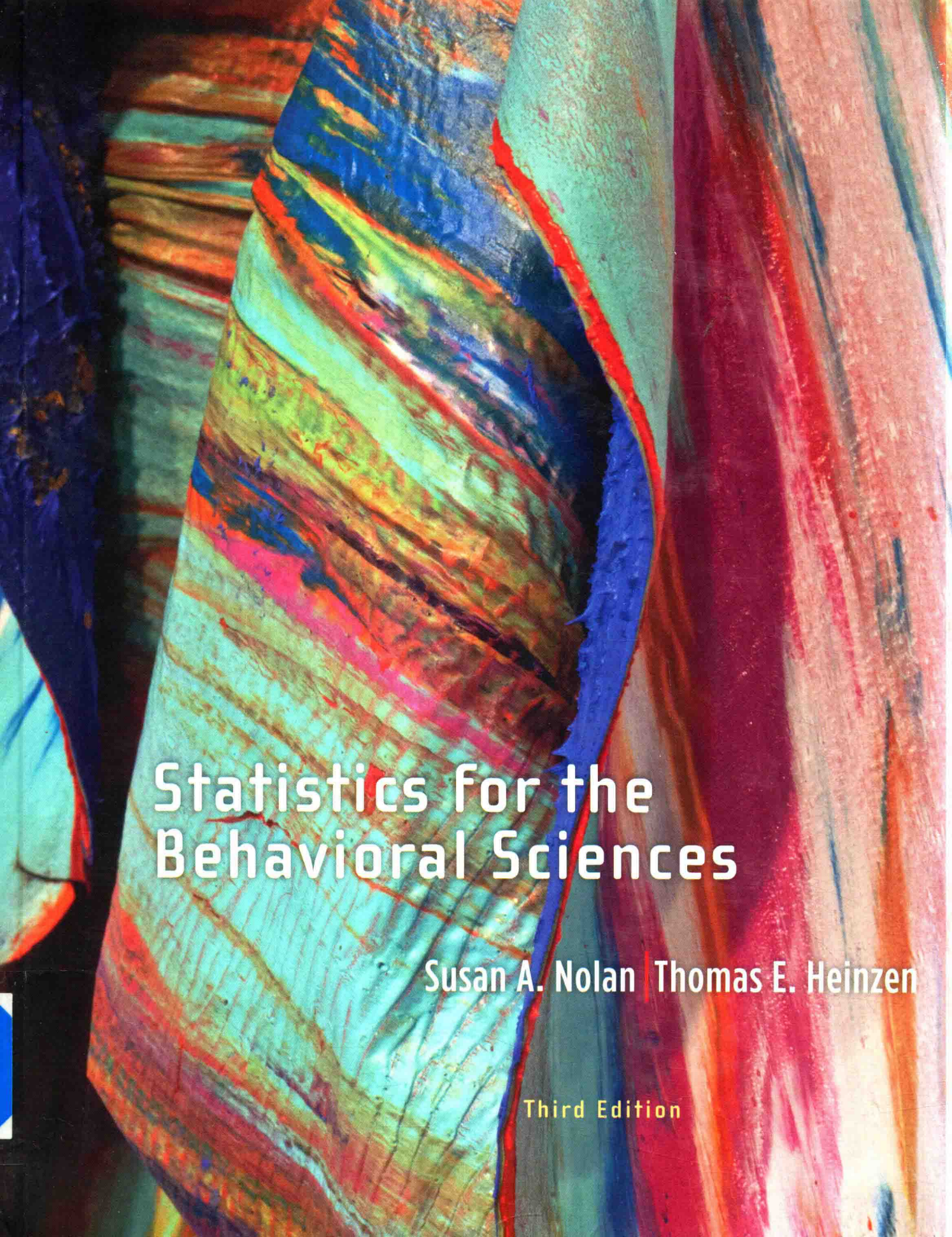

Statistics for the Behavioral Sciences

Susan A. Nolan | Thomas E. Heinzen

Third Edition

Statistics for the Behavioral Sciences

third edition

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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)

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

Interquartile Range

$$IQR = Q3 - Q1$$

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

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

CHAPTERS 9 and 10

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 11

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

$$s^2_{difference} = s^2_{MX} + s^2_{MY}$$

Standard Deviation of a 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 12

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

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

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

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

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

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

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

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

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

Effect Size for a One-Way Between-Groups ANOVA

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

(Chapter 12 formulas continued on inside back cover.)

To Diane and Jim (a.k.a. Mom and Dad) for all their love and support.

—Susan Nolan

To Mollie, Jodha, and Benjamin—from the luckiest grandpa in the world.

—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 the chair of the department of psychology as well as professor of psychology at Seton Hall University in New Jersey. She has served as a statistical consultant to researchers at universities, medical schools, corporations, and nongovernmental organizations. Susan is a representative from the American Psychological Association to the United Nations in New York City 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 was elected the 2014–2015 president of the Eastern Psychological Association. She is a fellow of the American Psychological Association.

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.

Caroline Dawnay

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.

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 motion graphs and the peculiar personalities who shaped the unfolding story of statistics, such as Stella Cunliffe. 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

PREFACE

Statistics is hot. According to the *New York Times* on June 20, 2013, statistics is perhaps the most promising, adventurous career option you can choose right now—and it 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 wearing green eyeshades and pocket protectors. The new reality requires smart, reflective people who have been trained to dip their spoons into the salty ocean of big data, transform those data into something we can consume, and still leave the ocean of data as a vibrant, ever-evolving home for exotic creatures. 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.

Trends in Statistics: What's Coming Next?

Statistics and statistical reasoning are in the midst of profound changes. Here are three 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: Bayesian Statistics. The field of statistics is also moving forward by looking backwards! The story of Thomas Bayes, an obscure clergyman born around 1701, demonstrates that some great ideas just won't go away. Imagine that a ball is thrown onto a square billiard table and that it comes to rest slightly to the left of center. But the ball is removed before we get to see where it landed—so its exact landing place is unknown to us; we can only estimate where it stopped. More balls are then rolled onto the table, each with the same random set of possibilities—and we are only told whether or not each ball has landed to the right or left of the original ball. With each additional piece of feedback, we can slowly come to estimate (with increasing confidence) where the first ball actually landed. By learning from prior experience (called *priors* in Bayesian statistics), we become slightly less wrong about the first ball's

location every time a new ball is rolled onto the billiard table. The heart of Bayesian reasoning is to gradually rule out what cannot be true, so the process of discovery becomes more exciting with every analysis. The implications are just starting to hit the world of behavioral statistics, and it is difficult to predict where all this excitement will take us next. But this is an impressive outcome for an obscure clergyman whose only mathematical paper was published after his death.

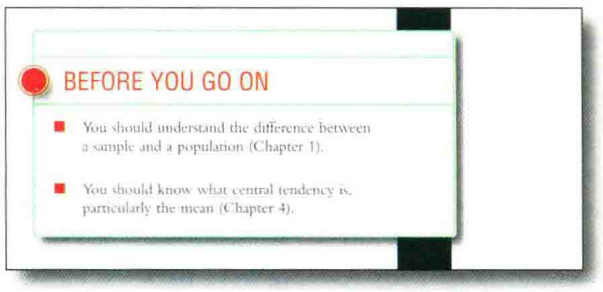
Trend 3: Free Software. Although earning a college degree is pretty expensive, the Internet has created opportunities for particular forms of education to progressively become less expensive. Massive open online courses (MOOCs) are just one of the more obvious efforts. One of your coauthors, Tom, took one MOOC with 80,000 other classmates. He didn't actually finish the course because early on, he already had gotten what he wanted out of the course and didn't need to learn how to write a research paper. Kahn Academy online tutorials are another excellent, low-cost (though it costs you time) way to become better educated. A third opportunity is the increase in free statistical programs 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 *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.



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. Appendix E, Figure E-1: Choosing the Appropriate Hypothesis Test 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 14 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.

Our data are now:

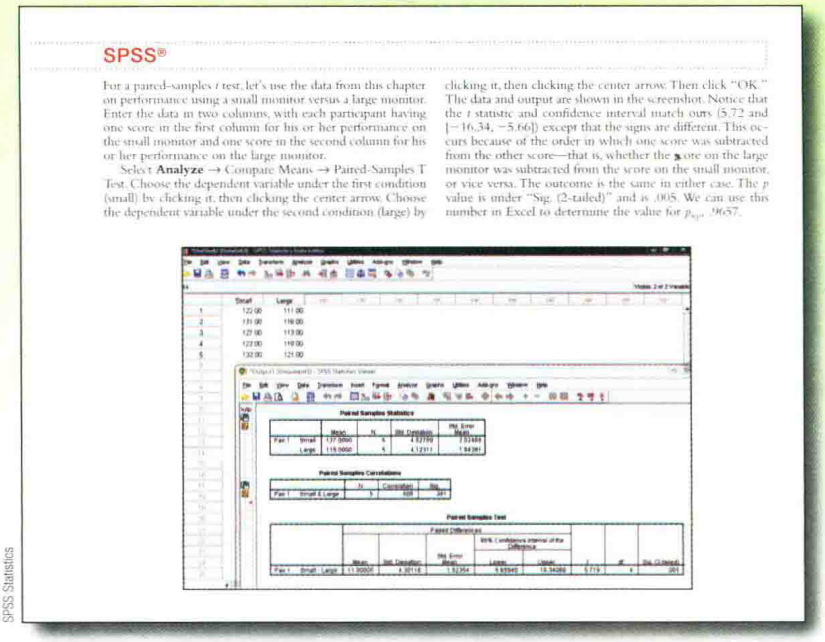
1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 4, 6, 8, 10

STEP 2: Find the middle score.

First, we count the scores. There are 14 scores. We then divide the number of scores by 2: $14/2 = 7$. If we add 0.5 to this result, we get 7.5; therefore, the median is the average of the 7th and 8th scores. The 7th and 8th 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®

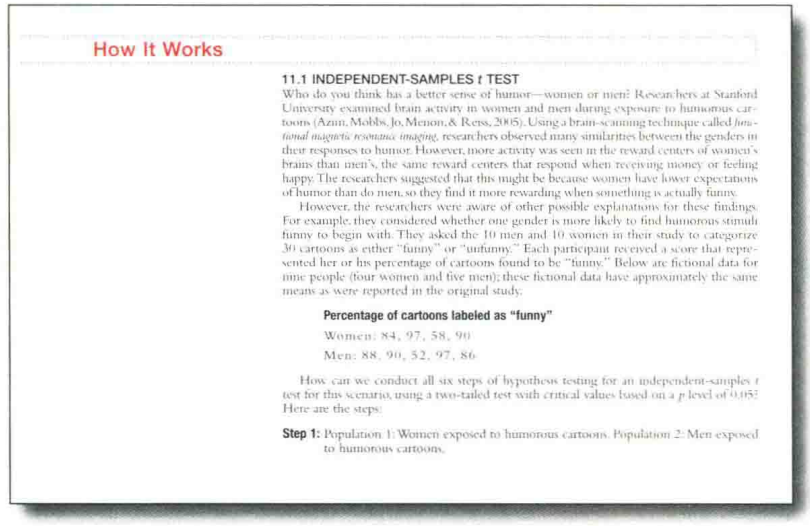
For a paired-samples *t* test, let's use the data from this chapter on performance using a small monitor versus a large monitor. Enter the data in two columns, with each participant having one score in the first column for his or her performance on the small monitor and one score in the second column for his or her performance on the large monitor.

Select **Analyze** → Compare Means → Paired-Samples T Test. Choose the dependent variable under the first condition (small) by clicking it, then clicking the center arrow. Choose the dependent variable under the second condition (large) by clicking it, then clicking the center arrow. Then click "OK." The data and output are shown in the screenshot. Notice that the *t* statistic and confidence interval match ours (5.72 and [−16.34, −5.66]) except that the signs are different. This occurs because of the order in which one score was subtracted from the other score—that is, whether the score on the large monitor was subtracted from the score on the small monitor, or vice versa. The outcome is the same in either case. The *p* value is under "Sig. (2-tailed)" and is .005. We can use this number in Excel to determine the value for $p_{.975}$: .9657.

SPSS Statistics

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

11.1 INDEPENDENT-SAMPLES *t* TEST

Who do you think has a better sense of humor—women or men? Researchers at Stanford University examined brain activity in women and men during exposure to humorous cartoons (Azim, Mobbs, Jo, Menon, & Reiss, 2005). Using a brain-scanning technique called *functional magnetic resonance imaging*, researchers observed many similarities between the genders in their responses to humor. However, more activity was seen in the reward centers of women's brains than men's, the same reward centers that respond when receiving money or feeling happy. The researchers suggested that this might be because women have lower expectations of humor than do men, so they find it more rewarding when something is actually funny.

However, the researchers were aware of other possible explanations for these findings. For example, they considered whether one gender is more likely to find humorous stimuli funny to begin with. They asked the 10 men and 10 women in their study to categorize 30 cartoons as either "funny" or "unfunny." Each participant received a score that represented her or his percentage of cartoons found to be "funny." Below are fictional data for nine people (four women and five men); these fictional data have approximately the same means as were reported in the original study.

Percentage of cartoons labeled as "funny"

Women: 84, 97, 58, 90

Men: 88, 90, 52, 97, 86

How can we conduct all six steps of hypothesis testing for an independent-samples *t* test for this scenario, using a two-tailed test with critical values based on a *p* level of 0.05? Here are the steps:

Step 1: Population 1: Women exposed to humorous cartoons. Population 2: Men exposed to humorous cartoons.

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, we have designed increasing challenges beginning with confidence-building Check Your Learning sections within each chapter. Many of the more than 1000 exercises available 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:

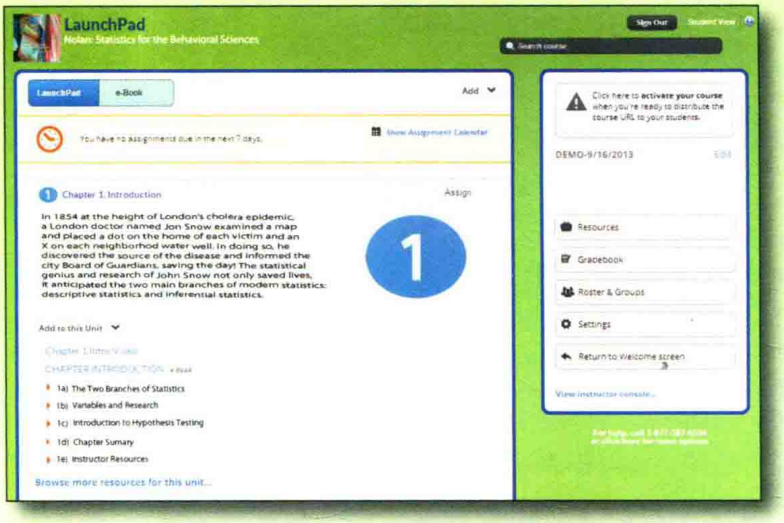
- **Clarifying the Concepts** questions help students to master the general concepts, the statistical terminology, and the conceptual assumptions of each topic.
- **Calculating the Statistics** exercises provide students a way to practice making the basic calculations for each formula and statistic.
- **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.

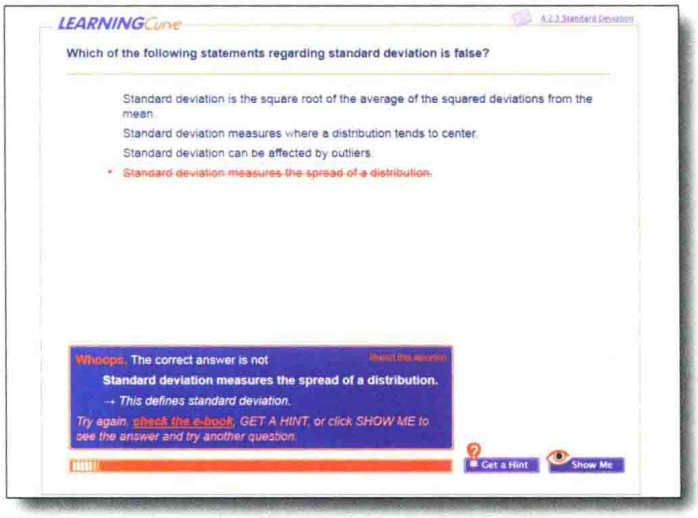


LaunchPad to Accompany *Statistics for the Behavioral Sciences*, Third Edition, can be previewed and purchased at **www.whfreeman.com/launchpad**

Statistics for the Behavioral Sciences, Third Edition, and LaunchPad can be ordered together (ISBN-10: 1-4641-9167-0 / ISBN-13: 978-1-4641-9167-1)

LaunchPad for *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 game-like 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 to understand 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 with algorithmically generated values, so each student can be assigned a unique version of the question. Assignments can be automatically graded, and the results are recorded in a customizable gradebook.

Additional Student Supplements

- ***SPSS: A User-Friendly Approach*** by Jeffrey Aspelmeier and Thomas Pierce of Radford University is an accessible introduction to using SPSS. The book uses a proven teaching method, building each section of the text around the storyline from a popular cartoon. Easing anxiety and giving students the

necessary support to learn the material, *SPSS: A User-Friendly Approach* provides instructors and students with an informative guide to the basics of SPSS.

- The **iClicker** Classroom Response System is a versatile polling system developed by educators for educators that makes class time more efficient and interactive. iClicker allows you to ask questions and instantly record students' responses, gauge students' understanding and opinions, and take attendance. It can help you gather data on students that you can use to teach statistics, connecting the concepts to students' lives. iClicker is available at a 10% discount when packaged with *Statistics for the Behavioral Sciences*, Third Edition.

Take advantage of our most popular combinations!

Worth Publishers is pleased to offer cost-saving packages of *Statistics for the Behavioral Sciences*, Third Edition, with our most popular supplements. Below is a list of some of the most popular combinations available for order through your local bookstore.

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Instructor Supplements

We understand that one book alone cannot meet the education needs and teaching expectations of the modern classroom. Therefore, we have engaged our colleagues to create a comprehensive supplements package that makes both teaching and learning statistics much easier.

- **Instructor's Resources** by Robin Freyberg, Stern College for Women, Yeshiva University, with contributions by Katherine Makarec, William Paterson University. The contents include Teaching Tips and sample course outlines. Each chapter includes a brief overview, discussion questions, classroom activities, handouts, additional reading suggestions, and online resources.
- **Test Bank** by Jennifer Coleman, Western New Mexico University, with contributions by Kelly M. Goedert, Seton Hall University, and Daniel Cruz, Caldwell College. The Test Bank includes multiple-choice, true/false, fill-in-the-blank, and critical thinking/problem-solving questions for each chapter.
- **Diploma Computerized Test Bank** (available for Windows or Macintosh on a single CD-ROM). The CD-ROM allows instructors to add an unlimited number of new questions; edit questions; format a test; scramble questions; and include figures, graphs, and pictures. The computerized Test Bank also allows instructors to export into a variety of formats compatible with many Internet-based testing products.
- Worth Publishers supports multiple **Course Management Systems** with enhanced cartridges that include Test Bank questions and other resources. Cartridges are provided free upon adoption of *Statistics for the Behavioral Sciences*, Third Edition, and can be requested through Worth's online catalog at **www.worthpublishers.com.**