IMAGINATION

ELEMENTARY STATISTICS FOR THE SOCIAL SCIENCES

Mc Graw Hill

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本书篇幅适中，内容安排层次分明。作者以决策树形式归纳的统计方法和统计步骤，有助于读者对统计知识的梳理和掌握。此外，本书附有学生版SPSS统计软件和若干数据资料，可供读者结合所学，进行相应的操作练习，以便在学习统计原理的同时熟悉统计软件，在运用统计软件的过程中加深对统计知识的理解和认识。

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Dedication

To Wanda, Daniel, Sarah, Kitty, Dorrance, and Agnes
for their love and encouragement.

To Daniel O. Price and P. Neal Ritchey
for their generous assistance.

In loving memory of Phillip Ritchey.

社会学经典教材影印丛书

学术顾问

（按姓氏拼音排序）

出 版 说 明

我们引进这套丛书的目的是介绍当前国外社会学理论和方法，使我国的读者能够直接阅读到西方学者撰写的社会学教材。

需要重申的是，作者本人的观点和结论有些值得商榷，甚至是不可取的，对此我们提请读者加以甄别，书中的观点均不代表我们出版社。

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导　读

强调统计思想甚于强调数学计算，这是当前国外统计教学，尤其是基础统计教学改革的一种取向。美国阿拉巴马大学教授费里斯·里奇撰写的《统计想象》一书，正是一本充分体现这种取向的教科书。它不仅适用于社会科学专业的统计课程，也可用作其他读者学习统计的参考书。

与同类教材相比，本书最明显的特点是：

第一，突出统计的思想性。作者认为，统计不是数学方法，而是一种思考问题的方法。虽然统计要涉及各种数学计算，但贯穿其中的是一种基本思维，即表现为部分相对于全体的“比例思维”(proportional thinking)，数学计算只是实现这种比例思维的工具。因此，书中对统计概念和原理的阐释，都围绕着比例思维的理念而展开；全书重点在介绍统计的思想方法，即“统计想象”(statistical imagination)，数学计算则处在次要的位置上。书中涉及的数学公式和运算方法，难度只相当于中学数学；它们有助于统计知识的诠释和应用，而不会构成阅读本书的障碍。

第二，体现统计的趣味性。统计是有用的，因此人们有学习统计的需要；但统计又往往给人以复杂枯燥的印象，从而会抑制人们学习统计的兴趣。注意到这一点，作者不仅尽量淡化本书的数学色彩，以降低学习统计的难度，而且着意从人们熟悉的社会现象和环境中引出话题或问题，并加以深入浅出的解说，使读者能在贴近社会、贴近生活的感觉中贴近统计，发现统计的趣味，体会统计的魅力，引发学习统计的兴趣。

第三，关注统计的两面性。本书每章都辟一节，评析与各章内容有关的属于无知或谬误性质的统计案例。书中列举的案例有很多来自日常生活；它们或见诸于大众传媒，或见诸于研究文献。这些案例提醒读者，统计作为一种认识工具，既可正确用以反映事实，也会因无知或错误的理解和应用而引致人们的认识偏差。同时，这些案例也可作为反面教材，帮助读者更加全面地理解和掌握统计知识，增强数据阅读和统计分析的能力。

本书篇幅适中，内容安排层次分明。作者以决策树形式归纳的统计方法和统计步骤，有助于读者对统计知识的梳理和掌握。此外，本书附有学生版 SPSS 统计软件和若干

数据资料，可供读者结合所学，进行相应的操作练习，以便在学习统计原理的同时熟悉统计软件，在运用统计软件的过程中加深对统计知识的理解和认识。

陆康强
复旦大学社会学系
2005 年 10 月 15 日

前　言

We all use statistical thinking—the calculation of likelihoods or probabilities—as we go about our daily lives. The simple decision about whether to carry an umbrella involves estimating the likelihood of rain. Probabilities come into play when one makes important life decisions such as whether to marry, take a job, invest in a stock, or change lanes in traffic. Even a moderate amount of statistical expertise in the workplace provides an employee with a competitive advantage. For students in scientific fields, statistical thinking is an essential ingredient for a clear understanding of the natural world, the social order, and human behavior. On a lighter note, statistical thinking underlies games of chance; just as gaming and gambling are fun, statistics is fun.

Unfortunately, students do not always appreciate how much fun a statistics course can be. Social science majors typically have a limited background in mathematics and resent being forced to take this required course. Some statistics texts disregard this fact by presenting complex formulas and thus cause unnecessary math anxiety. Other texts are "dumbed down" to reduce math anxiety, but usually by sacrificing basic statistical principles. This text attempts to teach the difficult concepts of statistics without sacrificing essential mathematics and calculations. However, it is designed to convince students that mathematics is only a tool for—not the essence of—learning statistics.

I learned that statistics can be taught thoroughly without overemphasizing mathematics when I had the great fortune of working as a graduate student assistant with Daniel O. Price, to whom this text is dedicated. His enthusiasm for the subject, along with his clear explanations of logical processes, caused me to fall in love with the subject matter. Like Dan, I have strived in over 20 years of teaching statistics to develop techniques to share this enthusiasm with students. In particular, I have targeted several conceptual hurdles

with the idea of easing students past them. The course design of this text follows four basic principles:

- Statistics is not about mathematics. Instead, it is a learned way of thinking about things.
- Early assignments should be designed to build students' confidence.
- Mastery of the basic elements of statistical reasoning facilitates mastery of the more complex elements; therefore, the learning process is a cumulative one.
- Statistics is learned by doing. There will be many assignments, but the subject matter is inherently interesting and enjoyable. Whistle while you work.

Let me describe these principles in a little more detail. The first is that statistics is not about mathematics per se but about proportional thinking: the visualization of a part to a whole. This view on reality I call *the statistical imagination*. This concept parallels C. Wright Mills's idea of the sociological imagination, which defines the relationship of the individual to the larger society. Similarly, the statistical imagination calls for viewing data in a number of larger contexts. First, observations of individual behavior are viewed within the context of the larger social structure. Second, conclusions about a large population of subjects based on a sample of those subjects are viewed as only one of many sets of conclusions, because a second sample will produce slightly different results. Third, interpretations of statistical data must take into account practical circumstances and cultural realities that provide the essential meaning of the numbers.

The second principle of this text is that the course design should allow students to succeed early on in building confidence and allaying fear of failure. Thus, in the very first pages of the text simple but essential statistical calculations of fractions, proportions, and percentages are introduced. These calculations are presented as ways to quantify proportional thinking, reinforcing the idea that mathematics is only a tool for—not the essence of—learning statistics. Moreover, statistical abstractions that appear as hurdles to many students (for example, the standard deviation, standardized scores, sampling error, and sampling distributions) are given plenty of attention. The theme of error control is emphasized to convey the importance of diligence in statistical work and to encourage students to develop a sense of competence.

The third principle is that for students to grasp the logic of inferential statistics and hypothesis testing successfully, the basic elements of the testing procedure must be well mastered. Part of this objective is achieved through text design. Lots of coverage is given to working with areas under a bell-shaped graphical curve called the normal distribution curve. Considerable time is allowed for actually producing sampling distributions: descriptions of the outcomes that occur when, say, 10 coins are repeatedly tossed or samples of beans are repeatedly drawn from a boxful. Through actual repeated sam-

pling, students learn that the statistics of any single sample are only one set of many possible estimates for the larger group from which the sample came. This hands-on approach will demystify this concept, which is at the core of statistical reasoning. Students learn that sampling distributions are real, not abstract, conjectures. The text also presents the logic of hypothesis testing in six steps, one of which requires drawing sampling distribution curves. This attention to detail fosters proportional thinking. The other part of the objective of mastering basic ideas is that students must apply themselves and keep up with course material and assignments.

The fourth principle is related to the previous ones: Statistics is learned by doing. Each chapter has pencil and paper questions and exercises that encourage the proportional thinking that underlies statistical analysis. For classes using computers, the *Computer Applications for The Statistical Imagination* compact disk provides *SPSS for Windows* software, chapter exercises, detailed illustrations on interpretating output, and a variety of data sets chosen to stimulate interest as well as expose students to real-world research. The disk has a point and click design that requires no prior experience in the use of computers.

To the Student

Through years of teaching statistics I have learned that students must be willing to work and keep up with this course. Attention to and success with early assignments make later, more abstract assignments much easier to grasp. Succeeding in a statistics course is much like an airliner taking off. A great deal of energy is used reaching altitude (Chapters 1 through 9), but then the plane can cruise the rest of the way (Chapters 10 through 16). This text is designed for early success to allay students' fears and reveal how enjoyable and interesting the subject is. Even an average student who is willing to put in the time and effort can earn an A in this course and have fun doing it. To borrow a line from a Walt Disney animated movie tune, a successful attitude for this course is "whistle while you work."

If you fear that this course will doom you because of your perceived weaknesses in math, put those fears aside. The course starts with simple calculations and builds on them. If you work hard and keep up, the math will not be an issue. Start by reviewing the basic mathematical procedures in Appendix A. Here are some study guides:

- Organize your study notes, assignments, returned papers, and the like, in a three-ring binder. This allows you to insert corrected materials and returned papers in their proper place and makes exam preparation highly efficient.
- Use proper reading technique. That is, look over a chapter for 20 to 30 minutes before reading it in detail. Read chapters before they are presented in class.

- Never miss a class or lab session. The material in this course is cumulative. Everything learned early on is applied in later chapters. Each chapter is a link in a chain, and a chain is only as strong as its weakest link. Keep up and this course is fun. Get behind and it becomes unnecessarily troublesome.
- In this course, do not be afraid to give back what is in the book. Complete sample exercises are provided for all procedures, and there is a summary of formulas at the end of each chapter. Exercises and tables distinguish between "givens" (information provided by a research problem) and "calculations" (what must be done to complete the problem). Follow the form of these exercises and "show the work" as well as the answer. In fact, answers to some of the problems are provided in Appendix C so that you may check your progress at home. A lifeless computer also can generate answers. Proper interpretation of the answer is what is important, and detailed work is necessary for learning the logic behind a procedure.
- Turn in work on time. Go over returned assignments and correct them immediately.
- Ask for assistance when needed. There is no such thing as a stupid question in this course, but failing to ask *is* stupid.
- Accept the fact that this course is fun. Concentrated effort will be rewarded not only in terms of earning a grade but also in terms of learning valuable job skills.

To the Instructor

This course is designed to cover basic elements of hypothesis testing in such a way that when inferential statistics are approached (Chapters 9 and beyond), the abstract concepts are easily achievable. The Instructor's Manual and the Test Bank and Solutions Manual that accompany this text provide details of the pointers listed below, along with lecture ideas, sample problems to present in class, multiple forms of assignments, quizzes, exams, and grading keys. Chapter exercises have a parallel, odd number–even number setup so that the odd-numbered exercises are assigned one term and the even-numbered are assigned the next.

While most instructors have developed their own effective techniques, I have found that the following pedagogical regimen maximizes students' success. This regimen has been class tested over 20 times, and it is based on the idea that assignments and quizzes are rehearsals for major exams. In my experience, major exams should be given "closed-book" (except for formulas and statistical tables). Open-book exams foster poor study habits. I alleviate the pressures of a closed-book exam, however, by providing students with ample opportunity to learn from mistakes on assignments.

- Require weekly assignments that are due on the class day after the completion of a lecture on a chapter's material.

- Return graded assignments at the next class and make assignment keys (from the Test Bank and Solutions Manual) available on reserve or provide multiple copies in a lab box. Since keys are to be made available, grading of assignments does not require extensive "red marking." (I have found that the availability of assignment keys does not compromise the next term's work. Moreover, exercises are designed with an odd-even format for alternating terms.)
- At the next class or in lab, quiz students on that chapter's material. Collect the quizzes five minutes after the first completed quiz is turned in. Distribute clean copies of the quiz and present or have students present the answers immediately.
- Give two or three in-term exams as well as a final exam (all closed-book except for formulas and statistical tables).

In my experience, several topics in the course must be given sufficient attention when presented or much time will be lost later attempting to fill in gaps.

- To eliminate math anxiety, allow students to enjoy early success with assignments on proportions, frequency distributions, and graphing. Moreover, a thorough review of proportions and percentages facilitates instruction on probability theory, sampling distributions, p-values, type I and type II errors, and so on.
- To foster linear thinking and proportional thinking skills, take plenty of time to explain the standard deviation and standardized scores and have the students work many problems partitioning areas under the normal curve.
- Actually generate at least two sampling distributions in class. Thereafter, when the concept is addressed, students will fully understand what a sampling distribution is.
- Require students to produce the details of the six steps of statistical inference—especially drawing the sampling distribution curve in step 2—on every hypothesis test on assignments, quizzes, and exams. Repeating this procedure will bring all students along. Some will grasp the details immediately (Chapter 9). By Chapter 11, every student who is truly working hard will have grasped the logic. Thereafter, you will be able to cruise because the pedagogical aspects of the six steps will be second nature to the students. Thus, in later chapters on bivariate analysis, you may concentrate on conceptual issues related to hypothesis testing and research ideas.

Special Features

- **Readability.** The text has been class tested many times.
- **Conceptual themes to spark interest.** The text is designed around

several conceptual themes that make statistics an enjoyable endeavor. First, statistics is about proportional thinking, and mathematical calculations are simply tools to assist in this process. Second, when the statistical imagination is used, statistical estimates are interpreted in relation to the larger pictures of not only a population of subjects but also a "population" of ideas, values, normative forces, practical circumstances, and theories. Distinctions are made between statistical significance and practical/theoretical significance. Third, the theme of error control emphasizes the importance of precision, diligence, and professionalism in the conduct of research.

- **Targeting results to the proper audience.** Discussions are included on how to present results to both scientific and public audiences, along with examples of tabular presentation.
- **Overcoming conceptual hurdles.** Conceptual hurdles are identified, and many devices learned by the author through long years of instruction are employed to get students past them. Such devices include a thorough delineation of the standard deviation, extensive coverage of standardized scores and sampling distributions, and a clear explanation of degrees of freedom.
- **A separate chapter on sampling distributions.** Sampling distributions are presented and illustrated to provide the essential ingredient of proportional thinking.
- **Six steps of statistical inference.** The logical procedures of hypothesis testing are consistently presented as "the six steps of statistical inference." Every statistical test is illustrated within this framework. Illustrations are preceded by a "Brief Checklist of the Six Steps of Statistical Inference."
- **The statistical hypothesis.** To avoid the vagaries and inconsistencies of the term *null hypothesis,* the straightforward term *statistical hypothesis* is substituted. In every situation, the statistical hypothesis is the one that generates the sampling distribution. It is noted where the term *null hypothesis* may be used correctly.
- **The four aspects of a relationship.** The interpretations of bivariate statistical tests follow four aspects of a relationship: existence, direction, strength, and nature.
- **Complete examples of each statistical procedure.** By adhering to the six steps of statistical inference and the four aspects of a relationship, complete examples keep students informed about what is expected on assignments and exams. Distinctions between "givens" and "calculations" facilitate problem solving.
- **Guidelines on choosing the proper statistical test.** Each hypothesis test is preceded by a box describing when to use a test (i.e., number of samples, level of measurements of variables, sample size). A cumulative

decision-tree diagram at the end of each hypothesis testing chapter further reinforces the test selection process.

- **Highlighting of important terms and formulas.** Concepts and formulas are boxed throughout for easy review, and each chapter has a summary of formulas. The index is thorough. Symbols and formulas are listed inside the book cover.
- **Conceptual diagrams.** To teach students to think proportionally, all hypothesis tests are presented with conceptual diagrams that distinguish populations and parameters from samples and statistics.
- **Varied chapter exercises.** Pencil and paper exercises present a good mix of practical, everyday life problems and scientific problems from a variety of social science and health journals. Exercises are ordered from simple to complex. Answers to selected exercises are provided in Appendix C.
- **Optional computer applications.** Whether or not a class is using computers, throughout the text the utility of computers is described. The optional *Computer Applications for The Statistical Imagination* compact disk contains *SPSS for Windows* software and varied data sets, such as the General Social Survey, an ecological data set extracted from U.S. Census population data and U.S. Department of Justice crime data, and surveys on homelessness and physicians' fears of malpractice litigation. Updates of the compact disk are periodically made available. With its point and click design, no prior experience with computers is required.
- **Statistical follies and fallacies.** Consistent with the error control theme, each chapter presents common (and often comical) misinterpretations of statistics in everyday life and by the mass media and researchers.

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Austin. Dan coauthored a statistics text with Margaret Hagood in the 1950s and taught Hubert M. Blalock, whose text *Social Statistics* (McGraw-Hill) was a mainstay for so many graduate students in the 1960s and 1970s. Many of the ideas and pedagogical devices of this text—the emphasis on reifying sampling distributions, the six steps of statistical inference, the four aspects of a relationship—I learned from Dan. In fact, he first suggested that I write a text as his coauthor. As it turned out, time passed and he retired before the project moved very far, but he has been helpful since. Second, special thanks to P. Neal Ritchey, my brother and fellow sociologist at the University of Cincinnati. When I encountered conceptual challenges, he was always there with the correct insights and answers. As this text went through drafts, he suspended his very busy schedule to read, critique, and edit for me, and he assisted in compiling data sets for the computer applications. I truly appreciate the advantages of having an older brother in the same field. My love and thanks go to Neal, who has guided me in so many endeavors over the years.

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Ferris J. Ritchey