EDITION 2

AN INTRODUCTION TO

STATISTICS

An Active Learning Approach

Kieth A. Carlson | Jennifer R. Winquist

	z for a Sample Mean	*Single-Sample t*	*Related t*	*Independent t*	*Correlation*
Research Situation	Testing difference between a sample mean (e.g., M = 98) and a population mean; σ known (e.g., μ = 100, σ = 15)	Testing difference between a sample mean (e.g., M = 98) and a population mean; σ unknown (e.g., μ = 100, σ = ?)	Testing difference between two related sample means (e.g., pre vs. post)	Testing difference between two sample means collected from different groups (e.g., men vs. women)	Testing relationship between two interval/ ratio variables—Pearson; if either is ordinal—Spearman
1. Assumptions	-Appropriate measurement -Normality -Independence -Homogeneity of variance	-Appropriate measurement -Normality -Independence -Homogeneity of variance	-Appropriate measurement -Normality -Independence	-Appropriate measurement -Normality -Independence -Homogeneity of variance	For Pearson -Appropriate measurement -Normality -Independence -Homoscedasticity -Linear relationship
2. Hypotheses	Two-tailed H_0: $\mu = 100$; H_1: $\mu \neq 100$ One-tailed H_0: $\mu \leq 100$; H_1: $\mu > 100$ OR H_0: $\mu \geq 100$; H_1: $\mu < 100$	Two-tailed H_0: $\mu = 100$; H_1: $\mu \neq 100$ One-tailed H_0: $\mu \leq 100$; H_1: $\mu > 100$ OR H_0: $\mu \geq 100$; H_1: $\mu < 100$	Two-tailed H_0: $\mu_D = 0$; H_1: $\mu_D \neq 0$ One-tailed H_0: $\mu_D \leq 0$; H_1: $\mu_D > 0$ OR H_0: $\mu_D \geq 0$; H_1: $\mu_D < 0$	Two-tailed H_0: $\mu_1 = \mu_2$; H_1: $\mu_1 \neq \mu_2$ One-tailed H_0: $\mu_1 \leq \mu_2$; H_1: $\mu_1 > \mu_2$ OR H_0: $\mu_1 \geq \mu_2$; H_1: $\mu_1 < \mu_2$	Two-tailed H_0: $\rho = 0$; H_1: $\rho \neq 0$ One-tailed H_0: $\rho \leq 0$; H_1: $\rho > 0$ OR H_0: $\rho \geq 0$; H_1: $\rho < 0$
3. Critical region	If two-tailed, $\alpha = .05$, CV = 1.96 or −1.96 If one-tailed, $\alpha = .05$, CV = 1.65 or −1.65	$df = N - 1$	$df = N - 1$	$df = (n_1 - 1) + (n_2 - 1)$	$df = N - 2$
4. Test statistic	$SEM_p = \frac{\sigma}{\sqrt{N}}$ $z = \frac{M - \mu}{SEM_p}$	$SEM_S = \frac{SD}{\sqrt{N}}$ $t = \frac{M - \mu}{SEM_S}$	$SEM_r = \frac{SD_D}{\sqrt{N}}$ $t = \frac{M_D}{SEM_r}$	$SD_p^2 = \frac{(n_1 - 1)SD_1^2 + (n_2 - 1)SD_2^2}{(n_1 - 1) + (n_2 - 1)}$ $SEM_i = \sqrt{\frac{SD_p^2}{n_1} + \frac{SD_p^2}{n_2}}$ $t = \frac{(M_1 - M_2)}{SEM_i}$	$SS_{XY} = \Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N}$ $r = \frac{SS_{XY}}{\sqrt{(SS_X)(SS_Y)}}$

	z for a Sample Mean	*Single-Sample t*	*Related t*	*Independent t*	*Correlation*
5. Effect size	$d = \frac{M - \mu}{\sigma}$ .2, .5, .8	$d = \frac{M - \mu}{SD}$ .2, .5, .8	$d = \frac{M_D}{SD_D}$ .2, .5, .8	$d = \frac{M_1 - M_2}{\sqrt{SD_p^2}}$ .2, .5, .8	r^2 .01, .09, .25
6. Confidence intervals	CI for sample mean $M \pm (t_{CI})\left(\sigma/\sqrt{N}\right)$ CI for mean difference $(M - \mu) \pm (t_{CI})\left(\sigma/\sqrt{N}\right)$	CI for sample mean $M \pm (t_{CI})\left(SD/\sqrt{N}\right)$ CI for mean difference $(M - \mu) \pm (t_{CI})\left(SD/\sqrt{N}\right)$	CI for each mean $M_D \pm (t_{CI})\left(SD/\sqrt{N}\right)$. CI for mean difference $(M_1 - M_2) \pm (t_{CI})\left(SD_D/\sqrt{N}\right)$	CI for each mean $M \pm (t_{CI})\left(SD/\sqrt{N}\right)$ CI for mean difference $(M_1 - M_2) \pm (t_{CI})\left(\sqrt{SD_p^2}/\sqrt{N}\right)$	CI for Pearson $(z_r) \pm (z_{CI})\left(\frac{1}{\sqrt{N-3}}\right)$
7. Summarize	There was (or was not) a significant difference between the sample mean (*M*, *SD*) and the population mean (*μ*, σ), *z* (*N*) = __, *p* = __, *d* = __, 95% CI [LB, UB]. *If appropriate, indicate which mean was significantly higher and describe the effect size.*	There was (or was not) a significant difference between the sample mean (*M*, *SD*) and the population mean (*μ*), *t* (*df*) = __, *p* = __, *d* = __, 95% CI [*LB*, *UB*]. *If appropriate, indicate which mean was significantly higher and describe the effect size.*	There was (or was not) a significant difference between the pre-treatment sample mean (*M*, *SD*) and the post treatment sample mean (*M*, *SD*), *t* (*df*) = __, *p* = __, *d* = __, 95% CI [LB, UB]. *If appropriate, indicate which mean was significantly higher and describe the effect size.*	There was (or was not) a significant difference between the Sample 1 mean (*M*, *SD*) and the Sample 2 mean (*M*, *SD*), *t* (*df*) = __ , *p* = __, *d* = __, 95% CI [LB, UB]. *If appropriate, indicate which mean was significantly higher and describe the effect size.*	There was (or was not) a linear association between Variable 1 and Variable 2, *r* (*df*) = ___, *p* = ___, 95% CI [LB, UB].
8. SPSS instructions for significance test	Not available	-Analyze -Compare Means -One-Sample *t* Test -Move DV into the Test Variables box -Change Test Value to μ -Click OK	-Analyze -Compare Means -Paired-Samples T Test -Move both IV conditions into Paired Variables box -Click OK	-Analyze -Compare Means -Independent-Samples T Test -Move IV into Grouping Variable box -Click Define Groups -Enter values that designate each IV condition -Move DV into Test Variables box -Click OK	For scatterplot: -Graph, Legacy Dialogs, Scatter/Dot, -Simple scatter -Click Define -Place variables on x- and y-axes For test: -Analyze, Correlate, Bivariate -Move variables into Variables box -Select Pearson or Spearman. Click OK

An Introduction to Statistics

Second Edition

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AN ACTIVE LEARNING APPROACH

Second Edition

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Contents

Detailed Contents

14 Goodness of Fit and Independence Chi-Square Statistics 567

Appendices 597

Preface

THE STORY OF THIS TEXT

Several years ago, we attended a teaching workshop in which the speaker described a common experience in college classrooms and the pedagogical problems it frequently creates. Instructors carefully define basic concepts (e.g., population, sample) and gradually progress to applying those concepts to more complex topics (e.g., sampling error) as the end of class approaches. Then students attempt homework assignments covering the more complicated topics. All too frequently, students think they understand things while listening to us in class, but when they attempt homework on their own, they have difficulty. While some students can eventually figure things out, others become frustrated; still others give up. The teaching workshop made us recognize, reluctantly, this happened to us (and our students) in our statistics classes. While we did our best to address this problem by refining our lectures, our students still struggled with homework assignments, and we were disappointed with their exam performance. Students frequently said to us, "I understand it when you do it in class, but when I try it on my own it doesn't make sense." This common experience motivated us to change our stats classes and, eventually, to write the first edition of this text.

We decided that we needed to change our course so that

1. students came to class understanding basic concepts and
2. students had an opportunity to *use* challenging concepts in class when we were there to answer their questions immediately,
3. students started to interpret and report statistical results like researchers.

We started by emphasizing the importance of actually reading the text before class. Even though we were using excellent statistics texts, many students insisted that they needed lectures to help them understand the text. Eventually, we opted for creating our own readings that emphasize the basics (i.e., the "easy" stuff). We embedded relatively easy reading questions to help students *read with purpose* so they came to class understanding the basic concepts. Next, over several years, we developed activities that reinforced the basics as well as introduced more challenging material (i.e., the "hard stuff"). Hundreds of students completed these challenging activities in our courses. After each semester, we strove to improve every activity based on our students' feedback and exam performance.

Our statistics courses are dramatically different from what they were a decade ago. In our old classes, few students read prior to class, and most class time was spent lecturing on the material in the book. In our current stats courses, students answer online reading questions prior to class, we give very brief lectures at the beginning of class, and students complete activities (i.e., assignments) during class.

We've compared our current students' attitudes about statistics to those taking our more traditional statistics course (Carlson & Winquist, 2011) and found our current students to be more confident in their ability to perform statistics and to like statistics more than their peers. We've also learned that after completing this revised statistics course, students score nearly a half a standard deviation higher on a nationally standardized statistics test that they take during their senior year (approximately 20 months after taking the course) compared to students taking the more traditional course (Winquist & Carlson, 2014).

Of course, not all our students master the course material. Student motivation still plays an important part in student learning. If students don't do the reading or don't work on understanding the assignments in each chapter, they will still struggle. In our current courses, we try to create a class that encourages students to read and complete the assignments by giving points for completing them. We have found that, if students do these things, they do well in our courses. We have far fewer struggling students in our current courses than we had in our traditional course, even though our exams are more challenging.

WHAT IS NEW IN THE SECOND EDITION

If you used the first edition of the text, the first thing you might notice is that the second edition has 14 chapters rather than 16, but the text is actually longer. In the first edition, all hypothesis tests followed the same five steps and statistical assumptions were addressed in Chapter 16. In the second edition, we eliminated Chapter 16 and included assessing the statistical assumptions as the first step of a six-step hypothesis-testing process. While talking about the statistical assumptions within every chapter is less concise, this repetition helps students recognize that different statistical tests analyze different types of variables. In addition, in response to reviewers' comments, we also combined Chapters 6 and 7 from the first edition into a single chapter in the second edition. Finally, in the first edition, we introduced the basics in the chapter and then added more complex material in the activities. Although this simplified the readings for students, it also made the book harder for students to use as a reference. In this edition, we include the more complex material in the chapters but kept the reading questions relatively simple. This way, students are exposed to the material prior to working with the more complex ideas in the assignments. Reflecting the rising prominence of confidence intervals in contemporary research and the most recent APA publication manual, we greatly expanded our coverage of confidence intervals in the second edition. We added integrative assignments in the related *t*, independent *t*, one-way analysis of variance (ANOVA), and correlation chapters to reinforce the different information researchers obtain from significance tests, effect sizes, and confidence intervals. These assignments encourage students to do more than "crunch numbers" by asking them to think like researchers, integrating information from significance tests, effect sizes, and confidence intervals.

Other noteworthy changes to the second edition include the following:

- New assignments are included on the hand calculations of a one-way ANOVA, running one-way ANOVA in SPSS, the differences between one-way and two-way ANOVA, and Spearman correlation.

- Twelve of the 14 chapters have been rewritten using more interesting examples from psychological research.
- Assignments contain fewer open-ended questions so students can check their own answers more accurately.
- Added coverage of effect sizes for pairwise comparisons.
- Added practice tests at the end of each chapter.

HOW TO USE THIS BOOK

This text certainly could be used in a lecture-based course in which the activities function as detailed, conceptually rich homework assignments. We also are confident that there are creative instructors and students who will find ways to use this text that we never considered. However, it may be helpful to know how we use this text. In our courses, students read the chapters and answer online reading questions prior to class. We allow them to retake the reading questions to correct any errors prior to class for half of the points they missed. We begin classes with brief lectures (about 15 minutes), and then students work for the remaining 60 minutes to complete the assignments during class. There are a number of advantages to this approach. One advantage is that students do the easier work (i.e., answering foundational questions) outside of class and complete the more difficult work in class when peers and an instructor can answer their questions. Another advantage is that students work at their own paces. We have used this approach for several years with positive results (Carlson & Winquist, 2011; Winquist & Carlson, 2014).

This approach encourages students to review and correct misunderstandings on the reading questions as well as the assignments. Mistakes are inevitable and even desirable. After all, each mistake is an opportunity to learn. In our view, students should first engage with the material without concern about evaluation. Therefore, we provide the final answers to all assignments to our students. Students then focus on finding their answers, checking them, and then correcting mistakes. We collect their answers to confirm that they showed how they arrived at each answer. We give points for completion (and showing work). Over the years, these assignment points have constituted between 7% and 17% of students' course grades. A simpler option we tried is telling students that completing the activities is essential to success in the course and not confirm activity completion at all. When we did this, we found greater variability in activity completion and exam performance.

UNIQUE FEATURES OF THIS TEXT

By now you probably recognize that this is not a typical statistics text. For ease of review, we've listed and described the two most unique aspects of this text:

- *Embedded reading questions*—All 14 chapters contain embedded reading questions that focus students' attention on the key concepts *as they read* each paragraph/section of the text. Researchers studying reading comprehension report that similar embedded questions help students with lower reading abilities achieve levels of performance comparable to that of students with greater reading abilities (Callender & McDaniel, 2007).

- *Activity (Assignment) sections*—All 14 chapters contain active learning assignments, called *Activities*. While the 14 chapters start by introducing foundational concepts, they are followed by activity sections in which students *test or demonstrate their understanding of basic concepts while they read detailed explanations of more complex statistical concepts*. When using most traditional textbooks, students perform statistical procedures *after* reading multiple pages. This text adopts a workbook approach in which students are actively performing tasks *while* they read explanations. Most of the activities are self-correcting, so if students misunderstand a concept, it is corrected early in the learning process. After completing these activities, students are far more likely to understand the material than when they simply read the material.

OTHER HELPFUL FEATURES

- *Learning objectives*—Each chapter and activity begin with clear learning objectives.
- *Practice tests*—All 14 chapters conclude with a practice test for solidifying student learning.
- *IBM® SPSS® Statistics**—All chapters contain detailed step-by-step instructions for conducting statistical procedures with SPSS as well as annotated explanations of SPSS output.
- *Emphasis on understanding*—Chapters use definitional formulas to explain the logic behind each statistical procedure and rely on SPSS for more advanced computations (e.g., factorial ANOVAs).
- *Writing results in APA format*—Many activity questions highlight how to write about statistical analyses in scholarly ways.

ANCILLARIES

- *Instructors' manual*—Includes lecture outlines and detailed answers to activities.
- *Blackboard cartridges*—Includes reading questions, practice tests, self-test questions, and activity answers.
- *Empirically validated test bank questions*—Exam questions that we used in our classes are available to instructors of the course.
- *Self-examination questions*—Additional sample examination questions are available to students on the Sage Publications website.
- *Short PowerPoint slideshows for most Activities*.

APPROPRIATE COURSES

This text is ideal for introductory statistics courses in psychology, sociology, social work, and the health, exercise, or life sciences. The text would work well for any course intending to teach the statistical procedures of hypothesis testing, effect sizes, and confidence intervals that are commonly used in the behavioral sciences.

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About the Authors

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CHAPTER 1

Introduction to Statistics and Frequency Distributions

LEARNING OBJECTIVES

After reading this chapter, you should be able to do the following:

- Explain how you can be successful in this course
- Use common statistical terms correctly in a statistical context
    - Statistic, parameter, sample, population, descriptive statistics, inferential statistics, sampling error, and hypothesis testing
- Identify the scale of measurement of a variable (nominal, ordinal, or interval/ratio)
- Determine if a variable is discrete or continuous
- Create and interpret frequency distribution tables, bar graphs, histograms, and line graphs
- Explain when to use a bar graph, histogram, and line graph
- Enter data into SPSS and generate frequency distribution tables and graphs

HOW TO BE SUCCESSFUL IN THIS COURSE

Have you ever read a few pages of a textbook and realized you were not thinking about what you were reading? Your mind wandered to topics completely unrelated to the text, and you could not identify the point of the paragraph (or sentence) you just read. For most of us, this experience is not uncommon even when reading books that we've chosen to read for pleasure. Therefore, it is not surprising that our minds wander while reading textbooks. Although this lack of focus is understandable, it seriously hinders effective reading. Thus, one goal of this book is to discourage mind wandering and to encourage *reading with purpose*. To some extent, you need to force yourself to read with purpose. As you read each paragraph, ask, "What is the purpose of this paragraph?" or "What am I supposed to learn from this paragraph?"

Reading Question

1. Reading with purpose means
   a. thinking about other things while you are reading a textbook.
   b. actively trying to extract information from a text by focusing on the main point of each paragraph.

This text is structured to make it easier for you to read with purpose. The chapters have frequent reading questions embedded in the text that make it easier for you to remember key points from preceding paragraphs. Resist the temptation to go immediately to the reading questions and search for answers in the preceding paragraphs. *Read first, and then answer the questions as you come to them*. Using this approach will increase your memory for the material in this text.

Reading Question

2. Is it better to read the paragraph and then answer the reading question or to read the reading question and then search for the answer? It's better to
   a. read the paragraph, then answer the reading question.
   b. read the reading question, then search for the question's answer.

After reading the chapters, you should have a basic understanding of the material that will provide the foundation you need to work with the more complex material in the activities. When completing these activities, you will demonstrate your understanding of basic material from the reading (by answering questions) before you learn more advanced topics. Your emphasis when working on the activities should be on understanding why the answers are correct. If you generate a wrong answer, figure out your error. We often think of errors as things that should be avoided at all costs. However, quite the opposite is true. Making mistakes and fixing them is how you learn. Every error is an opportunity to learn. If you find your errors and correct them, you will probably not repeat the error. Resist the temptation to "get the right answer quickly." It is more important that you understand why every answer is correct.

Reading Question

3. Which of the following best describes the activities in this book?
   a. Activities introduce new material that was not included in the chapter reading.
   b. All of the new material is in the reading. The activities are simply meant to give you practice with the material in the reading.

Reading Question

4. When completing activities, your primary goal should be to get the correct answer quickly.
   a. True
   b. False

At the end of each chapter, there are is a "Practice Test." After you complete the assigned activities in a chapter (and you understand why every answer is correct), you should complete the practice test. Most students benefit from a few repetitions of each problem type. The additional practice helps consolidate what you have learned so you don't forget it during tests. Finally, use the activities and the practice tests to study. Then, *after* you understand all of the activities and all of the practice tests, assess your understanding by taking an additional self-test on the SAGE website. Try to duplicate a testing situation as much as possible. Just sit down with a calculator and have a go at it. If you can do the self-test, you should feel confident in your knowledge of the material. Taking practice tests days before your actual test will give you time to review material if you discover you did not understand something.

Testing yourself is also a good way to lessen the anxiety that can occur during testing. Again, additional practice test questions are available on the SAGE website.

Reading Question

5. How should you use the self-tests?
   a. Use them to study; complete them open-book so you can be sure to look up all the answers.
   b. Use them to test what you know days before the exam; try to duplicate the testing situation as much as possible.

MATH SKILLS REQUIRED IN THIS COURSE

Students often approach their first statistics course with some anxiety. The primary source of this anxiety seems to be a general math anxiety. The good news is that the math skills required in this course are fairly basic. You need to be able to add, subtract, multiply, divide, square numbers, and take the square root of numbers using a calculator. You also need to be able to do some basic algebra. For example, you should be able to solve the following equation for X: $22 = \frac{X}{3}$. [The correct answer is $X = 66$.]

Reading Question

6. This course requires basic algebra.
   a. True
   b. False

Reading Question

7. Solve the following equation for X: $30 = \frac{X}{3}$.
   a. 10
   b. 90

You will also need to follow the correct order of mathematical operations. As a review, the correct order of operations is (1) the operations in parentheses, (2) exponents, (3) multiplication or division, and (4) addition or subtraction. Some of you may have learned the mnemonic, *P*lease *E*xcuse *M*y *D*ear *A*unt *S*ally, to help remember the correct order. For example, when solving the following equation, $(3 + 4)^2$, you would first add (3 + 4) to get 7 and then square the 7 to get 49. Try to solve the next more complicated problem. The answer is 7.125. If you have trouble with this problem, talk with your instructor about how to review the necessary material for this course.

$$X = \frac{(6-1)3^2 + (4-1)2^2}{(6-1) + (4-1)}.$$

Reading Question

8. Solve the following equation for X: $X = \frac{(3-1)4^2 + (5-1)3^2}{(3-1) + (5-1)}$.
   a. 11.33
   b. 15.25

You will be using a calculator to perform computations in this course. You should be aware that order of operations is very important when using your calculator. Unless you are very comfortable with the parentheses buttons on your calculator, we recommend that you do one step at a time rather than trying to enter the entire equation into your calculator.

Reading Question

9. Order of operations is only important when doing computations by hand, not when using your calculator.
   a. True
   b. False

Although the math in this course should not be new, you may see new notation throughout the course. When you encounter new notation, relax and realize that the notation is simply a shorthand way of giving instructions. While you will be learning how to *interpret* numbers in new ways, the actual mathematical skills in this course are no more complex than the order of operations. The primary goal of this course is teaching you to use numbers to make decisions. Occasionally, we will give you numbers solely to practice computation, but most of the time you will use the numbers you compute to make decisions within a specific, real-world context.

WHY DO YOU HAVE TO TAKE STATISTICS?

You are probably reading this book because you are required to take a statistics course to complete your degree. Students majoring in business, economics, nursing, political science, premedicine, psychology, social work, and sociology are often required to take at least one statistics course. There are a lot of different reasons why statistics is a mandatory course for students in these varied disciplines. The primary reason is that in every one of these disciplines, people make decisions that have the potential to improve people's lives, and these decisions should be informed by data. For example, a psychologist may conduct a study to determine if a new treatment reduces the symptoms of depression. Based on this study, the researcher will need to decide if the treatment is effective or not. If the wrong decision is made, an opportunity to help people with depression may be missed. Even more troubling, a wrong decision might harm people. While statistical methods will not eliminate wrong decisions, understanding statistical methods will allow you to reduce the number of wrong decisions you make. You are taking this course because the professionals in your discipline recognize that statistical methods improve decision making and make us better at our professions.

Reading Question

10. Why do many disciplines require students to take a statistics course? Taking a statistics course
    a. is a way to employ statistics instructors, which is good for the economy.
    b. can help people make better decisions in their chosen professions.

STATISTICS AND THE HELPING PROFESSIONS

When suffering from a physical or mental illness, we expect health professionals (e.g., medical doctors, nurses, clinical psychologists, and counselors) to accurately diagnose us and then prescribe effective treatments. We expect them to ask us detailed questions and then to use our answers (i.e., the data) to formulate a diagnosis. Decades of research has consistently found that health professionals who use statistics to make their diagnoses are more accurate than those who rely on their personal experience or intuition (e.g., Grove & Meehl, 1996).

For example, lawyers frequently ask forensic psychologists to determine if someone is likely to be violent in the future. In this situation, forensic psychologists typically review the person's medical and criminal records as well as interview the person. Based on the records and the information gained during the interview, forensic psychologists make a final judgment about the person's potential for violence in the future. While making their professional judgment, forensic psychologists weigh the relative importance of the information in the records (i.e., the person's behavioral history) and the information obtained via the interview. This is an extremely difficult task. Fortunately, through the use of statistics, clinicians have developed methods that enable them to optimally gather and interpret data. One concrete example is the Violence Risk Appraisal Guide (Harris, Rice, & Quinsey, 1993). The guide is a list of questions that the psychologist answers after reviewing someone's behavioral history and conducting an interview. The answers to the guide questions are mathematically combined to yield a value that predicts the likelihood of future violence. Research indicates that clinicians who use statistical approaches such as the Violence Risk Appraisal Guide make more accurate clinical judgments than those who rely solely on their own judgment (Yang, Wong, & Coid, 2010). Today, statistical procedures help psychologists predict many things, including violent behavior, academic success, marital satisfaction, and work productivity. In addition to enabling us to make better predictions, statistical procedures also help professionals determine which medical or behavioral treatments are most effective.

Reading Question

11. Decades of research indicates that professionals in the helping professions make better decisions when they rely on
    a. statistics.
    b. their intuition and clinical experience.

HYPOTHESIS TESTING, EFFECT SIZE, AND CONFIDENCE INTERVALS

The statistical decisions you will make in this course revolve around specific hypotheses. A primary purpose of this book is to introduce the statistical process of **null hypothesis significance testing (NHST)**, *a formal multiple-step procedure for evaluating the likelihood of a prediction, called a null hypothesis*. Knowledge of null hypothesis significance testing, also called **significance testing** or **hypothesis testing,** is fundamental to those working in the behavioral sciences, medicine, and the counseling professions. In later chapters, you will learn a variety of statistics that test different hypotheses. All the hypothesis testing procedures that you will learn are needed because of one fundamental problem that plagues all researchers—namely, the problem of sampling error. For example, researchers evaluating a new depression treatment want to know if it effectively lowers depression in all people with depression, called the population of people with depression. However, researchers cannot possibly study every depressed person in the world. Instead, researchers have to study a subset of this population, perhaps a sample of 100 people with depression. *The purpose of any sample is to represent the population from which it came.* In other words, if the 100 people with depression are a good sample, they will be similar to the population of people with depression. Thus, if the average score on a clinical assessment of depression in the population is 50, the average score of a good sample will also be 50. Likewise, if the ratio of women with depression to men with depression is 2:1 in the population, it will also be 2:1 in a good sample. Of course, you do not really expect a sample to be exactly like the population. *The differences between a sample and the population create* **sampling error.**

Reading Question

12. All hypothesis testing procedures were created so that researchers could
    a. study entire populations rather than samples.
    b. deal with sampling error.

Reading Question

13. If a sample represents a population well, it will
    a. respond in a way that is similar to how the entire population would respond.
    b. generate a large amount of sampling error.

While null hypothesis significance testing is extremely useful, it has limitations. Therefore, another primary purpose of this book is to describe these limitations and how researchers address them by using two additional statistical procedures. **Effect sizes** *describe the magnitude of a study's results,* helping researchers determine if a research result is large enough to be useful or if it is too small to be meaningful in "real-world" situations. **Confidence intervals** *identify the wide range of plausible values that might occur if sample results are applied to the entire population.* Each of these statistical procedures helps researchers give meaning to the results of a significance test. In fact, the American Psychological Association (APA) publication manual recommends that researchers use effect sizes and confidence intervals whenever significance tests are used (American Psychological Association, 2010). These three statistical procedures are most beneficial when they are used side by side.

Reading Question

14. Effect sizes and confidence intervals help researchers
    a. interpret (i.e., give meaning to) the results of significance tests.
    b. address the limitations of significance tests.
    c. do both of the above.

TESTING CAUSAL HYPOTHESES

While this book's main goal is teaching how to use the statistical procedures of hypothesis testing, effect sizes, and confidence intervals, you should know that there is a lot more to *causal* hypothesis testing than the statistics covered in this text. In many research situations, scientists want to know if manipulating one variable (the independent variable, or IV) *causes* a change in a second variable (the dependent variable, or DV). Testing *causal* hypotheses is particularly difficult because it requires carefully designed experiments. In these experiments, researchers must (1) manipulate the IV, (2) measure the DV after IV manipulation, (3) control for extraneous variables, and (4) provide evidence of a "significant" relationship between the IV manipulation and the DV score. For example, if we wanted to test the causal hypothesis that cell phone use while driving causes poorer driving performance, we would need to manipulate the IV (i.e., cell phone use) by having people operate a driving simulator while talking on a cell phone and also while not using a cell phone. Then, we would need to measure the DV of driving performance (e.g., braking reaction time or number of times people swerve out of their lane) when using a cell versus not. In order for us to feel confident that using the cell phone caused poorer driving performance, we would need to know that the two groups of people were equally good drivers and driving in equally challenging driving conditions in terms of traffic density, weather, destination, and so on. In other words, we need to make sure the test is "fair" in that the only difference between the two groups of drivers is whether or not they were using a cell phone while they were driving. Finally, only after carefully manipulating the IV, measuring the DV, and controlling extraneous variables do we use statistics to determine if the driving performances of those using cell phones versus not are so different that it justifies concluding that cell phone use while driving *causes* poorer driving performance. While the statistics you will learn in this text are a necessary component of testing causal hypotheses, they are not all you need to know. Causal hypothesis testing also requires mastery of experimental design. In a research methods course, you will learn how to design "fair" experiments that enable you to use the statistical procedures taught in this text to test causal hypotheses.

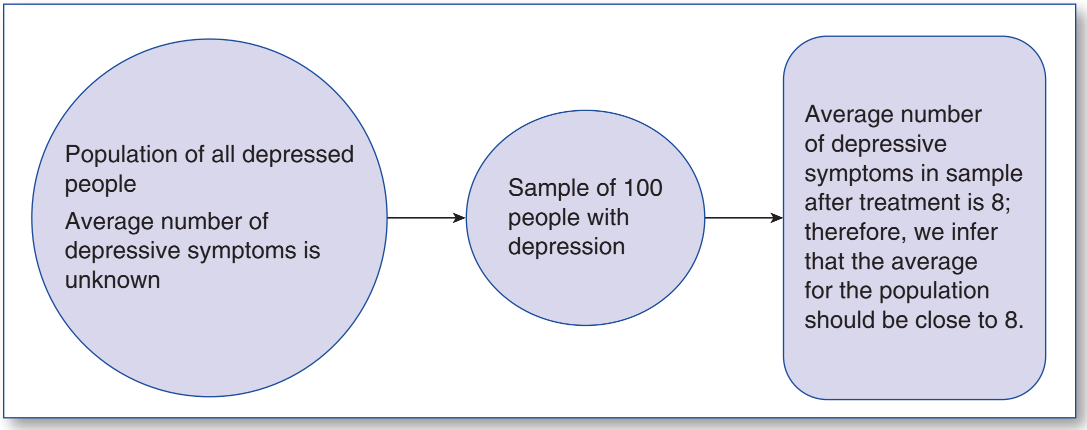
Reading Question

15. Testing casual hypotheses requires knowing how to
    a. use statistics.
    b. use research methods to design "fair" experiments.
    c. both of the above.

POPULATIONS AND SAMPLES

Suppose that a researcher studying depression gave a new treatment to a sample of 100 people with depression. Figure 1.1 is a pictorial representation of this research scenario. The large circle on the left represents a **population,** *a group of all things that share a set of characteristics*. In this case, the "things" are people, and the characteristic they all share is depression. Researchers want to know what the mean depression score for the population would be if all people with depression were treated with the new depression treatment. In other words, researchers want to know the **population parameter,** *the value that would be obtained if the entire population were actually studied*. Of course, the researchers don't have the resources to study every person with depression in the world, so they must instead study a **sample,** *a subset of the population that is intended to represent the population*. In most cases, the best way to get a sample that accurately represents the population is by taking a **random sample** from the population. When taking a **random sample,** *each individual in the population has the same chance of being selected for the sample*. In other words, while researchers want to know a population parameter, their investigations usually produce a **sample statistic,** *the value obtained from the sample*. The researchers then use the sample statistic value as an estimate of the population parameter value. The researchers are making an *inference* that the sample statistic is a value similar to the population parameter value based on the premise that the characteristics of those in the sample are similar to the characteristics of those in the entire population. *When researchers use a sample statistic to infer the value of a population parameter,* it is called **inferential statistics.** For example, a researcher studying depression wants to know how many depressive symptoms are exhibited by people in the general population. He can't survey everyone in the population, and so he selects a random sample of people

Figure 1.1 A Pictorial Representation of Using a Sample to Estimate a Population Parameter (i.e., Inferential Statistics)



from the population and finds that the average number of symptoms in the sample is 8 (see Figure 1.1). If he then inferred that the entire population of people would have an average of 8 depressive symptoms, he would be basing his conclusion on inferential statistics. It should be clear to you that if the sample did not represent the population well (i.e., if there was a lot of sampling error), the sample statistic would NOT be similar to the population parameter. In fact, **sampling error** is defined as *the difference between a sample statistic value and an actual population parameter value.*

Reading Question

16. The value obtained from a population is called a
    a. statistic.
    b. parameter.

Reading Question

17. Parameters are
    a. always exactly equal to sample statistics.
    b. often estimated or inferred from sample statistics.

Reading Question

18. When a statistic and parameter differ,
    a. it is called an inferential statistic.
    b. there is sampling error.

The researchers studying depression were using inferential statistics because they were using data from a sample to infer the value of a population parameter. The component of the process that makes it inferential is that researchers are using data they actually have to estimate (or infer) the value of data they don't actually have. In contrast, researchers use **descriptive statistics** *when their intent is to describe the data that they actually collected.* For example, if a clinical psychologist conducted a study in which she gave some of her clients a new depression treatment and she wanted to describe the average depression score of only those clients who got the treatment, she would be using descriptive statistics. Her intent is only to describe the results she observed in the clients who actually got the treatment. However, if she then wanted to estimate what the results would be if she were to give the same treatment to additional clients, she would then be performing inferential statistics.

Reading Question

19. Researchers are using descriptive statistics if they are using their results to
    a. estimate a population parameter.
    b. describe the data they actually collected.

Reading Question

20. Researchers are using inferential statistics if they are using their results to
    a. estimate a population parameter.
    b. describe the data they actually collected.

INDEPENDENT AND DEPENDENT VARIABLES

Researchers design experiments to test if one or more variables cause changes to another variable. For example, if a researcher thinks a new treatment reduces depressive symptoms, he could design an experiment to test this prediction. He might give a sample of people with depression the new treatment and withhold the treatment from another sample of people with depression. Later, if those who received the new treatment had lower levels of depression, he would have evidence that the new treatment reduces depression. In this experiment, the type of treatment each person received (i.e., new treatment vs. no treatment) is the **independent variable (IV)**. In this study, the experimenter manipulated the IV by giving one sample of people with depression the new treatment and another sample of people with depression a placebo treatment that is not expected to reduce depression. In this experiment, the IV has two **IV levels:** (1) the new treatment and (2) the placebo treatment. The main point of the study is to determine if the two different IV levels were differentially effective at reducing depressive symptoms. More generally, *the IV is a variable with two or more levels that are expected to have different impacts on another variable.* In this study, after both samples of people with depression were given their respective treatment levels, the amount of depression in each sample was compared by counting the number of depressive symptoms in each person. In this experiment, the number of depressive symptoms observed in each person is the **dependent variable (DV)**. Given that the researcher expects the new treatment to work and the placebo treatment not to work, he expects the new treatment DV scores to be lower than the placebo treatment DV scores. More generally, *the DV is the outcome variable that is used to compare the effects of the different IV levels.*

Reading Question

21. The IV (independent variable) in a study is the
    a. variable expected to change the outcome variable.
    b. outcome variable.

Reading Question

22. The DV (dependent variable) in a study is the
    a. variable expected to change the outcome variable.
    b. outcome variable.

In true experiments, those in which researchers manipulate a variable so that some participants have one value and others have a different value, the manipulated variable is always referred to as the IV. For example, if a researcher gives some participants a drug (Treatment A) and others a placebo (Treatment B), this manipulation defines the IV of treatment as having two levels—namely, drug and placebo. However, in this text, we also use the IV in a more general way. The IV is any variable predicted to influence another variable even when the IV was not manipulated. For example, if a researcher predicted that women would be more depressed than men, we will refer to gender as the IV because it is the variable that is expected to influence the DV (i.e., depression score). If you take a research methods course, you will learn an important distinction between manipulated IVs (e.g., type of treatment: drug vs. placebo) and *measured* IVs (e.g., gender: male vs. female). Very briefly, the ultimate goal of science is to discover causal relationships, and manipulated IVs allow researchers to draw causal conclusions while measured IVs do not. You can learn more about this important distinction and its implications for drawing causal conclusions in a research methods course.

Reading Question

23. All studies allow you to determine if the IV causes changes in the DV.
    a. True
    b. False

SCALES OF MEASUREMENT

All research is based on measurement. For example, if researchers are studying depression, they will need to devise a way to measure depression accurately and reliably. The way a variable is measured has a direct impact on the types of statistical procedures that can be used to analyze that variable. Generally speaking, researchers want to devise measurement procedures that are as precise as possible