UNDERSTANDING STATISTICS IN THE BEHAVIORAL SCIENCES

ROBERT R. PAGANO | TENTH EDITION

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IN THE BEHAVIORAL SCIENCES ■ **TENTH EDITION**

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ROBERT R. PAGANO

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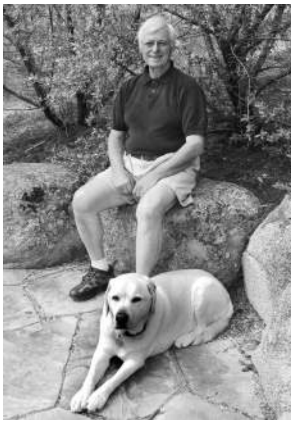
I dedicate this tenth edition to all truth-seekers. May this textbook aid you in forming an objective understanding of reality. May the data-based, objective approach taught here help inform your decisions and beliefs to help improve your life and the lives of the rest of us.

ABOUT THE AUTHOR



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ROBERT R. PAGANO received a Bachelor of Electrical Engineering degree from Rensselaer Polytechnic Institute in 1956 and a Ph.D. in Biological Psychology from Yale University in 1965. He was Assistant Professor and Associate Professor in the Department of Psychology at the University of Washington, Seattle, Washington, from 1965 to 1989. He was Associate Chairman of the Department of Neuroscience at the University of Pittsburgh, Pittsburgh, Pennsylvania, from 1990 to June 2000. While at the Department of Neuroscience, in addition to his other duties, he served as Director of Undergraduate Studies, was the departmental adviser for undergraduate majors, taught both undergraduate and graduate statistics courses, and served as a statistical consultant for departmental faculty. Bob was also Director of the Statistical Cores for two NIH center grants in schizophrenia and Parkinson's disease. He retired from the University of Pittsburgh in June 2000. Bob's current interests are in the physiology of consciousness, the physiology and psychology of meditation and in Positive Psychology. He has taught courses in introductory statistics at the University of Washington and at the University of Pittsburgh for over thirty years. He has been a finalist for the outstanding teaching award at the University of Washington for his teaching of introductory statistics.

Bob is married to Carol A. Eikleberry and they have a 21-year-old son, Robby. In addition, Bob has five grown daughters, Renee, Laura, Maria, Elizabeth, and Christina, one granddaughter, Mikaela, and a yellow lab. In his undergraduate years, Bob was an athlete, winning varsity letters in basketball, baseball and soccer. He loves tennis, but arthritis has temporarily caused a shift in retirement ambitions from winning the singles title at Wimbledon to watching the U.S. Open and getting in shape for doubles play sometime in the future. He also loves the outdoors, especially hiking, and his morning coffee. He especially values his daily meditation practice. His favorite cities to visit are Boulder, Estes Park, New York, Aspen, Santa Fe, and Santa Barbara.

BRIEF CONTENTS

PART ONE OVERVIEW 1

PART TWO DESCRIPTIVE STATISTICS 23

PART THREE INFERENTIAL STATISTICS 187

CONTENTS

PART ONE OVERVIEW 1

PART TWO DESCRIPTIVE STATISTICS 23

2 Basic Mathematical and Measurement Concepts 25

3 Frequency Distributions 47

PREFACE

I have been teaching a course in introductory statistics for more than 30 years, first within the Department of Psychology at the University of Washington, and most recently within the Department of Neuroscience at the University of Pittsburgh. Most of my students have been psychology majors pursuing the Bachelor of Arts degree, but many have also come from biology, business, education, neuroscience, nursing, the health sciences, and other fields. My introductory statistics course has been rated quite highly. While at the University of Washington, I was a finalist for the university's "Outstanding Teaching" award for teaching this course.

This textbook has been the mainstay of my teaching. Because most of my students have neither high aptitude nor strong interest in mathematics and are not well grounded in mathematical skills, I have used an informal, intuitive approach rather than a strictly mathematical one. My approach assumes only high-school algebra for background knowledge, and depends very little on equation derivation. It attempts to teach the introductory statistics material in a deep way, in a manner that facilitates conceptual understanding and critical thinking rather than mechanical, by-the-numbers problem solving.

My statistics course has been quite successful. Students are able to grasp the material, even the more complicated topics like "power," and at the same time they often report that they enjoy learning it. Student ratings of this course have been high. Their ratings of this textbook are even higher; among other things students say that the text is very clear. that they like the touches of humor, and that it helps them to have the material presented in such great detail. Some students have even commented that "this is the best textbook I have ever had." Admittedly, this kind of comment is not the most frequent one offered, but for an introductory statistics textbook, coming from psychology majors, I take it as high praise indeed.

I believe the factors that make my textbook successful are the following:

- It promotes understanding rather than mechanical problem solving.
- It is student-friendly and informally written, with touches of humor that connect with students and help lower anxiety.
- It is very clearly worded and written at the right level.

- It presents the material in great detail.
- It has good visuals.
- It uses a more extended treatment of sampling distributions and a particularly effective sequencing of the inferential material, beginning with the sign test instead of the conventional approach of beginning with the z test.
- It has interesting illustrative examples, and many ideally solved and end-of-chapter problems for students to practice with.

Rationale for Introducing Inferential Statistics with the Sign Test

Understanding the use of sampling distributions is critical to understanding inferential statistics. The first sampling distribution discussed by most texts is the sampling distribution of the mean, used in conjunction with the z test. The problem with this approach is that the sampling distribution of the mean is hard for students to understand. It cannot be generated from simple probability considerations, and its definition is very abstract and difficult to make concrete. Moreover, it is hard to relate the sampling distribution of the mean to its use in the z test. The situation is further complicated because at the same time as they are being asked to understand sampling distributions, students are being asked to understand a lot of other complicated concepts such as null hypothesis, alternative hypothesis, alpha level, Type I and Type II error, and so forth. As a result, many students do not develop an understanding of sampling distributions and why they are important in inferential statistics. I believe this lack of understanding persists throughout the rest of inferential statistics and undermines their understanding of this important material.

What appears to happen is that since students do not understand the use of sampling distributions, when they are asked to solve an inferential problem, they resort to mechanically going through the steps of (1) determining the appropriate statistic for the problem, (2) solving its equation by rote, (3) looking up the probability value in an appendix table, and (4) concluding regarding the null and alternative hypotheses. Many students follow this procedure without any insight as to why they are doing it, except that they know doing so will lead to the correct answer. Thus students are often able to solve problems without understanding what they are doing, all because they fail to develop a conceptual understanding of what a sampling distribution is and why it is important in inferential statistics.

To impart a basic understanding of sampling distributions, I believe it is much better to present an extended treatment of sampling distributions, beginning with the sign test rather than the z test. The sign test is a simple inference test for which the binomial distribution is the appropriate sampling distribution. The binomial distribution is very easy to understand and it can be derived from basic probability considerations. Moreover, its application to the inference process is clear and obvious. This combination greatly facilitates understanding inference and bolsters student confidence in their ability to successfully handle the inferential material. In my view, the appropriate pedagogical sequence is to present basic probability first, followed by the binomial distribution, which is then followed by the sign test. This is the sequence followed in this textbook (Chapters 8, 9, and 10, respectively).

Since the binomial distribution is entirely dependent on simple probability considerations, students can easily understand its generation and application. Moreover, the binomial distribution can also be generated by an empirical process that is used later in the text beginning with the sampling distribution of the mean in Chapter 12 and continuing for all of the remaining inference tests. Generating sampling distributions via an empirical approach helps make the concept of sampling distribution concrete and facilitates student understanding and application of sampling distributions. Since the sampling distribution of the sign test has been generated both by basic probability considerations and empirically, it serves as an important bridge to understanding all the sampling distributions discussed later in the textbook.

Introducing inferential statistics with the sign test has other advantages. All of the important concepts involving hypothesis testing can be illustrated; for example, null hypothesis, alternative hypothesis, alpha level, Type I and Type II errors, size of effect, and power. All of these concepts are learned before the formal discussion of sampling distributions and the *z* test in Chapter 12. Hence, they don't compete for the student's attention when the student is trying to understand sampling distributions. The sign test also provides an illustration of the before–after (repeated measures) experimental design. I believe this is a superior way to begin inference testing, because the before–after design is familiar to most students, is more intuitive, and is easier to understand than the single-sample design used with the *z* test.

After hypothesis testing is introduced using the sign test in Chapter 10, power is discussed using the sign test in Chapter 11. Many texts do not discuss power at all, or if they do, they give it abbreviated treatment. Power is a complicated topic. Using the sign test as the vehicle for a power analysis simplifies matters. Understanding power is necessary if one is to grasp the methodology of scientific investigation itself. When students gain insight into power, they can see why we bother discussing Type II errors. Furthermore, they see for the first time why we conclude by "retaining H_0" as a reasonable explanation of the data rather than by "accepting H_0 as true" (a most important and often unappreciated distinction). In this same vein, students also understand the error involved when one concludes that two conditions are equal from data that are not statistically significant. Thus power is a topic that brings the whole hypothesis-testing methodology into sharp focus.

At this state of the exposition, a diligent student can grasp the idea that data analysis basically involves two steps: (1) calculating the appropriate statistic, and (2) evaluating the statistic based on its sampling distribution. The time is ripe for a formal discussion of sampling distributions and how they can be generated. This is done at the beginning of Chapter 12. Then the sampling distribution of the mean is introduced. Rather than depending on an abstract theoretical definition of the sampling distribution of the mean, the text discusses how this sampling distribution can be generated empirically. This gives a much more concrete understanding of the sampling distribution of the mean and facilitates understanding its use with the *z* test.

Due to previous experience with the sign test and its easily understood sampling distribution, and using the empirical approach for generating the sampling distribution of the mean, most conscientious students have a good grasp of what sampling distributions are and why they are essential for inferential statistics. With this background, students comprehend that all of the concepts of hypothesis testing are the same as we go from inference test to inference test. What vary from experiment to experiment are the statistics used, and the accompanying sampling distribution. The stage is then set for moving through the remaining inference tests with understanding.

Other Important Textbook Features

There are other important features that are worth noting. Among them are the following:

- Chapter 1 discusses approaches for determining truth and establishes statistics as part of the scientific method, which is unusual for an introductory statistics textbook.

- Chapter 8 covers probability. It does not delve deeply into probability theory. I view this as a plus, because probability can be a very difficult topic and can cause students much unnecessary malaise unless treated at the right level. In my view the proper mathematical foundation for all of the inference tests contained in this textbook can be built simply by the use of basic probability definitions in conjunction with the addition and multiplication rules, as has been done in Chapter 8.
- In Chapter 14, the *t* test for correlated groups is introduced directly after the *t* test for single samples and is developed as a special case of the *t* test for single samples, only this time using difference scores rather than raw scores. This makes the *t* test for correlated groups quite easy to teach and easy for students to understand.
- In Chapter 14, understanding of power is deepened and the important principle of using the most powerful inference test is illustrated by analyzing the same data set with the *t* test for correlated groups and the sign test.
- In Chapter 14, the correlated and independent groups designs are compared with regard to power and utility.
- There is a discussion of the factors influencing the power of the *t* test in Chapter 14 and one-way ANOVA in Chapter 15.
- In Chapter 14, the confidence interval approach for evaluating the effect of the independent variable is presented along with the conventional hypothesis-testing approach.
- Chapter 18 is a summary chapter of all of the inferential statistics material. This chapter gives students the opportunity to choose among inference tests in solving problems. Students particularly like the decision tree presented here.
- *What Is the Truth?* sections: At the end of various chapters throughout the textbook, there are sections titled *What Is the Truth?* along with end-of chapter questions on these sections. These sections and questions are intended to illustrate real-world applications of statistics and to sharpen applied critical thinking.

Tenth Edition Changes

Textbook The following changes have been made in the textbook.

- **SPSS material has been greatly expanded.** Because of increased use of statistical software in recent years and in response to reviewer advice, I have greatly expended the SPSS material. In the tenth edition, there is SPSS coverage at the end of Chapters 2, 3, 4, 5, 6, 7, 13, 14, 15, 16, and 17. For each chapter, this material is comprised of a detailed illustrative SPSS example and solution along with at least two new SPSS problems to practice on. In addition, a new Appendix E contains a general introduction to SPSS. Students can now learn SPSS and practice on chapter-relevant problems without recourse to additional outside sources. The SPSS material at the end of Chapters 4 and 6 that was contained in the ninth edition has been dropped. The old Appendix E, *Symbols*, has been moved to the inside cover of the textbook.
- **ANOVA symbols throughout Chapters 15 and 16 have been changed.** The symbols used in the previous editions of the textbook in the ANOVA chapters have been changed to more conventionally used symbols. The specific changes are as follows. In Chapter 15, s_W^2, s_B^2, SS_T, SS_W, SS_B, df_T, df_W, and df_B have been changed to MS_{within}, $MS_{between}$, SS_{total}, SS_{within}, $SS_{between}$, df_{total}, df_{within}, and $\mathrm{df}_{between}$, respectively. In Chapter 16, s_W^2, s_R^2, s_C^2, s_{RC}^2, SS_T, SS_W, SS_R, SS_C,

SS_{RC}, df_T, df_W, df_R, df_C, and df_{RC} have been changed to $MS_{within\text{-}cells}$, MS_{rows}, $MS_{columns}$, $MS_{interaction}$, SS_{total}, $SS_{within\text{-}cells}$, SS_{rows}, $SS_{columns}$, $SS_{interaction}$, df_{total}, $\mathrm{df}_{within\text{-}cells}$, df_{rows}, $\mathrm{df}_{columns}$, and $\mathrm{df}_{interaction}$, respectively.

I made these changes because I believe students will have an easier time transitioning to advanced statistical textbooks and using statistical software—including SPSS—and because of reviewer recommendations. I have some regrets with moving to the new symbols, because I believe the old symbols provide a better transition from the *t* test to ANOVA, and because of the extra time and effort it may require of instructors who are used to the old symbols (my apologies to these instructors for the inconvenience).

- **In Chapter 15, the Newman-Keuls test has been replaced with the Scheffé test.** The Newman-Keuls test has been dropped because of recent criticism from statistical experts that the Newman-Keuls procedure of adjusting *r* can result in an experimentwise or familywise Type I error rate that exceeds the specified level. I have replaced the Newman-Keuls test with the Scheffé test. The Scheffé test has the advantages that (1) it uses a modified ANOVA technique that is relatively easy to understand and compute; (2) it is very commonly used in the research literature; (3) it is the most flexible and conservative *post hoc* test available; and (4) it provides a good contrast to the Tukey HSD test.
- ***What Is the Truth?* questions have been added at the end of the chapters that contain *What Is the Truth?* sections (Chapters 1, 3, 6, 8, 10, 11, 15, and 17).** These questions have been added to provide closer integration of the *What Is the Truth?* sections with the rest of the textbook content and to promote applied critical thinking.
- **In Chapter 7, the section titled *Regression of X on Y* has been dropped.** This section has been dropped because students can compute the regression of *Y* on *X* or of *X* on *Y* by just designating the predicted variable as the *Y* variable. Therefore there is little practical gain in devoting a separate section to the regression of *X* on *Y*. Separate treatment of the regression of *X* on *Y* does contribute additional theoretical insight into the topic of regression, but was judged not important enough to justify precious introductory textbook space.
- **The *To the Student* section has been amplified to include a discussion of anxiety reduction.** This material has been added to help students who experience excessive anxiety when dealing with the statistics material. Five options for reducing anxiety have been presented: (1) seeking help at the university counseling center, (2) taking up the practice of meditation, (3) learning and practicing autogenic techniques, (4) increasing bodily relaxation via progressive muscle relaxation, and (5) practicing the techniques advocated by positive psychology.
- **The index has been revised.** I favor a detailed index. In previous editions, the index has only been partially revised, finally resulting in an index in the ninth edition that has become unwieldy and redundant. In the tenth edition the index has been completely revised. The result is a streamlined index that I believe retains the detail necessary for a good index.
- **Minor wording changes have been made throughout the textbook to increase clarity.**

Ancillaries

Aplia™ has replaced Enhanced WebAssign, which was used in the ninth edition. Aplia is an online interactive learning solution that improves comprehension and outcomes by increasing student effort and engagement. Founded by a professor to enhance his own courses, Aplia provides automatically graded assignments that were written to make the most of the Web medium and contain detailed, immediate explanations on every question. Our easy-to-use system has been used by more than 2,000,000 students at over 1,800 institutions.

Aplia for Pagano's *Understanding Statistics in the Behavioral Sciences* also includes end-of-chapter questions directly from the text.

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Instructor's Manual with Test Bank The instructor's manual includes the textbook rationale, general teaching advice, advice to the student, and, for each chapter, a detailed chapter outline, learning objectives, a detailed chapter summary, teaching suggestions, discussion questions, and test questions and answers. Test questions are organized into multiple-choice, true/false, definitions, and short answer sections, and answers are also provided. Over 600 new test questions have been added to the tenth edition. The overall test bank has over 2,200 true/false, multiple-choice, and short-answer questions. The instructor's manual also includes answers to the end-of-chapter problems contained in the textbook for which no answers are given in the textbook.

Book Companion Website Available for use by all students, the book companion website offers chapter-specific learning tools including Know and Be Able to Do, practice quizzes, flash cards, glossaries, a link to Statistics and Research Methods Workshops, and more. Go to www.cengagebrain.com for access.

Acknowledgments

I have received a great deal of help in the development and production of this edition. First, I would like to thank Timothy C. Matray, my Sponsoring Editor. He has been a continuing pillar of support throughout the development and production of this edition. I am especially grateful for his input in deciding on revision items, finding appropriate experts to review the revised material, for the role he has played in facilitating the transition from Enhanced WebAssign to Aplia and the ideas he has contributed to advertising. Next, I would like to thank Bob Jucha, the Developmental Editor for this edition. I am grateful for his conduct of surveys and evaluations, his role in coordinating with Production, his advice, and his hard work. I am indebted to Vernon Boes, the Senior Art Director and his team. I think they have produced an outstanding cover and interior design for the tenth edition. I believe he and his team have created a peaceful and esthetic cover that continues our animal theme, as well as a very clean, attractive interior textbook design. I am particularly pleased to have had the opportunity to collaborate on this edition with my daughter, Maria E. Pagano, who is an Associate Professor in the Department of Psychiatry at Case Western University. It was a lot of fun, and she helped greatly in reviewing parts of the textbook, especially the SPSS material. I am also grateful to Dr. Lynn Johnson for reviewing the positive psychology material presented in the *To the Student* section.

The remaining Cengage Learning/Wadsworth staff that I would like to thank are Content Project Manager Charlene M. Carpentier, Assistant Editor Paige Leeds, Editorial Assistant Lauren Moody, Media Editor Mary Noel, and Marketing Manager Sean Foy.

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The material covered in this textbook, instructor's manual, and on the Web is appropriate for undergraduate students with a major in psychology or related behavioral science disciplines. I believe the approach I have followed helps considerably to impart this subject matter with understanding. I am grateful to receive any comments that will improve the quality of these materials.

Robert R. Pagano

TO THE STUDENT

Statistics uses probability, logic, and mathematics as ways of determining whether or not observations made in the real world or laboratory are due to random happenstance or due to an orderly effect one variable has on another. Separating happenstance, or chance, from cause and effect is the task of science, and statistics is a tool to accomplish that end. Occasionally, data will be so clear that the use of statistical analysis isn't necessary. Occasionally, data will be so garbled that no statistical analysis can meaningfully be applied to answer any reasonable question. However, most often, when analyzing the data from an experiment or study, statistics is useful in determining whether it is legitimate to conclude that an orderly effect has occurred. When this is the case, statistical analysis can also provide an estimate of the size of the effect.

It is useful to try to think of statistics as a means of learning a new set of problem-solving skills. You will learn new ways to ask questions, new ways to answer them, and a more sophisticated way of interpreting the data you read about in texts, journals, and newspapers.

In writing this textbook and creating the Web material, I have tried to make the material as clear, interesting, and easy to understand as I can. I have used a relaxed style, introduced humor, avoided equation derivation when possible, and chosen examples and problems that I believe will be interesting to students in the behavioral sciences. I have listed the objectives for each chapter so that you can see what is in store for you and guide your studying accordingly. I have also introduced "mentoring tips" throughout the textbook to help highlight important aspects of the material. While I was teaching at the University of Washington and the University of Pittsburgh, my statistics course was evaluated by each class of students that I taught. I found the suggestions of students invaluable in improving my teaching. Many of these suggestions have been incorporated into this textbook. I take quite a lot of pride in having been a finalist for the University of Washington Outstanding Teaching Award for teaching this statistics course, and in the fact that students have praised this textbook so highly. I believe much of my success derives from student feedback and the quality of this textbook.

Study Hints

- **Memorize symbols.** A lot of symbols are used in statistics. Don't make the material more difficult than necessary by failing to memorize what the symbols stand for. Treat them as though they were foreign vocabulary. Be able to go quickly from the symbol to what it stands for, and vice versa. The *Flash Cards* section in the accompanying Web material will help you accomplish this goal.
- **Learn the definitions for new terms.** Many new terms are introduced in this course. Part of learning statistics is learning the definitions of these new terms. If you don't know what the new terms mean, it will be impossible to do well in this course. Like the symbols, the new terms should be treated like foreign vocabulary. Be able to instantly associate each new term with its definition and vice versa. The *Flash Cards* section in the accompanying Web material will also help you accomplish this goal.
- **Work as many problems as needed for you to understand the material and produce correct answers.** In my experience there is a direct, positive relationship between working problems and doing well on this material. Be sure you try to understand the solutions. When using calculators and computers, there can be a tendency to press the keys and read the answer without really understanding the solution. I hope you won't fall into this trap. Also, work the problem from beginning to end, rather than just following someone else's solution and telling yourself that you could solve the problem if called upon to do so. Solving a problem from scratch is very different and often more difficult than "understanding" someone else's solution.
- **Don't fall behind.** The material in this course is cumulative. Do not let yourself fall behind. If you do, you will not understand the current material either.
- **Study several times each week, rather than just cramming.** A lot of research has shown that you will learn better and remember more material if you space your learning rather than just cramming for the test.
- **Read the material in the textbook prior to the lecture/discussion covering it.** You can learn a lot just by reading this textbook. Moreover, by reading the appropriate material just prior to when it is covered in class, you can determine the parts that you have difficulty with and ask appropriate questions when that material is covered by your instructor.
- **Pay attention and think about the material being covered in class.** This advice may seem obvious, but for whatever reason, it is frequently not followed by students. Often times I've had to stop my lecture or discussions to remind students about the importance of paying attention and thinking in class. I don't require students to attend my classes, but if they do, I assume they want to learn the material, and of course, attention and thinking are prerequisites for learning.
- **Ask the questions you need to ask.** Many of us feel our question is a "dumb" one, and we will be embarrassed because the question will reveal our ignorance to the instructor and the rest of the class. Almost always, the "dumb" question helps others sitting in the class because they have the same question. Even when this is not true, it is very often the case that if you don't ask the question, your learning is blocked and stops there, because the answer is necessary for you to continue learning the material. Don't let possible embarrassment hinder your learning. If it doesn't work for you to ask in class, then ask the question via email, or make an appointment with the instructor and ask then.
- **Compare your answers to mine.** For most of the problems I have used a hand calculator or computer to find the solutions. Depending on how many decimal

places you carry your intermediate calculations, you may get slightly different answers than I do. In most cases I have used full calculator or computer accuracy for intermediate calculations (at least five decimal places). In general, you should carry all intermediate calculations to at least two more decimal places than the number of decimal places in the rounded final answer. For example, if you intend to round the final answer to two decimal places, than you should carry all intermediate calculations to at least four decimal places. If you follow this policy and your answer does not agree with ours, then you have probably made a calculation error.

- **One final topic: Dealing with anxiety.** Anyone who has taught an introductory statistics class for psychology majors is aware that many students have a great deal of anxiety about taking a statistics course. Actually, a small or even moderate level of anxiety can facilitate learning, but too much anxiety can be an impediment. Fortunately, we know a fair amount about anxiety and techniques that help reduce it. If you think the level of fear or anxiety that you experience associated with statistics is causing you a problem, I suggest you avail yourself of one or more of the following options.
  - *Visit the counseling center at your college or university.* Many students experience anxiety associated with courses they are taking, especially math courses. Counseling centers have lots of experience helping these students overcome their anxiety. The services provided are confidential and usually free. If I were a student having a problem with course-related anxiety, this is the first place I would go for help.
  - *Meditation.* There has been a lot of research looking at the physiological and psychological effects of meditation. The research shows that meditation results in a more relaxed individual who generally experiences an increased sense of well-being. Being more relaxed can have the beneficial effect of lowering one's anxiety level in the day-to-day learning of statistics material. Meditation can have additional benefits, including developing mindfulness and equanimity. Equanimity is defined as calmness in the face of stress. Developing the trait of equanimity can be especially useful in dealing with anxiety. I have included a short reference section below for those interested in pursuing this topic further.
  - *Autogenic training and progressive muscle relaxation.* These are well-established techniques for promoting general relaxation. Autogenic training is a relaxation technique first developed by the German psychiatrist Johannes Schultz in the early 1930s. It involves repeating a series of autohypnotic sentences like "my right arm is heavy," or "my heartbeat is calm and regular," designed to calm one's autonomic nervous system. Progressive muscle relaxation is another well-established relaxation technique. It was developed by American physician Edmund Jacobson in the early 1920s. It is a technique developed to reduce anxiety by sequentially tensing and relaxing various muscle groups and focusing on the accompanying sensations. I have included a short reference section below for those interested in pursuing either of these techniques further
  - *Positive psychology.* Positive psychology is an area within psychology that was initiated about 15 years ago in the American Psychological Association presidential address of Martin Seligman. Its focus of interest is happiness or well-being. It studies normal and above-normal functioning individuals. Rather than attempting to help clients lead more positive lives by tracing the etiology of negative emotional states such as depression or anxiety, as does traditional

clinical psychology, positive psychology attempts to promote greater happiness by incorporating techniques into one's life that research has revealed promote positive emotions. Some of the techniques recommended include learning and practicing optimism; learning to be grateful and to express gratitude; spending more time in areas involving personal strengths; sleeping well, getting proper nutrition, increasing exercise; savoring positive experiences, reframing (finding the good in the bad), skill training in detachment from negative thoughts, decreasing fear and anxiety by confronting or doing feared things or activities, doing good deeds and random acts of kindness, increasing connections with others, and increasing compassion and forgiveness. As with the other options, I have included below a short reference section for pursuing positive psychology further. I have also included a website for the Positive Psychology Center located at the University of Pennsylvania that I have found useful.

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I wish you great success in understanding the material contained in this textbook.

Robert R. Pagano

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PART ONE

OVERVIEW

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1

Statistics and Scientific Method

CHAPTER OUTLINE

LEARNING OBJECTIVES

After completing this chapter, you should be able to:

- Describe the four methods of establishing truth.
- Contrast observational and experimental research.
- Contrast descriptive and inferential statistics.
- Define the following terms: population, sample, variable, independent variable, dependent variable, constant, data, statistic, and parameter.
- Identify the population, sample, independent and dependent variables, data, statistic, and parameter from the description of a research study.
- Specify the difference between a statistic and a parameter.
- Give two reasons why random sampling is important.
- Understand the illustrative example, do the practice problem, and understand the solution.

INTRODUCTION

Have you ever wondered how we come to know truth? Most college students would agree that finding out what is true about the world, ourselves, and others constitutes a very important activity. A little reflection reveals that much of our time is spent in precisely this way. If we are studying geography, we want to know what is *true* about the geography of a particular region. Is the region mountainous or flat, agricultural or industrial? If our interest is in studying human beings, we want to know what is *true* about humans. Do we *truly* possess a spiritual nature, or are we *truly* reducible solely to atoms and molecules, as the reductionists would have it? How do humans think? What happens in the body to produce a sensation or a movement? When I get angry, is it *true* that there is a unique underlying physiological pattern? What is the pattern? Is my *true* purpose in life to become a teacher? Is it *true* that animals think? We could go on indefinitely with examples because so much of our lives is spent seeking and acquiring truth.

METHODS OF KNOWING

Historically, humankind has employed four methods to acquire knowledge. They are authority, rationalism, intuition, and the scientific method.

Authority

MENTORING TIP

Which of the four methods do you use most often?

When using the method of *authority*, we consider something true because of tradition or because some person of distinction says it is true. Thus, we may believe in the theory of evolution because our distinguished professors tell us it is true, or we may believe that God truly exists because our parents say so. Although this method of knowing is currently in disfavor and does sometimes lead to error, we use it a lot in living our daily lives. We frequently accept a large amount of information on the basis of authority, if for no other reason than we do not have the time or the expertise to check it out firsthand. For example, I believe, on the basis of physics authorities, that electrons exist, but I have never seen one; or perhaps closer to home, if the surgeon general tells me that smoking causes cancer, I stop smoking because I have faith in the surgeon general and do not have the time or means to investigate the matter personally.

Rationalism

The method of *rationalism* uses reasoning alone to arrive at knowledge. It assumes that if the premises are sound and the reasoning is carried out correctly according to the rules of logic, then the conclusions will yield truth. We are very familiar with reason because we use it so much. As an example, consider the following syllogism:

All statistics professors are interesting people.
Mr. X is a statistics professor.
Therefore, Mr. X is an interesting person.

Assuming the first statement is true (who could doubt it?), then it follows that if the second statement is true, the conclusion must be true. Joking aside, hardly anyone would question the importance of the reasoning process in yielding truth. However, there are a great number of situations in which reason alone is inadequate in determining the truth.

To illustrate, let's suppose you notice that John, a friend of yours, has been depressed for a couple of months. As a psychology major, you know that psychological problems can produce depression. Therefore, it is reasonable to believe John may have psychological problems that are producing his depression. On the other hand, you also know that an inadequate diet can result in depression, and it is reasonable to believe that this may be at the root of his trouble. In this situation, there are two reasonable explanations of the phenomenon. Hence, reason alone is inadequate in distinguishing between them. We must resort to experience. Is John's diet in fact deficient? Will improved eating habits correct the situation? Or does John have serious psychological problems that, when worked through, will lift the depression? Reason alone, then, may be sufficient to yield truth in some situations, but it is clearly inadequate in others. As we shall see, the scientific method also uses reason to arrive at truth, but reasoning alone is only part of the process. Thus, the scientific method incorporates reason but is not synonymous with it.

Intuition

Knowledge is also acquired through *intuition*. By intuition, we mean that sudden insight, the clarifying idea that springs into consciousness all at once as a whole. It is not arrived at by reason. On the contrary, the idea often seems to occur after conscious reasoning has failed. Beveridge* gives numerous occurrences taken from prominent individuals. Here are a couple of examples:

> Here is Metchnikoff's own account of the origin of the idea of phagocytosis: "One day when the whole family had gone to the circus to see some extraordinary performing apes, I remained alone with my microscope, observing the life in the mobile cells of a transparent starfish larva, when a new thought suddenly flashed across my brain. It struck me that similar cells might serve in the defense of the organism against intruders. Feeling that there was in this something of surpassing interest, I felt so excited that I began striding up and down the room and even went to the seashore to collect my thoughts."
>
> Hadamard cites an experience of the mathematician Gauss, who wrote concerning a problem he had tried unsuccessfully to prove for years: "Finally two days ago I succeeded … like a sudden flash of lightning the riddle happened to be solved. I cannot myself say what was the conducting thread which connected what I previously knew with what made my success possible."

It is interesting to note that the intuitive idea often occurs after conscious reasoning has failed and the individual has put the problem aside for a while. Thus, Beveridge† quotes two scientists as follows:

> Freeing my mind of all thoughts of the problem I walked briskly down the street, when suddenly at a definite spot which I could locate today—as if from the clear sky above me—an idea popped into my head as emphatically as if a voice had shouted it.
>
> I decided to abandon the work and all thoughts relative to it, and then, on the following day, when occupied in work of an entirely different type, an idea came to my mind as suddenly as a flash of lightning and it was the solution … the utter simplicity made me wonder why I hadn't thought of it before.

Despite the fact that intuition has probably been used as a source of knowledge for as long as humans have existed, it is still a very mysterious process about which we have only the most rudimentary understanding.

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*W. I. B. Beveridge, *The Art of Scientific Investigation*, Vintage Books/Random House, New York, 1957, pp. 94–95.
†Ibid., p. 92.

Scientific Method

Although the *scientific method* uses both reasoning and intuition for establishing truth, its reliance on objective assessment is what differentiates this method from the others. At the heart of science lies the *scientific experiment*. The method of science is rather straightforward. By some means, usually by reasoning deductively from existing theory or inductively from existing facts or through intuition, the scientist arrives at a hypothesis about some feature of reality. He or she then designs an experiment to objectively test the hypothesis. The data from the experiment are then analyzed statistically, and the hypothesis is either supported or rejected. The feature of overriding importance in this methodology is that no matter what the scientist believes is true regarding the hypothesis under study, the experiment provides the basis for an *objective* evaluation of the hypothesis. The data from the experiment force a conclusion consonant with reality. Thus, scientific methodology has a built-in safeguard for ensuring that truth assertions of any sort about reality must conform to what is demonstrated to be objectively true about the phenomena before the assertions are given the status of scientific truth.

An important aspect of this methodology is that the experimenter can hold incorrect hunches, and the data will expose them. The hunches can then be revised in light of the data and retested. This methodology, although sometimes painstakingly slow, has a self-correcting feature that, over the long run, has a high probability of yielding truth. Since in this textbook we emphasize statistical analysis rather than experimental design, we cannot spend a great deal of time discussing the design of experiments. Nevertheless, some experimental design will be covered because it is so intertwined with statistical analysis.

DEFINITIONS

In discussing this and other material throughout the book, we shall be using certain technical terms. The terms and their definitions follow:

- **Population** *A population is the complete set of individuals, objects, or scores that the investigator is interested in studying*. In an actual experiment, the population is the larger group of individuals from which the subjects run in the experiment have been taken.
- **Sample** *A sample is a subset of the population*. In an experiment, for economical reasons, the investigator usually collects data on a smaller group of subjects than the entire population. This smaller group is called the sample.
- **Variable** *A variable is any property or characteristic of some event, object, or person that may have different values at different times depending on the conditions*. Height, weight, reaction time, and drug dosage are examples of variables. A variable should be contrasted with a *constant*, which, of course, does not have different values at different times. An example is the mathematical constant π; it always has the same value (3.14 to two-decimal-place accuracy).
- **Independent variable (IV)** *The independent variable in an experiment is the variable that is systematically manipulated by the investigator*. In most experiments, the investigator is interested in determining the effect that one variable, say, variable A, has on one or more other variables. To do so, the investigator manipulates the levels of variable A and measures the effect on the other variables. Variable A is called the *independent* variable because its levels are controlled by the experimenter, independent of any change in the other variables. To illustrate, an investigator might be interested in the effect of alcohol on social behavior. To investigate this, he or she would probably vary the amount of alcohol

consumed by the subjects and measure its effect on their social behavior. In this example, the experimenter is manipulating the amount of alcohol and measuring its consequences on social behavior. Alcohol amount is the independent variable. In another experiment, the effect of sleep deprivation on aggressive behavior is studied. Subjects are deprived of various amounts of sleep, and the consequences on aggressiveness are observed. Here, the amount of sleep deprivation is being manipulated. Hence, it is the independent variable.

- **Dependent variable (DV)** *The dependent variable in an experiment is the variable that the investigator measures to determine the effect of the independent variable*. For example, in the experiment studying the effects of alcohol on social behavior, the amount of alcohol is the independent variable. The social behavior of the subjects is measured to see whether it is affected by the amount of alcohol consumed. Thus, social behavior is the dependent variable. It is called *dependent* because it may depend on the amount of alcohol consumed. In the investigation of sleep deprivation and aggressive behavior, the amount of sleep deprivation is being manipulated and the subjects' aggressive behavior is being measured. The amount of sleep deprivation is the independent variable, and aggressive behavior is the dependent variable.
- **Data** *The measurements that are made on the subjects of an experiment are called data*. Usually data consist of the measurements of the dependent variable or of other subject characteristics, such as age, gender, number of subjects, and so on. The data as originally measured are often referred to as *raw* or *original* scores.
- **Statistic** *A statistic is a number calculated on sample data that quantifies a characteristic of the sample*. Thus, the average value of a sample set of scores would be called a statistic.
- **Parameter** *A parameter is a number calculated on population data that quantifies a characteristic of the population*. For example, the average value of a population set of scores is called a parameter. It should be noted that a statistic and a parameter are very similar concepts. The only difference is that a statistic is calculated on a sample and a parameter is calculated on a population.

experiment

Mode of Presentation and Retention

Let's now consider an illustrative experiment and apply the previously discussed terms.

MENTORING TIP

Very often parameters are unspecified. Is a parameter specified in this experiment?

An educator conducts an experiment to determine whether the mode of presentation affects how well prose material is remembered. For this experiment, the educator uses several prose passages that are presented visually or auditorily. Fifty students are selected from the undergraduates attending the university at which the educator works. The students are divided into two groups of 25 students per group. The first group receives a visual presentation of the prose passages, and the second group hears the passages through an auditory presentation. At the end of their respective presentations, the subjects are asked to write down as much of the material as they can remember. The average number of words remembered by each group is calculated, and the two group averages are compared to see whether the mode of presentation had an effect.

In this experiment, the independent variable is the mode of presentation of the prose passages (i.e., auditory or visual). The dependent variable is the number of words remembered. The sample is the 50 students who participated in the experiment. The population is the larger group of individuals from which the sample was taken, namely, the undergraduates attending the university. The data are the number of words recalled by each student in the sample. The average number of words recalled by each group is a statistic because it quantifies a characteristic of the sample scores. Since there was no measurement made of any population characteristic, there was no parameter calculated in this experiment. However, for illustrative purposes, suppose the entire population had been given a visual presentation of the passages. If we calculate the average number of words remembered by the population, the average number would be called a parameter because it quantifies a characteristic of the population scores.

Now, let's do a problem to practice identifying these terms.

Practice Problem 1.1

For the experiment described below, specify the following: the independent variable, the dependent variable(s), the sample, the population, the data, the statistic(s), and the parameter(s).

A professor of gynecology at a prominent medical school wants to determine whether an experimental birth control implant has side effects on body weight and depression. A group of 5000 adult women living in a nearby city volunteers for the experiment. The gynecologist selects 100 of these women to participate in the study. Fifty of the women are assigned to group 1 and the other fifty to group 2 such that the mean body weight and the mean depression scores of each group are equal at the beginning of the experiment. Treatment conditions are the same for both groups, except that the women in group 1 are surgically implanted with the experimental birth control device, whereas the women in group 2 receive a placebo implant. Body weight and depressed mood state are measured at the beginning and end of the experiment. A standardized questionnaire designed to measure degree of depression is used for the mood state measurement. The higher the score on this questionnaire is, the more depressed the individual is. The mean body weight and the mean depression scores of each group at the end of the experiment are compared to determine whether the experimental birth control implant had an effect on these variables. To safeguard the women from unwanted pregnancy, another method of birth control that does not interact with the implant is used for the duration of the experiment.

SOLUTION

Independent variable: The experimental birth control implant versus the placebo.

Dependent variables: Body weight and depressed mood state.

Sample: 100 women who participated in the experiment.

Population: 5000 women who volunteered for the experiment.

Data: The individual body weight and depression scores of the 100 women at the beginning and end of the experiment.

Statistics: Mean body weight of group 1 at the beginning of the experiment, mean body weight of group 1 at the end of the experiment, mean depression score of group 1 at the beginning of the experiment, mean depression score of group 1 at the end of the experiment, plus the same four statistics for group 2.

Parameter: No parameters were given or computed in this experiment. If the gynecologist had measured the body weights of all 5000 volunteers at the beginning of the experiment, the mean of these 5000 weights would be a parameter.

SCIENTIFIC RESEARCH AND STATISTICS

Scientific research may be divided into two categories: *observational studies* and *true experiments*. Statistical techniques are important in both kinds of research.

Observational Studies

In this type of research, no variables are actively manipulated by the investigator, and hence observational studies cannot determine causality. Included within this category of research are (1) naturalistic observation, (2) parameter estimation, and (3) correlational studies. With *naturalistic observation research,* a major goal is to obtain an accurate description of the situation being studied. Much anthropological and etiological research is of this type. *Parameter estimation research* is conducted on samples to estimate the level of one or more population characteristics (e.g., the population average or percentage). Surveys, public opinion polls, and much market research fall into this category. In *correlational research*, the investigator focuses attention on two or more variables to determine whether they are related. For example, to determine whether obesity and high blood pressure are related in adults older than 30 years, an investigator might measure the fat level and blood pressure of individuals in a sample of adults older than 30. The investigator would then analyze the results to see whether a relationship exists between these variables; that is, do individuals with low fat levels also have low blood pressure, do individuals with moderate fat levels have moderate blood pressure, and do individuals with high fat levels have high blood pressure?

True Experiments

MENTORING TIP

Only true experiments can determine causality.

In this type of research, an attempt is made to determine whether changes in one variable cause* changes in another variable. In a true experiment, an independent variable is manipulated and its effect on some dependent variable is studied. If desired, there can be more than one independent variable and more than one dependent variable. In the simplest case, there is only one independent and one dependent variable. One example of this case is the experiment mentioned previously that investigated the effect of alcohol on social behavior. In this experiment, you will recall, alcohol level was manipulated by the experimenter and its effect on social behavior was measured.

RANDOM SAMPLING

In all of the research described previously, data are usually collected on a sample of subjects rather than on the entire population to which the results are intended to apply. Ideally, of course, the experiment would be performed on the whole population,

*We recognize that the topic of cause and effect has engendered much philosophical debate. However, we cannot consider the intricacies of this topic here. When we use the term *cause*, we mean it in the commonsense way it is used by non-philosophers. That is, when we say that *A* caused *B*, we mean that a change in *A* produced a change in *B* with all other variables appropriately controlled.

but usually it is far too costly, so a sample is taken. Note that not just any sample will do. The sample should be a *random* sample. Random sampling is discussed in Chapter 8. For now, it is sufficient to know that random sampling allows the laws of probability, also discussed in Chapter 8, to apply to the data and at the same time helps achieve a sample that is representative of the population. Thus, the results obtained from the sample should also apply to the population. Once the data are collected, they are statistically analyzed and the appropriate conclusions about the population are drawn.

DESCRIPTIVE AND INFERENTIAL STATISTICS

Statistical analysis, of course, is the main theme of this textbook. It has been divided into two areas: (1) *descriptive statistics* and (2) *inferential statistics*. Both involve analyzing data. If an analysis is done for the purpose of describing or characterizing the data, then we are in the area of descriptive statistics. To illustrate, suppose your biology professor has just recorded the scores from an exam he has recently given you. He hands back the tests and now wants to describe the scores. He might decide to calculate the average of the distribution to describe its *central tendency*. Perhaps he will also determine its range to characterize its *variability*. He might also plot the scores on a graph to show the *shape* of the distribution. Since all of these procedures are for the purpose of describing or characterizing the data already collected, they fall within the realm of descriptive statistics.

Inferential statistics, on the other hand, is not concerned with just describing the obtained data. Rather, it embraces techniques that allow one to use obtained sample data to make inferences or draw conclusions about populations. This is the more complicated part of statistical analysis. It involves probability and various inference tests, such as *Student's* t *test* and the *analysis of variance*.

To illustrate the difference between descriptive and inferential statistics, suppose we were interested in determining the average IQ of the entire freshman class at your university. It would be too costly and time-consuming to measure the IQ of every student in the population, so we would take a random sample of, say, 200 students and give each an IQ test. We would then have 200 *sample* IQ scores, which we want to use to determine the average IQ in the *population*. Although we can't determine the exact value of the population average, we can estimate it using the sample data in conjunction with an inference test called Student's t test. The results would allow us to make a statement such as, "We are 95% confident that the interval of 115–120 contains the mean IQ of the population." Here, we are not just describing the obtained scores, as was the case with the biology exam. Rather, we are using the sample scores to infer to a population value. We are therefore in the domain of inferential statistics. *Descriptive* and *inferential statistics* can be defined as follows:

definitions

- **Descriptive statistics** *is concerned with techniques that are used to describe or characterize the obtained data.*
- **Inferential statistics** *involves techniques that use the obtained sample data to infer to populations.*

USING COMPUTERS IN STATISTICS

MENTORING TIP

It is easy to use this textbook with SPSS. Relevant chapters contain SPSS material specific to those chapters, and Appendix E presents a general introduction to SPSS.

The use of computers in statistics has increased greatly over the past decade. In fact, today almost all research data in the behavioral sciences are analyzed by statistical computer programs rather than "by hand" with a calculator. This is good news for students, who often like the ideas, concepts, and results of statistics but hate the drudgery of hand computation. The fact is that researchers hate computational drudgery too, and therefore almost always use a computer to analyze data sets of any appreciable size. Computers have the advantages of saving time and labor, minimizing the chances of computational error, allowing easy graphical display of the data, and providing better management of large data sets. However, as useful as computers are, there is often not enough time in a basic statistics course to include them. Therefore, this textbook is written so that you can learn the statistical content with or without the use of computers.

Several computer programs are available to do statistical analysis. The most popular are the Statistical Package for the Social Sciences (SPSS), Statistical Analysis System (SAS), SYSTAT, MINITAB, and Excel. Versions of these programs are available for both mainframes and microcomputers. I believe it is worth taking the extra time to learn one or more of them.

Although, as mentioned previously, I have written this textbook for use with or without computers, this edition makes it easy for you to use SPSS with the textbook. Of course, you or your instructor will have to supply the SPSS software. Chapters 2, 3, 4, 5, 6, 7, 13, 14, 15, 16, and 17 each contain chapter-specific SPSS material near the end. Appendix E, *Introduction to SPSS,* provides general instruction in SPSS. SPSS is probably the most popular statistical software program used in psychology. The software varies somewhat for different versions of SPSS; however, the changes are usually small. The SPSS material in this edition has been written using *SPSS, an IBM company, Windows Version 19.*

As you begin solving problems using computers, I believe you will begin to experience the fun and power that statistical software can bring to your study and use of statistics. In fact, once you have used software like SPSS to analyze data, you will probably wonder, "Why do I have to do any of these complicated calculations by hand?" Unfortunately, when you are using statistical software to calculate the value of a statistic, it does not help you understand that statistic. Understanding the statistic and its proper use is best achieved by doing hand calculations or step-by-step calculations using Excel. Of course, once you have learned everything you can from these calculations, using statistical software like SPSS to grind out correct values of the statistic seems eminently reasonable.

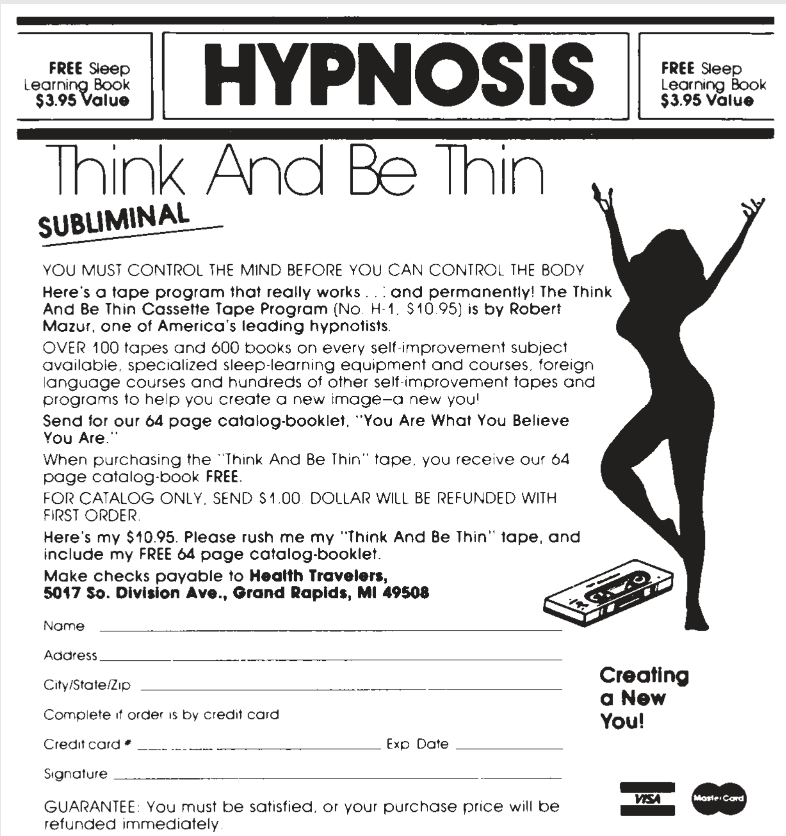
STATISTICS AND THE "REAL WORLD"

As I mentioned previously, one major purpose of statistics is to aid in the scientific evaluation of truth assertions. Although you may view this as rather esoteric and far removed from everyday life, I believe you will be convinced, by the time you have finished this textbook, that understanding statistics has very important practical aspects that can contribute to your satisfaction with and success in life. As you go through this textbook, I hope you will become increasingly aware of how frequently in ordinary life we are bombarded with "authorities" telling us, based on "truth assertions," what we should do, how we should live, what we should buy, what we should value, and so on. In areas of real importance to you, I hope you will begin to ask questions such as: "Are these truth assertions supported by data?" "How good are the data?" "Is chance a reasonable explanation of the data?" If there are no data presented, or if the data presented are of the form "My experience is that …" rather than from well-controlled experiments, I hope that you will begin to question how seriously you should take the authority's advice.

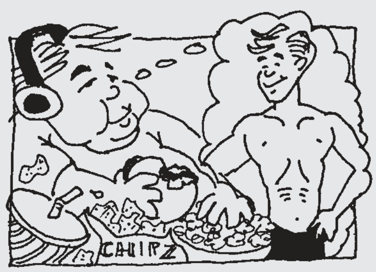
To help develop this aspect of your statistical decision making, I have included, at the end of certain chapters, applications taken from everyday life. These are titled, "What Is the Truth?" To begin, let's consider the following material.

WHAT IS THE TRUTH? Data, Data, Where Are the Data?

The accompanying advertisement was printed in an issue of *Psychology Today*. From a scientific point of view, what's missing?



Answer This ad is similar to a great many that appear these days. It promises a lot, but offers no experimental data to back up its claims. The ad puts forth a truth assertion: "Think And Be Thin." It further claims "Here's a tape program that really works … and permanently!" The program consists of listening to a tape with subliminal messages that is supposed to program your mind to produce thinness. The glaring lack is that there are no controlled experiments, no data offered to substantiate the claim. This is the kind of claim that cries out for empirical verification. Apparently, the authors of the ad do not believe the readers of *Psychology Today* are very sophisticated, statistically. I certainly hope the readers of this textbook would ask for the data before they spend 6 months of their time listening to a tape, the message of which they can't even hear! ■



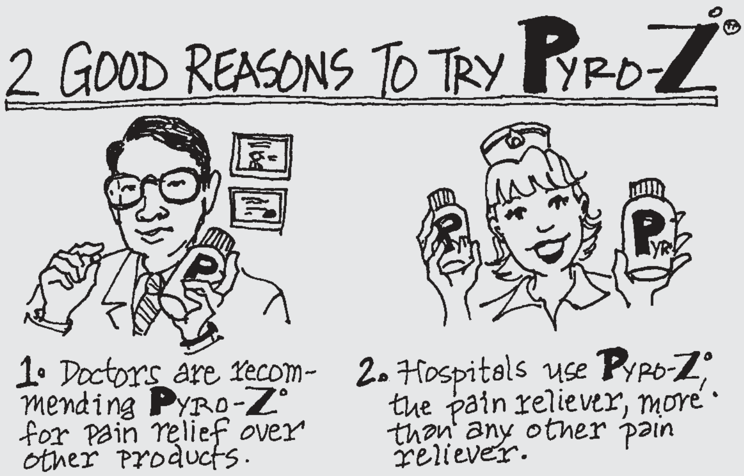
WHAT IS THE TRUTH? Authorities Are Nice, but …

An advertisement promoting Anacin-3 appeared in an issue of *Cosmopolitan*. The heading of the advertisement was "3 Good Reasons to Try Anacin-3." The advertisement pictured a doctor, a nurse, and a pharmacist making the following three statements:

1. "*Doctors* are recommending acetaminophen, the aspirin-free pain reliever in Anacin-3, more than any other aspirin-free pain reliever."
2. "*Hospitals* use acetaminophen, the aspirin-free pain reliever in Anacin-3, more than any other aspirin-free pain reliever."
3. "*Pharmacists* recommend acetaminophen, the aspirin-free pain reliever in Anacin-3, more than any other aspirin-free pain reliever."

From a scientific point of view, is anything missing?

Answer This is somewhat better than the previous ad. At least relevant authorities are invoked in support of the product. However, the ad is misleading and again fails to present the appropriate data. Much better than the "3 Good Reasons to Try Anacin-3" given in the ad would be reason 4, data from well-conducted experiments showing that (a) acetaminophen is a better pain reliever than any other aspirin-free pain reliever and (b) Anacin-3 relieves pain better than any competitor. Any guesses about why these data haven't been presented? As a budding statistician, are you satisfied with the case made by this ad? ■



WHAT IS THE TRUTH? Data, Data, What Are the Data?—1

In the previous "What Is the Truth?" sections, no data were presented to justify the authors' claims, a cardinal error in science. A little less grievous, but nonetheless questionable, is when data are presented in a study or experiment but the conclusions drawn by the authors seem to stay far from the actual data. A study reported in a recent newspaper article illustrates this point. The article is shown below.

CAVEMEN WERE PRETTY NICE GUYS

By VIRGINIA FENTON
The Associated Press

PARIS—Neanderthals might not have been as savage as we think. A 200,000-year-old jawbone discovered in France suggests the primitive hominids took care of each other, in this case feeding a toothless peer, an international team of experts said Friday.

A damaged jawbone, discovered last year in southern France, shows that its owner survived without teeth for up to several years—impossible without a helping hand from his or her peers, said Canadian paleontologist Serge Lebel.

Lebel directed an international team of experts who discovered the fossil in July 2000. Also on the team was the noted specialist of the Neanderthal period Erik Trinkaus of Washington University in St. Louis and colleagues from Germany, Portugal and France.

"This individual must have been quite weak and needed preparation of his or her food, and the social group probably took care of him or her," Lebel said at a news conference.

"We mustn't dehumanize these beings. They show an entirely human kind of behavior," said Lebel, who works at the University of Quebec.

"Others in the group may have gone as far as chewing the food for their sick peer, as well as cutting and cooking it," he said.

"The discovery may push back ideas of the beginning of social care by 150,000 years," Lebel said. "A similar infection that caused a hominid to lose his teeth had previously only been found in fossils dating back 50,000 years," he said.

The team's findings were published in the Sept. 25 issue of the U.S. periodical Proceedings of the National Academy of Sciences*.*

However, University of Pittsburgh anthropologist Jeffrey Schwartz was skeptical.

"You can eat a lot without your teeth. There is no reason to think the individual couldn't have been chewing soft food—snails, mollusks, even worms."

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Do you think the finding of a 200,000-year-old, damaged jawbone by the international team of experts is an adequate database for the conclusions put forth by Dr. Lebel? Or, like Dr. Schwartz, are you skeptical? You can probably guess into which camp I fall. ■

WHAT IS THE TRUTH? Data, Data, What Are the Data?—2

As discussed in this chapter, using data as the basis for truth assertions is an important part of the scientific process. Sometimes, however, data are reported in a manner that is distorted, leading to false conclusions rather than truth. This point is illustrated in the following article that recently appeared in a local newspaper.

PUNDITS TWIST FACTS INTO URBAN LEGEND

By TIM RUTTEN

Urban legends are anecdotes so engaging, entertaining, anxiety-affirming or prejudice-confirming that people repeat them as true, even when they are not.

Their journalistic equivalent is the pithy "poll result" or "study finding" that so neatly encapsulates a social ill or point of partisan contention that no talk-show host or stump orator can resist it.

Ronald Reagan, for example, was so notoriously fond of dubious anecdotes that some of his close associates speculated that his years as an actor had rendered him utterly incapable of passing up a good line.

That provenance-be-damned attitude hardly ended with the Great Communicator's retirement.

CNN political analyst William Schneider, an authority on opinion polling, believes that highly charged political issues or campaigns are particularly prone to spin off fictional study results, which then take on a life of their own.

"Social Security is a classic case," Schneider said. "There is a political legend that a 'recent' poll, which is never specified, showed that more young Americans believe Elvis is alive than expect to collect a Social Security check when they retire. Over the past few years, every conservative on Earth and every Republican politician in Washington, including President Bush, has referred to this finding. They all just say, 'Polls or studies show this,' but none ever has. Republicans go on citing this bogus finding because—whether it's true or not—it has great value as political currency."

Recently, it was possible to watch another such journalistic legend being born. The Wall Street Journal's ***Leisure & Arts page published an article excerpted from a speech delivered a week before by Bruce Cole, chairman of the National Endowment for the Humanities.*** *In it, he decried the fact "that Americans do not know their history" and reflected on this collective amnesia's particular perils in the wake of Sept. 11, whose memory he fears might even now be fading.*

All fair points. However, in their support, Cole cited "a nationwide survey recently commissioned by Columbia Law School," which, he said, "found that almost two-thirds of all Americans think Karl Marx's socialist dogma, 'From each according to his ability, to each according to his needs,' was or may have been written by the Founding Fathers and was included in the Constitution."

Clear; helpful; alarming. Plausible, even, given the popular taste for altruistic banality. Everything, in other words, that a good rhetorical point should be. The problem is that is not what the Columbia poll found.

(continued)

WHAT IS THE TRUTH? *(continued)*

It is, however, what the May 29 press release announcing the poll's findings said. In fact, its first paragraph read: "Almost two-thirds of Americans think Karl Marx's maxim, 'From each according to his ability, to each according to his needs' was or could have been written by the framers and included in the Constitution."

Note the subtle shift from the release's "could have been written" to Cole's—or his speech writer's—"may have been written."

The announcement's second paragraph quotes Columbia Law School professor Michael Dorf on the troubling implications of the Marx "finding" and points the reader to a column the professor has written for a legal Web site, Findlaw.com. In that column, Dorf wrote that "The survey found that 69 percent of respondents either thought that the United States Constitution contained Marx's maxim, or did not know whether or not it did."

That is further still from Cole's recitation of the finding.

What of the actual poll, which asked a national sample of 1,000 respondents five yes-or-no questions about the Constitution?

In response to the query about whether the Marxist maxim is contained in the document, 35 percent said yes; 31 percent said no; and 34 percent said "they did not know."

Was Dorf entitled to conflate the yes and don't-know respondents into a single, alarming two-thirds? No, Schneider said. "That is a total misinterpretation of what people mean when they tell a pollster they don't know. When people say that, they mean 'I have no idea.' Choosing to interpret it as meaning 'I think it may be true or could be true' simply is misleading on the writer's part."

What it does do is add pungency to a finding Schneider described as "wholly unremarkable. It's not at all surprising that about a third of respondents thought that is in the Constitution. Most people, for example, think the right to privacy exists in the Constitution, when no such right is enumerated anywhere in it."

In fact, what is remarkable—and far more relevant at the moment—about the Columbia poll is what it shows Americans do know about their Constitution: Fully 83 percent of the respondents recognized the first sentence of the 14th Amendment as part of the national charter, while 60 percent correctly understood that the president may not suspend the Bill of Rights in time of war.

More than two-thirds of those asked were aware that Supreme Court justices serve for life.

The only other question the respondents flubbed was whether the court's overturning of Roe vs. Wade would make abortion "illegal throughout the United States."

Fewer than a third of those polled correctly said it would not, because state statutes guaranteeing choice would remain on the books.

These facts notwithstanding, it is a safe bet that radio and television talk-show hosts, editorial writers and all the rest of the usually suspect soon will be sighing, groaning, sneering and raging about Americans' inability to distinguish the thought of James Madison from that of Karl Marx. How long will it be before public education, the liberal media, humanism and single-parent families are blamed?

Commentary pages are the soft underbelly of American journalism. Their writers, however self-interested, are held to a different, which is to say lower, standard of proof because of their presumed expertise.

In fact, they are responsible for regularly injecting false information of this sort into our public discourse. In the marketplace of ideas, as on the used car lot, caveat emptor still is the best policy.

Source: "Regarding Media: Surveying a Problem with Polls" by Tim Rutten, *Los Angeles Times*, June 14, 2002.

Do you think William Schneider is too cynical, or do you agree with the article's conclusion? "In fact, they are responsible for regularly injecting false information of this sort into our public discourse. In the marketplace of ideas, as on the used car lot, caveat emptor still is the best policy." ■

SUMMARY

In this chapter, I have discussed how truth is established. Traditionally, four methods have been used: authority, reason, intuition, and science. At the heart of science is the scientific experiment. By reasoning or through intuition, the scientist forms a hypothesis about some feature of reality. He or she designs an experiment to objectively test the hypothesis. The data from the experiment are then analyzed statistically, and the hypothesis is either confirmed or rejected.

Most scientific research falls into two categories: observational studies and true experiments. Natural observation, parameter estimation, and correlational studies are included within the observational category. Their major goal is to give an accurate description of the situation, estimate population parameters, or determine whether two or more of the variables are related. Since there is no systematic manipulation of any variable by the experimenter when doing an observational study, this type of research cannot determine whether changes in one variable will cause changes in another variable. Causal relationships can be determined only from true experiments.

In true experiments, the investigator systematically manipulates the independent variable and observes its effect on one or more dependent variables. Due to practical considerations, data are collected on only a sample of subjects rather than on the whole population. It is important that the sample be a random sample. The obtained data are then analyzed statistically.

The statistical analysis may be descriptive or inferential. If the analysis just describes or characterizes the obtained data, we are in the domain of descriptive statistics. If the analysis uses the obtained data to infer to populations, we are in the domain of inferential statistics. Understanding statistical analysis has important practical consequences in life.

IMPORTANT NEW TERMS

Constant (p. 6)
Correlational studies (p. 9)
Data (p. 7)
Dependent variable (p. 7)
Descriptive statistics (p. 10)
Independent variable (p. 6)
Inferential statistics (p. 10)
Method of authority (p. 4)
Method of intuition (p. 5)
Method of rationalism (p. 4)
Naturalistic observation research (p. 9)
Observational studies (p. 9)
Parameter (p. 7)
Parameter estimation research (p. 9)
Population (p. 6)
Sample (p. 6)
Scientific method (p. 6)
SPSS (p. 11)
Statistic (p. 7)
True experiment (p. 9)
Variable (p. 6)

QUESTIONS AND PROBLEMS

Note to the student: You will notice that at the end of specific problems in this and all other chapters except Chapter 2, I have identified, in color, a specific area within psychology and related fields to which the problems apply. For example, Problem 6, part **b,** is a problem in the area of biological psychology. It has been labeled "biological" at the end of the problem ("psychology" is left off of each label for brevity). The specific areas identified are cognitive psychology, social psychology, developmental psychology, biological psychology, clinical psychology, industrial/organizational (I/O) psychology, health psychology, education, and other. I hope this labeling will be useful to your instructor in selecting assigned homework problems and to you in seeing the broad application of this material as well as in helping you select additional problems you might enjoy solving beyond the assigned ones.

1. Define each of the following terms:

Population	Dependent variable
Sample	Constant
Data	Statistic
Variable	Parameter
Independent variable	

2. What are four methods of acquiring knowledge? Write a short paragraph describing the essential characteristics of each.
3. How does the scientific method differ from each of the methods listed here?
   a. Method of authority
   b. Method of rationalism
   c. Method of intuition
4. Write a short paragraph comparing naturalistic observation and true experiments.
5. Distinguish between descriptive and inferential statistics. Use examples to illustrate the points you make.
6. In each of the experiments described here, specify (1) the independent variable, (2) the dependent variable, (3) the sample, (4) the population, (5) the data, and (6) the statistic:
   a. A health psychologist is interested in whether fear motivation is effective in reducing the incidence of smoking. Forty adult smokers are selected from individuals residing in the city in which the psychologist works. Twenty are asked to smoke a cigarette, after which they see a gruesome film about how smoking causes cancer. Vivid pictures of the diseased lungs and other internal organs of deceased smokers are shown in an effort to instill fear of smoking in these subjects. The other group receives the same treatment, except they see a neutral film that is unrelated to smoking. For 2 months after showing the film, the experimenter keeps records on the number of cigarettes smoked daily by the participants. A mean for each group is then computed, of the number of cigarettes smoked daily since seeing the film, and these means are compared to determine whether the fear-inducing film had an effect on smoking. health
   b. A physiologist wants to know whether a particular region of the brain (the hypothalamus) is involved in the regulation of eating. An experiment is performed in which 30 rats are selected from the university vivarium and divided into two groups. One of the groups receives lesions in the hypothalamus, whereas the other group gets lesions produced in a neutral area. After recovery from the operations, all animals are given free access to food for 2 weeks, and a record is kept of the daily food intake of each animal. At the end of the 2-week period, the mean daily food intake for each group is determined. Finally, these means are compared to see whether the lesions in the hypothalamus have affected the amount eaten. biological
   c. A clinical psychologist is interested in evaluating three methods of treating depression: medication, cognitive restructuring, and exercise. A fourth treatment condition, a waiting-only treatment group, is included to provide a baseline control group. Sixty depressed students are recruited from the undergraduate student body at a large state university, and fifteen are assigned to each treatment method. Treatments are administered for 6 months, after which each student is given a questionnaire designed to measure the degree of depression. The questionnaire is scaled from 0 to 100, with higher scores indicating a higher degree of depression. The mean depression values are then computed for the four treatments and compared to determine the relative effectiveness of each treatment. clinical, health
   d. A social psychologist is interested in determining whether individuals who graduate from high school but get no further education earn more money than high school dropouts. A national survey is conducted in a large Midwestern city, sampling 100 individuals from each category and asking each their annual salary. The results are tabulated, and mean salary values are calculated for each group. social
   e. A cognitive psychologist is interested in how retention is affected by the spacing of practice sessions. A sample of 30 seventh graders is selected from a local junior high school and divided into three