

# STATISTICS

for the

# BEHAVIORAL SCIENCES

SECOND EDITION



Gregory J. Privitera



# Statistics for the Behavioral Sciences

Second Edition

Gregory J. Privitera  
*St. Bonaventure University*



Los Angeles | London | New Delhi  
Singapore | Washington DC



Los Angeles | London | New Delhi  
Singapore | Washington DC

FOR INFORMATION:

SAGE Publications, Inc.  
2455 Teller Road  
Thousand Oaks, California 91320  
E-mail: [order@sagepub.com](mailto:order@sagepub.com)

SAGE Publications Ltd.  
1 Oliver's Yard  
55 City Road  
London EC1Y 1SP  
United Kingdom

SAGE Publications India Pvt. Ltd.  
B 1/1 Mohan Cooperative Industrial Area  
Mathura Road, New Delhi 110 044  
India

SAGE Publications Asia-Pacific Pte. Ltd.  
33 Pekin Street #02-01  
Far East Square  
Singapore 048763

Acquisitions Editor: Reid Hester  
Associate Editor: Nathan Davidson  
Editorial Assistant: Lucy Berbeo  
Production Editor: Olivia Weber-Stenis  
Copy Editor: Melinda Masson  
Typesetter: C&M Digitals (P) Ltd.  
Proofreader: Theresa Kay  
Indexer: Jean Casalegno  
Cover Designer: Bryan Fishman  
Marketing Manager: Shari Countryman

Copyright © 2015 by SAGE Publications, Inc.

All rights reserved. No part of this book may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying, recording, or by any information storage and retrieval system, without permission in writing from the publisher.

Printed in Canada.

Library of Congress Cataloging-in-Publication Data

Privitera, Gregory J.  
Statistics for the behavioral sciences/Gregory J. Privitera,  
St. Bonaventure University.—Second edition.

pages cm

Includes bibliographical references and index.

ISBN 978-1-4522-8690-7 (hardcover: alk. paper)

1. Social sciences—Statistical methods. 2. Psychology—Statistical methods. I. Title.

HA29.P755 2015

519.5—dc23

2014007660



14 15 16 17 18 10 9 8 7 6 5 4 3 2 1

# STATISTICS FOR THE BEHAVIORAL SCIENCES

## SECOND EDITION

● ● ● Award-winning author Gregory J. Privitera engages students in an ongoing spirit of discovery with **a focus on how statistics apply to modern research problems**. Fully updated with current research, robust pedagogy, and a new four-color design, this new edition includes even more real-world examples.



### Real-world

### examples

make statistics relevant for students.

Example 2.1



Example 2.1 applies the steps for distributing the frequency of scores in a data set.

A topic of interest in industrial/organizational psychology is studying issues of worker safety (Brundini, Shea, & Plomin, 2012; Loughlin & Frone, 2004). To study this topic, a researcher records the number of complaints about safety filed by employees of 45 local small businesses over the previous 3 years. The results are listed in Table 2.3. In this example, we can construct a frequency distribution of these data.

TABLE 2.3

45	98	83	50	86
66	66	88	95	73
88	55	76	115	66
92	110	79	105	101
101	85	90	92	81
55	95	91	92	
78	66	73	58	
86	92	51	63	
91	77	88	86	
94	80	102	107	

The number of safety complaints that employees of 45 local small businesses filed over the previous 3 years.

**Step 1:** Find the real range. The smallest value in Table 2.3 is 45, and the largest value is 115; therefore,  $115 - 45 = 70$ . The real range is  $70 + 1 = 71$ .

**Step 2:** Find the interval width. We can split the data into eight intervals (again, you choose the number of intervals). The interval width is the real range divided by the number of intervals:  $\frac{71}{8} = 8.88$ . The original data are listed as whole numbers, so we round up to the nearest whole number. The nearest whole number is the degree of accuracy of the data. The interval width is 9.

**Step 3:** Construct the frequency distribution. The frequency distribution table is shown in Table 2.4. The first interval starts with the smallest value (45) and contains nine values. To construct the next interval, add one degree of accuracy (or one whole number in this example), and repeat the steps to construct the remaining intervals.

Example 7.3

Participants in a random sample of 100 college students are asked to state the number of hours they spend studying during finals week. Among all college students at this school (the population), the mean study time is equal to 20 hours per week, with a standard deviation equal to 15 hours per week. Construct a sampling distribution of the mean.

To construct the sampling distribution, we must (1) identify the mean of the sampling distribution, (2) compute the standard error of the mean, and (3) distribute the possible sample means 3 SEM above and below the mean.

Because the sample mean is an unbiased estimator of the population mean, the mean of the sampling distribution is equal to the population mean. The mean of this sampling distribution is equal to 20. The standard error is the population standard deviation (15) divided by the square root of the sample size (100):

$$\sigma_M = \frac{\sigma}{\sqrt{n}} = \frac{15}{\sqrt{100}} = 1.50.$$



### 10.3 THE RELATED-SAMPLES t TEST: REPEATED-MEASURES DESIGN

Two designs associated with selecting related samples are the repeated-measures design and the matched pairs design. In Example 10.1, we compute the related-samples *t* test for a study using the repeated-measures design. In Example 10.2 (in Section 10.5), we compute a study using the matched pairs design.

Example 10.1

One area of focus in many areas of psychology and in education is an understanding and promoting reading among children and adults (Karr, Walcott, & Al-Ostas, 2012; White, Chen, & Forsyth, 2010). Suppose we conduct a study with this area of focus by testing if teacher supervision influences the time that elementary school children read. To test this, we stage two 5-minute reading sessions and record the time in seconds that children spend reading in each session. In one session, the children read with a teacher present in the room; in another session, the same group of children read without a teacher present. The difference in time spent reading in the presence versus absence of a teacher is recorded. Table 10.5 lists the results of this hypothetical study with difference scores (growth). Test whether or not reading times differ using a .05 level of significance.

**Step 1:** State the hypotheses. Because we are testing whether (i) or not (ii) a difference exists, the null hypothesis states that there is no mean difference, and the alternative hypothesis states that there is a mean difference:

$$H_0: \mu_{(D)} = 0 \quad \text{There is no mean difference in time spent reading in the presence versus absence of a teacher.}$$

$$H_1: \mu_{(D)} \neq 0 \quad \text{There is a mean difference in time spent reading in the presence versus absence of a teacher.}$$



FVI

The null and alternative hypotheses make statements about a population of mean difference scores.

*"I loved the book in the first-edition form and love it even more from the changes I have reviewed. I will continue to use the text and recommend it to colleagues."*

—Jeffrey Kinderdietz, Arizona State University



# A FOCUS ON CLARITY

## Research in Focus sections

provide context by reviewing the most current research that illustrates the most important statistical concepts.

### RESEARCH IN FOCUS: FREQUENCIES AND PERCENTS



Although graphs are often used to help the reader understand frequency data, bar charts and histograms are not always equally effective at summarizing percent data. For example, Hollands and Spence (1992, 1998) asked adult participants to identify relative percents displayed in bar charts and pie charts similar to those presented in this chapter. Their studies showed that participants required more time and made larger errors looking at bar charts than when they looked at pie charts. They went on to show that participants also required more time as the number of bars in the graph increased, whereas increasing the number of slices in a pie chart did not have this effect. They explained that most bar graphs, especially for frequency data, are not distributed in percentage units; hence, this reader cannot clearly estimate a proportion by simply viewing the scale. This research suggests that when you want to convey data as percents, pie charts tend even (given) would be a better choice for displaying the data.

1. Click on the Variable View tab and enter numbers in the Name column. We will enter whole numbers, so go to the Decimals column and reduce the value to 0.
2. Click on the Data View tab and enter the 20 values in the column you labeled numbers. You can enter the data in any order you wish, but make sure all the data are entered correctly.
3. Go to the menu bar and click Analyze, then Descriptive Statistics and Frequencies, to bring up a dialog box.
4. In the dialog box, select the numbers variable and click the arrow in the center to move numbers into the box labeled Variable(s) on the right. Because we only want the graphs and charts in this example, make sure the option to display frequency tables is not selected.
5. Click the Charts option in the dialog box, which is shown in Figure 2.12. In the dialog box, you have the option to select bar charts, pie charts, or histograms. Select each option to see how each displays; however, you can only select one option at a time. After you make your selection, click Continue.
6. Select OK, or select Paste and click the Run command to construct each graph.

### 2.12 SPSS in Focus: Histograms, Bar Charts, and Pie Charts

To review, histograms are used for continuous or quantitative data, and bar charts and pie charts are used for discrete, categorical, or qualitative data. As an exercise to compare histograms, bar charts, and pie charts, we can construct these graphs for the same data, even though we would never do this in practice. Suppose we measure the data shown in Table 2.16.

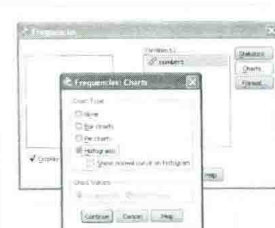
TABLE 2.16

1	4	5	7
2	3	6	8
3	5	7	9
2	6	5	4
4	7	8	5

A sample of 20 values

Because we are not distorting these values, we can just call the variable "numbers." Here are the steps:

FIGURE 2.12



A screenshot of the dialog box for Figure 2.12

In this example, you can also display the frequency table with the graph by keeping the option to display frequency tables selected. In this way, SPSS gives you many options for summarizing data using tables and graphs.

*"The SPSS coverage is exceptional."*

—Walter M. Yamada, Azusa Pacific University

### 10-8 APA IN FOCUS: REPORTING THE *t* STATISTIC AND EFFECT SIZE FOR RELATED SAMPLES

To summarize a related-samples *t* test, we report the test statistic, degrees of freedom, and *p* value. In addition, we summarize the means and standard error or standard deviations measured in the study in a figure or table or in the main text. When reporting results, though, it is not necessary to identify the type of *t* test computed in a results section. The type of *t* test that was used is typically reported in a data analysis section that precedes the results section, where the statistics are reported.

## APA in Focus sections

explain how to read and report statistical results in journals using current APA style.

*"APA in Focus is really useful for introducing students to the reporting standards from their very earliest exposures to these ideas."*

—Kristen T. Begosh, University of Delaware

**Making Sense sections** break down the most difficult concepts in statistics.



### MAKING SENSE MAKING THE GRADE

Instructors often weight grades for college courses. Suppose your statistics course includes an exam, a quiz, and a final class project. The instructor considers the exam to be the most important measure of learning and so gives it the greatest weight. Table 3.2 shows this weighted distribution.

TABLE 3.2

Type of Measure	Points	Weight
Exam	100	60%
Quiz	100	20%
Final project	100	20%

Grading distribution for students in a hypothetical statistics course

In this example, we have three class assignments with unequal weights. The score for each assignment is represented as *x* in the formula, and the weight is represented as *w* (instead of *n* for sample size). Notice that the sum of the weights is 100% or 1.00, which means that the denominator will always sum to 1.00. In these cases, when the sum of the weights equals 1.0, the weighted mean is calculated by computing the weighted sum:

$$\text{Weighted mean} = \sum (x \cdot w)$$

The exam, quiz, and final project are each worth the same number of points (100), but they are weighted differently. Suppose you score 70 points on the exam, 98 points on the quiz, and 100 points on the final project. If you compute an arithmetic mean to determine your grade, you would be wrong:

$$\frac{70 + 98 + 100}{300} = 0.89 \text{ or } 89\%$$

Instead, you apply the formula for weighted means to calculate your final average because each grade was weighted. Without doing the calculation, you might guess (incorrectly) that it is going to be lower than 89%. After you multiply each grade by its weight, then sum each product, you can verify your hunch:

$$\sum (x \cdot w) = (70 \cdot .60) + (98 \cdot .20) + (100 \cdot .20) = 0.816 \text{ or } 81.6\%$$

Your grade dropped from a B+ to a B—because your lowest score was on the most important (and most heavily weighted) measure of learning—the exam. You should be aware of this for any class you take. If an instructor puts particular weight on a certain graded assignment, then you should too. A weighted mean can significantly change a grade.

# A FOCUS ON PEDAGOGY AND PRACTICE



## 8 Hypothesis Testing: Significance, Effect Size, and Power

### Learning Objectives

1. Identify the four steps of hypothesis testing.
2. Define null hypothesis, alternative hypothesis, level of significance, test statistics,  $p$  value, and statistical significance.
3. Define Type I error and Type II error, and identify the type of error that researchers commit.
4. Calculate the one-sample  $t$  test and interpret the results.
5. Distinguish between a one-tailed test and a two-tailed test, and explain why a Type II error is possible only with one-tailed tests.
6. Calculate effect size and compute a Cohen's  $d$  for the one-sample  $t$  test.
7. Define power and identify six factors that influence power.
8. Summarize the results of a one-sample  $t$  test in American Psychological Association (APA) format.

Chapter Learning Objectives are revisited and explained in Chapter Summaries.

### CHAPTER SUMMARY ORGANIZED BY LEARNING OBJECTIVE

1. Identify the four steps of hypothesis testing.
  - Hypothesis testing is a systematic way of testing a claim or hypothesis about a parameter of a population using data measured on a sample. In this method, we test a hypothesis by determining the likelihood that a sample statistic would be selected if the hypothesis regarding the population parameter were true. The four steps of hypothesis testing are as follows:
    - Step 1: State the hypotheses.
    - Step 2: Set the criteria for a decision.
    - Step 3: Compute the test statistic.
    - Step 4: Make a decision.
2. Define null hypothesis, alternative hypothesis, level of significance, test statistics,  $p$  value, and statistical significance.
  - The null hypothesis ( $H_0$ ) is a statement about a population parameter, such as the population mean, that is assumed to be true.
  - The alternative hypothesis ( $H_1$ ) is a statement that directly contradicts a null hypothesis by stating that the actual value of a population parameter is either more, less than, or not equal to the value stated in the null hypothesis.
  - A level of significance is a criterion of evidence upon which a decision is made regarding the value stated in a null hypothesis. The criterion is based on the probability of obtaining a statistic measured on a sample if the value stated in the null hypothesis were true.
  - The test statistic is a mathematical formula that allows us to determine the likelihood of the null hypothesis being true. The value of a test statistic can be used to make inferences concerning the value of a population parameter stated in the null hypothesis.
  - A  $p$  value is the probability of obtaining a sample outcome given that the value stated in the null hypothesis is true. The  $p$  value of a sample outcome is compared to the level of significance.
  - Significance, or statistical significance, describes a decision made concerning a value stated in the null hypothesis. When a null hypothesis is rejected, a statistical significance level is reached, and the null hypothesis is rejected.
3. Define Type I error and Type II error, and identify the type of error that researchers commit.
  - We can decide to reject or reject a null hypothesis, and this decision can be

## Learning Checks

with answers appear throughout each chapter, helping students assess their understanding of key concepts.

## LEARNING CHECK 4

1. State the two steps for locating the cutoff score for a given proportion of data.
2. What are the  $z$  scores associated with the following probabilities toward the tail in a normal distribution?
  - (a) .4013
  - (b) .3050
  - (c) .0250
  - (d) .0505
3. State the  $z$  score that most closely approximates the following probabilities:
  - (a) Top 10% of scores
  - (b) Bottom 10% of scores
  - (c) Top 50% of scores

Answers: 1. Step 1: Locate the  $z$  score associated with a given proportion in the unit normal table. Step 2: Transform the  $z$  score into a raw score. 2. (a)  $z = 0.25$ , (b)  $z = 0.51$ , (c)  $z = 1.96$ , (d)  $z = 1.64$ . 3. (a)  $z = 1.28$ , (b)  $z = -1.28$ , (c)  $z = 0$ .

### END-OF-CHAPTER PROBLEMS

#### Factual Problems

1. Define normal distribution.
2. Why is the normal distribution applied to behavior?
3. Name the characteristics of the normal distribution.
4. What are the values of the mean and the standard deviation in the standard normal distribution?
5. What is a  $z$  score?
6. Name the standard normal transformation for mean and standard deviation.

#### Concept and Application Problems

1. Using the unit normal table, find the proportion under the standard normal curve that lies to the right of each of the following:
  - (a)  $z = 1.00$
  - (b)  $z = 1.65$
  - (c)  $z = 1.00$
  - (d)  $z = 2.00$
  - (e)  $z = -0.50$
2. Using the unit normal table, find the proportion under the standard normal curve that lies to the left of each of the following:
  - (a)  $z = 0.50$
  - (b)  $z = 1.52$
  - (c)  $z = 0.00$
  - (d)  $z = -0.50$
  - (e)  $z = -0.50$
3. Using the unit normal table, find the proportion under the standard normal curve that lies between each of the following:
  - (a) The mean and  $z = 1.96$
  - (b) The mean and  $z = 1.96$
  - (c)  $z = -0.50$  and  $z = 1.96$
  - (d)  $z = -0.50$  and  $z = -0.50$
  - (e)  $z = 1.96$  and  $z = 2.00$
4. What are two steps to locate proportions under the normal curve?
5. What are two ways to locate the cutoff score for a given proportion?
6. What type of distribution is the standard normal distribution?
7. The values of  $z$  and  $t$  are equal at  $t = 1.00$  and  $z = 1.00$ . What is the normal approximation to the  $t$  distribution?
8. State whether the test area is larger, the test area is equal to, or the test area is smaller to each of the following situations:
  - (a) The area to the left of  $z = 1.00$  and the area to the right of  $z = 1.00$
  - (b) The area to the left of  $z = 1.00$  and the area to the right of  $z = 1.00$
  - (c) The area between the mean and  $z = 1.00$  and the area to the right of  $z = 1.00$
  - (d) The area to the left of the mean and the area between  $z = 1.00$  and the area to the right of  $z = 1.00$
  - (e) The area to the right of  $z = 1.00$  and the area to the left of  $z = 1.00$
9. An athlete's performance is normally distributed with a mean of 100 and a standard deviation of 10. What percentage of athletes on the team score 110 or more?
10. A set of data is normally distributed with a mean of 100 and a standard deviation of 10. State whether the test area is larger, the test area is equal to, or the test area is smaller to each of the following situations for these data:
  - (a) The area above the mean and the area below the mean
  - (b) The area between 2.0 and 4.0 and the area between 1.5 and 4.7
  - (c) The area between the mean and 3.5 and the area above 3.5
  - (d) The area below 3.4 and the area above 3.4
  - (e) The area between 4.1 and 4.7 and the area between 2.9 and 3.3

#### Problems in Research

1. The accuracy of the decision. Moore (2007) stated that research on expert decision is based on three assumptions: (1) The decision is an ability that can be measured. (2) The ability is distributed like many other abilities (i.e., normally). (3) Therefore, only a very few people will be highly accurate. (p. 110). How does the researcher know that very few people will be highly accurate at decision?
2. A set of scores measuring aggression is normally distributed with a mean equal to 2.1 and a standard deviation equal to 2.5. Find the proportion:
  - (a) To the left of  $z = 1.96$
  - (b) To the right of  $z = 2.5$
  - (c) Between the mean and  $z = 1.96$
  - (d) To the right of  $z = 1.96$
3. A normal distribution has a mean equal to 45. What is the standard deviation of this normal distribution if 2.5% of the population is to the right of  $z = 1.64$ ?
4. A normal distribution has a mean equal to 10. What is the standard deviation of this normal distribution if the proportion to the right of  $z = 1.28$  is 0.10?
5. A normal distribution has a standard deviation equal to 10. What is the mean of this normal distribution if the probability of scoring above  $z = 2.00$  is 0.025?
6. A normal distribution has a standard deviation equal to 10. What is the mean of this normal distribution if the probability of scoring below  $z = 1.96$  is 0.975?
7. According to national data, about 10% of American college students earn a graduate degree. Using the normal distribution, what is the probability that exactly 25 students will earn a graduate degree? Hint: Use the normal approximation to the binomial distribution, where  $p = 0.10$  and  $q = 0.90$ .
8. Body image satisfaction among men and women. May, Bucchieri, and Jones (2007) reported 107 men and 103 women completed a series of surveys pertaining to factors such as body image and body satisfaction. Using the body image satisfaction scale, where higher scores indicate greater satisfaction, they found that men scored  $M = 4.13$  ( $SD = 0.70$ ), whereas women scored  $M = 4.44$  ( $SD = 0.70$ ) on the body image satisfaction scale. Are these data normally distributed?

"I like the objectives, the readability of the text, the straightforwardness of the presentations of concepts, the problems that are quite appropriate on many levels (computation, theory, etc.), and the emphasis on SPSS."

—Ted R. Bitner,  
DePauw University



More than 30 problems (organized by type) at the end of each chapter provide a wealth of opportunities for practice.

# A FOCUS ON RESOURCES



edge.sagepub.com/priviterastats2e

## Instructor Edge—

**SAGE edge for Instructors** supports teaching by making it easy to integrate quality content and create a rich learning environment for students. The SAGE edge instructor site includes:

- Extensive author-created test bank
- Sample course syllabi
- Editable, chapter-specific PowerPoint slides
- EXCLUSIVE Access to full-text SAGE journal articles
- Multimedia content
- Lecture notes
- A course cartridge for easy LMS integration

## Student Edge—

**SAGE edge for Students** provides a personalized approach to help students accomplish their coursework goals in an easy-to-use learning environment and features elements such as:

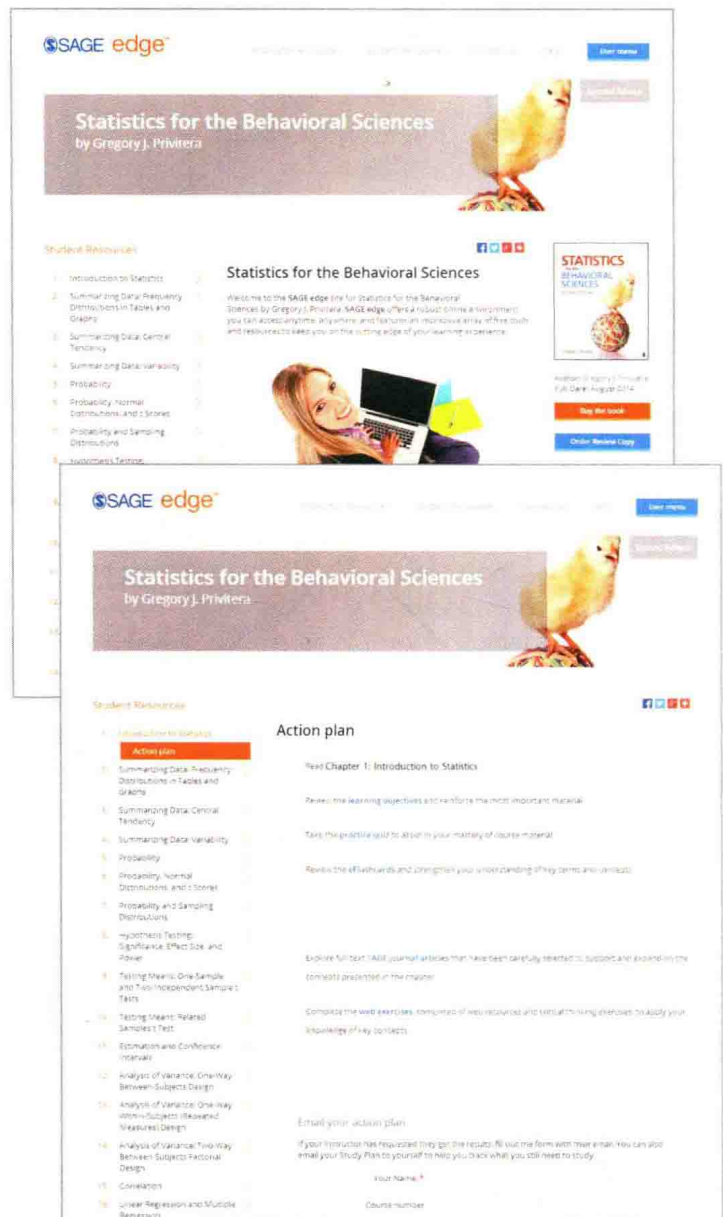
- Mobile-friendly eFlashcards and quizzes
- An online action plan that includes tips and feedback on course progress
- Chapter summaries
- Interactive exercises and meaningful web links
- EXCLUSIVE Access to full-text SAGE journal articles

## Price Edge—

SAGE provides students a great value and is priced **40+% less** than the average competing text price.

## Also Available:

- **WebAssign**, a powerful tool for creating online, auto-graded homework specific to the text
- **Student Study Guide**, with additional activities and exercises—only \$5 when bundled with the text!



*"I think the resource package is excellent."*

—Ronald W. Stoffey,  
Kutztown University of Pennsylvania



# Statistics for the Behavioral Sciences

Second Edition

Gregory J. Privitera

# ... Detailed Contents

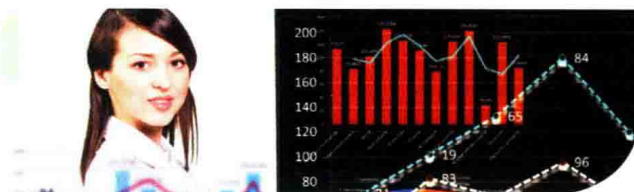
About the Author	xxiii
Acknowledgments	xxv
Preface to the Instructor	xxviii
To the Student—How to Use SPSS With This Book	xxxv

## PART I INTRODUCTION AND DESCRIPTIVE STATISTICS



<b>Chapter 1. Introduction to Statistics</b>	<b>2</b>
1.1 The Use of Statistics in Science	3
1.2 Descriptive and Inferential Statistics	4
Descriptive Statistics	5
Inferential Statistics	6
<b>MAKING SENSE—Populations and Samples</b>	<b>7</b>
1.3 Research Methods and Statistics	8
Experimental Method	9
<b>MAKING SENSE—Experimental and Control Groups</b>	<b>11</b>
Quasi-Experimental Method	12
Correlational Method	13
1.4 Scales of Measurement	15
Nominal Scales	15
Ordinal Scales	16
Interval Scales	17
Ratio Scales	18

1.5 Types of Variables for Which Data Are Measured	19
Continuous and Discrete Variables	19
Quantitative and Qualitative Variables	19
1.6 Research in Focus: Evaluating Data and Scales of Measurement	21
1.7 SPSS in Focus: Entering and Defining Variables	22
Chapter Summary Organized by Learning Objective	25
Key Terms	25
End-of-Chapter Problems	26
Factual Problems	26
Concept and Application Problems	26
Problems in Research	28



<b>Chapter 2. Summarizing Data: Frequency Distributions in Tables and Graphs</b>	<b>30</b>
2.1 Why Summarize Data?	31
2.2 Frequency Distributions for Grouped Data	32
Simple Frequency Distributions	33
Cumulative Frequency	37
Relative Frequency	39
Relative Percent	39
Cumulative Relative Frequency and Cumulative Percent	40

2.3 Identifying Percentile Points and Percentile Ranks	41
2.4 SPSS in Focus: Frequency Distributions for Quantitative Data	43
2.5 Frequency Distributions for Ungrouped Data	46
2.6 Research in Focus: Summarizing Demographic Information	48
2.7 SPSS in Focus: Frequency Distributions for Categorical Data	49
2.8 Pictorial Frequency Distributions	50
2.9 Graphing Distributions:	
Continuous Data	52
Histograms	52
Frequency Polygons	53
Ogives	53
Stem-and-Leaf Displays	55
2.10 Graphing Distributions: Discrete and Categorical Data	56
Bar Charts	57
Pie Charts	58
2.11 Research in Focus: Frequencies and Percents	60
2.12 SPSS in Focus: Histograms, Bar Charts, and Pie Charts	60
Chapter Summary Organized by Learning Objective	62
Key Terms	64
End-of-Chapter Problems	64
Factual Problems	64
Concept and Application Problems	65
Problems in Research	68



<b>Chapter 3. Summarizing Data: Central Tendency</b>	<b>70</b>
3.1 Introduction to Central Tendency	71
3.2 Measures of Central Tendency	72
The Mean	72
The Weighted Mean	74
<b>MAKING SENSE—Making the Grade</b>	<b>75</b>
The Median	76
The Mode	78
3.3 Characteristics of the Mean	80
Changing an Existing Score	80
Adding a New Score or Removing an Existing Score	80
Adding, Subtracting, Multiplying, or Dividing Each Score by a Constant	82
Summing the Differences of Scores From Their Mean	83
Summing the Squared Differences of Scores From Their Mean	84
3.4 Choosing an Appropriate Measure of Central Tendency	85
Using the Mean to Describe Data	85
Using the Median to Describe Data	87
Using the Mode to Describe Data	88
3.5 Research in Focus: Describing Central Tendency	90
3.6 SPSS in Focus: Mean, Median, and Mode	91
Chapter Summary Organized by Learning Objective	93
Key Terms	94

End-of-Chapter Problems	94
Factual Problems	94
Concept and Application Problems	94
Problems in Research	96



## Chapter 4. Summarizing Data: Variability

4.1 Measuring Variability	98
4.2 The Range	99
4.3 Research in Focus: Reporting the Range	100
4.4 Quartiles and Interquartiles	101
4.5 The Variance	103
Population Variance	104
Sample Variance	105
4.6 Explaining Variance for Populations and Samples	107
The Numerator: Why Square Deviations From the Mean?	107
The Denominator: Sample Variance as an Unbiased Estimator	108
The Denominator: Degrees of Freedom	110
4.7 The Computational Formula for Variance	111
4.8 The Standard Deviation	115
4.9 What Does the Standard Deviation Tell Us?	116

## MAKING SENSE—Standard Deviation and Nonnormal Distributions 118

4.10 Characteristics of the Standard Deviation	118
4.11 SPSS in Focus: Range, Variance, and Standard Deviation	121

Chapter Summary Organized by Learning Objective	122
Key Terms	123
End-of-Chapter Problems	124
Factual Problems	124
Concept and Application Problems	124
Problems in Research	126

## PART II PROBABILITY AND THE FOUNDATIONS OF INFERENCE STATISTICS

129



## Chapter 5. Probability 130

5.1 Introduction to Probability	131
5.2 Calculating Probability	131
5.3 Probability and Relative Frequency	134
5.4 The Relationship Between Multiple Outcomes	137
Mutually Exclusive Outcomes	137
Independent Outcomes	139
Complementary Outcomes	140
Conditional Outcomes	141
5.5 Conditional Probabilities and Bayes's Theorem	143
5.6 SPSS in Focus: Probability Tables	144
Construct a Probability Table	144
Construct a Conditional Probability Table	145
5.7 Probability Distributions	147
5.8 The Mean of a Probability Distribution and Expected Value	149

## **MAKING SENSE—Expected Value and the “Long-Term Mean”**

**151**

5.9 Research in Focus: When Are Risks Worth Taking?	152
5.10 The Variance and Standard Deviation of a Probability Distribution	153
5.11 Expected Value and the Binomial Distribution	156
The Mean of a Binomial Distribution	157
The Variance and Standard Deviation of a Binomial Distribution	157
5.12 A Final Thought on the Likelihood of Random Behavioral Outcomes	159
Chapter Summary Organized by Learning Objective	159
Key Terms	161
End-of-Chapter Problems	161
Factual Problems	161
Concept and Application Problems	162
Problems in Research	164

Locating Proportions Above the Mean	176
Locating Proportions Below the Mean	178
Locating Proportions Between Two Values	180

6.7 Locating Scores	182
---------------------	-----

6.8 SPSS in Focus: Converting Raw Scores to Standard z Scores	185
---	-----

## **MAKING SENSE—Standard Deviation and the Normal Distribution**

**186**

6.9 Going From Binomial to Normal	188
-----------------------------------	-----

6.10 The Normal Approximation to the Binomial Distribution	191
--	-----

Chapter Summary Organized by Learning Objective	193
---	-----

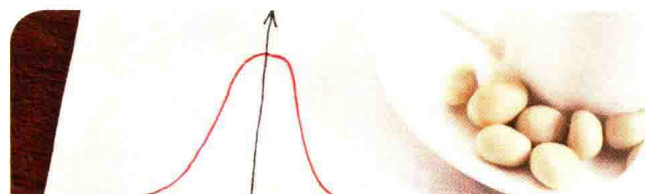
Key Terms	194
-----------	-----

End-of-Chapter Problems	195
-------------------------	-----

Factual Problems	195
------------------	-----

Concept and Application Problems	195
----------------------------------	-----

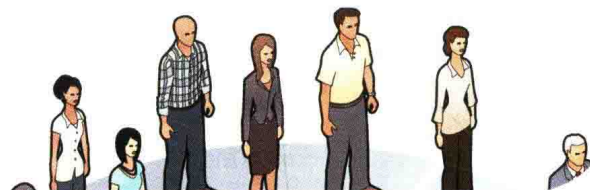
Problems in Research	196
----------------------	-----



## **Chapter 6. Probability, Normal Distributions, and z Scores**

**166**

6.1 The Normal Distribution in Behavioral Science	167
6.2 Characteristics of the Normal Distribution	167
6.3 Research in Focus: The Statistical Norm	170
6.4 The Standard Normal Distribution	171
6.5 The Unit Normal Table: A Brief Introduction	173
6.6 Locating Proportions	175



## **Chapter 7. Probability and Sampling Distributions**

**198**

7.1 Selecting Samples From Populations	199
Inferential Statistics and Sampling Distributions	199
Sampling and Conditional Probabilities	200

7.2 Selecting a Sample: Who's In and Who's Out?	202
Sampling Strategy: The Basis for Statistical Theory	203
Sampling Strategy: Most Used in Behavioral Research	204

7.3 Sampling Distributions: The Mean	206
Unbiased Estimator	206
Central Limit Theorem	207

Minimum Variance	209
Overview of the Sample Mean	209
7.4 Sampling Distributions: The Variance	210
Unbiased Estimator	211
Skewed Distribution Rule	212
No Minimum Variance	212
<b>MAKING SENSE—Minimum Variance Versus Unbiased Estimator</b>	<b>213</b>
Overview of the Sample Variance	214
7.5 The Standard Error of the Mean	214
7.6 Factors That Decrease Standard Error	216
7.7 SPSS in Focus: Estimating the Standard Error of the Mean	217
7.8 APA in Focus: Reporting the Standard Error	219
7.9 Standard Normal Transformations With Sampling Distributions	221
Chapter Summary Organized by Learning Objective	224
Key Terms	225
End-of-Chapter Problems	225
Factual Problems	225
Concept and Application Problems	226
Problems in Research	227

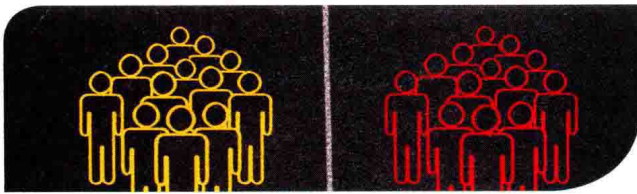
## PART III MAKING INFERENCES ABOUT ONE OR TWO MEANS 229



### Chapter 8. Hypothesis Testing: Significance, Effect Size, and Power 230

8.1 Inferential Statistics and Hypothesis Testing	231
8.2 Four Steps to Hypothesis Testing	233

<b>MAKING SENSE—Testing the Null Hypothesis</b>	<b>234</b>
8.3 Hypothesis Testing and Sampling Distributions	237
8.4 Making a Decision: Types of Error	239
Decision: Retain the Null Hypothesis	239
Decision: Reject the Null Hypothesis	240
8.5 Testing for Significance: Examples Using the z Test	240
Nondirectional Tests ( $H_1: \neq$ )	241
Directional Tests ( $H_1: >$ or $H_1: <$ )	244
8.6 Research in Focus: Directional Versus Nondirectional Tests	247
8.7 Measuring the Size of an Effect: Cohen's $d$	248
8.8 Effect Size, Power, and Sample Size	251
The Relationship Between Effect Size and Power	251
The Relationship Between Sample Size and Power	254
8.9 Additional Factors That Increase Power	255
Increasing Power: Increase Effect Size, Sample Size, and Alpha	255
Increasing Power: Decrease Beta, Standard Deviation ( $\sigma$ ), and Standard Error	256
8.10 SPSS in Focus: A Preview for Chapters 9 to 18	257
8.11 APA in Focus: Reporting the Test Statistic and Effect Size	257
Chapter Summary Organized by Learning Objective	258
Key Terms	260
End-of-Chapter Problems	260
Factual Problems	260
Concept and Application Problems	260
Problems in Research	262

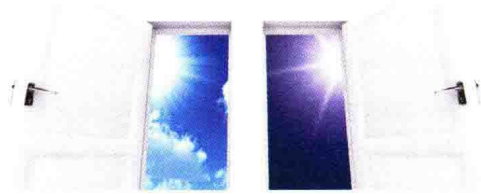


## Chapter 9. Testing Means: One-Sample and Two-Independent-Sample $t$ Tests 264

9.1 Going From $z$ to $t$	265
9.2 The Degrees of Freedom	266
9.3 Reading the $t$ Table	267
9.4 One-Sample $t$ Test	268
9.5 Effect Size for the One-Sample $t$ Test	273
Estimated Cohen's $d$	273
Proportion of Variance	273
9.6 SPSS in Focus: One-Sample $t$ Test	276
9.7 Two-Independent-Sample $t$ Test	278

## MAKING SENSE—The Pooled Sample Variance 282

9.8 Effect Size for the Two-Independent-Sample $t$ Test	284
Estimated Cohen's $d$	285
Proportion of Variance	285
9.9 SPSS in Focus: Two-Independent-Sample $t$ Test	287
9.10 APA in Focus: Reporting the $t$ Statistic and Effect Size	289
Chapter Summary Organized by Learning Objective	289
Key Terms	291
End-of-Chapter Problems	291
Factual Problems	291
Concept and Application Problems	292
Problems in Research	294



## Chapter 10. Testing Means: The Related-Samples $t$ Test 296

10.1 Related and Independent Samples	297
The Repeated-Measures Design	297
The Matched-Pairs Design	298
10.2 Introduction to the Related-Samples $t$ Test	300
The Test Statistic	302
Degrees of Freedom	302
Assumptions	302
10.3 The Related Samples $t$ Test: Repeated-Measures Design	303

## MAKING SENSE—Increasing Power by Reducing Error 306

10.4 SPSS in Focus: The Related-Samples $t$ Test	307
10.5 The Related-Samples $t$ Test: Matched-Pairs Design	309
10.6 Measuring Effect Size for the Related-Samples $t$ Test	313
Estimated Cohen's $d$	314
Proportion of Variance	314
10.7 Advantages for Selecting Related Samples	315
10.8 APA in Focus: Reporting the $t$ Statistic and Effect Size for Related Samples	316
Chapter Summary Organized by Learning Objective	316
Key Terms	318

End-of-Chapter Problems	318
Factual Problems	318
Concept and Application Problems	319
Problems in Research	321



## Chapter 11. Estimation and Confidence Intervals 324

11.1 Point Estimation and Interval Estimation	325
11.2 The Process of Estimation	327
11.3 Estimation for the One-Sample $z$ Test	329

### MAKING SENSE—Estimation, Significance, and Effect Size 333

11.4 Estimation for the One-Sample $t$ Test	334
11.5 SPSS in Focus: Confidence Intervals for the One-Sample $t$ Test	337
11.6 Estimation for the Two-Independent-Sample $t$ Test	339
11.7 SPSS in Focus: Confidence Intervals for the Two-Independent-Sample $t$ Test	340
11.8 Estimation for the Related-Samples $t$ Test	341
11.9 SPSS in Focus: Confidence Intervals for the Related-Samples $t$ Test	343
11.10 Characteristics of Estimation: Precisions and Certainty	344
11.11 APA in Focus: Reporting Confidence Intervals	346
Chapter Summary Organized by Learning Objective	346
Key Terms	348
End-of-Chapter Problems	348

Factual Problems	348
Concept and Application Problems	348
Problems in Research	351

## PART IV MAKING INFERENCES ABOUT THE VARIABILITY OF TWO OR MORE MEANS 353



## Chapter 12. Analysis of Variance: One-Way Between-Subjects Design 354

12.1 Increasing $k$ : A Shift to Analyzing Variance	355
12.2 An Introduction to Analysis of Variance	356
Identifying the Type of ANOVA	357
Two Ways to Select Independent Samples	357
Changes in Notation	359
12.3 Sources of Variation and the Test Statistic	360
12.4 Degrees of Freedom	362
12.5 The One-Way Between-Subjects ANOVA	364

### MAKING SENSE—Mean Squares and Variance 372

12.6 What Is the Next Step?	372
12.7 Post Hoc Comparisons	373
Fisher's Least Significant Difference (LSD) Test	375
Tukey's Honestly Significant Difference (HSD) Test	376
12.8 SPSS in Focus: The One-Way Between-Subjects ANOVA	379

12.9 Measuring Effect Size	383
Eta-Squared ( $\eta^2$ or $R^2$ )	383
Omega-Squared ( $\omega^2$ )	384
12.10 APA in Focus: Reporting the <i>F</i> Statistic, Significance, and Effect Size	385
Chapter Summary Organized by Learning Objective	386
Key Terms	388
End-of-Chapter Problems	388
Factual Problems	388
Concept and Application Problems	389
Problems in Research	392



## **Chapter 13. Analysis of Variance: One-Way Within-Subjects (Repeated-Measures) Design** 394

13.1 Observing the Same Participants Across Groups	395
The One-Way Within-Subjects ANOVA	395
Selecting Related Samples: The Within- Subjects Design	395
13.2 Sources of Variation and the Test Statistic	396
Between-Groups Variation	396
Error Variation	397

### **MAKING SENSE—Sources of Error** 399

13.3 Degrees of Freedom	400
13.4 The One-Way Within-Subjects ANOVA	400

### **MAKING SENSE—Mean Squares and Variance** 409

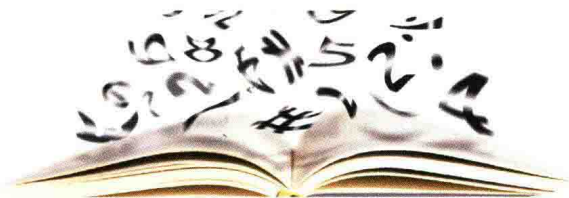
13.5 Post Hoc Comparisons: Bonferroni Procedure	409
--	-----

13.6 SPSS in Focus: The One-Way Within-Subjects ANOVA	412
13.7 Measuring Effect Size	416
Partial Eta-Squared ( $\eta^2_p$ )	416
Partial Omega-Squared ( $\omega^2_p$ )	417
13.8 The Within-Subjects Design: Consistency and Power	418
13.9 APA in Focus: Reporting the <i>F</i> Statistic, Significance, and Effect Size	423
Chapter Summary Organized by Learning Objective	423
Key Terms	425
End-of-Chapter Problems	425
Factual Problems	425
Concept and Application Problems	426
Problems in Research	429



## **Chapter 14. Analysis of Variance: Two-Way Between- Subjects Factorial Design** 432

14.1 Observing Two Factors at the Same Time	433
14.2 New Terminology and Notation	434
14.3 Designs for the Two-Way ANOVA	436
The 2-Between or Between-Subjects Design	436
The 1-Between 1-Within or Mixed Design	437
The 2-Within or Within-Subjects Design	438
14.4 Describing Variability:	
Main Effects and Interactions	439
Sources of Variability	439
Testing Main Effects	442
Testing the Interaction	443

<b>MAKING SENSE—Graphing Interactions</b>	<b>445</b>	<b>MAKING SENSE—Understanding Covariance</b>	<b>486</b>
Outcomes and Order of Interpretation	446	Effect Size: The Coefficient of Determination	489
14.5 The Two-Way Between-Subjects ANOVA	447	Hypothesis Testing: Testing for Significance	489
14.6 Analyzing Main Effects and Interactions	456	15.4 SPSS in Focus: Pearson Correlation Coefficient	491
Interactions: Simple Main Effect Tests	456	15.5 Assumptions of Tests for Linear Correlations	492
Main Effects: Pairwise Comparisons	461	Homoscedasticity	492
14.7 Measuring Effect Size	463	Linearity	492
Eta-Squared ( $\eta^2$ or $R^2$ )	463	Normality	492
Omega-Squared ( $\omega^2$ )	463	15.6 Limitations in Interpretation: Causality, Outliers, and Restrictions of Range	495
14.8 SPSS in Focus: The Two-Way Between-Subjects ANOVA	464	Causality	495
14.9 APA in Focus: Reporting Main Effects, Interactions, and Effect Size	467	Outliers	496
Chapter Summary Organized by Learning Objective	468	Restriction of Range	497
Key Terms	470	15.7 Alternative to Pearson $r$ : Spearman Correlation Coefficient	499
End-of-Chapter Problems	470	15.8 SPSS in Focus: Spearman Correlation Coefficient	502
Factual Problems	470	15.9 Alternative to Pearson $r$ : Point-Biserial Correlation Coefficient	503
Concept and Application Problems	470	15.10 SPSS in Focus: Point-Biserial Correlation Coefficient	507
Problems in Research	473	15.11 Alternative to Pearson $r$ : Phi Correlation Coefficient	509
		15.12 SPSS in Focus: Phi Correlation Coefficient	512
		15.13 APA in Focus: Reporting Correlations	514
		Chapter Summary Organized by Learning Objective	515
		Key Terms	517
		End-of-Chapter Problems	517
		Factual Problems	517
		Concept and Application Problems	517
		Problems in Research	522
<b>PART V MAKING INFERENCES ABOUT PATTERNS, FREQUENCIES, AND ORDINAL DATA</b>	<b>477</b>		
			
<b>Chapter 15. Correlation</b>	<b>478</b>		
15.1 The Structure of a Correlational Design	479		
15.2 Describing a Correlation	479		
The Direction of a Correlation	480		
The Strength of a Correlation	482		
15.3 Pearson Correlation Coefficient	484		