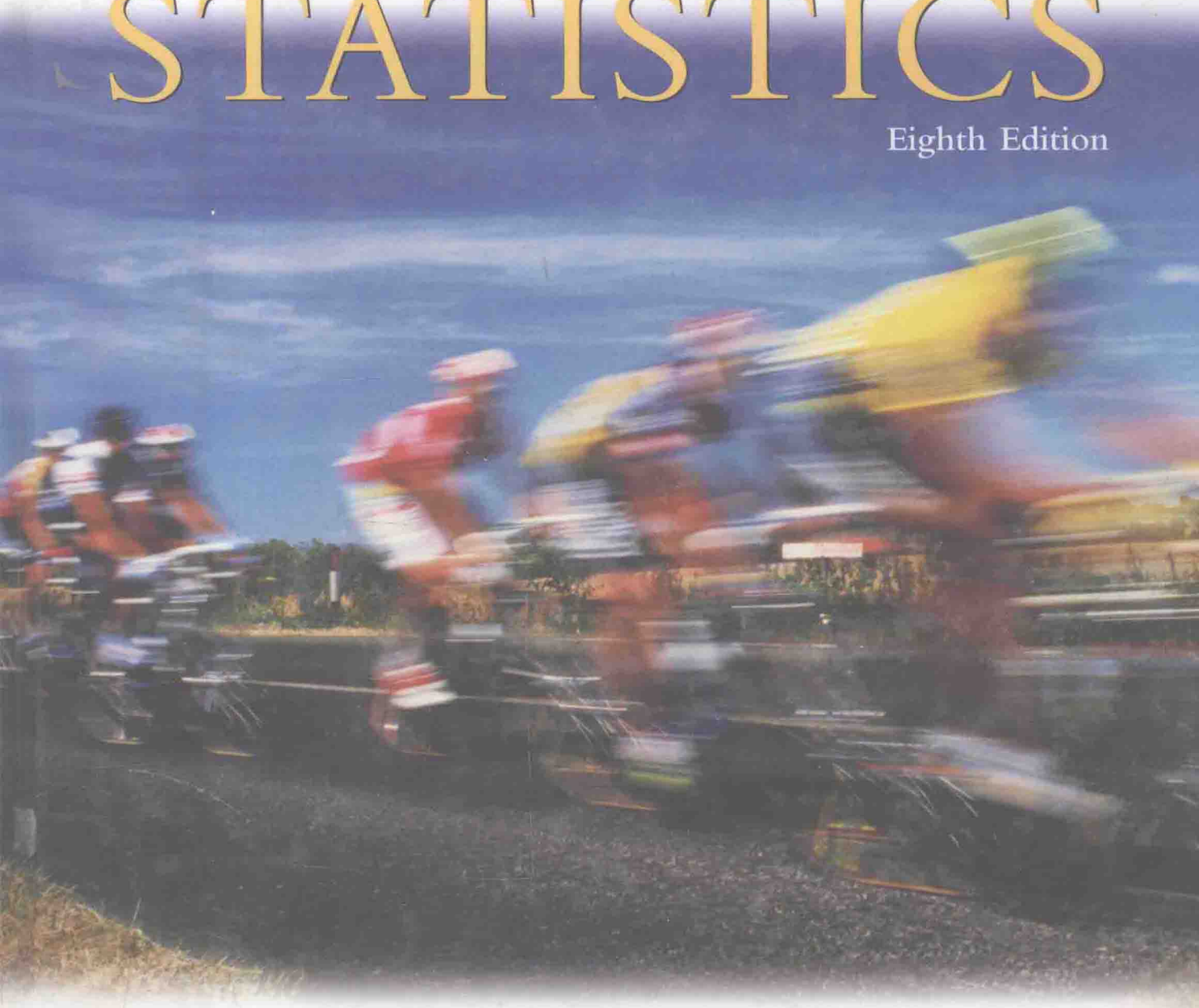
A First Course in STATISTICS

Eighth Edition



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McClave • Sincich

A FIRST COURSE IN STATISTICS

Eighth Edition

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PREFACE

STATISTICS IN THE NEW MILLENIUM

This eighth edition of *A First Course in Statistics* is an introductory text emphasizing inference, with extensive coverage of data collection and analysis as needed to evaluate the reported results of statistical studies and make good decisions. As in earlier editions, the text stresses the development of statistical thinking, the assessment of credibility and value of the inferences made from data, both by those who consume and those who produce them. This one-semester text covers basic statistical and probability topics through simple linear regression. It assumes a mathematical background of basic algebra.

NEW TO THE EIGHTH EDITION

- Exercise sets have been revised to provide a greater variety in level of difficulty. In addition to "Learning the Mechanics" exercises, "Applied Exercises" are categorized into "Basic," "Intermediate," and "Advanced" at the end of each section.
- All printouts from statistical software (SAS, SPSS, MINITAB, and STATISTIX) have been revised to reflect the latest versions of the software.
- The sections in Chapter 8 (Comparing Population Proportions) have been reorganized with emphasis on whether one or two qualitative variables are analyzed.

TRADITIONAL STRENGTHS

We have maintained the pedagogical features of *A First Course in Statistics* that we believe make it unique among introductory statistics texts. These features, which assist the student in achieving an overview of statistics and an understanding of its relevance in the social and life sciences, business, and everyday life, are as follows:

- **Use of Examples as a Teaching Device** Almost all new ideas are introduced and illustrated by data-based applications and examples. We believe that students better understand definitions, generalizations, and abstractions *after* seeing an application.
- **Exploring Data with Statistical Computer Software** Each statistical analysis method presented is demonstrated using output from four leading statistical software packages: SAS, SPSS, MINITAB, or STATISTIX. In addition, output and keystroke instructions for the TI-83 Graphing Calculator are covered in optional boxes.
- **Nonparametric Methods Integrated** Throughout the text, optional sections on alternative distribution-free (nonparametric) procedures follow the relevant sections.
- **Statistics in Action** Each chapter concludes with a case study on a contemporary, controversial, or high-profile issue. Data from the study are presented for analysis and questions, prompting the students to evaluate the findings and

to think through the statistical issues involved. Additional cases appear on the Web site.

- **Real Data Exercises** The text includes more than 800 exercises illustrated by applications in almost all areas of research. All the applied exercises employ the use of current real data extracted from a wide variety of publications (e.g., newspapers, magazines, journals, and the Internet). Many students have trouble learning the mechanics of statistical techniques when all problems are couched in terms of realistic applications. For this reason, all exercise sections are divided into four parts:

  Learning the Mechanics. Designed as straightforward applications of new concepts, these exercises allow students to test their ability to comprehend a mathematical concept or a definition.

  Applying the Concepts—Basic. Based on applications taken from a wide variety of journals, newspapers, and other sources, these short exercises help the student begin developing the skills necessary to diagnose and analyze real-world problems.

  Applying the Concepts—Intermediate. Based on more detailed real-world applications, these exercises require students to apply their knowledge of the technique presented in the section.

  Applying the Concepts—Advanced. These more challenging real-data exercises require students to utilize their critical thinking skills.

- **Quick Review** Each chapter ends with a list of key terms and formulas, with reference to the page number where they first appear.
- **Language Lab** Following the Quick Review is a pronunciation guide to Greek letters and other special terms. Usage notes are also provided.
- **Student Projects** Presented at the end of each chapter, these projects emphasize gathering data, analyzing data, and/or report writing.
- **Footnotes** Although the text is designed for students with a non-calculus background, footnotes explain the role of calculus in various derivations. Footnotes are also used to inform the student about some of the theory underlying certain methods of analysis. These footnotes allow additional flexibility in the mathematical and theoretical level at which the material is presented.

ACKNOWLEDGMENTS

This book reflects the efforts of a great many people over a number of years. First, we would like to thank the following professors, whose reviews and comments on this and prior editions of *Statistics* and/or *A First Course in Statistics* have contributed to the eighth edition:

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SUPPLEMENTS FOR THE INSTRUCTOR

Annotated Instructor's Edition (AIE) (ISBN 0-13-067423-0)

Marginal notes placed next to discussions of essential teaching concepts include:

- Teaching Tips—suggest alternative presentations or point out common student errors
- Exercises—reference specific section and chapter exercises that reinforce the concept
- Short Answers—section and chapter exercise answers are provided next to the selected exercises

Instructor's Solutions Manual by Nancy S. Boudreau (ISBN 0-13-067419-2)

Solutions to all of the even-numbered exercises are given in this manual. Careful attention has been paid to ensure that all methods of solution and notation are consistent with those used in the core text. Solutions to the odd-numbered exercises are found in the *Student's Solutions Manual.*

Test Bank by Mark Dummeldinger (ISBN 0-13-067410-9)

The *Test Bank* includes more than 1,000 problems that correlate to problems presented in the text.

Instructor's Notes by Mark Dummeldinger (ISBN 0-13-066074-4)

This printed resource contains suggestions for using the questions at the end of the *Statistics in Action* cases as the basis for class discussion and a complete short answer book with letter of permission to duplicate for student use.

TestGen-EQ (0-13-066078-7)

TestGen-EQ is a computerized test bank which allows you to view and edit test bank questions, transfer them to exams, and print in a variety of formats. The program offers many options for organizing and displaying test banks and tests and a built-in random number and test generator allows instructors to create multiple versions of exams.

WebCT/BlackBoard by Engin Sungur

The *BlackBoard* and *WebCT* sites offer course-compatible content including the *Student's Solutions Manual*, technology help, quizzes, and lecture content. These sites also include Web-based statistical applets (STATLETS^{TM}) designed specifically for the text by StatPoint, LLC, which encourage students to develop their conceptual understanding of statistics by providing accessible computational and graphing capabilities matched with specific questions to reinforce understanding of key concepts from the text.

CourseCompass by Engin Sungur

CourseCompass is the perfect course management solution that combines quality Prentice Hall content with state-of-the-art *BlackBoard* technology! It is a dynamic, interactive online course management tool powered by *BlackBoard*. This exciting product allows you to teach with market-leading Prentice Hall content in an easy-to-use customizable format. This site offers course-compatible content, including the *Student's Solutions Manual*, technology help, quizzes, and lecture content. This site also includes Web-based statistical applets (STATLETS™) designed specifically for the eighth edition of the text by StatPoint, LLC, which encourage students to develop their conceptual understanding of statistics by providing accessible computational and graphing capabilities matched with specific questions to reinforce understanding of key concepts from the text.

Companion Website (0-13-066073-6)

Located at *http://www.prenhall.com/mcclave*, the *Companion Website* is an online, interactive study guide, matched to each chapter of the text, with an online syllabus builder, technology help, quizzes, objectives, Internet destinations, PowerPoint downloads, and the text's data files available for download.

SUPPLEMENTS AVAILABLE FOR THE STUDENT

Data CD

The text is accompanied by a CD which contains files for all of the data sets marked with a CD icon in the text. These include data sets for text examples, exercises, and *Statistics in Action* cases. All data files are saved in ASCII format for easy importing into statistical software (e.g., SAS, SPSS, MINITAB, or STATISTIX). A list of the data sets, with file names and variables, is provided in Appendix B.

Student's Solutions Manual by Nancy S. Boudreau (ISBN 0-13-067418-4)

Fully worked-out solutions to all of the odd-numbered exercises are provided in this manual. Careful attention has been paid to ensure that all methods of solution and notation are consistent with those used in the core text.

TI-83 Manual by Singh Kelly (0-13-066919-9)

MINITAB Manual by Augustin Vukov (0-13-066922-9)

Microsoft Excel Manual by Anne Drougas (0-13-066921-0)

Each spiral-bound companion manual works hand-in-glove with the text. Step-by-step keystroke-level instructions, with screen captures, provide detailed help for using the technology to work pertinent exercises. A cross-reference chart indicates which text examples are included and the exact page reference in both the text and technology manual. Output with brief instruction is provided for selected odd-numbered exercises to reinforce the examples.

WebCT/BlackBoard by Engin Sungur

The *BlackBoard* and *WebCT* sites offer course-compatible content including the *Student's Solutions Manual*, technology help, quizzes, and lecture content. These sites also include Web-based statistical applets (STATLETS™) designed specifically for the text by StatPoint, LLC, which encourage students to develop their conceptual understanding of statistics by providing accessible computational and graphing capabilities matched with specific questions to reinforce understanding of key concepts from the text.

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LIST OF DATA SOURCES

ABC News
Academy of Management Journal
Adapted Physical Activity Quarterly
Alachua County (Florida) Property Appraisers Office
American Association for Marriage and Family Therapy
American Association of Nurse Anesthetists Journal
American Automobile Association
American Cancer Society
American Education Research Journal
American Journal of Audiology
American Journal of Dance Therapy
American Journal of Orthopsychiatry
American Journal of Political Science
American Journal of Psychiatry
American Journal of Psychology
American Journal of Public Health
American Journal of Speech-Language Pathology
American Journal on Mental Retardation
American Psychologist
American Psychosomatic Society
American Rifleman
American Sociological Review
American Scientist
American Statistical Association
American Statistician
AmStat News
Animal Behavior
Annals of the Association of American Geographers
Annals of Internal Medicine
Annals of Tourism Research
Applied Animal Behaviour Science
Applied Psycholinguistics
Applied Spectroscopy
Aquatic Botany
Arctic and Alpine Research
Archives of Disease in Childhood
Archives of Internal Medicine
Association for the Advancement of Applied Sport Psychology
Astronomical Journal
Astronomy
Australian Journal of Zoology
Bayonet Point Hospital (St. Petersburg, Florida)
Beanie World Magazine
Benefits Quarterly
Biogen, Inc.
Brain and Behaviour Evolution
Brain and Language
British Journal of Sports Medicine
Business Week
CACI Marketing Systems
Card Fax
Car and Driver
Cell Biology
Centers for Disease Control and Prevention
Chance
Chemosphere
Chest
Children and Youth Services Review
Christianity Today
Chromatographia
Clinical Kinesiology
Clinical Psychology Review
Cognitive Aging Conference
College Entrance Examination Board
College Student Journal
Collegium Antropologicum
Communication Research
Community Mental Health Journal
Consumer Reports
Consumer's Research
Dermatology
Dini Miller, Virginia Tech University
Discover
Ear & Hearing
Ecological Applications
Economic Botany
Educational Technology
Elizabeth Schreiber, University of Kansas
Entrepreneur
Environmental Entomology
Environmental Protection Agency
Environmental Science & Engineering
Environmental Science & Technology
Ethology
European Journal of Operational Research
Exceptional Children
Explore (University of Florida)
Federal Trade Commission
Fisheries Science
Florida Attoney General's Office
Florida Department of Health and Administrative Services
Florida Employer Opinion Survey
Florida Scientist
Florida Shredder's Association
Florida Trend
Food and Drug Administration
Forbes
Fortune
Frances VanVoorhis
Genetical Research
Geoderma
Geography
Geological Magazine
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Health Education Journal
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International Journal of Radiation Oncology and Biological Physics
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Johnson & Johnson, Inc.
Journal of the Academy of Rehabilitative Audiology
Journal of Adlerian Theory, Research and Practice
Journal of Advanced Nursing
Journal of Agricultural, Biological, and Environmental Statistics
Journal of Allergy and Clinical Immunology
Journal of the American Medical Association
Journal of the American Mosquito Control Association
Journal of the American Statistical Association
Journal of Applied Biology
Journal of Applied Biomechanics
Journal of Applied Business Research
Journal of Applied Ecology
Journal of Applied Phycology
Journal of Applied Physics
Journal of Applied Psychology
Journal of Behavioral Medicine
Journal of Business Communications
Journal of Business & Economic Statistics
Journal of Business Ethics
Journal of Business Finance and Accounting
Journal of Child Psychology and Psychiatry
Journal of Colloid and Interface Science
Journal of Communication Disorders
Journal of Computer Information Systems

Journal of Consulting and Clinical Psychology
Journal of Drug Issues
Journal of Economics
Journal of Educational Statistics
Journal of Ethnopharmacology
Journal of Experimental Psychology
Journal of Experimental Zoology
Journal of Family Violence
Journal of Fish Biology
Journal of Gang Research
Journal of Genetic Psychology
Journal of Geography
Journal of Hazardous Materials
Journal of Head Trauma Rehabilitation
Journal of Human Stress
Journal of Information Science
Journal of Infrastructure Systems
Journal of Intellectual Disability Research
Journal of Leisure Research
Journal of Marketing Research
Journal of Marriage and the Family
Journal of the Mosquito Control Association
Journal of the National Cancer Institute
Journal of Negro Education
Journal of Nonverbal Behavior
Journal of Nursing Education
Journal of Nutrition
Journal of Occupational Psychology
Journal of Organic Chemistry
Journal of Orthopsychiatry
Journal of Parapsychology
Journal of Peace Research
Journal of Political Economy
Journal of Portfolio Management
Journal of Psychology
Journal of Psychology and Aging
Journal of Quality Technology
Journal of Quantitative Criminology
Journal of Real Estate Research
Journal of Rehabilitation
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Journal of Soil and Water Conservation
Journal of Speech, Language, and Hearing Research
Journal of Sport and Social Issues
Journal of Sport Behavior
Journal of Sports Medicine and Physical Fitness
Journal of STAR Research
Journal of Statistics Education
Journal of Studies in Technical Careers
Journal of Testing and Evaluation
Journal of Visual Impairment & Blindness
Journal of Wildlife Management
Journal of Zoology
Kelly Uscategui, University of Connecticut
Ladies Home Journal
Lei Lei, Rutgers University
Library Acquisitions: Practice & Theory
Liquid Assets: The International Guide to Fine Wines
Major League Baseball
Management Science
Marine Technology
Mathematical Geology
Memory & Cognition
Merck Research Labs
Meteoritics
Minneapolis Star and Tribune
Minnesota Department of Transportation
Moffitt Cancer Research Center (University of South Florida)
Motivation and Emotion
National Aeronautics and Space Administration
National Center for Education Statistics
National Center for Environmental Health
National Direct Student Loan Program
National Earthquake Information Center
National Highway Traffic Safety Administration
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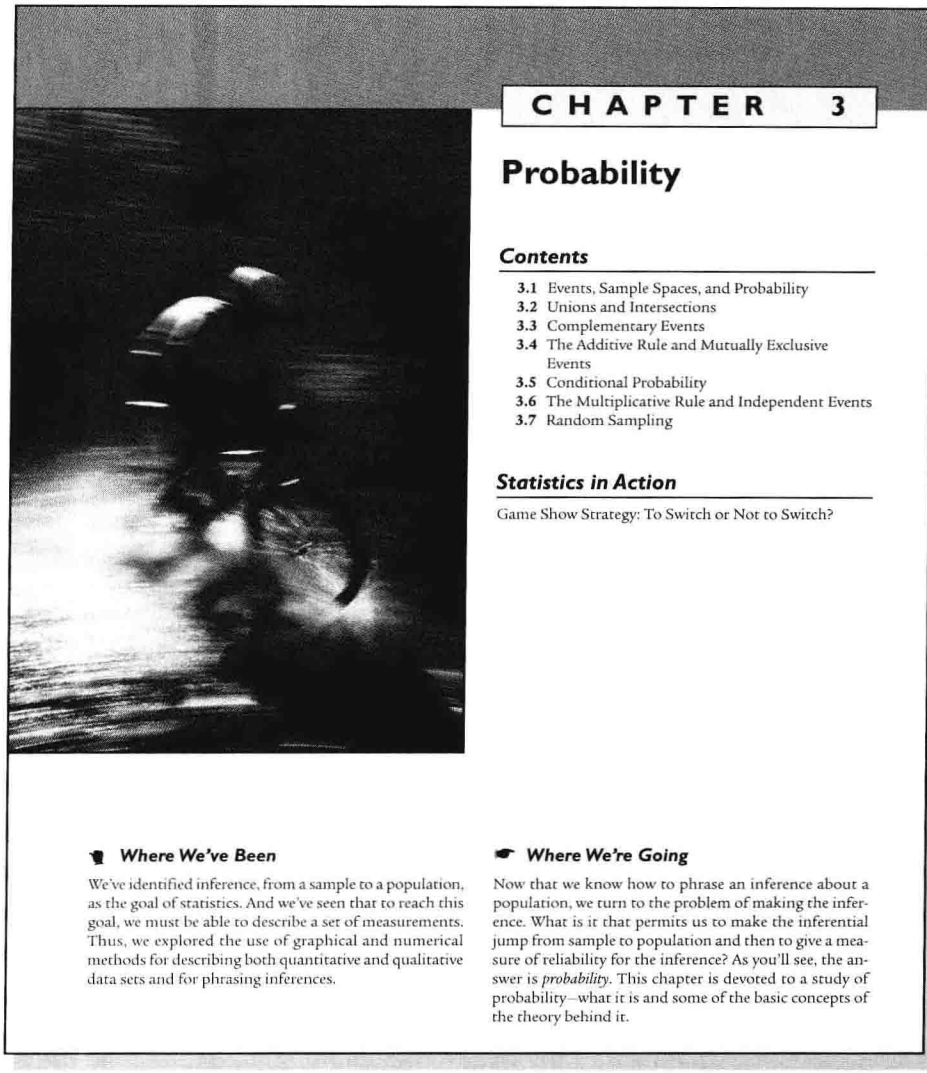
National Oceanic and Atmospheric Administration
National Wildlife
Nature
Naval Research Logistics
Networks
Newark Star-Ledger
New England Journal of Medicine
New Jersey Business
New Scientist
New York Times
Newsweek
Nilson Report
Optometry and Vision Science
Organizational Behaviour and Human Decision Processes
Organizational Science
Parade Magazine
Pediatric Exercise Science
Perception & Psychophysics
Physical Therapy
Phytopathology
Planta Medica
Political Science & Politics
Principles of Operation Management
Proceedings of the National Academy of Sciences
Production and Inventory Management Journal
Professional Geographer
Progress in Natural Science
Psychological Assessment
Psychological Reports
Psychology and Aging
Psychosomatic Medicine
Quality Congress Transactions
Quality Engineering
Quality Management Journal
Quality Progress
Queuing Models
Rehabilitative Psychology
Research Review
Robinson Appraisal Co., Inc.
Science
Science Education
Science News
Scientific American
Sleep
Social Psychology Quarterly
Sociological Methods & Research
Sociology of Sport Journal
Soil Science
Sporting News
Sports Illustrated
Statistical Abstract of the United States
Statistical Bulletin
Statistics in Sport
St. Petersburg Times
Susan Farber, *Identical Twins Reared Apart*
Tampa Tribune
Teaching Psychology
Teaching Sociology
Technometrics
The Bell Curve: Intelligence and Class Structure in American Life
The Condor
The Movie Times
Time
UCLA Journal of Environmental Law & Policy
University of Florida
University of South Florida Office of Research
U.S. Army Corps of Engineers
U.S. Bureau of Labor Statistics
U.S. Chess Federation
U.S. Department of Energy
U.S. Golf Association
U.S. News & World Report
USA Today
USF Magazine
Wall Street Journal
Washington Post
Wetlands
Wine Spectator
Work and Occupations
World Archaeology
World Development
World Economy
Zoological Science

HOW TO USE THIS BOOK

To the Student

The following pages will demonstrate how to use this text in the most effective way to make studying easier and to understand the connection between statistics and your world.



CHAPTER 3

Probability

Contents

Statistics in Action

Game Show Strategy: To Switch or Not to Switch?

Where We've Been

We've identified inference, from a sample to a population, as the goal of statistics. And we've seen that to reach this goal, we must be able to describe a set of measurements. Thus, we explored the use of graphical and numerical methods for describing both quantitative and qualitative data sets and for phrasing inferences.

Where We're Going

Now that we know how to phrase an inference about a population, we turn to the problem of making the inference. What is it that permits us to make the inferential jump from sample to population and then to give a measure of reliability for the inference? As you'll see, the answer is *probability*. This chapter is devoted to a study of probability—what it is and some of the basic concepts of the theory behind it.

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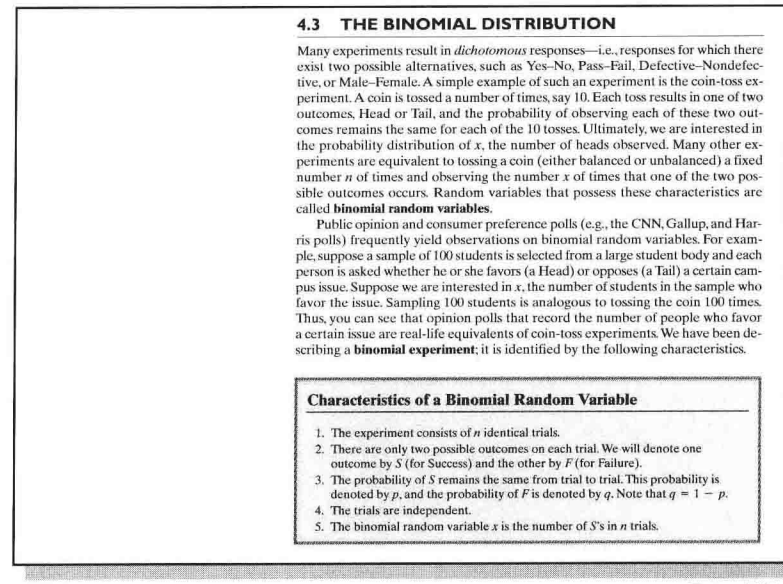
Chapter Openers Show Links Between Old and New Topics

- **Where We've Been** quickly reviews how information learned previously applies to the chapter at hand.
- **Where We're Going** highlights how the chapter topics fit into your growing understanding of statistics.

Easy to Locate Boxes Highlight Important Information

- Definitions, Strategies, Key Formulas, and other important information is highlighted for quick reference.
- Helps students to prepare for quizzes and tests by reviewing the highlighted information.



4.3 THE BINOMIAL DISTRIBUTION

Many experiments result in *dichotomous* responses—i.e., responses for which there exist two possible alternatives, such as Yes–No, Pass–Fail, Defective–Nondefective, or Male–Female. A simple example of such an experiment is the coin-toss experiment. A coin is tossed a number of times, say 10. Each toss results in one of two outcomes, Head or Tail, and the probability of observing each of these two outcomes remains the same for each of the 10 tosses. Ultimately, we are interested in the probability distribution of x, the number of heads observed. Many other experiments are equivalent to tossing a coin (either balanced or unbalanced) a fixed number n of times and observing the number x of times that one of the two possible outcomes occurs. Random variables that possess these characteristics are called **binomial random variables**.

Public opinion and consumer preference polls (e.g., the CNN, Gallup, and Harris polls) frequently yield observations on binomial random variables. For example, suppose a sample of 100 students is selected from a large student body and each person is asked whether he or she favors (a Head) or opposes (a Tail) a certain campus issue. Suppose we are interested in x, the number of students in the sample who favor the issue. Sampling 100 students is analogous to tossing the coin 100 times. Thus, you can see that opinion polls that record the number of people who favor a certain issue are real-life equivalents of coin-toss experiments. We have been describing a **binomial experiment**; it is identified by the following characteristics.

Characteristics of a Binomial Random Variable

1. The experiment consists of n identical trials.
2. There are only two possible outcomes on each trial. We will denote one outcome by S (for Success) and the other by F (for Failure).
3. The probability of S remains the same from trial to trial. This probability is denoted by p, and the probability of F is denoted by q. Note that $q = 1 - p$.
4. The trials are independent.
5. The binomial random variable x is the number of S's in n trials.

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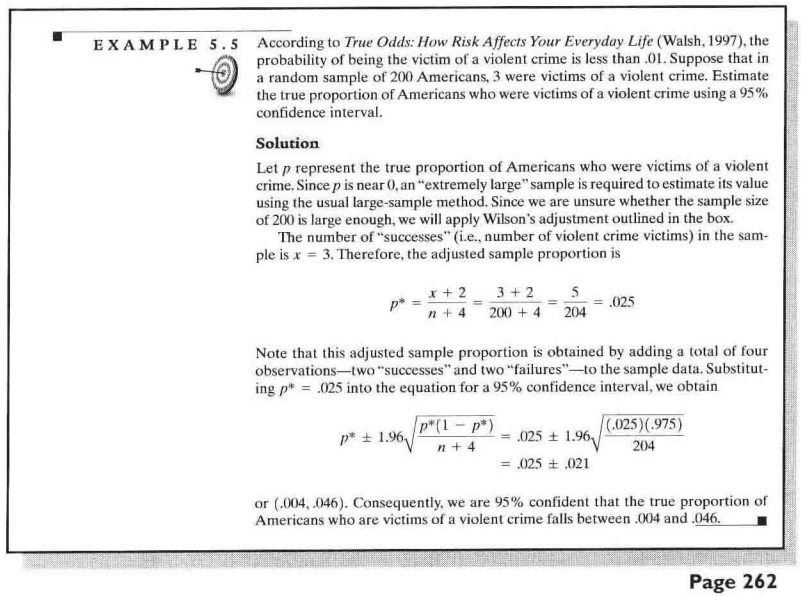

EXAMPLE 5.5

According to *True Odds: How Risk Affects Your Everyday Life* (Walsh, 1997), the probability of being the victim of a violent crime is less than .01. Suppose that in a random sample of 200 Americans, 3 were victims of a violent crime. Estimate the true proportion of Americans who were victims of a violent crime using a 95% confidence interval.

Solution

Let p represent the true proportion of Americans who were victims of a violent crime. Since p is near 0, an "extremely large" sample is required to estimate its value using the usual large-sample method. Since we are unsure whether the sample size of 200 is large enough, we will apply Wilson's adjustment outlined in the box.

The number of "successes" (i.e., number of violent crime victims) in the sample is $x = 3$. Therefore, the adjusted sample proportion is

$$p^* = \frac{x + 2}{n + 4} = \frac{3 + 2}{200 + 4} = \frac{5}{204} = .025$$

Note that this adjusted sample proportion is obtained by adding a total of four observations—two "successes" and two "failures"—to the sample data. Substituting $p^* = .025$ into the equation for a 95% confidence interval, we obtain

$$p^* \pm 1.96\sqrt{\frac{p^*(1 - p^*)}{n + 4}} = .025 \pm 1.96\sqrt{\frac{(.025)(.975)}{204}}$$
$$= .025 \pm .021$$

or (.004, .046). Consequently, we are 95% confident that the true proportion of Americans who are victims of a violent crime falls between .004 and .046. ■

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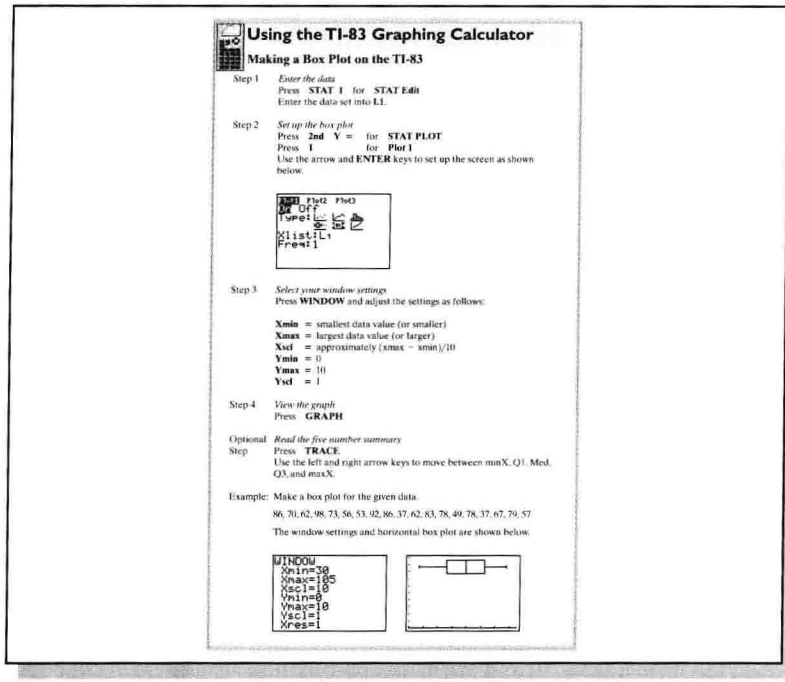
Learn by Example Approach

- New ideas are introduced and illustrated with data-based applications and examples. Complete solutions and explanations are also provided to help students prepare for end-of-section exercises.
- Tangible applications and examples help students to digest theory because they are always provided *before* definitions, generalizations, or abstractions.
- All examples are numbered for easy reference.
- The end of the solution is marked with a ■ symbol.



Using the TI-83 Graphing Calculator

Making a Box Plot on the TI-83

Step 1 *Enter the data*
Press **STAT 1** for **STAT Edit**
Enter the data set into **L1**.

Step 2 *Set up the box plot*
Press **2nd Y =** for **STAT PLOT**
Press **1** for **Plot 1**
Use the arrow and **ENTER** keys to set up the screen as shown below.

Plot1 Plot2 Plot3
On Off
Type:
Xlist:L1
Freq:1

Step 3 *Select your window settings*
Press **WINDOW** and adjust the settings as follows:

Xmin = smallest data value (or smaller)
Xmax = largest data value (or larger)
Xscl = approximately (xmax − xmin)/10
Ymin = 0
Ymax = 10
Yscl = 1

Step 4 *View the graph*
Press **GRAPH**

Optional Step *Read the five number summary*
Press **TRACE**.
Use the left and right arrow keys to move between minX, Q1, Med, Q3, and maxX.

Example: Make a box plot for the given data.

86, 70, 62, 98, 73, 56, 53, 92, 86, 37, 62, 83, 78, 49, 78, 37, 67, 79, 57

The window settings and horizontal box plot are shown below.

WINDOW
Xmin=30
Xmax=105
Xscl=10
Ymin=0
Ymax=10
Yscl=1
Xres=1

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TI-83 Graphing Calculator Key Stroke Level Instruction Contained in Boxes

- Gives students step-by-step instruction on how to use the TI-83.
- Helps students to see how technology can be used as a substitute for hand computation.
- Teaches students valuable skills they may use in later careers.

Emphasis on Real Data

- Most of the 1200+ exercises contain data or information taken from current newspaper articles, magazines, journals, and the internet. Statistics are all around you.
- Real data is also integrated into examples, chapter content, graphs, tables, etc.

Computer Output Integrated Throughout

Exploring Data with Statistical Computer Software

- Statistical software packages, such as SPSS, MINITAB, SAS, or STATISTIX, crunch data quickly so students can spend time analyzing the results. Learning how to interpret statistical output will prove helpful in future classes or on the job.
- When computer output appears in examples, the solution explains how to read and interpret the output.
- Output and instructions for the TI-83 graphing calculator are also provided.

	Sample Size	Youngest Tertile Mean Height	Middle Tertile Mean Height	Oldest Tertile Mean Height	*F* Value	*p*-Value
Boys	1439	0.33	0.33	0.16	4.57	0.01
Girls	1409	0.27	0.18	0.21	0.85	0.43

Source: Wake, M., Coghlan, D., and Hesketh, K. "Does height influence progression through primary school grades?" *The Archives of Disease in Childhood*, Vol. 82, Apr. 2000 (Table 2).

a. What is the null hypothesis for the ANOVA of the boys' data?
b. Interpret the results of the test, part **a**. Use $\alpha = .05$.
c. Repeat parts **a** and **b** for the girls' data.
d. Summarize the results of the hypothesis tests in the words of the problem.

7.82 The *Journal of Hazardous Materials* (July 1995) published the results of a study of the chemical properties of three different types of hazardous organic solvents used to clean metal parts: aromatics, chloroalkanes, and esters. One variable studied was sorption rate, measured as mole percentage. Independent samples of solvents from each type were tested and their sorption rates were recorded, as shown in the table. A MINITAB analysis of variance of the data is provided.

SORPRATE

Aromatics		Chloroalkanes		Esters		
1.06	.95	1.58	1.12	.29	.43	.06
.79	.65	1.45	.91	.06	.51	.09
.82	1.15	.57	.83	.44	.10	.17
.89	1.12	1.16	.43	.61	.34	.60
1.05				.55	.53	.17

Source: Reprinted from *Journal of Hazardous Materials*, Vol. 42, No. 2, J. D. Ortego *et al.*, "A review of polymeric geosynthetics used in hazardous waste facilities," p. 142 (Table 9), July 1995, Elsevier Science-NL, Sara Burgerhartstraat 25, 1055 KV Amsterdam, The Netherlands.

MINITAB Output for Exercise 7.82

```
Analysis of Variance for SORPRATE
Source     DF       SS        MS       F       P
SOLVENT     2   3.3054    1.6527   24.51   0.000
Error      29   1.9553    0.0674
Total      31   5.2608
```

a. Construct an ANOVA table from the MINITAB printout.
b. Is there evidence of differences among the mean sorption rates of the three organic solvent types? Test using $\alpha = .10$.

Applying the Concepts—Intermediate

7.83 Studies conducted at the University of Melbourne (Australia) indicate that there may be a difference between the pain thresholds of blondes and brunettes. Men and women of various ages were divided into four categories according to hair color: light blond, dark blond, light brunette, and dark brunette. The purpose of the experiment was to determine whether hair color is related to the amount of pain evoked by common types of mishaps and assorted types of trauma. Each person in the experiment was given a pain threshold score based on his or her performance in a pain sensitivity test (the higher the score, the higher the person's pain tolerance). SAS was used to conduct the analysis of variance of the data listed in the table on p. 385. The SAS printout provided below.

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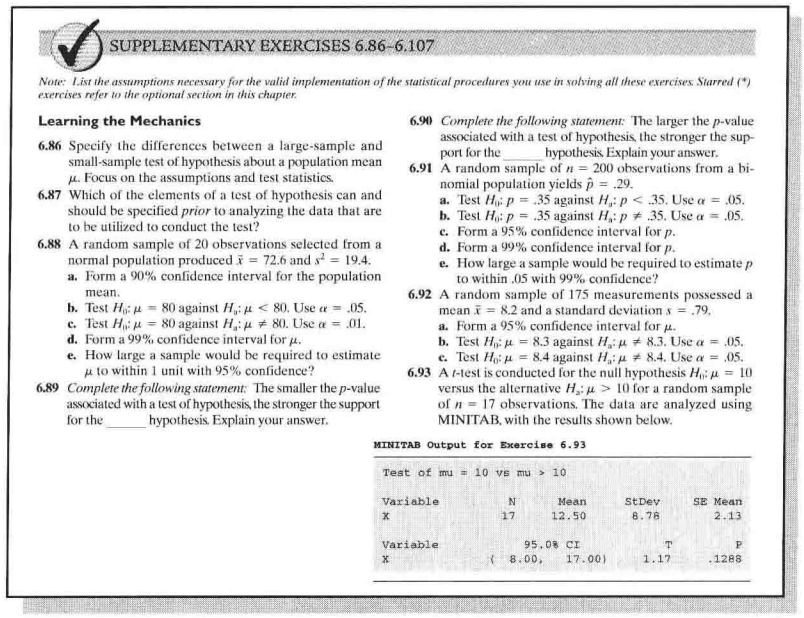
Lots of Exercises for Practice

Every section in the book is followed by an Exercise Set divided into four parts:

- **Learning the Mechanics** Designed as straightfoward applications of new concepts, these exercises allow students to test their ability to comprehend a mathematical concept or presentation.
- **Applying the Concepts—Basic** Based on applications taken from a wide variety of journals, newspapers, and other sources, these short exercises help the student to begin developing the skills necessary to diagnose and analyze real-world problems.



SUPPLEMENTARY EXERCISES 6.86–6.107

Note: List the assumptions necessary for the valid implementation of the statistical procedures you use in solving all these exercises. Starred (*) exercises refer to the optional section in this chapter.

Learning the Mechanics

6.86 Specify the differences between a large-sample and small-sample test of hypothesis about a population mean μ. Focus on the assumptions and test statistics.

6.87 Which of the elements of a test of hypothesis can and should be specified *prior* to analyzing the data that are to be utilized to conduct the test?

6.88 A random sample of 20 observations selected from a normal population produced $\bar{x} = 72.6$ and $s^2 = 19.4$.
- **a.** Form a 90% confidence interval for the population mean.
- **b.** Test H_0: $\mu = 80$ against H_a: $\mu < 80$. Use $\alpha = .05$.
- **c.** Test H_0: $\mu = 80$ against H_a: $\mu \neq 80$. Use $\alpha = .01$.
- **d.** Form a 99% confidence interval for μ.
- **e.** How large a sample would be required to estimate μ to within 1 unit with 95% confidence?

6.89 *Complete the following statement:* The smaller the p-value associated with a test of hypothesis, the stronger the support for the _____ hypothesis. Explain your answer.

6.90 *Complete the following statement:* The larger the p-value associated with a test of hypothesis, the stronger the support for the _____ hypothesis. Explain your answer.

6.91 A random sample of $n = 200$ observations from a binomial population yields $\hat{p} = .29$.
- **a.** Test H_0: $p = .35$ against H_a: $p < .35$. Use $\alpha = .05$.
- **b.** Test H_0: $p = .35$ against H_a: $p \neq .35$. Use $\alpha = .05$.
- **c.** Form a 95% confidence interval for p.
- **d.** Form a 99% confidence interval for p.
- **e.** How large a sample would be required to estimate p to within .05 with 99% confidence?

6.92 A random sample of 175 measurements possessed a mean $\bar{x} = 8.2$ and a standard deviation $s = .79$.
- **a.** Form a 95% confidence interval for μ.
- **b.** Test H_0: $\mu = 8.3$ against H_a: $\mu \neq 8.3$. Use $\alpha = .05$.
- **c.** Test H_0: $\mu = 8.4$ against H_a: $\mu \neq 8.4$. Use $\alpha = .05$.

6.93 A t-test is conducted for the null hypothesis H_0: $\mu = 10$ versus the alternative H_a: $\mu > 10$ for a random sample of $n = 17$ observations. The data are analyzed using MINITAB, with the results shown below.

MINITAB Output for Exercise 6.93

```
Test of mu = 10 vs mu > 10

Variable          N       Mean      StDev     SE Mean
X                17      12.50       8.78        2.13

Variable                95.0% CI          T          P
X                ( 8.00,   17.00)       1.17      .1288
```

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- **a.** Interpret the p-value.
- **b.** What assumptions are necessary for the validity of this test?
- **c.** Calculate and interpret the p-value assuming the alternative hypothesis was instead H_a: $\mu \neq 10$.

Applying the Concepts—Basic

6.94 An article in the *Annals of the Association of American Geographers* (June 1992) revealed that only 133 of 337 randomly selected residences in Los Angeles County were protected by earthquake insurance.
- **a.** What are the appropriate null and alternative hypotheses to test the research hypothesis that less than 40% of the residents of Los Angeles County were protected by earthquake insurance?
- **b.** Do the data provide sufficient evidence to support the research hypothesis? Use $\alpha = .10$.
- **c.** Calculate and interpret the p-value for the test.

6.95 When a new drug is formulated, the pharmaceutical company must subject it to lengthy and involved testing before receiving the necessary permission from the Food and Drug Administration (FDA) to market the drug. The FDA requires the pharmaceutical company to provide substantial evidence that the new drug is safe for potential consumers.
- **a.** If the new drug testing were to be placed in a test of hypothesis framework, would the null hypothesis be that the drug is safe or unsafe? The alternative hypothesis?
- **b.** Given the choice of null and alternative hypotheses in part **a**, describe Type I and Type II errors in terms of this application. Define α and β in terms of this application.
- **c.** If the FDA wants to be very confident that the drug is safe before permitting it to be marketed, is it more important that α or β be small? Explain.

***6.96** The American Cancer Society funds medical research focused on finding treatments for various forms of cancer. One new treatment is being tested to determine whether the average remission time for a particularly aggressive form of cancer is extended by the treatment. Assume that current treatments have been shown to provide a median remission time of 4.5 years. Seven patients with this cancer are given the new treatment, and their remission times (in years) are as follows:

REMISSION

5.3	7.3	3.6	5.2	6.1	4.8	8.4

Use the sign test to determine if the median remission time is increased by the new treatment. Test at $\alpha = .05$.

6.97 In a British study, 12 healthy college students, deprived of one night's sleep, received an array of tests intended to measure thinking time, fluency, flexibility, and originality of thought. The overall test scores of the sleep-deprived students were compared to the average score expected from students who received their accustomed sleep (*Sleep*, Jan. 1989). Suppose the overall scores of the 12 sleep-deprived students had a mean of $\bar{x} = 63$ and a standard deviation of 17. (Lower scores are associated with a decreased ability to think creatively.)
- **a.** Test the hypothesis that the true mean score of sleep-deprived subjects is less than 80, the mean score of subjects who received sleep prior to taking the test. Use $\alpha = .05$.
- **b.** What assumption is required for the hypothesis test of part **a** to be valid?

6.98 "Take the Pepsi Challenge" was a marketing campaign used by the Pepsi-Cola Company. Coca-Cola drinkers participated in a blind taste test in which they tasted unmarked cups of Pepsi and Coke and were asked to select their favorite. Pepsi claimed that "in recent blind taste tests, more than half the Diet Coke drinkers surveyed said they preferred the taste of Diet Pepsi" (*Consumer's Research*, May 1993). Suppose 100 Diet Coke drinkers took the Pepsi Challenge and 56 preferred the taste of Diet Pepsi. Test the hypothesis that more than half of all Diet Coke drinkers will select Diet Pepsi in a blind taste test. Use $\alpha = .05$.

Applying the Concepts—Intermediate

6.99 In order to be effective, a certain mechanical component used in a spacecraft must have a mean length of life greater than 1,100 hours. Owing to the prohibitive cost of this component, only three were tested under simulated space conditions. The lifetimes (hours) of the components were recorded and the computed statistics were $\bar{x} = 1{,}173.6$ and, $s = 36.3$. These data were analyzed using MINITAB, as shown below.

MINITAB Output for Exercise 6.99

```
Test of mu = 1100 vs mu > 1100

Variable      N      Mean     StDev    SE Mean
X             3    1173.6      36.3      20.96

Variable              95.0% CI          T       P
X              ( 1083.5, 1263.7)     3.51   .0362
```

- **a.** Verify that the software has correctly calculated the t statistic, and use Table IV of Appendix A to determine whether the p-value is in the appropriate range.
- **b.** Interpret the p-value.
- **c.** What assumptions are necessary for the validity of this test?
- **d.** Which type of error, I or II, is of greater concern for this test? Explain.
- **e.** Would you recommend that this component be passed as meeting specifications?

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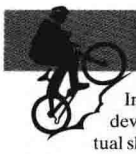
- **Applying the Concepts—Intermediate** Based on more detailed real-world applications, these exercises require students to apply their knowledge of the technique presented in the section.
- **Applying the Concepts—Advanced** These more challenging real-data exercises require students to utilize their critical thinking skills.

Statistics In Action Case Studies Explore High Interest Issues

- Each chapter concludes with a data-based case study that showcases controversial, contemporary, or high-profile issues.
- **Focus** questions are provided to help you evaluate the findings.
- Additional cases are available on the companion website located at **www.prenhall.com/mcclave**



STATISTICS IN ACTION: *The "Eye Cue" Test: Does Experience Improve Performance?*

In 1948, famous child psychologist Jean Piaget devised a test of basic perceptual and conceptual skills dubbed the "water-level task." Subjects were shown a drawing of a glass being held perfectly still (at a 45° angle) by an invisible hand so that any water in it had to be at rest (see Figure 2.39).

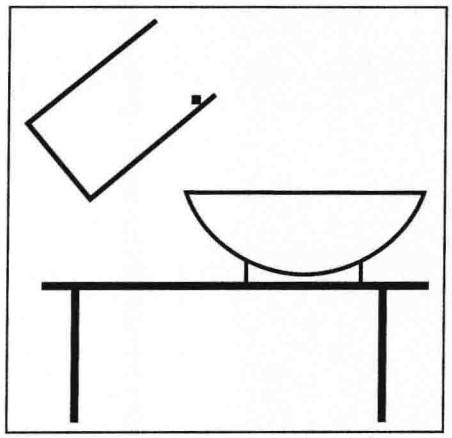


FIGURE 2.39

Drawing of the Water-Level Task

The task for the subject was to draw a line representing the surface of the water—a line that would touch the black dot pictured on the right side of the glass. Piaget found that young children typically failed the test. Fifty years later, research psychologists still use the water-level task to test the perception of both adults and children. Surprisingly, about 40% of the adult population also fail. In addition, males tend to do better than females, and younger adults tend to do better than older adults.

Will people with experience handling liquid-filled containers perform better on this "eye cue" test? This question was the focus of research conducted by psychologists Heiko Hecht (NASA) and Dennis R. Proffitt (University of Virginia) and published in *Psychological Science* (Mar. 1995). The researchers presented the task to each of six different groups: (1) male college students, (2) female college students, (3) professional waitresses, (4) housewives, (5) male bartenders, and (6) male bus drivers. A total of 120 subjects (20 per group) participated in the study. Two of the groups, waitresses and bartenders, were assumed to have considerable experience handling liquid-filled glasses.

After each subject completed the drawing task, the researchers recorded the deviation* (in angle degrees) of the judged line from the true line. If the deviation was within 5° of the true water surface angle, the answer was considered correct. Deviations of more than 5° in either direction were considered incorrect answers.

The data for the water-level task (simulated based on summary results presented in the journal article) are provided in the file EYECUE on the data disk that accompanies this text. For each of the 120 subjects in the experiment, the following variables (in the order they appear on the data file) were measured:

EYECUE

Variables
GENDER (F or M)
GROUP (Student, Waitres, Wife, Bartend, or Busdriv)
DEVIATION (angle, in degrees, of the judged line from the true line)
JUDGE (Within5, More5Above, More5Below)

Focus

a. Use a graphical method to describe the qualitative responses for all 120 subjects.
b. Construct graphs that researchers could use to describe the effect of gender on the qualitative measure of task performance. Do the results tend to support or refute the prevailing theory that males do better than females?
c. Construct graphs that the researchers could use to describe the effect of age on the qualitative measure of task performance. [*Note*: The college students in the study were much younger than the subjects in the other four groups.] Do the results tend to support or refute the prevailing theory that younger adults do better than older adults?
d. Construct graphs that the researchers could use to describe the effect of experience in handling liquid-filled containers on the qualitative measure of task performance. Comment on the theory that experience improves task performance.
e. Refer to parts **a–d**. What are the drawbacks to using graphical displays of sample data to infer the nature of the population?
f. Repeat parts **a–e**, but use the quantitative measure of task performance, i.e., the actual deviations in water-line angles (in degrees) for each subject.
g. Discuss which graphs—those of parts **a–d** or those of part **f**—are more informative.
h. For each group of subjects, find and interpret numerical descriptive measures of the data for the quantitative measure of task performance. What do you conclude from this analysis?

*The true surface line is perfectly parallel to the table top.