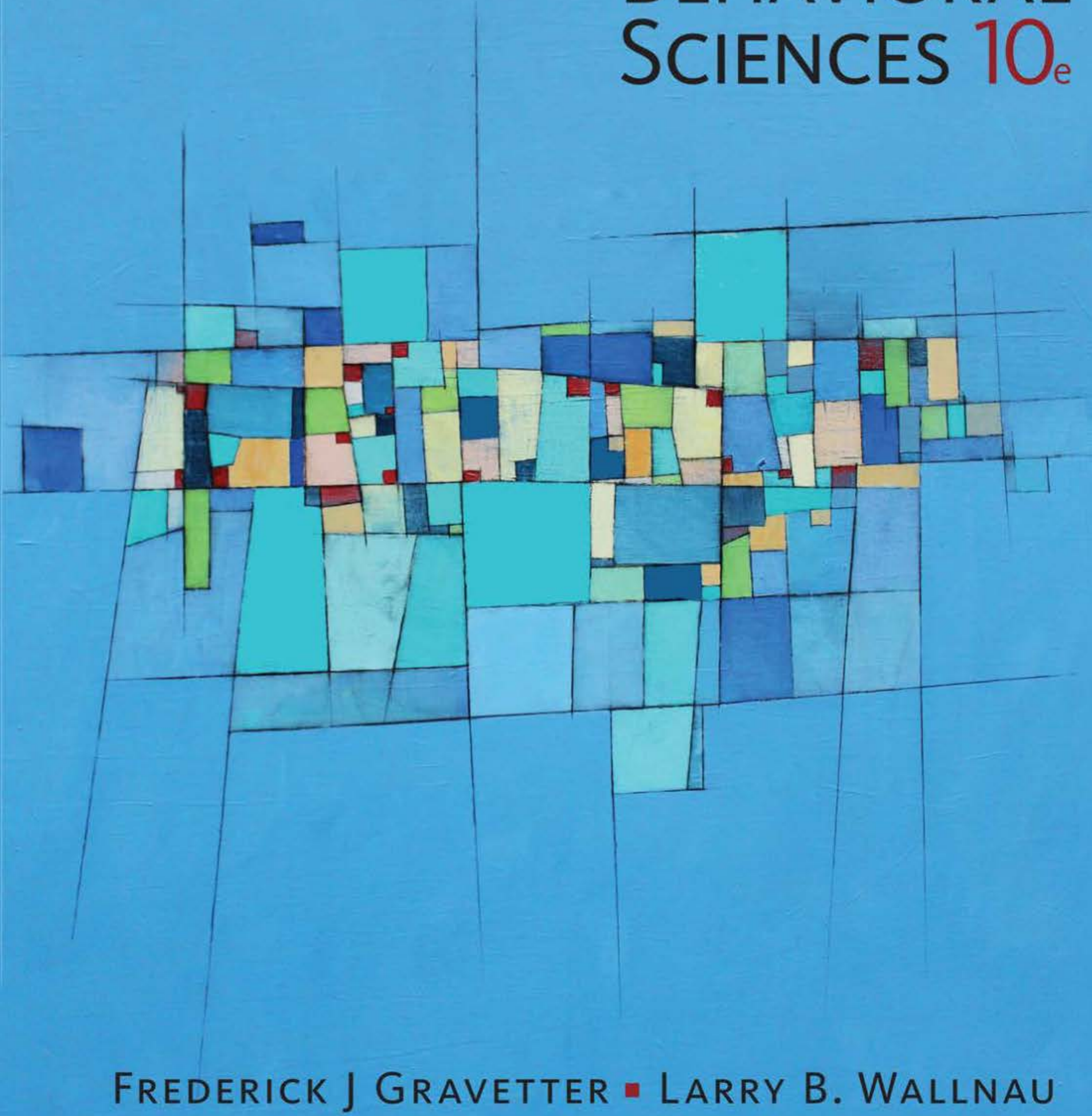
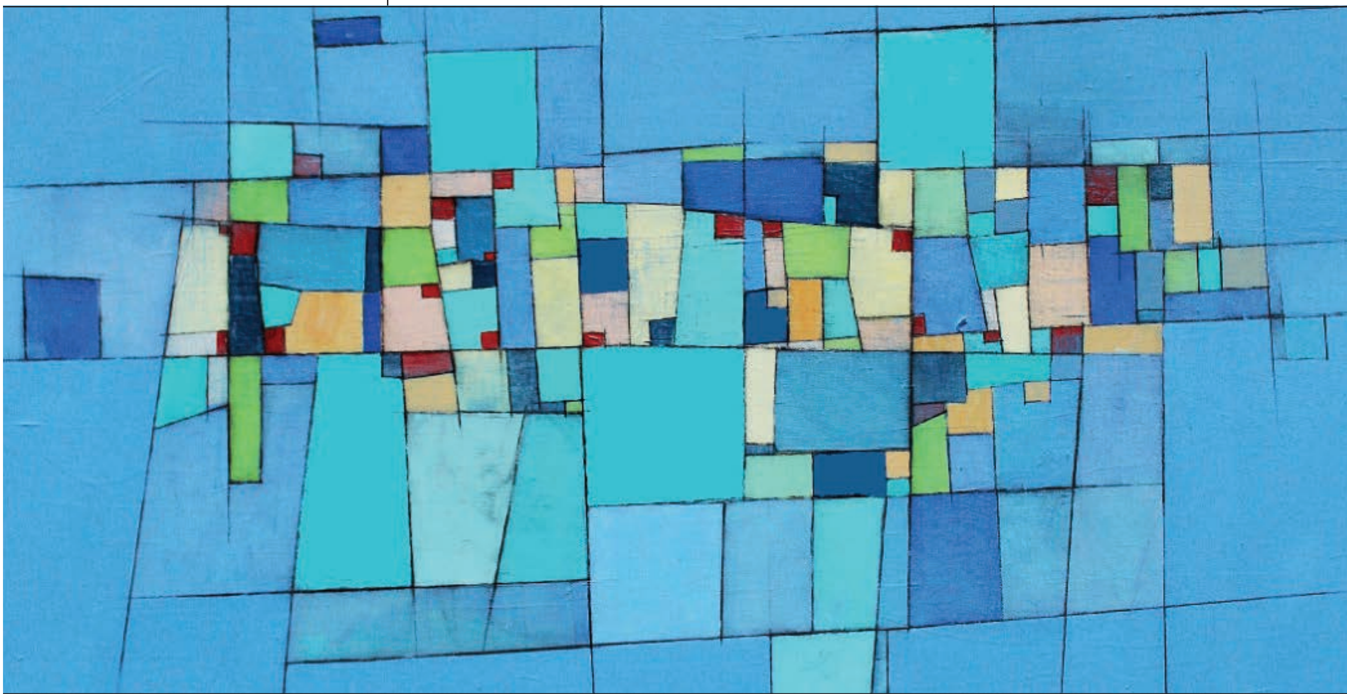
STATISTICS FOR THE BEHAVIORAL SCIENCES 10e



FREDERICK J GRAVETTER ▪ LARRY B. WALLNAU

EDITION 10

Statistics for the Behavioral Sciences



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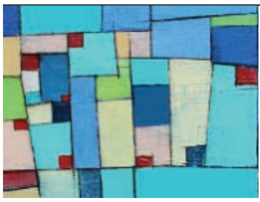

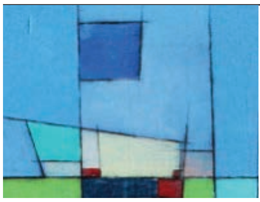

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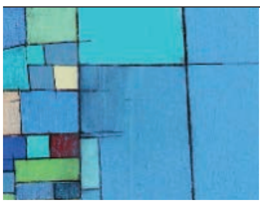

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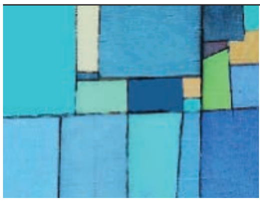

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PREFACE

Many students in the behavioral sciences view the required statistics course as an intimidating obstacle that has been placed in the middle of an otherwise interesting curriculum. They want to learn about human behavior—not about math and science. As a result, the statistics course is seen as irrelevant to their education and career goals. However, as long as the behavioral sciences are founded in science, knowledge of statistics will be necessary. Statistical procedures provide researchers with objective and systematic methods for describing and interpreting their research results. Scientific research is the system that we use to gather information, and statistics are the tools that we use to distill the information into sensible and justified conclusions. The goal of this book is not only to teach the methods of statistics, but also to convey the basic principles of objectivity and logic that are essential for science and valuable for decision making in everyday life.

Those of you who are familiar with previous editions of *Statistics for the Behavioral Sciences* will notice that some changes have been made. These changes are summarized in the section entitled "To the Instructor." In revising this text, our students have been foremost in our minds. Over the years, they have provided honest and useful feedback. Their hard work and perseverance has made our writing and teaching most rewarding. We sincerely thank them. Students who are using this edition should please read the section of the preface entitled "To the Student."

The book chapters are organized in the sequence that we use for our own statistics courses. We begin with descriptive statistics, and then examine a variety of statistical procedures focused on sample means and variance before moving on to correlational methods and nonparametric statistics. Information about modifying this sequence is presented in the *To The Instructor* section for individuals who prefer a different organization. Each chapter contains numerous examples, many based on actual research studies, learning checks, a summary and list of key terms, and a set of 20–30 problems.

Ancillaries

Ancillaries for this edition include the following.

- **MindTap® Psychology:** *MindTap® Psychology for Gravetter/Wallnau's Statistics for The Behavioral Sciences, 10th Edition* is the digital learning solution that helps instructors engage and transform today's students into critical thinkers. Through paths of dynamic assignments and applications that you can personalize, real-time course analytics, and an accessible reader, MindTap helps you turn cookie cutter into cutting edge, apathy into engagement, and memorizers into higher-level thinkers.

  As an instructor using MindTap you have at your fingertips the right content and unique set of tools curated specifically for your course, such as video tutorials that walk students through various concepts and interactive problem tutorials that provide students opportunities to practice what they have learned, all in an interface designed to improve workflow and save time when planning lessons and course structure. The control to build and personalize your course is all yours, focusing on the most relevant material while also lowering costs for your students. Stay connected and informed in your course through real time student tracking that provides the opportunity to adjust the course as needed based on analytics of interactivity in the course.

- **Online Instructor's Manual:** The manual includes learning objectives, key terms, a detailed chapter outline, a chapter summary, lesson plans, discussion topics, student activities, "What If" scenarios, media tools, a sample syllabus and an expanded test bank. The learning objectives are correlated with the discussion topics, student activities, and media tools.
- **Online PowerPoints:** Helping you make your lectures more engaging while effectively reaching your visually oriented students, these handy Microsoft PowerPoint® slides outline the chapters of the main text in a classroom-ready presentation. The PowerPoint® slides are updated to reflect the content and organization of the new edition of the text.
- **Cengage Learning Testing, powered by Cognero®:** Cengage Learning Testing, Powered by Cognero®, is a flexible online system that allows you to author, edit, and manage test bank content. You can create multiple test versions in an instant and deliver tests from your LMS in your classroom.

Acknowledgments

It takes a lot of good, hard-working people to produce a book. Our friends at Cengage have made enormous contributions to this textbook. We thank: Jon-David Hague, Product Director; Timothy Matray, Product Team Director; Jasmin Tokatlian, Content Development Manager; Kimiya Hojjat, Product Assistant; and Vernon Boes, Art Director. Special thanks go to Stefanie Chase, our Content Developer and to Lynn Lustberg who led us through production at MPS.

Reviewers play a very important role in the development of a manuscript. Accordingly, we offer our appreciation to the following colleagues for their assistance: Patricia Case, University of Toledo; Kevin David, Northeastern State University; Adia Garrett, University of Maryland, Baltimore County; Carrie E. Hall, Miami University; Deletha Hardin, University of Tampa; Angela Heads, Prairie View A&M University; Roberto Heredia, Texas A&M International University; Alisha Janowski, University of Central Florida; Matthew Mulvaney, The College at Brockport (SUNY); Nicholas Von Glahn, California State Polytechnic University, Pomona; and Ronald Yockey, Fresno State University.

To the Instructor

Those of you familiar with the previous edition of *Statistics for the Behavioral Sciences* will notice a number of changes in the 10th edition. Throughout this book, research examples have been updated, real world examples have been added, and the end-of-chapter problems have been extensively revised. Major revisions for this edition include the following:

1. Each section of every chapter begins with a list of Learning Objectives for that specific section.
2. Each section ends with a Learning Check consisting of multiple-choice questions with at least one question for each Learning Objective.

3. The former Chapter 19, Choosing the Right Statistics, has been eliminated and an abridged version is now an Appendix replacing the Statistics Organizer, which appeared in earlier editions.

Other examples of specific and noteworthy revisions include the following.

Chapter 1 The section on data structures and research methods parallels the new Appendix, Choosing the Right Statistics.

Chapter 2 The chapter opens with a new Preview to introduce the concept and purpose of frequency distributions.

Chapter 3 Minor editing clarifies and simplifies the discussion the median.

Chapter 4 The chapter opens with a new Preview to introduce the topic of Central Tendency. The sections on standard deviation and variance have been edited to increase emphasis on concepts rather than calculations.

Chapter 5 The section discussion relationships between z, X, μ, and σ has been expanded and includes a new demonstration example.

Chapter 6 The chapter opens with a new Preview to introduce the topic of Probability. The section, Looking Ahead to Inferential Statistics, has been substantially shortened and simplified.

Chapter 7 The former Box explaining difference between standard deviation and standard error was deleted and the content incorporated into Section 7.4 with editing to emphasize that the standard error is the primary new element introduced in the chapter. The final section, Looking Ahead to Inferential Statistics, was simplified and shortened to be consistent with the changes in Chapter 6.

Chapter 8 A redundant example was deleted which shortened and streamlined the remaining material so that most of the chapter is focused on the same research example.

Chapter 9 The chapter opens with a new Preview to introduce the t statistic and explain why a new test statistic is needed. The section introducing Confidence Intervals was edited to clarify the origin of the confidence interval equation and to emphasize that the interval is constructed at the sample mean.

Chapter 10 The chapter opens with a new Preview introducing the independent-measures t statistic. The section presenting the estimated standard error of $(M_1 - M_2)$ has been simplified and shortened.

Chapter 11 The chapter opens with a new Preview introducing the repeated-measures t statistic. The section discussing hypothesis testing has been separated from the section on effect size and confidence intervals to be consistent with the other two chapters on t tests. The section comparing independent- and repeated-measures designs has been expanded.

Chapter 12 The chapter opens with a new Preview introducing ANOVA and explaining why a new hypothesis testing procedure is necessary. Sections in the chapter have been reorganized to allow flow directly from hypothesis tests and effect size to post tests.

Chapter 13 Substantially expanded the section discussing factors that influence the outcome of a repeated-measures hypothesis test and associated measures of effect size.

Chapter 14 The chapter opens with a new Preview presenting a two-factor research example and introducing the associated ANOVA. Sections have been reorganized so that simple main effects and the idea of using a second factor to reduce variance from individual differences are now presented as extra material related to the two-factor ANOVA.

Chapter 15 The chapter opens with a new Preview presenting a correlational research study and the concept of a correlation. A new section introduces the *t* statistic for evaluating the significance of a correlation and the section on partial correlations has been simplified and shortened.

Chapter 16 The chapter opens with a new Preview introducing the concept of regression and its purpose. A new section demonstrates the equivalence of testing the significance of a correlation and testing the significance of a regression equation with one predictor variable. The section on residuals for the multiple-regression equation has been edited to simplify and shorten.

Chapter 17 A new chapter Preview presents an experimental study with data consisting of frequencies, which are not compatible with computing means and variances. Chi-square tests are introduced as a solution to this problem. A new section introduces Cohen's *w* as a means of measuring effect size for both chi-square tests.

Chapter 18 Substantial editing clarifies the section explaining how the real limits for each score can influence the conclusion from a binomial test.

The former Chapter 19 covering the task of matching statistical methods to specific types of data has been substantially shortened and converted into an Appendix.

Matching the Text to Your Syllabus

The book chapters are organized in the sequence that we use for our own statistics courses. However, different instructors may prefer different organizations and probably will choose to omit or deemphasize specific topics. We have tried to make separate chapters, and even sections of chapters, completely self-contained, so they can be deleted or reorganized to fit the syllabus for nearly any instructor. Some common examples are as follows.

- It is common for instructors to choose between emphasizing analysis of variance (Chapters 12, 13, and 14) or emphasizing correlation/regression (Chapters 15 and 16). It is rare for a one-semester course to complete coverage of both topics.
- Although we choose to complete all the hypothesis tests for means and mean differences before introducing correlation (Chapter 15), many instructors prefer to place correlation much earlier in the sequence of course topics. To accommodate this, Sections 15.1, 15.2, and 15.3 present the calculation and interpretation of the Pearson correlation and can be introduced immediately following Chapter 4 (variability). Other sections of Chapter 15 refer to hypothesis testing and should be delayed until the process of hypothesis testing (Chapter 8) has been introduced.
- It is also possible for instructors to present the chi-square tests (Chapter 17) much earlier in the sequence of course topics. Chapter 17, which presents hypothesis tests for proportions, can be presented immediately after Chapter 8, which introduces the process of hypothesis testing. If this is done, we also recommend that the Pearson correlation (Sections 15.1, 15.2, and 15.3) be presented early to provide a foundation for the chi-square test for independence.

To the Student

A primary goal of this book is to make the task of learning statistics as easy and painless as possible. Among other things, you will notice that the book provides you with a number of opportunities to practice the techniques you will be learning in the form of Learning Checks, Examples, Demonstrations, and end-of-chapter problems. We encourage you to take advantage of these opportunities. Read the text rather than just memorizing the formulas. We have taken care to present each statistical procedure in a conceptual context that explains why the procedure was developed and when it should be used. If you read this material and gain an understanding of the basic concepts underlying a statistical formula, you will find that learning the formula and how to use it will be much easier. In the "Study Hints," that follow, we provide advice that we give our own students. Ask your instructor for advice as well; we are sure that other instructors will have ideas of their own.

Over the years, the students in our classes and other students using our book have given us valuable feedback. If you have any suggestions or comments about this book, you can write to either Professor Emeritus Frederick Gravetter or Professor Emeritus Larry Wallnau at the Department of Psychology, SUNY College at Brockport, 350 New Campus Drive, Brockport, New York 14420. You can also contact Professor Emeritus Gravetter directly at fgravett@brockport.edu.

■ Study Hints

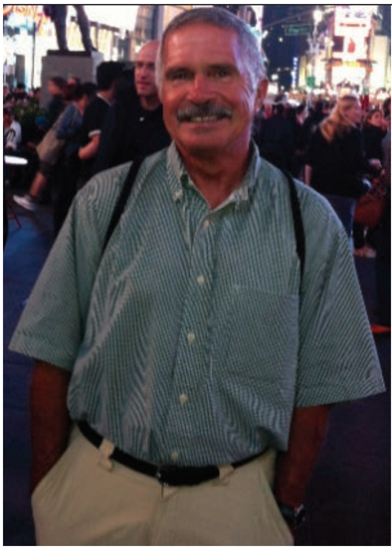
You may find some of these tips helpful, as our own students have reported.

- The key to success in a statistics course is to keep up with the material. Each new topic builds on previous topics. If you have learned the previous material, then the new topic is just one small step forward. Without the proper background, however, the new topic can be a complete mystery. If you find that you are falling behind, get help immediately.
- You will learn (and remember) much more if you study for short periods several times per week rather than try to condense all of your studying into one long session. For example, it is far more effective to study half an hour every night than to have a single 3½-hour study session once a week. We cannot even work on *writing* this book without frequent rest breaks.
- Do some work before class. Keep a little ahead of the instructor by reading the appropriate sections before they are presented in class. Although you may not fully understand what you read, you will have a general idea of the topic, which will make the lecture easier to follow. Also, you can identify material that is particularly confusing and then be sure the topic is clarified in class.
- Pay attention and think during class. Although this advice seems obvious, often it is not practiced. Many students spend so much time trying to write down every example presented or every word spoken by the instructor that they do not actually understand and process what is being said. Check with your instructor—there may not be a need to copy every example presented in class, especially if there are many examples like it in the text. Sometimes, we tell our students to put their pens and pencils down for a moment and just listen.
- Test yourself regularly. Do not wait until the end of the chapter or the end of the week to check your knowledge. After each lecture, work some of the end-of-chapter problems and do the Learning Checks. Review the Demonstration Problems, and be sure you can define the Key Terms. If you are having trouble, get your questions answered *immediately*—reread the section, go to your instructor, or ask questions in class. By doing so, you will be able to move ahead to new material.

- Do not kid yourself! Avoid denial. Many students observe their instructor solve problems in class and think to themselves, "This looks easy, I understand it." Do you really understand it? Can you really do the problem on your own without having to leaf through the pages of a chapter? Although there is nothing wrong with using examples in the text as models for solving problems, you should try working a problem with your book closed to test your level of mastery.
- We realize that many students are embarrassed to ask for help. It is our biggest challenge as instructors. You must find a way to overcome this aversion. Perhaps contacting the instructor directly would be a good starting point, if asking questions in class is too anxiety-provoking. You could be pleasantly surprised to find that your instructor does not yell, scold, or bite! Also, your instructor might know of another student who can offer assistance. Peer tutoring can be very helpful.

Frederick J Gravetter
Larry B. Wallnau

ABOUT THE AUTHORS



Frederick Gravetter

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CHAPTER

1

Introduction to Statistics

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PREVIEW

Before we begin our discussion of statistics, we ask you to read the following paragraph taken from the philosophy of Wrong Shui (Candappa, 2000).

> **The Journey to Enlightenment**
> In Wrong Shui, life is seen as a cosmic journey, a struggle to overcome unseen and unexpected obstacles at the end of which the traveler will find illumination and enlightenment. Replicate this quest in your home by moving light switches away from doors and over to the far side of each room.*

Why did we begin a statistics book with a bit of twisted philosophy? In part, we simply wanted to lighten the mood with a bit of humor—starting a statistics course is typically not viewed as one of life's joyous moments. In addition, the paragraph is an excellent counterexample for the purpose of this book. Specifically, our goal is to do everything possible to prevent you from stumbling around in the dark by providing lots of help and illumination as you journey through the world of statistics. To accomplish this, we begin each section of the book with clearly stated learning objectives and end each section with a brief quiz to test your mastery of the new material. We also introduce each new statistical procedure by explaining the purpose it is intended to serve. If you understand why a new procedure is needed, you will find it much easier to learn.

The objectives for this first chapter are to provide an introduction to the topic of statistics and to give you some background for the rest of the book. We discuss the role of statistics within the general field of scientific inquiry, and we introduce some of the vocabulary and notation that are necessary for the statistical methods that follow.

As you read through the following chapters, keep in mind that the general topic of statistics follows a well-organized, logically developed progression that leads from basic concepts and definitions to increasingly sophisticated techniques. Thus, each new topic serves as a foundation for the material that follows. The content of the first nine chapters, for example, provides an essential background and context for the statistical methods presented in Chapter 10. If you turn directly to Chapter 10 without reading the first nine chapters, you will find the material confusing and incomprehensible. However, if you learn and use the background material, you will have a good frame of reference for understanding and incorporating new concepts as they are presented.

*Candappa, R. (2000). *The little book of wrong shui.* Kansas City: Andrews McMeel Publishing. Reprinted by permission.

1.1 Statistics, Science, and Observations

LEARNING OBJECTIVES

1. Define the terms population, sample, parameter, and statistic, and describe the relationships between them.
2. Define descriptive and inferential statistics and describe how these two general categories of statistics are used in a typical research study.
3. Describe the concept of sampling error and explain how this concept creates the fundamental problem that inferential statistics must address.

■ Definitions of Statistics

By one definition, *statistics* consist of facts and figures such as the average annual snowfall in Denver or Derrick Jeter's lifetime batting average. These statistics are usually informative and time-saving because they condense large quantities of information into a few simple figures. Later in this chapter we return to the notion of calculating statistics (facts and figures) but, for now, we concentrate on a much broader definition of statistics. Specifically, we use the term statistics to refer to a general field of mathematics. In this case, we are using the term *statistics* as a shortened version of *statistical procedures*. For example, you are probably using this book for a statistics course in which you will learn about the statistical techniques that are used to summarize and evaluate research results in the behavioral sciences.

Research in the behavioral sciences (and other fields) involves gathering information. To determine, for example, whether college students learn better by reading material on printed pages or on a computer screen, you would need to gather information about students' study habits and their academic performance. When researchers finish the task of gathering information, they typically find themselves with pages and pages of measurements such as preferences, personality scores, opinions, and so on. In this book, we present the statistics that researchers use to analyze and interpret the information that they gather. Specifically, statistics serve two general purposes:

1. Statistics are used to organize and summarize the information so that the researcher can see what happened in the research study and can communicate the results to others.
2. Statistics help the researcher to answer the questions that initiated the research by determining exactly what general conclusions are justified based on the specific results that were obtained.

DEFINITION

The term **statistics** refers to a set of mathematical procedures for organizing, summarizing, and interpreting information.

Statistical procedures help ensure that the information or observations are presented and interpreted in an accurate and informative way. In somewhat grandiose terms, statistics help researchers bring order out of chaos. In addition, statistics provide researchers with a set of standardized techniques that are recognized and understood throughout the scientific community. Thus, the statistical methods used by one researcher will be familiar to other researchers, who can accurately interpret the statistical analyses with a full understanding of how the analysis was done and what the results signify.

Populations and Samples

Research in the behavioral sciences typically begins with a general question about a specific group (or groups) of individuals. For example, a researcher may want to know what factors are associated with academic dishonesty among college students. Or a researcher may want to examine the amount of time spent in the bathroom for men compared to women. In the first example, the researcher is interested in the group of *college students*. In the second example, the researcher wants to compare the group of *men* with the group of *women*. In statistical terminology, the entire group that a researcher wishes to study is called a *population*.

DEFINITION

A **population** is the set of all the individuals of interest in a particular study.

As you can well imagine, a population can be quite large—for example, the entire set of women on the planet Earth. A researcher might be more specific, limiting the population for study to women who are registered voters in the United States. Perhaps the investigator would like to study the population consisting of women who are heads of state. Populations can obviously vary in size from extremely large to very small, depending on how the investigator defines the population. The population being studied should always be identified by the researcher. In addition, the population need not consist of people—it could be a population of rats, corporations, parts produced in a factory, or anything else an investigator wants to study. In practice, populations are typically very large, such as the population of college sophomores in the United States or the population of small businesses.

Because populations tend to be very large, it usually is impossible for a researcher to examine every individual in the population of interest. Therefore, researchers typically select a smaller, more manageable group from the population and limit their studies to the individuals in the selected group. In statistical terms, a set of individuals selected from a population is called a *sample*. A sample is intended to be representative of its population, and a sample should always be identified in terms of the population from which it was selected.

DEFINITION

A **sample** is a set of individuals selected from a population, usually intended to represent the population in a research study.

Just as we saw with populations, samples can vary in size. For example, one study might examine a sample of only 10 students in a graduate program and another study might use a sample of more than 10,000 people who take a specific cholesterol medication.

So far we have talked about a sample being selected from a population. However, this is actually only half of the full relationship between a sample and its population. Specifically, when a researcher finishes examining the sample, the goal is to generalize the results back to the entire population. Remember that the research started with a general question about the population. To answer the question, a researcher studies a sample and then generalizes the results from the sample to the population. The full relationship between a sample and a population is shown in Figure 1.1.

Variables and Data

Typically, researchers are interested in specific characteristics of the individuals in the population (or in the sample), or they are interested in outside factors that may influence the individuals. For example, a researcher may be interested in the influence of the weather on people's moods. As the weather changes, do people's moods also change? Something that can change or have different values is called a *variable.*

DEFINITION

A **variable** is a characteristic or condition that changes or has different values for different individuals.

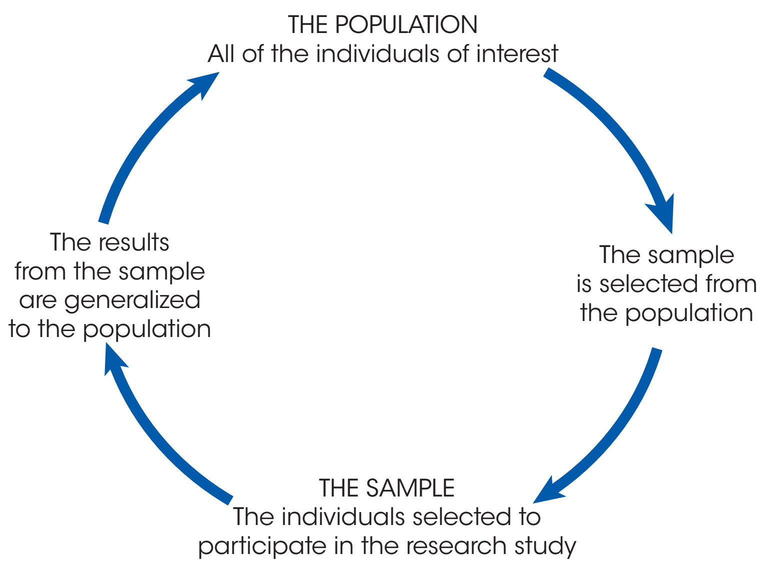


FIGURE 1.1
The relationship between a population and a sample.

Once again, variables can be characteristics that differ from one individual to another, such as height, weight, gender, or personality. Also, variables can be environmental conditions that change such as temperature, time of day, or the size of the room in which the research is being conducted.

To demonstrate changes in variables, it is necessary to make measurements of the variables being examined. The measurement obtained for each individual is called a *datum*, or more commonly, a *score* or *raw score*. The complete set of scores is called the *data set* or simply the *data*.

DEFINITION

Data (plural) are measurements or observations. A **data set** is a collection of measurements or observations. A **datum** (singular) is a single measurement or observation and is commonly called a **score** or **raw score**.

Before we move on, we should make one more point about samples, populations, and data. Earlier, we defined populations and samples in terms of *individuals*. For example, we discussed a population of graduate students and a sample of cholesterol patients. Be forewarned, however, that we will also refer to populations or samples of *scores*. Because research typically involves measuring each individual to obtain a score, every sample (or population) of individuals produces a corresponding sample (or population) of scores.

■ Parameters and Statistics

When describing data it is necessary to distinguish whether the data come from a population or a sample. A characteristic that describes a population—for example, the average score for the population—is called a *parameter*. A characteristic that describes a sample is called a *statistic*. Thus, the average score for a sample is an example of a statistic. Typically, the research process begins with a question about a population parameter. However, the actual data come from a sample and are used to compute sample statistics.

DEFINITION

A **parameter** is a value, usually a numerical value, that describes a population. A parameter is usually derived from measurements of the individuals in the population.

A **statistic** is a value, usually a numerical value, that describes a sample. A statistic is usually derived from measurements of the individuals in the sample.

Every population parameter has a corresponding sample statistic, and most research studies involve using statistics from samples as the basis for answering questions about population parameters. As a result, much of this book is concerned with the relationship between sample statistics and the corresponding population parameters. In Chapter 7, for example, we examine the relationship between the mean obtained for a sample and the mean for the population from which the sample was obtained.

■ Descriptive and Inferential Statistical Methods

Although researchers have developed a variety of different statistical procedures to organize and interpret data, these different procedures can be classified into two general categories. The first category, *descriptive statistics*, consists of statistical procedures that are used to simplify and summarize data.

DEFINITION

Descriptive statistics are statistical procedures used to summarize, organize, and simplify data.

Descriptive statistics are techniques that take raw scores and organize or summarize them in a form that is more manageable. Often the scores are organized in a table or a graph so that it is possible to see the entire set of scores. Another common technique is to summarize a set of scores by computing an average. Note that even if the data set has hundreds of scores, the average provides a single descriptive value for the entire set.

The second general category of statistical techniques is called *inferential statistics*. Inferential statistics are methods that use sample data to make general statements about a population.

DEFINITION

Inferential statistics consist of techniques that allow us to study samples and then make generalizations about the populations from which they were selected.

Because populations are typically very large, it usually is not possible to measure everyone in the population. Therefore, a sample is selected to represent the population. By analyzing the results from the sample, we hope to make general statements about the population. Typically, researchers use sample statistics as the basis for drawing conclusions about population parameters. One problem with using samples, however, is that a sample provides only limited information about the population. Although samples are generally *representative* of their populations, a sample is not expected to give a perfectly accurate picture of the whole population. There usually is some discrepancy between a sample statistic and the corresponding population parameter. This discrepancy is called *sampling error*, and it creates the fundamental problem inferential statistics must always address.

DEFINITION

Sampling error is the naturally occurring discrepancy, or error, that exists between a sample statistic and the corresponding population parameter.

The concept of sampling error is illustrated in Figure 1.2. The figure shows a population of 1,000 college students and 2 samples, each with 5 students who were selected from the population. Notice that each sample contains different individuals who have different characteristics. Because the characteristics of each sample depend on the specific people in the sample, statistics will vary from one sample to another. For example, the five students in sample 1 have an average age of 19.8 years and the students in sample 2 have an average age of 20.4 years.

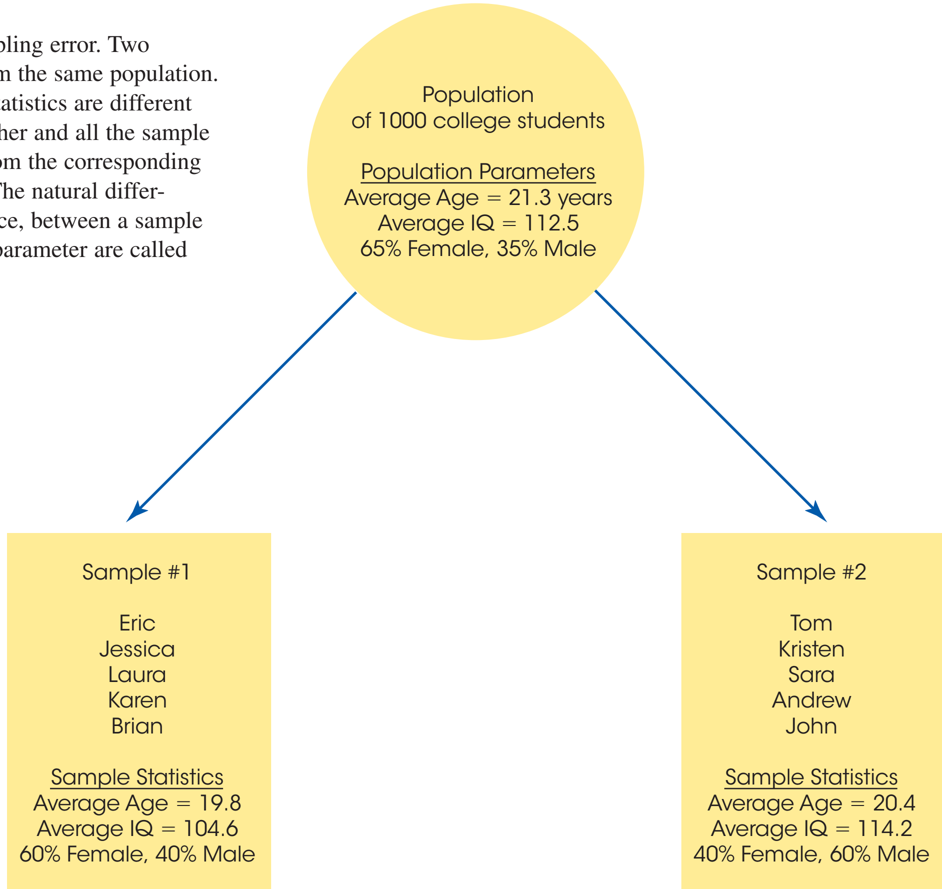
It is also very unlikely that the statistics obtained for a sample will be identical to the parameters for the entire population. In Figure 1.2, for example, neither sample has statistics that are exactly the same as the population parameters. You should also realize that Figure 1.2 shows only two of the hundreds of possible samples. Each sample would contain different individuals and would produce different statistics. This is the basic concept of sampling error: sample statistics vary from one sample to another and typically are different from the corresponding population parameters.

One common example of sampling error is the error associated with a sample proportion. For example, in newspaper articles reporting results from political polls, you frequently find statements such as this:

Candidate Brown leads the poll with 51% of the vote. Candidate Jones has 42% approval, and the remaining 7% are undecided. This poll was taken from a sample of registered voters and has a margin of error of plus-or-minus 4 percentage points.

The "margin of error" is the sampling error. In this case, the percentages that are reported were obtained from a sample and are being generalized to the whole population. As always, you do not expect the statistics from a sample to be perfect. There always will be some "margin of error" when sample statistics are used to represent population parameters.

FIGURE 1.2
A demonstration of sampling error. Two samples are selected from the same population. Notice that the sample statistics are different from one sample to another and all the sample statistics are different from the corresponding population parameters. The natural differences that exist, by chance, between a sample statistic and population parameter are called sampling error.



As a further demonstration of sampling error, imagine that your statistics class is separated into two groups by drawing a line from front to back through the middle of the room. Now imagine that you compute the average age (or height, or IQ) for each group. Will the two groups have exactly the same average? Almost certainly they will not. No matter what you chose to measure, you will probably find some difference between the two groups. However, the difference you obtain does not necessarily mean that there is a systematic difference between the two groups. For example, if the average age for students on the right-hand side of the room is higher than the average for students on the left, it is unlikely that some mysterious force has caused the older people to gravitate to the right side of the room. Instead, the difference is probably the result of random factors such as chance. The unpredictable, unsystematic differences that exist from one sample to another are an example of sampling error.

■ Statistics in the Context of Research

The following example shows the general stages of a research study and demonstrates how descriptive statistics and inferential statistics are used to organize and interpret the data. At the end of the example, note how sampling error can affect the interpretation of experimental results, and consider why inferential statistical methods are needed to deal with this problem.

EXAMPLE 1.1

Figure 1.3 shows an overview of a general research situation and demonstrates the roles that descriptive and inferential statistics play. The purpose of the research study is to address a question that we posed earlier: Do college students learn better by studying text on printed pages or on a computer screen? Two samples are selected from the population of college students. The students in sample A are given printed pages of text to study for 30 minutes and the students in sample B study the same text on a computer screen. Next, all of the students are given a multiple-choice test to evaluate their knowledge of the material. At this point, the researcher has two sets of data: the scores for sample A and the scores for sample B (see the figure). Now is the time to begin using statistics.

First, descriptive statistics are used to simplify the pages of data. For example, the researcher could draw a graph showing the scores for each sample or compute the average score for each sample. Note that descriptive methods provide a simplified, organized

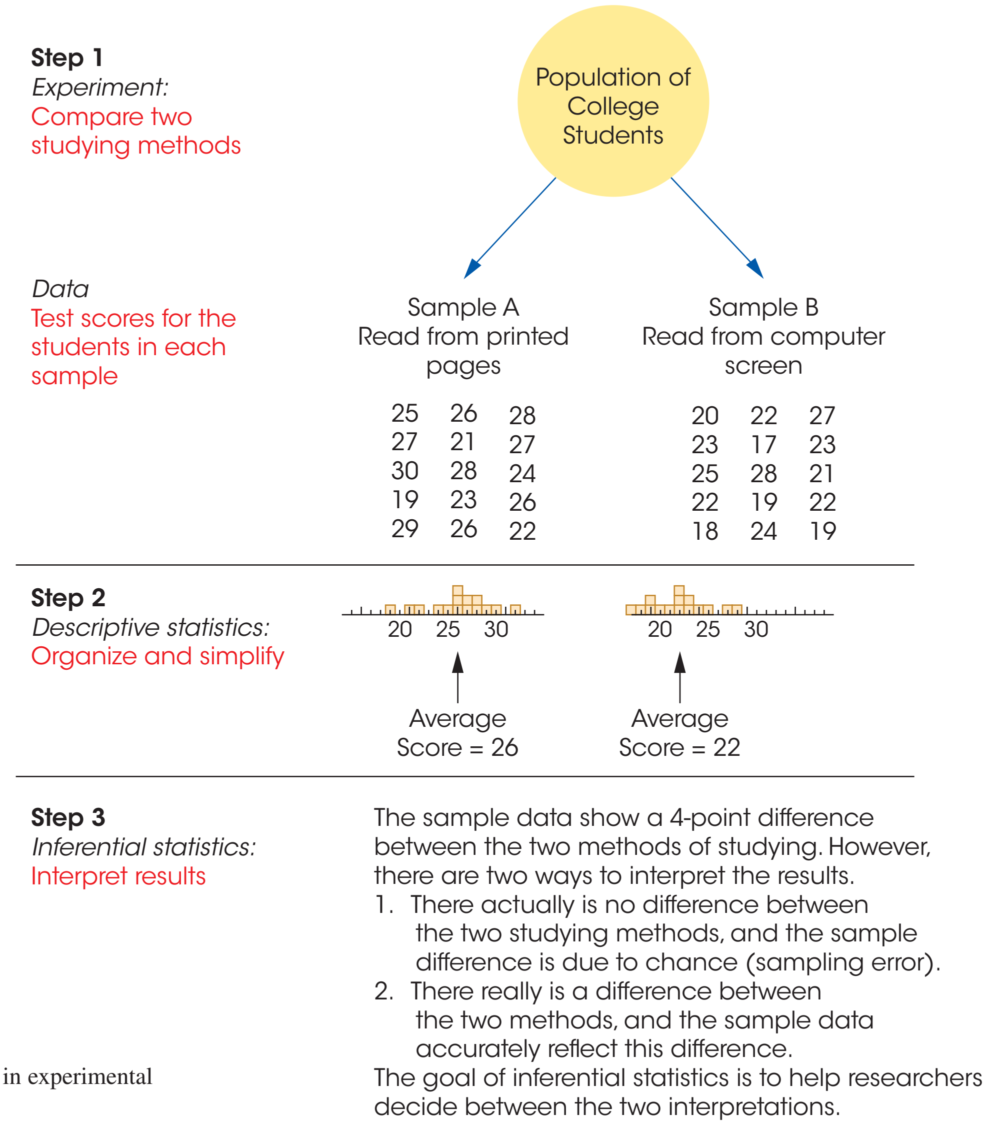


FIGURE 1.3
The role of statistics in experimental research.

description of the scores. In this example, the students who studied printed pages had an average score of 26 on the test, and the students who studied text on the computer averaged 22.

Once the researcher has described the results, the next step is to interpret the outcome. This is the role of inferential statistics. In this example, the researcher has found a difference of 4 points between the two samples (sample A averaged 26 and sample B averaged 22). The problem for inferential statistics is to differentiate between the following two interpretations:

1. There is no real difference between the printed page and a computer screen, and the 4-point difference between the samples is just an example of sampling error (like the samples in Figure 1.2).
2. There really is a difference between the printed page and a computer screen, and the 4-point difference between the samples was caused by the different methods of studying.

In simple English, does the 4-point difference between samples provide convincing evidence of a difference between the two studying methods, or is the 4-point difference just chance? The purpose of inferential statistics is to answer this question. ■

LEARNING CHECK

1. A researcher is interested in the sleeping habits of American college students. A group of 50 students is interviewed and the researcher finds that these students sleep an average of 6.7 hours per day. For this study, the average of 6.7 hours is an example of a(n) ________.
   a. parameter
   b. statistic
   c. population
   d. sample
2. A researcher is curious about the average IQ of registered voters in the state of Florida. The entire group of registered voters in the state is an example of a ________.
   a. sample
   b. statistic
   c. population
   d. parameter
3. Statistical techniques that summarize, organize, and simplify data are classified as ________.
   a. population statistics
   b. sample statistics
   c. descriptive statistics
   d. inferential statistics
4. In general, ________ statistical techniques are used to summarize the data from a research study and ________ statistical techniques are used to determine what conclusions are justified by the results.
   a. inferential, descriptive
   b. descriptive, inferential
   c. sample, population
   d. population, sample