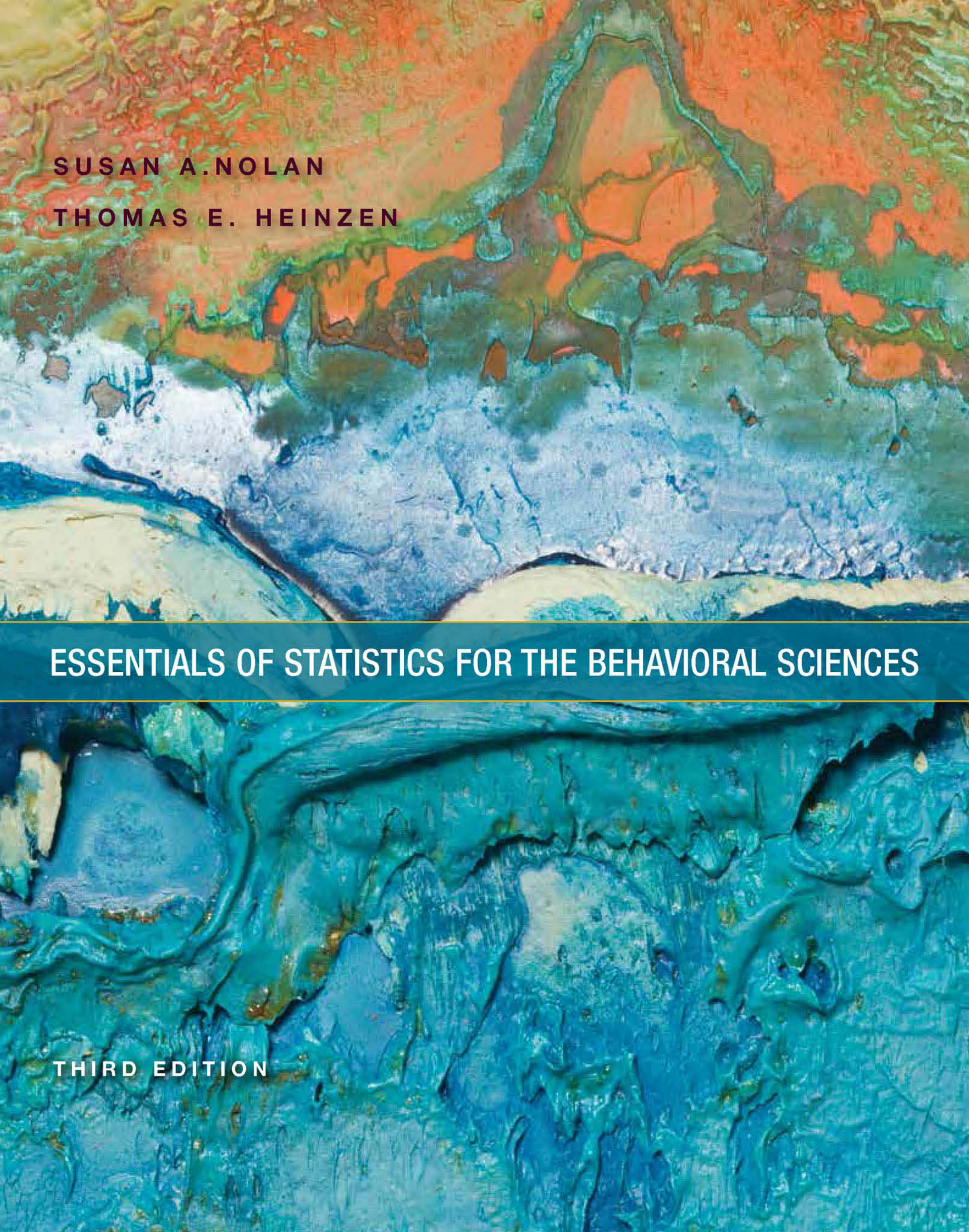

SUSAN A. NOLAN

THOMAS E. HEINZEN

ESSENTIALS OF STATISTICS FOR THE BEHAVIORAL SCIENCES

THIRD EDITION

FORMULAS

CHAPTER 4

Mean of a Sample

$$M = \frac{\Sigma X}{N}$$

Range

$$\text{range} = X_{highest} - X_{lowest}$$

Variance

$$SD^2 = \frac{\Sigma(X - M)^2}{N}$$

Standard Deviation

$$SD = \sqrt{SD^2}$$

Standard Deviation (when we don't already have variance)

$$SD = \sqrt{\frac{\Sigma(X - M)^2}{N}}$$

CHAPTER 6

z Score

$$z = \frac{(X - \mu)}{\sigma}$$

Raw Score from a z Score

$$X = z(\sigma) + \mu$$

Standard Error

$$\sigma_M = \frac{\sigma}{\sqrt{N}}$$

z Statistic for a Distribution of Means

$$z = \frac{(M - \mu_M)}{\sigma_M}$$

CHAPTER 8

Confidence Interval for a z Test

$$M_{lower} = -z(\sigma_M) + M_{sample}$$

$$M_{upper} = z(\sigma_M) + M_{sample}$$

Effect Size for a z Test

$$\text{Cohen's } d = \frac{(M - \mu)}{\sigma}$$

CHAPTER 9

Standard Deviation of a Sample

$$s = \sqrt{\frac{\Sigma(X - M)^2}{(N - 1)}}$$

Standard Error of a Sample

$$s_M = \frac{s}{\sqrt{N}}$$

t Statistic for a Single-Sample t Test

$$t = \frac{(M - \mu_M)}{s_M}$$

Degrees of Freedom for a Single-Sample t Test or a Paired-Samples t Test

$$df = N - 1$$

Confidence Interval for a Single-Sample t test

$$M_{lower} = -t(s_M) + M_{sample}$$

$$M_{upper} = t(s_M) + M_{sample}$$

Effect Size for a Single-Sample t Test or a Paired-Samples t Test

$$\text{Cohen's } d = \frac{(M - \mu)}{s}$$

CHAPTER 10

Degrees of Freedom for an Independent-Samples *t* Test

$$df_{total} = df_X + df_Y$$

Pooled Variance

$$s^2_{pooled} = \left(\frac{df_X}{df_{total}}\right) s^2_X + \left(\frac{df_Y}{df_{total}}\right) s^2_Y$$

Variance for a Distribution of Means for an Independent-Samples *t* Test

$$s^2_{M_X} = \frac{s^2_{pooled}}{N_X} \qquad s^2_{M_Y} = \frac{s^2_{pooled}}{N_Y}$$

Variance for a Distribution of Differences Between Means

$$s^2_{difference} = s^2_{M_X} + s^2_{M_Y}$$

Standard Deviation of the Distribution of Differences Between Means

$$s_{difference} = \sqrt{s^2_{difference}}$$

t Statistic for an Independent-Samples *t* Test

$$t = \frac{(M_X - M_Y) - (\mu_X - \mu_Y)}{s_{difference}}$$

often abbreviated as:

$$t = \frac{(M_X - M_Y)}{s_{difference}}$$

Confidence Interval for an Independent-Samples *t* Test

$$(M_X - M_Y)_{lower} = -t\,(s_{difference}) + (M_X - M_Y)_{sample}$$

$$(M_X - M_Y)_{upper} = t\,(s_{difference}) + (M_X - M_Y)_{sample}$$

Pooled Standard Deviation

$$s_{pooled} = \sqrt{s^2_{pooled}}$$

Effect Size for an Independent-Samples *t* Test

$$\text{Cohen's } d = \frac{(M_X - M_Y) - (\mu_X - \mu_Y)}{s_{pooled}}$$

CHAPTER 11

One-Way Between-Groups ANOVA

$$df_{between} = N_{groups} - 1$$

$$df_{within} = df_1 + df_2 + \ldots + df_{last}$$

(in which df_1 etc. are the degrees of freedom, $N - 1$, for each sample)

$$df_{total} = df_{between} + df_{within}$$

or $df_{total} = N_{total} - 1$

$$GM = \frac{\Sigma(X)}{N_{total}}$$

$SS_{total} = \Sigma(X - GM)^2$ for each score

$SS_{within} = \Sigma(X - M)^2$ for each score

$SS_{between} = \Sigma(M - GM)^2$ for each score

$$SS_{total} = SS_{within} + SS_{between}$$

$$MS_{between} = \frac{SS_{between}}{df_{between}}$$

$$MS_{within} = \frac{SS_{within}}{df_{within}}$$

$$F = \frac{MS_{between}}{MS_{within}}$$

Effect Size for a One-Way Between-Groups ANOVA

$$R^2 = \frac{SS_{between}}{SS_{total}}$$

Chapter 11 formulas continued on inside back cover

Leslie Wayne

Essentials of Statistics for the Behavioral Sciences

third edition

Susan A. Nolan | **Thomas E. Heinzen**

Seton Hall University

William Paterson University

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For my mother-in-law, Olga Stojadinović Bojanić

—Susan Nolan

To the person who had the best idea that anyone ever had: Charles Darwin

—Tom Heinzen

ABOUT THE AUTHORS

Ivan Bojanic

SUSAN NOLAN turned to psychology after suffering a career-ending accident on her second workday as a bicycle messenger. A native of Boston, she graduated from the College of Holy Cross and earned her PhD in clinical psychology from Northwestern University. Her research involves experimental investigations of the role of gender in the interpersonal consequences of depression, and studies on gender and mentoring in the fields of science, technology, engineering, and mathematics; her research has been funded by the National Science Foundation. Susan is a professor of psychology at Seton Hall University in New Jersey. She served as a representative from the American Psychological Association (APA) to the United Nations in New York City for 5 years, and is the vice president for Diversity and International Relations of the Society for the Teaching of Psychology (STP). She also was the chair of the 2012 Society for the Teaching of Psychology (STP) Presidential Task Force on Statistical Literacy. Susan is past president of the Eastern Psychological Association (EPA) and a 2015–2016 U.S. Fulbright scholar. She is a fellow of the EPA, the APA, and the Association for Psychological Science.

Susan's academic schedule allows her to pursue one travel adventure per year, a tradition that she relishes. Over the years she has ridden her bicycle across the United States (despite her earlier crash), swapped apartments to live in Montréal (her favorite North American city), and explored the Adriatic coast in an intermittently roadworthy 1985 Volkswagen Scirocco. She writes much of the book on her annual trip to Bosnia and Herzegovina, where she and her husband, Ivan Bojanic, own a small house on the Vrbas River in the city of Banja Luka. They currently reside in Jersey City, New Jersey, where Susan roots feverishly, if quietly, for the Boston Red Sox.

TOM HEINZEN was a 29-year-old college freshman; he began graduate school 8 days after the birth of his fourth daughter, and is still amazed that he and his wife somehow managed to stay married. A magna cum laude graduate of Rockford College, he earned his PhD in social psychology at the State University of New York at Albany in just 3 years.

Caroline Dawney

He published his first book on frustration and creativity in government 2 years later; was a research associate in public policy until he was fired for arguing over the shape of a graph; consulted for the Johns Hopkins Center for Talented Youth; and then began a teaching career at William Paterson University of New Jersey. He founded the psychology club, established an undergraduate research conference, and has been awarded various teaching honors while continuing to write journal articles, books, plays, and two novels that support the teaching of general psychology and statistics. He is also the editor of *Many Things to Tell You*, a volume of poetry by elderly writers.

He has recently become enamored with the potential of game-based designs to influence students at risk for not completing their degrees. He belongs to numerous professional societies, including the APA, the EPA, the APS, and the New York Academy of Science, whose meeting place next to the former Twin Towers offers such a spectacular view of New York City that they have to cover the windows so the speakers don't lose their focus during their talks.

His wife, Donna, is a physician assistant who has volunteered her time in relief work following hurricanes Mitch and Katrina; and their daughters work in public health, teaching, and medicine. Tom is an enthusiastic but mediocre tennis player and, as a Yankees, Cubs, and emerging Pittsburgh Pirates fan, sympathizes with Susan's tortured New England loyalties.

BRIEF CONTENTS

CONTENTS

PREFACE

Statistics is hot. According to an article in the *New York Times*, statistics is perhaps the most promising, adventurous career option you can choose right now—and the field is likely to expand significantly in the future, thanks to the large amounts of information (called *big data*) available to us in this digital age. Gone is the stereotype of boring (but influential) statistics geeks hiding behind their glowing screens. The new reality requires smart, reflective people who have been trained to explore big data, transforming them into something useful, while not losing sight of the people behind the numbers. This book trains you to find and create data, ask tough questions about a data set, interpret the feedback coming from data analysis, and display data in ways that reveal a precise, coherent, data-driven story. Statistical reasoning is not *at* the cutting edge of information; statistical reasoning *is* the cutting edge of information.

If you dare to embrace what your professor is teaching you, it will bring you to the brink of personal and social change. You will have to make many decisions about *how* you think—and that covers, well, your entire life. There are probably some natural boundaries to the benefits of statistical reasoning, such as the power of intuition. But every time we think we have bumped into a boundary, somebody busts through it, wins a Nobel Prize, and challenges the rest of us to become more creative as we learn how to live together on this beautiful planet.

We dare you to love this course.

Principles for Teaching Statistics

In their classic and persuasive article, Marsha Lovett and Joel Greenhouse (2000) present principles to teach statistics more effectively (all based on empirical research from cognitive psychology). And other researchers continue to build on their helpful work (see Benassi, Overson, & Hakala, 2014). We look to this body of research as we create every edition of this statistics text, from designing the pedagogy to deciding what specific examples to include. Six principles emerge from this research on teaching statistics and drive our text:

1. **Practice and participation.** Recent research has shown that active learning, broadly defined, increases student performance and reduces the failure rate in science courses, including psychology courses (Freeman et al., 2013). This principle pertains to work outside the classroom as well (Lovett & Greenhouse, 2000). Based on these findings, we encourage students to actively participate in their learning throughout the text. Students can practice their knowledge through the many applied exercises, especially in the Applying the Concepts and Putting It All Together sections. In these sections, the source of the original data is often supplied, whether it is data from the Centers for Disease Control or a Marist poll, encouraging students to dig deeper. And students can take advantage of data sets from the General Social Survey and EESEE Case Studies to "play" with statistics beyond the exercises in the book.
2. **Vivid examples.** Researchers have found that students are most likely to remember concepts illustrated with a vivid instructional tool (VanderStoep, Fagerlin, & Feenstra, 2000). So, whenever possible, we use striking, vivid examples to make statistical concepts memorable, including the weights of cockroaches to explain

standardization, destructive hurricanes in the discussion of confounding variables, entertainment by a clown during in vitro fertilization to teach chi square, a Damien Hirst dot painting to explain randomness, and a house purchase by Beyoncé to highlight celebrity outliers. Vivid examples are often accompanied by photos to enhance their memorability. When such examples are drawn from outside the academic literature, we follow with engaging research examples from the behavioral sciences to increase the memorability of important concepts.

3. **Integrating new knowledge with previous knowledge.** When connecting new material to existing student knowledge, students can more easily embed that new material into "a framework that will enable them to learn, retrieve, and use new knowledge when they need it" (p. 7, Ambrose & Lovett, 2014). Throughout the text, we illustrate new concepts with examples that connect to things most students already know. Chapter 1 includes an exercise that uses students' knowledge of contemporary music, specifically the percentage of rhyming words in rap lyrics, to teach students how to operationalize variables. In Chapter 2, an example from *Britain's Got Talent* uses students' understanding of the ranking systems on reality shows to explain ordinal variables. In Chapter 5, we use students' understanding of the potential fallibility of pregnancy tests to teach the difference between Type I and Type II errors. And in Chapter 14, we use the predictive abilities of Facebook profiles to teach regression. Learning in different contexts helps students to transfer knowledge to new situations, so we use multiple examples for each concept – typically an initial one that is easier to grasp followed by more traditional behavioral science research examples.
4. **Confronting misconceptions.** Conversely, some kinds of prior knowledge can slow students down (Lovett & Greenhouse, 2000). Students know many statistical words – from independent to variability to significant. But they know the "everyday" definitions of these words, and this prior knowledge can impede their learning of the statistical definitions. Throughout the book, we point out students' likely prior understanding of these key terms, and contrast that with the newer statistical definitions. We also include exercises aimed at having students explain the various ways a given word can be understood. Plus, in Chapter 5, we introduce ways in which other types of misconceptions can emerge through illusory correlation, confirmation bias, and coincidence. Throughout the rest of the book, we highlight these types of flawed thinking with examples, and show how statistics can be the antidote to these kinds of misconceptions – whether it's a belief that holiday weight gain is a serious problem, cheating is associated with better grades, or online personality quizzes are always accurate.
5. **Real-time feedback.** It's not uncommon – in fact, it's actually expected – for students to make mistakes when they first try their hand at a new statistical technique. Research demonstrates that one of the best ways to get past these errors is to provide students with immediate feedback (Kornell & Metcalfe, 2014). For this reason, we include solutions at the back of the book for all Check Your Learning exercises that fall after each section of a chapter and for the odd-numbered exercises at the end of each chapter. Importantly, we don't just provide final answers. We offer fully worked-out solutions that show students all of the steps and calculations to arrive at the final answers. That way, students can figure out exactly where they went astray. Learning is simply more efficient when students

can immediately correct their mistakes or receive validation that they answered correctly. This learning is also bolstered by other types of feedback embedded in the book that students can use as models. These include worked-out examples in the chapters and additional "How It Works" worked-out examples at the end of each chapter. As Lovett and Greenhouse (2000) explain "seeing worked examples before solving new problems makes the subsequent problem solving an easier task" (p. 201).

6. **Repetition.** There is a growing literature on the role of "desirable difficulty" in learning – that is, students learn better when they struggle with new material with support (Clark & Bjork, 2014). The three techniques of spacing, interleaving, and testing – all based on the central idea of repetition – help to create the right level of difficulty to help students learn more efficiently.

   - *Spacing* involves repeated practice sessions with the same material with delays in between. Our book is set up to encourage spacing. For example, the Before You Go On sections at the beginning of each chapter offer students a chance to review previous material. Several sets of Check Your Learning questions are included across each chapter, and more exercises are included at the end of each chapter.
   - *Interleaving* refers to the practice of mixing the types of exercises the student is practicing. Rather than practicing each new task in one block of exercises, students mix exercises on a new topic with repeats of exercises on earlier topics. This repetition of practice with earlier concepts increases retention of material. We build in exercises that encourage interleaving in the Putting It All Together sections, which ask students to return to concepts learned in earlier chapters.
   - *Testing* is possibly the best way to learn new material. Simply studying does not introduce the desirable difficulty that enhances learning, but testing forces errors and drives efficient retention of new material. The tiered exercises throughout the chapter and at the end of the chapter provide numerous opportunities for testing – and then more testing. We encourage students to aim for repeated practice, completing more exercises than assigned, rather than by studying in more traditional, but less effective, ways.

Trends in Statistics: What's Coming Next?

Statistics and statistical reasoning are in the midst of profound changes. Here are two important trends:

Trend 1: Visual Displays of Data. On the one hand, Chapter 3 of this text reminds us that there is nothing very new about creating visual displays of data. On the other hand, the entire field has gone topsy-turvy with graphic artists, newspaper editors, journalists, and anyone with an imagination and a computer jumping into the action. Data graphics are the hot new way to search for patterns, tell data-driven stories, and gain new insights from the enormous volumes of information available to us. This trend isn't coming; it's here. And the field needs a lot of guidance, without suppressing all that energy and creativity. In short, the field needs smart, hard-working, creative, and visually oriented behavioral scientists.

Trend 2: Free Software. Although earning a college degree is pretty expensive, the Internet has created opportunities for particular forms of education to progressively become less expensive. Massive open online courses (MOOCs) are just one of the more obvious efforts. One of your coauthors, Tom, took one MOOC with 80,000 other classmates. Kahn Academy online tutorials are another excellent, low-cost (though it costs you time) way to become better educated. A third opportunity is through the free statistical programs that are increasingly available online. We introduce one in this book: G*Power is free software that helps researchers determine statistical power and the appropriate sample size. Another is a statistical program simply called *R*. This is a free, sophisticated, open-source statistical software package; you can download it right now from the R Foundation. R will always be in development because its users are always improving it. As of this writing, R is still not that easy to use but people keep improving it. The future of statistics will probably have free, open-source software that is fairly easy to use.

What's New in the Third Edition

In this new edition of *Essentials of Statistics for the Behavioral Sciences*, we connect students to statistical concepts as efficiently and memorably as possible. We've sharpened the focus of the book on the core concepts and introduce each topic with a vivid, real-world example. Our pedagogy first emphasizes mastering concepts, and then gives students multiple step-by-step examples of the process of each statistical method, including the mathematical calculations. The extensive Check Your Learning exercises at the end of each section of the chapter, along with the end-of-chapter exercises and the new LaunchPad Web site, give students lots of opportunities to practice. Indeed, there are close to twice as many exercises in the third edition as in the first. We've also clarified our approach by fine-tuning the following features throughout the book.

Before You Go On

Each chapter opens with a Before You Go On section that highlights the concepts students need to have mastered before they move on to the next chapter.

BEFORE YOU GO ON

- You should understand the difference between a sample and a population (Chapter 1).
- You should know how to measure central tendency, especially the mean (Chapter 4).

Mastering the Formulas and Mastering the Concepts

Some of the most difficult tasks for students new to statistics are identifying the key points and connecting this new knowledge to what they have covered in previous chapters. The unique Mastering the Formula and Mastering the Concept marginal notes provide students with helpful explanations that identify each formula when it is first introduced and each important concept at its point of relevance. Figure E-1 ("Choosing the Appropriate Hypothesis Test") in Appendix E is a terrific summary that shows students how to apply statistical techniques to their research. It's the entire text summarized on a single page; students will learn it quickly and use it for the rest of their careers in statistics.

MASTERING THE FORMULA ▶

6-2: The formula to calculate the raw score from a *z* score is

$$X = z(\sigma) + \mu.$$

We multiply the *z* score by the population standard deviation, then add the population mean.

MASTERING THE CONCEPT ▶

3-1: Graphs can be misleading. As critical thinkers, we want to know whether a sample represents a population, how the variables were actually measured, and whether a graph tells an accurate data story.

Illustrative, Step-by-Step Examples

The text is filled with real-world examples from a wide variety of sources in the behavioral sciences. We outline statistical techniques in a step-by-step fashion, guiding students through each concept by applying the material creatively and effectively.

EXAMPLE 4.4

Here is an example with an even number of scores. We now include all 16 countries from the World Cup data in Example 4.1, including the score of 2 that we omitted in Example 4.3.

STEP 1: Arrange the scores in ascending order.

The data are now:

1 1 1 1 2 2 2 2 2 2 2 3 3 4 6 8 10

STEP 2: Find the middle score.

First, we count the scores. There are 16. We then divide the number of scores by 2: $16/2 = 8$. If we add 0.5 to this result, we get 8.5; therefore, the median is the average of the 8th and 9th scores. The 8th and 9th scores are 2 and 2. The median is their mean—the mean of 2 and 2 is 2. ■

SPSS®

For instructors who integrate SPSS into their course, each chapter includes outlined instructions and screenshots of SPSS output to help students master the program using data from the text.

SPSS®

SPSS is divided into two main screens. The easiest way to move back and forth between these two screens is by using the two tabs located at the lower left labeled "Variable View" and "Data View."

To name the variables, go to "Variable View" and select:

Name. Type in a short version of the variable name—for example, BDI for the Beck Depression Inventory, a common measure of depressive symptoms.

Type. For nominal variables, such as gender, change the type to "String" by clicking the cell in the column labeled "Type" or by clicking the little gray box, choosing "String," and clicking "OK."

To tell SPSS what the variable name means, select:

Label. Type in the full name of the variable, such as Beck Depression Inventory.

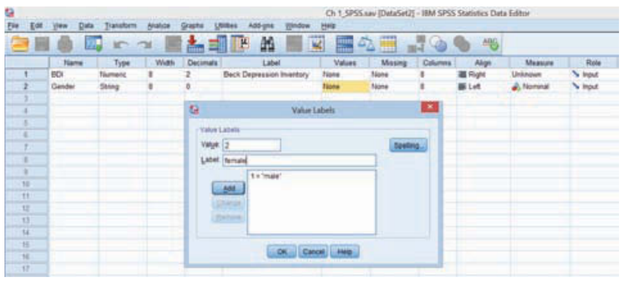
To tell SPSS what the numbers assigned to any nominal variable actually mean, select:

Values. In the column labeled "Values," click on the cell next to the appropriate variable, then click on the little gray box on the right of that cell to access the tool that allows you to identify the values (or levels) of the variables. For example, if the nominal variable "gender" is part of the study, tell SPSS that 1 equals male and 2 equals female. The numbers are the values and the words are the labels. See the accompanying screenshot to see what this looks like.

Now tell SPSS what kind of variables these are by selecting:

Measure. Highlight the type of variable by clicking on the cell in the column labeled "Measure" next to each variable, then clicking on the arrow to access the tool that allows you to identify whether the variable is scale, ordinal, or nominal. This is not necessary for nominal variables if the type is already listed as "String."

After describing all of the variables in the study in "Variable View," switch over to "Data View." The information you entered was automatically transferred to that screen, but now the variables are displayed across the tops of the columns instead of along the left-hand side of the rows. You can now enter the data in "Data View" under the appropriate heading; each participant's data are entered across one row.



Source: SPSS

How It Works—Chapter-Specific Worked-Out Exercises

Many students have anxiety as they approach end-of-chapter exercises. To ease that anxiety, the How It Works section provides students with step-by-step worked-out exercises representative of those they will see at the end of the chapter. This section appears just before the end-of-chapter exercises and acts as a model for the more challenging Applying the Concepts and Putting It All Together questions.

How It Works

9.1 CONDUCTING A SINGLE-SAMPLE *t* TEST

In How It Works 7.2, we conducted a z test for data from the Consideration of Future Consequences (CFC) scale (Adams, 2012). How can we conduct all six steps of hypothesis testing for a single-sample t test for the same data using a p level of 0.05 and a two-tailed test? To start, we use the population mean CFC score of 3.20, but pretend that we no longer know the population standard deviation. As before, we wonder whether behavioral sciences students who joined a career discussion group might have improved CFC scores, on average, compared with the population. Forty-five students attended these discussion groups, and had a mean CFC score of 3.45 with a standard deviation of 0.52.

Step 1: Population 1: All students in career discussion groups. Population 2: All students who did not participate in career discussion groups.

The comparison distribution will be a distribution of means. The hypothesis test will be a single-sample t test because we have only one sample and we know the population mean, but we do not know the population standard deviation. This study meets two of the three assumptions and may meet the third. The dependent variable is scale. In addition, there are more than 30 participants in the sample, indicating that the comparison distribution will be normal. The data were not randomly selected, however, so we must be cautious when generalizing.

Building Better Graphs Using Excel

A new appendix guides students through the basics of creating a clear, readable graph with Excel. Using an example from the text, students are guided through the steps of creating a graph and then changing Excel's default choices to meet the criteria for an excellent graph.

Game Design and Practice

Like a computer game that uses repetition and small changes to lift its players to higher levels of achievement, *Essentials of Statistics for the Behavioral Sciences* has increasingly difficult challenges, beginning with confidence-building Check Your Learning sections within each chapter. Many of the more than 1000 exercises in the text are based on real data, so professors and students can choose from among the most engaging exercises. Students can develop the ability to read, understand, and report statistics used in scientific journals by selecting from four tiers of exercises:

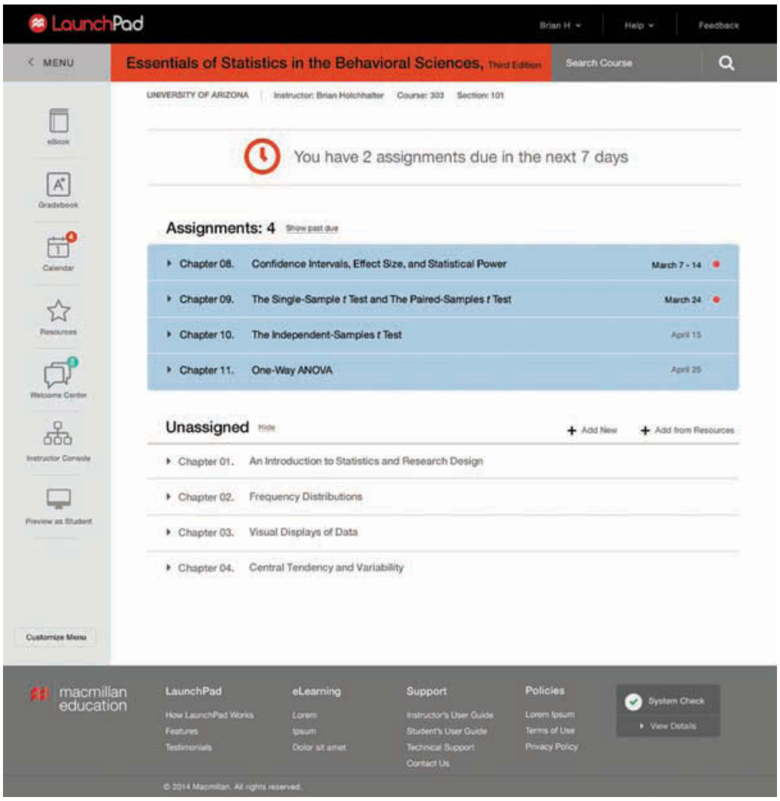
- **Clarifying the Concepts** questions help students to master the general concepts, the statistical terminology, and the conceptual assumptions of each topic.
- **Calculating the Statistics** exercises provide students a way to practice making the basic calculations for each formula and statistic.
- **Applying the Concepts** exercises apply statistical questions to real-world situations across the behavioral sciences and require students to bridge their knowledge of concepts and calculations.
- **Putting It All Together** exercises ask students both to apply the concepts from the chapter to a real-world situation and to connect the chapter's concepts to ideas from previous chapters.

Media and Supplements

LaunchPad with LearningCurve Quizzing

A comprehensive Web resource for teaching and learning statistics

LaunchPad combines Worth Publishers' award-winning media with an innovative platform for easy navigation. For students, it is the ultimate online study guide, with rich interactive tutorials, videos, an e-Book, and the LearningCurve adaptive quizzing system. For instructors, LaunchPad is a full course space where class documents can be posted, quizzes can be easily assigned and graded, and students' progress can be assessed and recorded. Whether you are looking for the most effective study tools or a robust platform for an online course, LaunchPad is a powerful way to enhance your class.

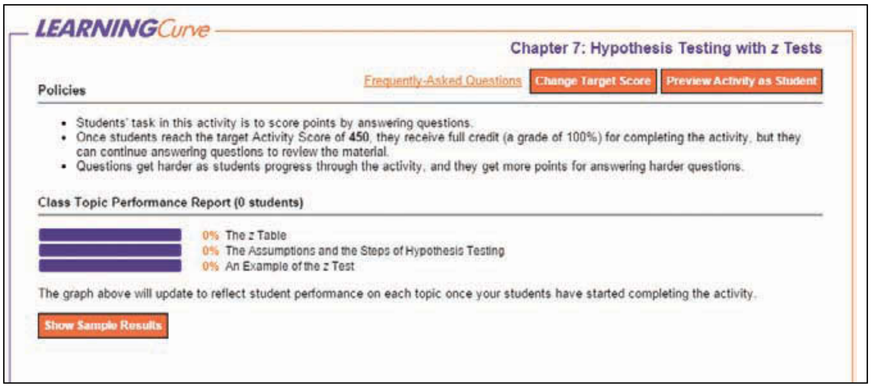


LaunchPad to Accompany *Essentials of Statistics for the Behavioral Sciences*, Third Edition, can be previewed and purchased at **launchpadworks.com**.

Essentials of Statistics for the Behavioral Sciences, Third Edition, and LaunchPad can be ordered together (ISBN-10: 1-319-05345-9/ISBN-13: 978-1-319-05345-1).

LaunchPad for *Essentials of Statistics for the Behavioral Sciences*, Third Edition, includes all the following resources:

- The **LearningCurve** quizzing system was designed using the latest findings from learning and memory research. It combines adaptive question selection, immediate and valuable feedback, and a gamelike interface to engage students in a learning experience that is unique to them. Each LearningCurve quiz is fully integrated with other resources in LaunchPad through the Personalized Study Plan, so students can review Worth's library of videos and activities. State-of-the-art question analysis reports allow instructors to track the progress of individual students as well as their class as a whole.



- An **interactive e-Book** allows students to highlight, bookmark, and make their own notes, just as they would with a printed textbook. Students can use Google-style searching and take advantage of in-text glossary definitions.

- The **Statistical Video Series** consists of StatClips, StatClips Examples, and Statistically Speaking "Snapshots." The videos can be used to view animated lecture videos, whiteboard lessons, and documentary-style footage that illustrate key statistical concepts and help students visualize statistics in real-world scenarios.

  StatClips lecture videos, created and presented by Alan Dabney, PhD, Texas A&M University, are innovative visual tutorials that illustrate key statistical concepts. In 3 to 5 minutes, each StatClips video combines dynamic animation, data sets, and interesting scenarios to help students understand the concepts in an introductory statistics course.

  In **StatClips Examples,** Alan Dabney walks students through step-by-step examples related to the StatClips lecture videos to reinforce the concepts through problem solving.

  SnapShots videos are abbreviated, student-friendly versions of the Statistically Speaking video series, and they bring the world of statistics into the classroom. In the same vein as the successful PBS series *Against All Odds: Inside Statistics*, Statistically Speaking uses new and updated documentary footage and interviews that show real people using data analysis to make important decisions in their careers and in their daily lives. From business to medicine, from the environment to understanding the census, SnapShots help students see why statistics is important for their careers and how statistics can be a powerful tool for understanding their world.

  Statistical Applets allow students to master statistical concepts by manipulating data. The applets can also be used to solve problems.

  EESEE Case Studies, taken from the *Electronic Encyclopedia of Statistical Exercises and Examples*, offer students additional applied exercises and examples.

- A **data set from the General Social Survey (GSS)** gives students access to data from one of the most trusted sources of sociological information. Since 1972, the GSS has collected data that reflect changing opinions and trends in the United States. A number of exercises in the text use GSS data, and this data set allows students to explore further.

- The **Assignment Center** lets instructors easily construct and administer tests and quizzes from the book's Test Bank and course materials. The Test Bank includes a subset of questions from the end-of-chapter exercises and uses algorithmically generated values so that each student can be assigned a unique version of the question. Assignments can be automatically graded, and the results can be recorded in a customizable Gradebook.

Additional Student Supplements

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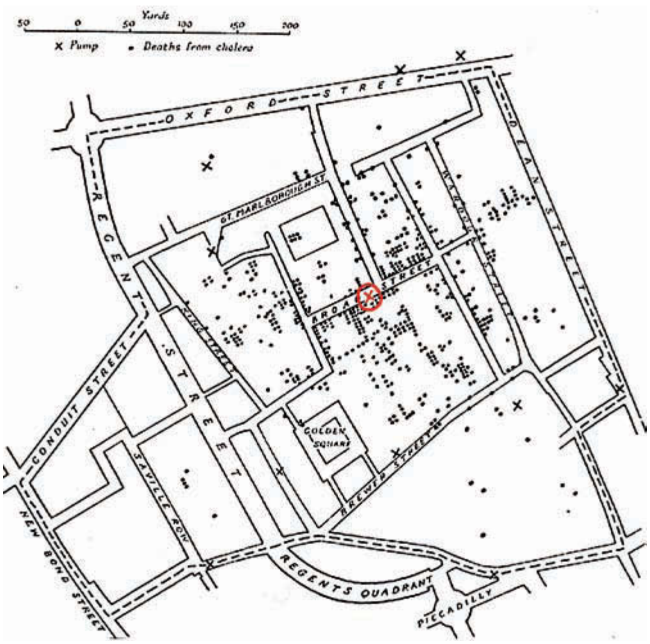
CHAPTER 1

An Introduction to Statistics and Research Design

BEFORE YOU GO ON

- You should be familiar with basic mathematics (see Reference for Basic Mathematics in Appendix A).



Source: Map 1. Published by C.F. Cheffins, Lith, Southhampton Buildings, London, England, 1854 in Snow, John. *On the Mode of Communication of Cholera*, 2nd Ed, John Churchill, New Burlington

John Snow's Famous Map By mapping cholera deaths in relation to the Broad Street water well, Dr. John Snow solved the urgent mystery of how cholera could infect so many people so suddenly. The X's are all neighborhood wells. The X in the red circle is the Broad Street well. Each dot indicates that a person living at this address died of cholera, and a cluster of cases is clearly seen around the Broad Street well (but not around the other wells). Snow was careful to include the other X's to demonstrate that the deaths were closer to one specific source of water.

Statistics saves lives.

The London cholera epidemic of 1854 hit with terrifying swiftness and apparent randomness. Some 500 people died during the first 10 days and no one could figure out why. Everyone involved only knew that the disease dehydrated its victims in gruesome ways no matter how much water the sufferer drank. It was as if an angel of death had decided, during that late summer of 1854, to take a random stroll through London's Golden Square neighborhood. A workhouse with 535 inmates had only a few mortalities; a nearby brewery with 70 employees was untouched by the epidemic; yet another nearby factory suffered 18 deaths.

Dr. John Snow had spent years trying to determine how cholera was communicated from one person to another (Vinten-Johansen, Brody, Paneth, Rachman, & Rip, 2003) and was searching for a pattern behind the apparent randomness. He marked the location of each cholera victim's home on a map and then added an X for each neighborhood's water well. The visual presentation of these data revealed a relation between distance from the well and numbers of deaths! The closer a home was to the well on Broad Street (see the red X circled in the accompanying image), the more likely it was that a death from cholera had occurred.

Snow proposed a simple solution: Remove the pump handle—a health intervention that startled the Board of Guardians of St. James's parish. Surprisingly, when the authorities finally removed the Broad Street pump handle, cholera deaths declined dramatically. Nevertheless, Snow still had a statistical problem: The rate of deaths from cholera had started to decline before the handle was removed! How could this happen? Did Snow's intervention really make a difference? The answer is both disturbing and insightful: So many people had died or fled the neighborhood around the Broad Street well that there were fewer people left to be infected.

- A **descriptive statistic** organizes, summarizes, and communicates a group of numerical observations.
- An **inferential statistic** uses sample data to make general estimates about the larger population.
- A **sample** is a set of observations drawn from the population of interest.
- The **population** includes all possible observations about which we'd like to know something.

The Two Branches of Statistics

The statistical genius and research of Dr. Snow not only saved lives, it anticipated the two main branches of modern statistics: descriptive statistics and inferential statistics.

Descriptive Statistics

***Descriptive statistics** organize, summarize, and communicate a group of numerical observations.* Descriptive statistics describe large amounts of data in a single number or in just a few numbers. Here's an illustration using familiar numbers: body weights. The Centers for Disease Control and Prevention (CDC, 2004, 2012) reported that people in the United States weigh more now than they did four decades ago. The average weight for women increased from 140.2 pounds in 1960 to 166.2 in 2010. For men, the average weight rose from 166.3 to 195.5 pounds in the same time span. These averages are descriptive statistics because they *describe* the weights of many people in just one number. A single number reporting the average communicates the observations more clearly than would a long list of weights for every person studied by the CDC.

◀ MASTERING THE CONCEPT

1-1: Descriptive statistics summarize numerical information about a sample. Inferential statistics draw conclusions about the broader population based on numerical information from a sample.

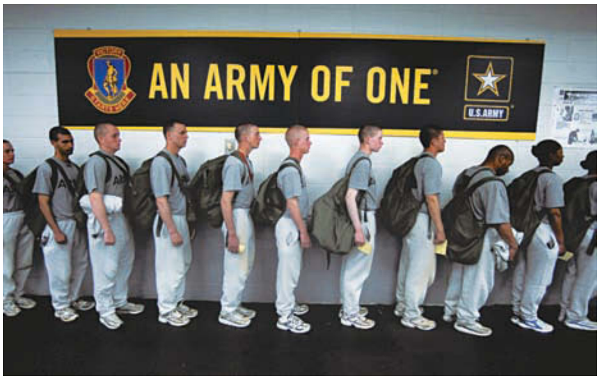
Inferential Statistics

Inferential statistics *use sample data to make general estimates about the larger population.* Inferential statistics infer, or make an intelligent guess about, the population. For example, the CDC made inferences about weight even though it did not actually weigh *everyone* in the United States. Instead, the CDC studied a smaller representative group of U.S. citizens to make an intelligent guess about the entire population.

Distinguishing Between a Sample and a Population

A ***sample*** *is a set of observations drawn from the population of interest.* Researchers usually study a sample, but they are really interested in the ***population***, which *includes all possible observations about which we'd like to know something.* For example, the average weight of the CDC's samples of women and men were used to estimate the average weight for the entire U.S. population, which was the CDC's interest.

Samples are used most often because researchers are rarely able to study every person (or organization or laboratory rat) in a population. For one thing, it's far too expensive. In addition, it would take too long. Snow did not want to interview every family in the Broad Street neighborhood—people were dying too fast! Fortunately, what he learned from his sample also applied to the larger population.



U.S. Air Force photo by Staff Sgt. Shawn Weismiller

Descriptive Statistics Summarize Information It is more useful to use a single number to summarize many people's weights than to provide a long, overwhelming list of each person's weight.

CHECK YOUR LEARNING

Reviewing the Concepts

- Descriptive statistics organize, summarize, and communicate large amounts of numerical information.
- Researchers working with sample data use inferential statistics to draw conclusions about larger populations.
- Samples, or selected observations of a population, are intended to be representative of the larger population.

Clarifying the Concepts

1-1 Which are used in inferential statistics: samples or populations?

continued on next page

Calculating the Statistics

1-2a If your professor calculated the average grade for your statistics class, would that be considered a descriptive statistic or an inferential statistic?

1-2b If that same class average is used to predict something about how future students might do in statistics, would it be considered a descriptive statistic or an inferential statistic?

Applying the Concepts

1-3 Researcher Andrew Gelman wrote about his research in the *New York Times* (February 18, 2013): "The average American knows about 600 people. How do we know this? Researchers led by my Columbia colleague Tian Zheng posed a series of questions to a representative sample of 1,500 Americans."

a. What is the sample?

b. What is the population?

c. What is the descriptive statistic?

d. What is the inferential statistic?

Solutions to these Check Your Learning questions can be found in Appendix D.

- A **variable** is any observation of a physical, attitudinal, or behavioral characteristic that can take on different values.
- A **discrete observation** can take on only specific values (e.g., whole numbers); no other values can exist between these numbers.
- A **continuous observation** can take on a full range of values (e.g., numbers out to several decimal places); an infinite number of potential values exists.
- A **nominal variable** is a variable used for observations that have categories, or names, as their values.
- An **ordinal variable** is a variable used for observations that have rankings (i.e., 1st, 2nd, 3rd…) as their values.
- An **interval variable** is a variable used for observations that have numbers as their values; the distance (or interval) between pairs of consecutive numbers is assumed to be equal.

How to Transform Observations into Variables

Like John Snow, we begin the research process by making observations and transforming them into a useful format. For example, Snow observed the locations of people who had died of cholera and placed these locations on a map that also showed wells in the area. The numbers of cholera deaths and their distances from the Broad Street well are both *variables*. ***Variables*** *are observations of physical, attitudinal, and behavioral characteristics that can take on different values.* Behavioral scientists often study abstract variables such as motivation and self-esteem; they typically begin the research process by transforming their observations into numbers.

Researchers use both discrete and continuous numerical observations to quantify variables. ***Discrete observations*** *can take on only specific values (e.g., whole numbers); no other values can exist between these numbers.* For example, if we measured the number of times study participants get up early in a particular week, the only possible values would be whole numbers. It is reasonable to assume that each participant could get up early 0 to 7 times in any given week but not 1.6 or 5.92 times.

Continuous observations *can take on a full range of values (e.g., numbers out to several decimal places); an infinite number of potential values exists.* For example, a person might complete a task in 12.83912 seconds. The possible values are continuous, limited only by the number of decimal places we choose to use.

Discrete Observations

Two types of observations are always discrete: nominal variables and ordinal variables. ***Nominal variables*** *are used for observations that have categories, or names, as their values.* For example, when entering data into a statistical computer program, a researcher might code male participants with the number 1 and female participants with the number 2. In this case, the numbers only identify the gender category for each participant. They do not imply any other meaning. For instance, men aren't better than women because they get the first number and women aren't twice as good as men because they happen to be coded as a 2. Note that nominal variables are always discrete (whole numbers).

***Ordinal variables** are used for observations that have rankings (i.e., 1st, 2nd, 3rd…) as their values.* In reality television shows, like *Britain's Got Talent* or *American Idol*, for example, a performer finishes the season in a particular place, or rank. Whether or not the performer goes on to get a record deal, fame, and fortune is determined by his or her rank at the end of the season. It doesn't matter if the performer was first because she was slightly more talented than the next performer or much more talented. Like nominal variables, ordinal variables are always discrete. A singer could be 1st or 3rd or 12th, but could not be ranked 1.563.

- A **ratio variable** is a variable that meets the criterion for an interval variable but also has a meaningful zero point.

Virginia Sherwood/NBC/NBCU Photo Bank via Getty Images

Ordinal Variables Are Ranked Ashleigh and Pudsey came in first in a recent season of *Britain's Got Talent*, becoming the first winning act that included a dog; classical singers Jonathan and Charlotte came in second. This is an ordinal variable, so they are still ranked first and second regardless of how much better Ashleigh and Pudsey were than Jonathan and Charlotte.

Continuous Observations

Two types of observations can be continuous: interval variables and ratio variables. ***Interval variables** are used for observations that have numbers as their values; the distance (or interval) between pairs of consecutive numbers is assumed to be equal.* For example, temperature is an interval variable because the interval from one degree to the next is always the same. Some interval variables are also discrete variables, such as the number of times one has to get up early each week. This is an interval variable because the distance between numerical observations is assumed to be equal. The difference between 1 and 2 times is the same as the difference between 5 and 6 times. However, this observation is also discrete because, as noted earlier, the number of days in a week cannot be anything but a whole number. Several behavioral science measures are treated as interval measures but also can be discrete, such as some personality measures and attitude measures.

Sometimes discrete interval observations, such as the number of times one has to get up early each week, are also ***ratio variables**, variables that meet the criteria for interval variables but also have meaningful zero points.* For example, if someone never has to get up early, then zero is a meaningful observation and could represent a variety of life circumstances. Perhaps the person is unemployed, retired, ill, or merely on vacation. Another example of a discrete ratio variable is the number of times a rat pushes a lever to receive food. This also has a true zero point—the rat might never push the bar (and go hungry). Ratio observations that are not discrete include time running out in a basketball game and crossing the finish line in a race.

Many cognitive studies use the ratio variable of reaction time to measure how quickly people process difficult information. For example, the Stroop test is a ratio measure that assesses how long it takes to read a list of color words printed in ink of the wrong color (Figure 1-1), such as when the word *red* is printed in blue or the word *blue* is printed in green. If it takes you 1.264 seconds to press a computer key that accurately identifies that the word *red* printed in blue actually reads *red*, then your reaction time is a ratio variable; time always implies a meaningful zero.

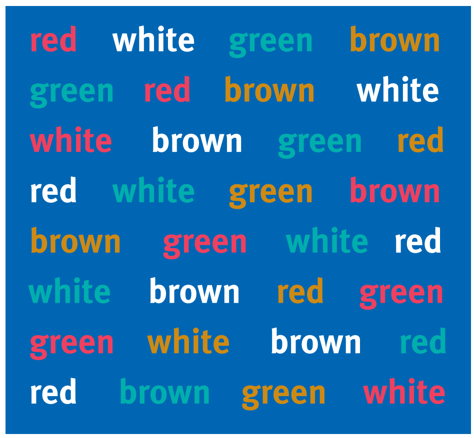


FIGURE 1-1
Reaction Time and the Stroop Test

Read these words out loud to yourself as quickly as possible. Notice what happens in the third line. Your reaction time (how long it takes to read the list) is a ratio variable (also called a scale variable). The Stroop test assesses how long it takes to read a list of colored words printed in the wrong color, such as the word *red* printed in the color white.

MASTERING THE CONCEPT ►

1-2: The three main types of variables are nominal (or categorical), ordinal (or ranked), and scale. The third type (scale) includes both interval variables and ratio variables; the distances between numbers on the measure are meaningful.

Many statistical computer programs refer to both interval numbers and ratio numbers as *scale observations* because both interval observations and ratio observations are analyzed with the same statistical tests. Specifically, *a* ***scale variable*** *is a variable that meets the criteria for an interval variable or a ratio variable.* Throughout this text, we use the term *scale variable* to refer to variables that are interval or ratio, but it is important to remember the distinction between interval variables and ratio variables. Table 1-1 summarizes the four types of variables.

TABLE 1-1. Quantifying Observations

There are four types of variables that researchers can use to quantify their observations. Two of them, nominal and ordinal, are always discrete. Interval variables can be discrete or continuous; ratio variables are almost always continuous. (Interval variables and ratio variables are often referred to as "scale variables")

	Discrete	Continuous
Nominal	Always	Never
Ordinal	Always	Never
Interval	Sometimes	Sometimes
Ratio	Seldom	Almost always

CHECK YOUR LEARNING

Reviewing the Concepts

> Variables are quantified with discrete or continuous observations.

> Depending on the study, statisticians select nominal, ordinal, or scale (interval or ratio) variables.

Clarifying the Concepts

1-4 What is the difference between discrete observations and continuous observations?

Calculating the Statistics

1-5 Three students complete a Stroop test. Lorna finishes in 12.67 seconds; Desiree finishes in 14.87 seconds; and Marianne finishes in 9.88 seconds.

a. Are these data discrete or continuous?

b. Is the variable an interval or a ratio observation?

c. On an ordinal scale, what is Lorna's score?

Applying the Concepts

1-6 Eleanor Stampone (1993) randomly distributed pieces of paper to students in a large lecture center. Each paper contained one of three short paragraphs that described the interests and appearance of a female student. The descriptions were identical in every way except for one adjective. The student was described as having "short," "mid-length," or "very long" hair. At the bottom of each piece of paper, Stampone asked the participants (both female and male) to fill out a measure that indicated the probability that the student described in the scenario would be sexually harassed.

a. What is the nominal variable used in Stampone's hair-length study? Why is this considered a nominal variable?

b. What is the ordinal variable used in the study? Why is this considered an ordinal variable?

c. What is the scale variable used in the study? Why is this considered a scale variable?

Solutions to these Check Your Learning questions can be found in Appendix D.

Variables and Research

A major aim of research is to understand the relations among variables with many different values. It is helpful to remember that variables vary. For example, when studying a discrete nominal variable such as gender, we refer to gender as the variable because it can vary—either male or female. The term *level*, along with the terms *value* and *condition*, all refer to the same idea. ***Levels** are the discrete values or conditions that variables can take on.* For example, male is a level of the variable gender. Female is another level of the variable gender. In both cases, gender is the variable. Similarly, when studying a continuous, scale variable, such as how fast a runner completes a marathon, we refer to time as the variable. For example, 3 hours, 42 minutes, 27 seconds is one of an infinite number of possible times it would take to complete a marathon. With this in mind, let's explore the three types of variables: independent, dependent, and confounding.

- A **scale variable** is a variable that meets the criteria for an interval variable or a ratio variable.
- A **level** is a discrete value or condition that a variable can take on.
- An **independent variable** has at least two levels that we either manipulate or observe to determine its effects on the dependent variable.
- A **dependent variable** is the outcome variable that we hypothesize to be related to or caused by changes in the independent variable.
- A **confounding variable** is any variable that systematically varies with the independent variable so that we cannot logically determine which variable is at work; also called a *confound.*

Independent, Dependent, and Confounding Variables

The three types of variables that we consider in research are independent, dependent, and confounding. Two of these, independent variables and dependent variables, are necessary for good research. But the third type, a confounding variable, is the enemy of good research. We usually conduct research to determine if one or more independent variables predict a dependent variable. *An **independent variable** has at least two levels that we either manipulate or observe to determine its effects on the dependent variable.* For example, if we are studying whether gender predicts one's attitude about politics, then the independent variable is gender.

*The **dependent variable** is the outcome variable that we hypothesize to be related to or caused by changes in the independent variable.* For example, we hypothesize that the dependent variable (attitudes about politics) depends on the independent variable (gender). If in doubt as to which is the independent variable and which is the dependent variable, ask yourself which one depends on the other; that one is the dependent variable.

◀ MASTERING THE CONCEPT

1-3: We conduct research to see if the independent variable predicts the dependent variable.

By contrast, a ***confounding variable** is any variable that systematically varies with the independent variable so that we cannot logically determine which variable is at work.* So how do we decide which is the independent variable and which might be a confounding variable (also called a *confound*)? Well, it all comes down to what *you* decide to study. Let's use an example. Suppose you want to lose weight, so you start using a diet drug *and* begin exercising at the same time. The drug and the exercising are confounded because you cannot logically tell which one is responsible for any weight loss. If we hypothesize that a particular diet drug leads to weight loss, then whether someone uses the diet drug becomes the independent variable, and exercise becomes the potentially confounding variable that we would try to control. On the other hand, if we hypothesize that exercise leads to weight loss, then whether someone exercises or not becomes the independent variable and whether that person uses diet drugs along with it becomes the potentially confounding variable that we would try to control. In both of these cases, the dependent variable would be weight loss. But the researcher has to make some decisions about which variables to treat as independent variables, which variables must be controlled, and which variables to treat as dependent. You, the experimenter, are in control of the experiment.


Rex Features via AP Images

Was the Damage from Wind or Water? During hurricanes, like Hurricane Sandy in 2012, high winds are often confounded with high water so it is not always possible to determine whether property damage was due to wind (insured) or to water (often not insured).

- **Reliability** refers to the consistency of a measure.
- **Validity** refers to the extent to which a test actually measures what it was intended to measure.

Reliability and Validity

You probably have a lot of experience in assessing variables—at least on the receiving end. You've taken standardized tests when applying to your university; you've taken short surveys to choose the right product for you, whether jeans or smart phones; and you've taken online quizzes—perhaps ones sent through social networking sites like Facebook, such as the Dogster Breed Quiz, which uses a 10-item scale to assess the breed of dog you are most like (http://www.dogster.com/quizzes/what_dog_breed_are_ you/, 2015).

How good is this quiz? One of the authors took the quiz—answering one of the questions by choosing a light chicken salad over alternative choices of heavier fare—and was declared to be a bulldog: "You may look like the troublemaker of the pack, but it turns out your tough guy mug is worse than its bite." To determine whether a measure is a good one, we need to know if it is both reliable and valid.

*A **reliable** measure is consistent.* If you were to weigh yourself on your bathroom scale now, and then again in an hour, you would expect your weight to be almost exactly the same. If your weight, as shown on the scale, remains the same when you haven't done anything to change it, then your bathroom scale is reliable. As for the Dogster Breed Quiz, the bulldog author took it twice and was a bulldog the second time as well, one indication of reliability.

Reliable and Valid New guidelines have made projective personality tests such as the Rorschach more reliable, but it is still unclear whether they provide a valid measure. A measure must be both reliable (consistent over time) and valid (assesses what it is intended to assess).

But a reliable measure is not necessarily a valid measure. *A **valid** measure is one that measures what it was intended to measure.* Your bathroom scale could be incorrect but consistently incorrect—that is, reliable but not valid. A more extreme example is using a ruler when you want to know your weight. You would get a number, and that number might be reliable, but it would not be a valid measure of your weight.

And the Dogster Breed Quiz? It's probably not an accurate measure of personality. The quiz, for example, lists an unlikely mix of celebrities, with seemingly different personalities, as bulldogs—Ellen DeGeneres, Whoopi Goldberg, Jack Black, and George W. Bush! However, we're guessing that no one has done the statistical work to determine whether it is valid or not. When you take such online quizzes, our advice is to view the results as entertaining rather than enlightening.

A measure with poor reliability cannot have high validity. It is not possible to measure what we intend to measure when the test itself produces varying results. The well-known Rorschach inkblot test is one example of a test whose reliability is questionable, so the validity of the information it produces is difficult to interpret (Wood, Nezworski, Lilienfeld, & Garb, 2003). For instance, two clinicians might analyze the identical set of responses to a Rorschach test and develop quite different interpretations of those responses—meaning it lacks reliability. Reliability can be increased with scoring guidelines, but that doesn't mean validity is increased. Just because two clinicians scoring a Rorschach test designate a person as psychotic, it doesn't necessarily mean the person *is* psychotic. Reliability is necessary, but not sufficient, to create a valid measure. Nevertheless, the idea that ambiguous images somehow invite revealing information remains attractive to many people; as a result, tests such as the Rorschach are still used frequently, even though there is much controversy about them (Wood et al., 2003).

MASTERING THE CONCEPT ►

1-4: A good measure is both reliable and valid.

CHECK YOUR LEARNING

Reviewing the Concepts

> Independent variables are manipulated or observed by the experimenter.

> Dependent variables are outcomes in response to changes or differences in the independent variable.

> Confounding variables systematically vary with the independent variable, so we cannot logically tell which variable may have influenced the dependent variable.

> Researchers control factors that are not of interest in order to explore the relation between an independent variable and a dependent variable.

> A measure is useful only if it is both reliable (consistent over time) and valid (assesses what it is intended to assess).

Clarifying the Concepts

1-7 The ________ variable predicts the ________ variable.

Calculating the Statistics

1-8 A researcher examines the effects of two variables on memory. One variable is beverage (caffeine or no caffeine) and the other variable is the subject to be remembered (numbers, word lists, aspects of a story).

a. Identify the independent and dependent variables.

b. How many levels do the variables "beverage" and "subject to be remembered" have?

Applying the Concepts

1-9 Kiho Kim and Stevia Morawski (2012) studied 360 students in a university cafeteria, measuring how much food students wasted. The researchers compared waste among students when trays were available to waste among students when trays were not available. They found that students wasted 32% less food when trays were not available.

a. What is the independent variable in this study?

b. What are the levels of the independent variable?

c. What is the dependent variable? Suggest at least one way in which Kim and Morawski might have measured this.

d. What would it mean for the food waste measure to be reliable?

e. What would it mean for the food waste measure to be valid?

Solutions to these Check Your Learning questions can be found in Appendix D.

Introduction to Hypothesis Testing

When John Snow suggested that the pump handle be removed from the Broad Street well, he was testing his idea that an independent variable (contaminated well water) led to a dependent variable (deaths from cholera). Behavioral scientists use research to test ideas through a specific statistics-based process called ***hypothesis testing***, *the process of drawing conclusions about whether a particular relation between variables is supported by the evidence.* Typically, researchers examine data from a sample to draw conclusions about a population, but there are many ways to conduct research. In this section, we discuss the process of determining the variables, two ways to approach research, and two experimental designs.

Determining which breed of dog you most resemble might seem silly; however, adopting a dog is a very important decision. Can an online quiz such as the *Animal Planet* "Dog Breed Selector" help (http://animal.discovery.com/breed-selector/dog-breeds.html, 2015)? We could conduct a study by having 30 people choose a

▪ **Hypothesis testing** is the process of drawing conclusions about whether a particular relation between variables is supported by the evidence.