Mind on Statistics

Fourth Edition

Jessica M. Utts

University of California, Davis

Robert F. Heckard

Pennsylvania State University

BROOKS/COLE
CENGAGE Learning™

Australia • Brazil • Canada • Mexico • Singapore
Spain • United Kingdom • United States

Brief Contents

1	Statistics Success Stories and Cautionary Tales	1
2	Turning Data Into Information	12
3	Sampling: Surveys Stories and Cautionary Tales	70
4	Gathering Useful Data for Examining Relationships	116
5	Statistics Success Stories and Cautionary Tales	150
6	Statistics Success Stories and Cautionary Tales	192
7	Probability	228
8	Relationships and Cautionary Tales	278
9	Understanding Sampling Distributions: Statistics a Random Variables	330
10	Statistics Success Stories and Cautionary Tales	400
11	Some Important Statistical Principles	442
12	Examining Relationships	494
13	Distributions: Statistics a Random Variables	550
14	Statistics Success Stories and Cautionary Tales	598
15	Stories and Cautionary for Statistics	634
16	Tools for Conceptual Understanding	668
17	Understanding Stories and Cautionary Tales	704

Contents

Preface

1 Statistics Success Stories and Cautionary Tales 1

1.1 What Is Statistics? 1
1.2 Seven Statistical Stories with Morals 2
1.3 The Common Elements in the Seven Stories 7
Key Terms 8
In Summary Boxes 8
Exercise 9

2 Turning Data Into Information 12

2.1 What Is Statistics? 1
2.2 Seven Statistical Stories with Morals 2
2.3 The Common Elements in the Seven Stories 7
Key Terms 8
In Summary List 8
Exercise 9

3 Statistics Success Stories and Cautionary Tales 70

3.1 What Is Statistics? 71
3.2 Seven Statistical Stories with Morals 75
3.3 The Common Elements in the Seven Stories 80
3.4 Seven Statistical Stories with Morals 96
Key Terms 8
In Summary List 8
Exercise 9

4 Statistics Success Stories and Cautionary Tales 116

4.1 What Is Statistics? 1
4.2 Seven Statistical Stories with Morals 2
4.3 The Common Elements in the Seven Stories 7
4.4 The Common Elements in the Seven Stories 7
4.5 The Common Elements in the Seven Stories 7
Key Terms 8
In Summary List 8
Exercise 9

15 Statistics Success Stories and Cautionary Tales 634

15.1 What Is Statistics? 1
15.2 Seven Statistical Stories with Morals 2
15.3 The Common Elements in the Seven Stories 7
Key Terms 8
In Summary List 8
Exercise 9

16 Analysis of Variance 668

16.1 What Is Statistics? 1
16.2 Seven Statistical Stories with Morals 2
16.3 The Common Elements in the Seven Stories 7
16.4 The Common Elements in the Seven Stories 7
16.5 The Common Elements in the Seven Stories 7
Key Terms 8
In Summary List 8
Exercise 9

17 Turning Information Into Wisdom 704

17.1 What Is Statistics? 1
17.2 Seven Statistical Stories with Morals 2
17.3 The Common Elements in the Seven Stories 7
17.4 The Common Elements in the Seven Stories 7
17.5 The Common Elements in the Seven Stories 7
Key Terms 8
In Summary List 8
Exercise 9

Preface

A Challenge

The seven stories were meant to bring life to our definition of statistics. Let's consider that definition again:

- Collection of procedures and principles for gathering data and analyzing information to help people make decisions when faced with uncertainty.
- Make decisions when faced with uncertainty.

Think back over the seven stories. In every story, *data are used to make a judgment about a situation*. This common theme is what statistics is all about.

What Is Statistics and Who Should Care?

Each story illustrates part of the process of discovery of new knowledge, for which statistical methods can be very useful. The basic steps in this process are as follows:

1. *Asking the right question(s).*
2. *Collecting useful data*, which includes deciding how much is needed.
3. *Summarizing and analyzing data*, with the goal of answering the questions.
4. *Making decisions and generalizations* based on the observed data.
5. *Turning the data and subsequent decisions into new knowledge.*

We'll explore these five steps throughout the book, concluding with a chapter on "Turning Information into Wisdom." We're confident that your active participation in this exploration will benefit you in your everyday life and in your future professional career.

How Is this Book Different? Two Basic Premises of Learning

New! Original **Journal Articles** for the principles in this book will help you to understand how to be a better decision maker.

Example: What percentage of college students favors the legalization of marijuana, and what percentage of college students opposes legalization of marijuana?

Opinion about the legalization of marijuana is a categorical variable with two possible response categories (favor or oppose). In general, for one categorical variable, it is useful to ask what percentage of individuals fall into each category.

New to this Edition

Example: In Case Study 1.6, we asked if the risk of having a heart attack was different for the physicians who took aspirin than for those who took a placebo.

Does the likelihood of a male physician having a heart attack depend onwhether he has been taking aspirin or a placebo?

In a practical sense, almost all decisions in life are based on knowledge obtained by gathering and assimilating data. Sometimes the data are quantitative, as when an instructor must decide what grades to give on the basis of a collection of homework and exam scores. Sometimes the information is more qualitative and the process of assimilating it is informal, such as when you decide what you are going to wear to a party. In either case, the principles in this book will help you to understand how to be a better decision maker.

Student Resources: Tools for Expanded Learning

Updated! **Techinical Notes** In either case, the principles in this book will help you to understand how to be a better decision maker.

The **Empirical** applet on the CD accompanying this book can be used to explore how well the Empirical Rule works for each of eight variables, some with bell-shaped distributions and some with skewed distributions. The data are from the **UCDavis1** and **pennstate1** datasets on the CD for this book. A general description of the eight variables is given at the top of the Web page that includes the applet. For each variable, the applet will display a histogram along with information about the intervals ***mean±s*** and ***mean±2s***. The percent of the sample contained in each interval is reported. When the Empirical Rule applies, these two percents should be about 68% and 95%, respectively.

Tools for Conceptual Understanding

Open the **Empirical** applet. Figure 2.20 shows the initial applet display, a summary of the hours of sleep the previous night for $n = 173$ students in a UC Davis statistics class. A histogram of the hours of sleep data is displayed with superimposed vertical lines indicating the intervals ***mean±s*** and ***mean±2s***. Notice that the histogram has approximately a bell shape. Below the histogram, we see that the sample mean = 6.935 hours and the standard deviation is $s = 1.705$. Notice also that the interval ***mean±s*** = (5.23, 8.64) contains 114 of the 173 data values, which is 65.9%. The interval ***mean±2s*** = (3.525, 10.35) contains 166/173 = 95.95% of the data values. These percents are consistent with the Empirical Rule —not surprising since the distribution is approximately bell-shaped.

After examining the results for the hours of sleep variable, click on ***TVHours***, the second variable in the menu at the left of the applet display. Figure 2.21 displays the result, a summary of self-reported weekly hours of watching television for the same 173 students in the hours of sleep example. Notice that the distribution is skewed to the right, and there is an extreme outlier at 100 hours, so the Empirical Rule won't work well. Here, the interval ***mean±s***, given as − 1.484 to 19.26 hours, contains about 89% of the dataset, much more than the (approximate) 68% that would be in this interval if the Empirical Rule applied. Another difficulty is that the lower value of the interval is negative, an impossible value for weekly hours of watching television. This also is the case for the interval ***mean±2s*** = (− 11.86, 29.63).

Investigating Real-Life Questions

New!

Open the **Empirical** applet. Figure 2.20 shows the initial applet display, a summary of the hours of sleep the previous night for $n = 173$ students in a UC Davis statistics class. A histogram of the hours of sleep data is displayed with superimposed vertical lines indicating the intervals ***mean±s*** and ***mean±2s***. Notice that the histogram has approximately a bell shape. Below the histogram, we see that the sample mean = 6.935 hours and the standard deviation is $s = 1.705$. Notice also that the interval ***mean±s*** = (5.23, 8.64) contains 114 of the 173 data values, which is 65.9%. The interval ***mean±2s*** = (3.525, 10.35) contains 166/173 = 95.95% of the data values. These percents are consistent with the Empirical Rule —not surprising since the distribution is approximately bell-shaped.

After examining the results for the hours of sleep variable, click on ***TVHours***, the second variable in the menu at the left of the applet display. Figure 2.21 displays the result, a summary of self-reported weekly hours of watching television for the same 173 students in the hours of sleep example. Notice that the distribution is skewed to the right, and there is an extreme outlier at 100 hours, so the Empirical Rule won't work well. Here, the interval ***mean*±s**, given as − 1.484 to 19.26 hours, contains about 89% of the dataset, much more than the (approximate) 68% that would be in this interval if the Empirical Rule applied. Another difficulty is that the lower value of the interval is negative, an impossible value for weekly hours of watching television. This also is the case for the interval ***mean*± *2s*** = (− 11.86, 29.63).

Updated! **After examining the results** for the hours of sleep variable, click on ***TVHours***, the second variable in the menu at the left of the applet display. Figure 2.21 displays the result, a summary of self-reported weekly hours of watching television for the same 173 students in the hours of sleep example. Notice that the distribution is skewed to the right, and there is an extreme outlier at 100 hours, so the Empirical Rule won't work well. Here, the interval ***mean*±s**, given as − 1.484 to 19.26 hours, contains about 89% of the dataset, much more than the (approximate) 68% that would be in this interval if the Empirical Rule applied. Another difficulty is that the lower value of the interval is negative, an impossible value for weekly hours of watching television. This also is the case for the interval ***mean*± *2s*** = (− 11.86, 29.63).

Acknowledgments

Let's face it. You're a busy person. Why should you spend your time learning about a subject that sounds as dull as statistics? In this chapter, we give seven examples of situations in which statistics either provided enlightenment or misinformation. With these examples, we hope to convince you that learning about this subject will be interesting and useful.

Each of the stories in this chapter illustrates one or more concepts that will be developed throughout the book. These concepts are given as "the moral of the story" after a case is presented. Definitions of some terms used in the story also are provided following each case. By the time you read all of these stories, you already will have an overview of what statistics is all about.

When you hear the word statistics you probably think of lifeless or gruesome numbers, such as the population of your state or the number of violent crimes committed in your city last year. The word statistics, however, actually is used to mean two different things. The better-known definition is that statistics are numbers measured for some purpose.

1

Is a male or a female more likely to be behind the wheel of this speeding car?

See Case Study 1.1 *(p. 2)*

Statistics Success Stories and Cautionary Tales

The seven stories in this chapter are meant to bring life to the term statistics. When you are finished reading these stories, if you still think the subject of statistics is lifeless or gruesome, check your pulse!

Let's face it. You're a busy person. Why should you spend your time learning about a subject that sounds as dull as statistics? In this chapter, we give seven examples of situations in which statistics either provided enlightenment or misinformation. With these examples, we hope to convince you that learning about this subject will be interesting and useful.

Each of the stories in this chapter illustrates one or more concepts that will be developed throughout the book. These concepts are given as "the moral of the story" after a case is presented. Definitions of some terms used in the story also are provided following each case. By the time you read all of these stories, you already will have an overview of what statistics is all about.

1.1 What Is Statistics?

When you hear the word statistics you probably think of lifeless or gruesome numbers, such as the population of your state or the number of violent crimes committed in your city last year. The word statistics, however, actually is used to mean two different things. The better-known definition is that statistics are numbers measured for some purpose. A more complete definition, and the one that forms the substance of this book, is the following:

DEFINITION

Statistics is a collection of procedures and principles for gathering data and analyzing information to help people make decisions when faced with uncertainty.

Procedures and principles for gathering data and analyzing information to help people make decisions when faced with uncertainty.

The symbol is nearly always used to represent the mean of a sample. Notation for calculating the sample mean of a list of values is:

$$\overline{x} = \frac{\Sigma x_1}{n}$$

The capitalGreek letter sigma, written as Σ, is the universal symbol meaning "add up whatever follows." Therefore, for a dataset with individual values.

Principles for gathering data and analyzing information to help people make decisions when faced with uncertainty.

The stories in this chapter are meant to bring life to this definition. When you are finished reading them, if you still think the subject of statistics is lifeless or gruesome, check your pulse!

1.2 Seven Statistical Stories with Morals

The best way to gain an understanding of some of the ideas and methods used in statistical studies is to see them in action. Each of the seven stories presented in this section includes interesting lessons about how to gain information from data. The methods and ideas will be expanded throughout the book, but these seven stories will give you an excellent overview of why it is useful to study statistics. To help you understand some basic statistical principles, each case study is accompanied by a "moral of the story" and by some definitions. All of the ideas and definitions will be discussed in greater detail in subsequent chapters.

CASE STUDY 1.1 Who Are Those Speedy Drivers?

A survey taken in a large statistics class at Penn State University contained the question "What's the fastest you have ever driven a car? ____mph." The data provided by the 87 males and 102 females who responded are listed here.

Males: 110 109 90 140 105 150 120 110 110 90 115 95 145 140 110 105 85 95 100 115 124 95 100 125 140 85 120 115 105 125 102 85 120 110 120 115 94 125 80 85 140 120 92 130 125 110 90 110 110 95 95 110 105 80 100 110 130 105 105 120 90 100 105 100 120 100 100 80 100 120 105 60 125 120 100 115 95 110 101 80 112 120 110 115 125 55 90

Females: 80 75 83 80 100 100 90 75 95 85 90 85 90 90 120 85 100 120 75 85 80 70 85 110 85 75 105 95 75 70 90 70 82 85 100 90 75 90 110 80 80 110 110 95 75 130 95 110 110 80 90 105 90 110 75 100 90 110 85 90 80 80 85 50 80 100 80 80 80 95 100 90 100 95 80 80 50 88 90 90 85 70 90 30 85 85 87 85 90 85 75 90 102 80 100 95 110 80 95 90 80 90

From these numbers, can you tell which sex tends to have driven faster and by how much? Notice how difficult it is to make sense of the data when you are simply presented with a list. Even if the numbers had been presented in numerical order, it would be difficult to compare the two sexes.

Your first lesson in statistics is how to formulate a simple summary of a long list of numbers. The **dotplot** shown in Figure 1.1 helps us see the pattern in the data. In the plot, each dot represents the response of an individual student. We can see that the men tend to claim a higher "fastest ever driven" speed than do the women.

The graph shows us a lot, and calculating some statistics that summarize the data will provide additional insight. There are a variety of ways to do so, but for this example, we examine a **five-number summary** of the data for males and females. The five numbers are the lowest value; the cutoff points for 1/4, 1/2, and 3/4 of the data; and the highest value. The three middle values of the summary (the cutoff points for 1/4, 1/2, and 3/4 of the data) are called the lower quartile, median, and upper quartile, respectively. Five-number summaries can be represented like this:

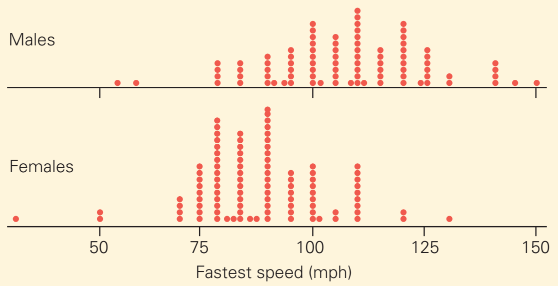


Figure 1.1 Responses to "What's the fastest you've ever driven?"

	Males (87 Students)		Females (102 Students)	
Median	110		89	
Quartiles	95	120	80	95
Extremes	55	150	30	130

Some interesting facts become immediately obvious from these summaries. By looking at the medians, you see that half of the men have driven 110 miles per hour or more, whereas the halfway point for the women is only 89 miles per hour. In fact, 3/4 of the men have driven 95 miles per hour or more, but only 1/4 of the women have done so. These facts were not at all obvious from the original lists of numbers.

Table 1.1 The Effect of Aspirin on Heart Attacks

Treatment	Heart Attacks	Doctors in Group	Attacks per 1000 Doctors
Aspirin	104	11,037	9.42
Placebo	189	11,034	17.13

1.3 The Common Elements in the Seven Stories

The seven stories were meant to bring life to our definition of statistics. Let's consider that definition again:

> **Statistics** is a collection of procedures and principles for gathering data and analyzing information to help people make decisions when faced with uncertainty.

Think back over the seven stories. In every story, *data are used to make a judgment about a situation*. This common theme is what statistics is all about.

The Discovery of Knowledge

Each story illustrates part of the process of discovery of new knowledge, for which statistical methods can be very useful. The basic steps in this process are as follows:

1. *Asking the right question(s)*.
2. *Collecting useful data*, which includes deciding how much is needed.
3. *Summarizing and analyzing data*, with the goal of answering the questions.
4. *Making decisions and generalizations* based on the observed data.
5. *Turning the data and subsequent decisions into new knowledge*.

We'll explore these five steps throughout the book, concluding with a chapter on "Turning Information into Wisdom." We're confident that your active participation in this exploration will benefit you in your everyday life and in your future professional career.

One Categorical Variable

Example: What percentage of college students favors the legalization of marijuana, and what percentage of college students opposes legalization of marijuana?

Opinion about the legalization of marijuana is a categorical variable with two possible response categories (favor or oppose). In general, for one categorical variable, it is useful to ask what percentage of individuals fall into each category.

Two Categorical Variables

Example: In Case Study 1.6, we asked if the risk of having a heart attack was different for the physicians who took aspirin than for those who took a placebo.

Does the likelihood of a male physician having a heart attack depend onwhether he has been taking aspirin or a placebo?

In a practical sense, almost all decisions in life are based on knowledge obtained by gathering and assimilating data. Sometimes the data are quantitative, as when an instructor must decide what grades to give on the basis of a collection of homework and exam scores. Sometimes the information is more qualitative and the process of assimilating it is informal, such as when you decide what you are going to wear to a party. In either case, the principles in this book will help you to understand how to be a better decision maker.

THOUGHT QUESTION 1.1 Think about a decision that you recently had to make. What "data" did you use to help you make the decision? Did you have as much information as you would have liked? If you could freely use them, how would you use the principles in this chapter to help you gain more useful information?*

***HINT:** As an example, how did you decide to live where you are living? What additional data, if any, would have been helpful?

IN SUMMARY Some Important Statistical Principles

The "moral of the story" items for the case studies presented in this chapter give a good overview of many of the important ideas covered in this book. Here is a summary:

- Simple summaries of data can tell an interesting story and are easier to digest than long lists.
- When discussing the change in the rate or risk of occurrence of something, make sure you also include the base rate or baseline risk.
- A representative sample of only a few thousand, or perhaps even a few hundred, can give reasonably accurate information about a population of many millions.
- An unrepresentative sample, even a large one, tells you almost nothing about the population.
- Cause-and-effect conclusions cannot generally be made on the basis of an observational study.
- Cause-and-effect conclusions can generally be made on the basis of randomized experiments.
- A statistically significant finding does not necessarily have practical significance or importance. When a study reports a statistically significant finding, find out the magnitude of the relationship or difference.

Key Terms

Every term in this chapter is discussed more extensively in later chapters, so don't worry if you don't understand all of the terminology that has been introduced here. The following list indicates the page number(s) where the important terms in this chapter are introduced and defined.

Section 1.1
statistics, 1

Case Study 1.1
dotplot, 2
five-number summary, 2
data, 2, 3
median, 2, 3
lower quartile, 2, 3
upper quartile, 2, 3
base rate, 3

Case Study 1.3
population, 3, 4
random sample, 3, 4
sample survey, 4
margin of error, 4

Case Study 1.4
nonresponse bias, 4
self-selected sample, 4
volunteer sample, 4

Case Study 1.5
observational study, 5
variable, 5
confounding variable, 5

Case Studies 1.6 and 1.7
randomized experiment, 5, 6
treatment, 5, 6
random assignment, 5, 6
placebo, 5, 6

In Summary Boxes

dotplot, 2
five-number summary, 2
data, 2, 3
median, 2, 3
lower quartile, 2, 3
upper quartile, 2, 3
rate, 3
risk, 3
base rate, 3
baseline risk, 3
population, 3, 4
random sample, 3, 4
sample survey, 4
margin of error, 4
nonresponse bias, 4
self-selected sample, 4
volunteer sample, 4
observational study, 5
variable, 5
confounding variable, 5
randomized experiment, 5, 6
treatment, 5, 6
random assignment, 5, 6
placebo, 5, 6

Exercises

◆ Denotes dataset is available in StatisticsNow at **http://1pass.thomson.com** or on your CD but is **not required** to solve the exercise.

Bold-numbered exercises have answers in the back of the text and fully worked solutions in the Student Solutions Manual.

Note: *Many of these exercises will be repeated in later chapters in which the relevant material is covered in more detail.*

Section 1.2

Skills Exercises

1.1 A five-number summary for the heights in inches of the women who participated in the survey in Case Study 1.1 is as shown.

	Female Heights (Inches)	
Median	65	
Quartiles	63.5	67.5
Extremes	59	71

a. What is the median height for these women?
b. What is the range of heights, that is, the difference in heights between the shortest and the tallest women?
c. What is the interval of heights containing the shortest 1/4 of the women?
d. What is the interval of heights containing the middle 1/2 of the women?

1.2 In the year 2000, Vietnamese American women had the highest rate of cervical cancer in the country. Suppose thatamong200,000Vietnamese Americanwomen, 86 developed cervical cancer.

a. Calculate the rate of cervical cancer for these women.
b. What is the estimated risk of developing cervical cancer forVietnamese Americanwomenin the next year?
c. Explain the conceptual difference between the rate and the risk, in the context of this example.

1.3 Using Case Study 1.6 as an example, explain the difference between a population and a sample.

1.4 A telephone survey of 2000 Canadians conducted March 20–30, 2001, found that "Overall, about half of Canadians in the poll say the right number of immigrants are coming into the country and that immigration has a positive effect on Canadian communities. Only 16 percent view it as a negative impact while onethird said it had no impact at all" (The Ottawa Citizen, August 17, 2001, p. A6.).

a. What is the population for this survey?
b. How many people were in the sample used for this survey?
c. What is the approximate margin of error for this survey?
d. Provide an interval of numbers that is 95% certain to cover the true percentage of Canadians who view immigration as having a negative impact.

1.5 In Case Study 1.3, the margin of error for the sample of 496 teenagers was about 4.5%. How many teenagers should be in the sample to produce each of the following as the approximate margin of error?

a. Margin of error = .05 or 5%.
b. Margin of error = .30 or 30%.

1.6 A proposed study design is to leave 100 questionnaires by the checkout line in a student cafeteria. The questionnaire can be picked up by any student and returned to the cashier. Explain why this volunteer sample is a poor study design.

1.7 For each of the examples given here, decide whether the study was an observational study or a randomized experiment.

a. A group of 100 students was randomly divided, with 50 assigned to receive vitamin C and the remaining 50 to receive a placebo, to determine whether vitamin C helps to prevent colds.
b. All patients who received a hip transplant operation at Stanford University Hospital during 1995 to 2005 will be followed for 10 years after their operation to determine the success (or failure) of the transplant.
c. A group of students who were enrolled in an introductory statistics course were randomly assigned to take a Web-based course or to take a traditional lecture course. The two methods were compared by giving the same final examination in both courses.
d. A group of smokers and a group of nonsmokers who visited a particular clinic were asked to come in for a physical exam every 5 years for the rest of their lives to monitor and compare their health status.

1.8 Suppose that an observational study showed that students who get at least 7 hours of sleep performed better on exams than students who didn't. Which of the following are possible confounding variables, and which are not? Explain why in each case.

a. Number of courses the student took that term.
b. Weight of the student.
c. Number of hours the student spent partying in a typical week.

Section Exercises

1.9 Explain the distinction between statistical significance and practical significance. Can the result of a study be statistically significant but not practically significant?

1.10 ◆ A headline in a major newspaper read, "Breast-Fed Youth Found to Do Better in School."

1.24 Refer to the study in Exercise 1.23, in which there was a statistically significant difference in the percentage of smokers who quit using a nicotine patch and a placebo patch. Now read the two cautions in the "moral of the story" for Case Study 1.7. Discuss each of them in the context of this study.

1.25 Refer to the study in Exercises 1.23 and 1.24, comparing the percentage of smokers who quit using a nicotine patch and a placebo patch. Refer to the definition of statistics given on page 1, and explain how it applies to this study.

1.25 ◆ Refer to the study in Exercises 1.23 and 1.24, comparing the percentage of smokers who quit using a nicotine patch and a placebo patch. Refer to the definition of statistics given on page 1, and explain how it applies to this study.

Chapter Exercises

1.26 The Roper Organization conducted a poll in 1992 (Roper, 1992) in which one of the questions asked was whether or not the respondent had ever seen a ghost. Of the 1525 people in the 18- to 29-year-old age group, 212 said "yes."

a. What is the risk of someone in this age group having seen a ghost?
b. What is the approximate margin of error that accompanies the proportion in part (a)?
c. What is the interval that is 95% certain to contain the actual proportion of people in this age group who have seen a ghost?

1.27 Refer to Exercise 1.26. The Roper Organization selected a random sample of adults in the United States for this poll. Suppose listeners to a late-night radio talk show were asked to call and report whether or not they had ever seen a ghost.

a. What is this type of sample called?
b. Do you think the proportion reporting that they had seen a ghost for the radio poll would be higher or lower than the proportion for the Roper poll? Explain.

Dataset Exercises

1.28 A popular Sunday newspaper magazine often includes a yes-or-no survey question such as "Do you think there is too much violence on television?" or "Do you think parents should use physical discipline?" Readers are asked to mail their answers to the magazine, and the results are reported in a subsequent issue.

a. What is this type of sample called?
b. Do you think the results of these polls represent the opinions of all readers of the magazine? Explain.

1.29 Refer to Case Study 1.6. Go through the five steps listed under "The Discovery of Knowledge" in Section 1.3, and show how each step was addressed in this study.

1.30 Refer to Case Study 1.5. Explain what mistakes were made in the implementation of steps 4 and 5 of "The Discovery of Knowledge" when USA Today reported the results of this study.

1.31 A popular Sunday newspaper magazine often includes a yes-or-no survey question such as "Do you think there is too much violence on television?" or "Do you think parents should use physical discipline?" Readers are asked to mail their answers to the magazine, and the results are reported in a subsequent issue.

a. What is this type of sample called?
b. Do you think the results of these polls represent the opinions of all readers of the magazine? Explain.

1.32 Refer to Case Study 1.6. Go through the five steps listed under "The Discovery of Knowledge" in Section 1.3, and show how each step was addressed in this study.

Section 1.3

Section Exercises

1.33 ◆ Refer to Case Study 1.5. Explain what mistakes were made in the implementation of steps 4 and 5 of "The Discovery of Knowledge" when USA Today reported the results of this study. A popular Sunday newspaper magazine often includes a yes-or-no survey question such as "Do you think there is too much violence on television?" or "Do you think parents should use physical discipline?" Readers are asked to mail their answers to the magazine, and the results are reported in a subsequent issue.

a. What is this type of sample called?
b. Do you think the results of these polls represent the opinions of all readers of the magazine? Explain.

1.34 Refer to Case Study 1.6. Go through the five steps listed under "The Discovery of Knowledge" in Section 1.3, and show how each step was addressed in this study.

1.35 Refer to Case Study 1.5. Explain what mistakes were made in the implementation of steps 4 and 5 of "The Discovery of Knowledge" when USA Today reported the results of this study.

1.36 Refer to the study in Exercises 1.23 and 1.24, comparing the percentage of smokers who quit using a nicotine patch and a placebo patch. Refer to the definition of statistics given on page 1, and explain how it applies to this study.

Thought Questions

1.37 Refer to the study in Exercises 1.23 and 1.24, comparing the percentage of smokers who quit using a nicotine patch and a placebo patch. Refer to the definition of statistics given on page 1, and explain how it applies to this study.

1.38 Refer to the study in Exercises 1.23 and 1.24, comparing the percentage of smokers who quit using a nicotine patch and a placebo patch. Refer to the definition of statistics given on page 1, and explain how it applies to this study.

1.39 Refer to the study in Exercises 1.23 and 1.24, comparing the percentage of smokers who quit using a nicotine patch and a placebo patch. Refer to the definition of statistics given on page 1, and explain how it applies to this study.

2.3 Summarizing One or Two Categorical Variables

Numerical Summaries

To summarize a categorical variable, the first step is to count how many individuals fall into each possible category. Percentages usually are more informative than counts, so the second step is to calculate the percentage in each category. These two easy steps can also be used to summarize a combination of two categorical variables.

Example 2.1 **Seatbelt Use by Twelfth-Graders** How often do you wear a seatbelt when driving a car? This is one of many questions asked in a biennial nationwide survey of American high school students. The survey, conducted as part of a federal program called the Youth Risk Behavior Surveillance System, is sponsored and organized by the U.S. Centers for Disease Control. Survey questions concern potentially risky behaviors such as cigarette smoking, alcohol use, and so on. For the question about seatbelt use when driving, possible answers were Always, Most times, Sometimes, Rarely, and Never. An additional choice allowed respondents to say that they don't drive, which often was the case because many survey participants were under the minimum legal driving age.

Table 2.1 Seatbelt Use by Twelfth-Graders When Driving

Response	Count	Percent
Always	1686	55.4%
Most times	578	19.0%
Sometimes	414	13.6%
Rarely	249	8.2%
Never	115	3.8%
Total	3042	100.00%

Table 2.1 summarizes responses in the 2003 survey given by twelfth-grade students who said that they drive. The total sample size for the table is $n = 3042$ students. Notice that a majority, $1686/3042 = .554$, or 55.4%, said that they always wear a seatbelt when driving, while just $115/3042 = .038$, or 3.8%, said that they never wear a seatbelt. Because 55.4% said that they always wear a seatbelt, we can calculate the percentage who don't always wear a seatbelt as $100\% - 55.4\% = 44.6\%$. Alternatively, the percentage saying that they don't always wear a seatbelt could be determined as $19.0\% + 13.6\% + 8.2\% + 3.8\%$, the sum of the percentages for all categories other than Always.

One stereotype about males and females is that males are more likely to engage in risky behaviors than females are. Do you think the percentage who never wear a seatbelt is greater for males than it is for females? Are females more likely to say that they always wear a seatbelt? Table 2.2 summarizes seatbelt use for twelfth-grade males and females in the sample. To facilitate comparison, percentages are given within each sex. Using these percentages, we see that females were more likely than males to respond Always.

2.8 Exercises are on page 66

Explanatory and Response Variables for Categorical Variables

In both Example 2.1 and Example 2.2, percentages were given across rows. For instance, Table 2.3 in Example 2.2 shows that 90% ($100\% \times 155/172$) of children who had slept in darkness were free of myopia but only 45% of those who had slept in full light were free of myopia. The table does not provide "column percentages" such as the fact that 34/342 or about 10% of those who were free of myopia had slept in full light.

In summarizing two categorical variables, it may be possible to identify one variable as a response variable (or outcome variable), and the other as an explanatory variable. In Example 2.1, the **outcome variable** is how often a student wears a seatbelt when driving, and the explanatory variable is gender (male or female). In Example 2.2, the outcome variable is degree of myopia, and the explanatory variable is the amount of sleeptime lighting.

Notice that in both examples, the categories of the explanatory variable defined the rows of the table and the categories of the response variable defined the columns. Tables often are formed this way, and when they are, the row percentages are of more interest than the column percentages. No matter how the table is constructed, you should determine whether one variable is a response variable and the other is an explanatory variable. Within each explanatory group, we are interested in knowing what percentage fell into each response or outcome category.

MINITAB TIP **Numerically Describing One or Two Categorical Variables**

- To determine how many and what percentage fall into the categories of a single categorical variable, use **Stat>Tables>Tally Individual Variables**. In the dialog box, specify a column containing the raw data for a categorical variable. Click on any desired options for counts and percentages under "Display."
- To create a two-way table for two categorical variables, use **Stat>Tables>Crosstabulation and Chi-Square**. Specify a categorical variable in the "For rows" box and another categorical variable in the "For columns" box. Select any desired percentages (row, column, and/or total) under "Display."

SPSS TIP **Numerically Describing One or Two Categorical Variables**

- To create a frequency table for one categorical variable, use **Analyze>Descriptive Statistics>Frequencies**.
- To create a two-way table for two categorical variables, use **Analyze>Descriptive Statistics>Crosstabs**. Use the ***Cells*** button to request row and/or column percentages.

Visual Summaries for Categorical Variables

There are two simple visual summaries that are used for categorical data:

- **Pie charts** are useful for summarizing a single categorical variable if there are not too many categories.
- **Pie charts** are useful for summarizing a single categorical variable if there are not too many categories.
- **Bar graphs** are useful for summarizing one or two categorical variables and are particularly useful for making comparisons when there are two categorical variables.

Both of these simple graphical displays are easy to construct and interpret, as the following examples demonstrate.

Example 2.3 **Humans Are Not Good Randomizers** Question 5 in the class survey described in Section 2.1 asked students to "Randomly pick a number between 1 and 10." The pie chart shown in Figure 2.1 illustrates that the results are not even close to being evenly distributed across the numbers. Notice that almost 30% of the students chose 7, while only just over 1% chose the number 1.

Figure 2.2 illustrates the same results with a bar graph. This bar graph shows the actual frequencies of responses on the vertical axis. The display makes it even more obvious that the number of students who chose 7 was more than double that of the next most popular choice. We also see that very few students chose either 1 or 10.

2.5 Numerical Summaries of Quantitative Variables

In this section, we learn how to compute numerical summaries of these features for quantitative data. Recall from Section 2.1 that the numbers in a data set are called raw data. To write formulas for some of the summaries in this section, we need notation for the raw data.

Describing the Location of a Dataset

The word location is used as a synonym for the "middle" or "center" of a dataset. There are two common ways to describe this feature.

- The **mean** is the usual numerical average, calculated as the sum of the data values divided by the number of values. It is nearly universal to represent the mean of a sample with the symbol $\overline{x}$ read as "x-bar."
- The **median** of a sample is the middle data value for an odd number of observations, after the sample has been ordered from smallest to largest. It is the average of the middle two values, in an ordered sample, for an even number of observations. We will use the letter M to represent the median of a sample.

FORMULA

Determining the Mean and Median

The Mean

The symbol $\overline{x}$ is nearly always used to represent the mean of a sample. Notation for calculating the sample mean of a list of values is

$$\overline{x} = \frac{\Sigma x_1}{n}$$

The capital Greek letter sigma, written as Σ, is the universal symbol meaning "add up whatever follows." Find *M* by averaging the values that are $(n/2)$ and $(n/2) + 1$ from the top or the bottom of the ordered list.

Therefore, for a dataset with individual values, the notation is the same as saying "add together all the values."

The Median

It would require more notation than is convenient to write a formula for the median, so we simply write the rule:

- If n is odd, the median M is the middle of the ordered values. Find M by counting $(n + 1)/2$ up from the bottom or down from the top of the ordered list.
- If n is even, the median Mis the average of the middle two of the values.

Note: If you are determining a median "by hand," your first step should be to put the data in order from lowest to highest.

The first of the next two examples illustrates how to find the median when the sample size is odd; the second shows how to find the median when the sample size is even. The second example also demonstrates how an outlier can cause the values of the mean and median to differ.

Percentiles

The quartiles and the median are special cases of **percentiles** for a dataset. In general, the kth percentile is a number that has $k\%$ of the data values at or below it and $(100 - k)\%$ of the data values at or above it. The lower quartile, median, and upper quartile are also the 25th percentile, 50th percentile, and 75th percentile, respectively. If you are told that you scored at the 90th percentile on a standardized test (such as the SAT), it indicates that 90% of the scores were at or below your score, while 10% were at or above your score.

EXCEL TIP

Suppose the dataset has been stored in a range of cells, which we represent by the word *list* in what follows. For instance, if the dataset is in column A, rows 1 to 30, then "list" is A1:A30. You can also "list" the actual numerical values themselves, rather than the range of cells containing them. All of these commands are part of the "statistical functions" provided by Excel. You can insert them directly into a cell by preceding the command with the symbol @. Some values have multiple options.

Average(list) = mean

Quartile(list, 0) = *Min(list)* = minimum value

Quartile(list, 1) = lower quartile

Quartile(list, 2) = *Median(list)* = median

Quartile(list, 3) = upper quartile

Quartile(list, 4) = *Max(list)* = maximum value

Small(list,k) gives the *k*th-smallest value, for example, *small(list,1)* = minimum

Large(list,k) gives the kth-largest value, for example, *large(list,n)* = minimum

Percentile(list,p) gives the kth percentile, where $p = k/100$. In other words, you must express the desired percentile as a proportion rather than a percent. For instance, to find the 90th percentile, use *percentile(list,.9)*.

Count(list) = *n*, the number of values in the dataset.

Note: As with most computer programs, Excel uses a more precise algorithm to find the upper and lower quartiles than the one we recommend using if you are finding them "by hand," so your values may differ slightly.

TECHNICAL NOTE

Population Mean and Standard Deviation

For reasons that will become clear later in this book, datasets are commonly treated as if they represent a sample from a larger population. However, in situations in which the dataset includes measurements for an entire population, the notations for the mean and standard deviation are different, and the formula for the standard deviation is also slightly different. A **population mean** is represented by the Greek letter m ("mu"), and a **population standard deviation** is represented by the Greek letter s ("sigma"). The formula for the population standard deviation is

$$\sigma = \frac{\Sigma(x_i - \mu)^2}{n}$$

Notice that the difference between this formula and the sample version is that the denominator is now n instead of $n - 1$. Also, the appropriate notation for the mean (population) is used.

TI-84 TIP

Numerical Summaries of a Quantitative Variable

- First store the data values into a list, say L1.
- Press STAT. Scroll horizontally to **CALC**, then scroll vertically to **1:1-Var Stats** and press ENTER. Assuming the data are in list L1, complete the expression as **1-Var Stats L1** followed by ENTER. The display will show the mean, standard deviation (both sample and population), the five-number summary, the sample size, the sum of x-values, and the sum of x2 values.

SKILLBUILDER APPLET

2.8 The Empirical Rule in Action

The **Empirical** applet on the CD accompanying this book can be used to explore how well the Empirical Rule works for each of eight variables, some with bell-shaped distributions and some with skewed distributions. The data are from the **UCDavis1** and **pennstate1** datasets on the CD for this book. A general description of the eight variables is given at the top of the Web page that includes the applet. For each variable, the applet will display a histogram along with information about the intervals ***mean±s*** and ***mean±2s***. The percent of the sample contained in each interval is reported. When the Empirical Rule applies, these two percents should be about 68% and 95%, respectively.

What to Do

Open the **Empirical** applet. Figure 2.20 shows the initial applet display, a summary of the hours of sleep the previous night for $n = 173$ students in a UC Davis statistics class. A histogram of the hours of sleep data is displayed with superimposed vertical lines indicating the intervals ***mean±s*** and ***mean±2s***. Notice that the histogram has approximately a bell shape. Below the histogram, we see that the sample mean = 6.935 hours and the standard deviation is $s = 1.705$. Notice also that the interval ***mean±s*** = (5.23, 8.64) contains 114 of the 173 data values, which is 65.9%. The interval ***mean±2s*** = (3.525, 10.35) contains 166/173 = 95.95% of the data values. These percents are consistent with the Empirical Rule —not surprising since the distribution is approximately bell-shaped.

After examining the results for the hours of sleep variable, click on ***TVHours***, the second variable in the menu at the left of the applet display. Figure 2.21 displays the result, a summary of self-reported weekly hours of watching television for the same 173 students in the hours of sleep example. Notice that the distribution is skewed to the right, and there is an extreme outlier at 100 hours, so the Empirical Rule won't work well. Here, the interval ***mean±s***, given as − 1.484 to 19.26 hours, contains about 89% of the dataset, much more than the (approximate) 68% that would be in this interval if the Empirical Rule applied. Another difficulty is that the lower value of the interval is negative, an impossible value for weekly hours of watching television. This also is the case for the interval ***mean±2s*** = (− 11.86, 29.63).

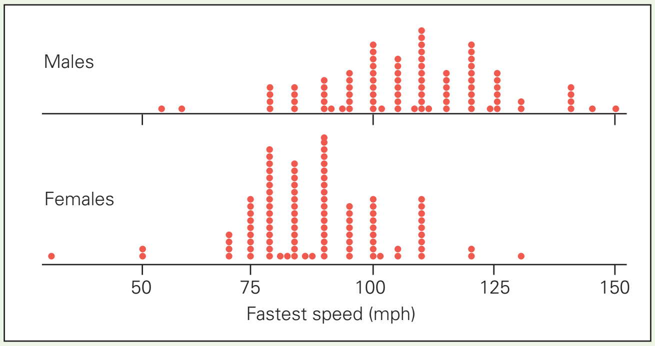


Figure 2.20 The Empirical applet display of hours of sleep reported by n = 173 students

Lessons Learned

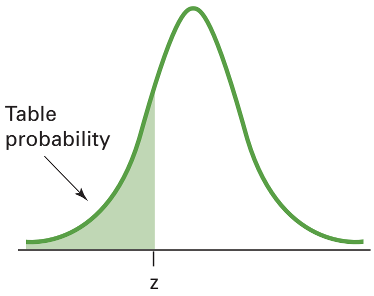
You'll see that the Empirical Rule works well when the distribution is more or less bell-shaped. But when the distribution is skewed or an extreme outlier is present, you will see that the interval ***mean±2s*** tends to include noticeably more than 68% of the dataset, and the values in the interval ***mean±2s*** generally don't match the characteristics of the actual data.

2.8 Exercises are on page 66

Appendix of Tables

Table A.1	Standard Normal Probabilities
Table A.2	t^* Multipliers for Confidence Intervals and Rejection Region Critical Values
Table A.3	One-Sided p-Values for Significance Tests Based on a t-Statistic
Table A.4	Critical Values for F-Test
Table A.5	Chi-Square Distribution

Table A.1 Standard Normal Probabilities (for $z > 0$)



z	.0	.01	.02	.03	.04	.05	.06	.07	.08	.09
−3.4	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0003	.0002
−3.3	.0005	.0005	.0005	.0004	.0004	.0004	.0004	.0004	.0004	.0003
−3.2	.0007	.0007	.0006	.0006	.0006	.0006	.0006	.0005	.0005	.0005
−3.1	.0010	.0009	.0009	.0009	.0008	.0008	.0008	.0008	.0007	.0007
−3.0	.0013	.0013	.0013	.0012	.0012	.0011	.0011	.0011	.0010	.0010
−2.9	.0019	.0018	.0018	.0017	.0016	.0016	.0015	.0015	.0014	.0014
−2.8	.0026	.0025	.0024	.0023	.0023	.0022	.0021	.0021	.0020	.0019
−2.7	.0035	.0034	.0033	.0032	.0031	.0030	.0029	.0028	.0027	.0026
−2.6	.0047	.0045	.0044	.0043	.0041	.0040	.0039	.0038	.0037	.0036
−2.5	.0062	.0060	.0059	.0057	.0055	.0054	.0052	.0051	.0049	.0048
−2.4	.0082	.0080	.0078	.0075	.0073	.0071	.0069	.0068	.0066	.0064
−2.3	.0107	.0104	.0102	.0099	.0096	.0094	.0091	.0089	.0087	.0084
−2.2	.0139	.0136	.0132	.0129	.0125	.0122	.0119	.0116	.0113	.0110
−2.1	.0179	.0174	.0170	.0166	.0162	.0158	.0154	.0150	.0146	.0143
−2.0	.0228	.0222	.0217	.0212	.0207	.0202	.0197	.0192	.0188	.0183
−1.9	.0287	.0281	.0274	.0268	.0262	.0256	.0250	.0244	.0239	.0233
−1.8	.0359	.0351	.0344	.0336	.0329	.0322	.0314	.0307	.0301	.0294
−1.7	.0446	.0436	.0427	.0418	.0409	.0401	.0392	.0384	.0375	.0367
−1.6	.0548	.0537	.0526	.0516	.0505	.0495	.0485	.0475	.0465	.0455
−1.5	.0668	.0655	.0643	.0630	.0618	.0606	.0594	.0582	.0571	.0559
−1.4	.0808	.0793	.0778	.0764	.0749	.0735	.0721	.0708	.0694	.0681
−1.3	.0968	.0951	.0934	.0918	.0901	.0885	.0869	.0853	.0838	.0823
−1.2	.1151	.1131	.1112	.1093	.1075	.1056	.1038	.1020	.1003	.0985
−1.1	.1357	.1335	.1314	.1292	.1271	.1251	.1230	.1210	.1190	.1170
−1.0	.1587	.1562	.1539	.1515	.1492	.1469	.1446	.1423	.1401	.1379
−0.9	.1841	.1814	.1788	.1762	.1736	.1711	.1685	.1660	.1635	.1611
−0.8	.2119	.2090	.2061	.2033	.2005	.1977	.1949	.1922	.1894	.1867
−0.7	.2420	.2389	.2358	.2327	.2296	.2266	.2236	.2206	.2177	.2148
−0.6	.2743	.2709	.2676	.2643	.2611	.2578	.2546	.2514	.2483	.2451
−0.5	.3085	.3050	.3015	.2981	.2946	.2912	.2877	.2843	.2810	.2776
−0.4	.3446	.3409	.3372	.3336	.3300	.3264	.3228	.3192	.3156	.3121
−0.3	.3821	.3783	.3745	.3707	.3669	.3632	.3594	.3557	.3520	.3483
−0.2	.4207	.4168	.4129	.4090	.4052	.4013	.3974	.3936	.3897	.3859
−0.1	.4602	.4562	.4522	.4483	.4443	.4404	.4364	.4325	.4286	.4247
−0.0	.5000	.4960	.4920	.4880	.4840	.4801	.4761	.4721	.4681	.4641

In the Extreme (for $z < 0$)

z	–3.09	–3.79	–4.26	–4.75	–5.20	–5.61	–6.00
Probabbility	.001	0.0001	0.00001	0.000001	0.0000001	0.00000001	0.000000001

S-PLUS was used to determine information for the "In the Extreme" portion of the table.

References

Abelson, R. P., E. F. Loftus, and A. G. Greenwald (1992). "Attempts to improve the accuracy of self-reports of voting," in *Questions about Questions,* J. M. Tanur (ed.), New York: Russell Sage Foundation, pp. 138–153.

American Statistical Association (1999). Ethical guidelines for statistical practice; available at http://www.amstat.org/ profession/.

Anastasi, Anne (1988). *Psychological Testing,* 6th ed., New York: Macmillan.

Anderson, M. J., and S.E. Fienberg (2001). *Who Counts? The Politics of Census-Taking in Contemporary America,* New York: Russell Sage Foundation.

Araf, J. (1994). "Leave Earth or perish: Sagan," *China Post,* December 14, 1994, p. 4.

Ashenfelter, Orley (1994). "Report on expected absentee ballot," revised March 29, 1994. Unpublished report submitted to Judge Clarence Newcomer, U.S. District Court, Eastern District of Pennsylvania, March 30, 1994.

Baird, D. D., and A. J. Wilcox (1985). "Cigarette smoking associated with delayed conception," *Journal of the American Medical Association,* Vol. 253, pp. 2979–2983.

Bem, D., and C. Honorton (1994). "Does psi exist? Replicable evidence for an anomalous process of information transfer," *Psychological Bulletin,* Vol. 115, No. 1, pp. 4 –18.

Bickel, P. J., E. A. Hammel, and J. W. O'Connell (1975). "Sex bias in graduate admissions: Data from Berkeley," *Science,* Vol. 187, pp. 298–304.

Borzekowski, D. L. G, T. N. Robinson, and J. D. Killen (2000). "Does the camera add 10 pounds?: Media use, perceived importance of appearance, and weight concerns among teenage girls," *Journal of Adolescent Health,* Vol. 26, pp. 36 – 41.

Bryson, M. C. (1976). "The *Literary Digest* poll: Making of a statistical myth," *American Statistician,* Vol. 30, pp. 184 –185.

Capron, C., and M. Duyme (1991). "Children's IQs and SES of biological and adoptive parents in a balanced cross-fostering study," *European Bulletin of Cognitive Psychology,* Vol. 11, No. 3, pp. 323 –348.

Carpenter, J., J. Hagemaster, and B. Joiner (1998). Letter to the editor, *Journal of the American Medical Association,* Vol. 280, No. 22, p. 1905.

Carter, C. L., D. Y Jones, A. Schatzkin, and L. A. Brinton (1989). "A prospective study of reproductive, familial, and socioeconomic risk factors for breast cancer using NHANES I data," *Public Health Reports,* Vol. 104, January –February 1989, pp. 45–49.

Casella, George, and Roger L. Berger (2002). *Statistical Inference,* 2nd ed., Belmont, CA: Brooks/Cole.

Chambers, Chris (2000). "Americans are overwhelmingly happy and optimistic about the future of the United States," Gallup Poll Press Release, October 13, 2000, www.gallup.com/poll/releases/pr001013.asp.

————(2000). "Americans dissatis

Citro, C. F. and J. L. Norwood (eds.) (1997). *The Bureau of Transportation Statistics: Priorities for the Future,* Washington, D.C.: National Academy Press.

Clark, H. H., and M. F. Schober (1992). "Asking questions and in *Questions about Questions,*

J. M. Tanur (ed.), New York: Russell Sage Foundation, pp. 15–48.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences,* 2nd ed., Hillsdale, NJ: Lawrence Erlbaum Associates.

Cohn, Victor, and Lewis Cope (2001). *News and Numbers: A Guide to Reporting Statistical Claims and Controversies in Health and Other Fields,* 2nd ed., Ames, IA: Iowa State University Press.

Cole, C. R., J. M. Foody, E. H. Blackstone, and M. S. Lauer (2000). "Heart rate recovery after submaximal exercise as a predictor of mortality in a cardiovascularly healthy cohort," *Annals of Internal Medicine,* Vol. 132, pp. 552–555.

Coren, S., and D. Halpern (1991). "Left-handedness: A marker for decreased survival ?•tness," *Psychological Bulletin,* Vol. 109, No. 1, pp. 90–106.

Crossen, Cynthia (1994). *Tainted Truth,* New York: Simon and Schuster.

Dabbs, J. M., D. de LaRue, and P. Williams (1990). "Testosterone and occupational choice: Actors, ministers, and other men," *Journal of Personality and Social Psychology,* Vol. 59, No. 6, pp. 1261–1265.

Davidson, R. J., J. Kabat-Zinn, J. Schumacher, M. Rosenkranz,

D. Muller, S. F. Santorelli, F. Urbanowski, A. Harrington, K. Bonus, and J. F. Sheridan (2003). "Alterations in brain and immune function produced by mindfulness meditation," *Psychosomatic Medicine,* Vol. 65, pp. 564–570.

Davis, Robert (1998). "Prayer can lower blood pressure," *USA Today,* August 11, 1998, p. 1D.

Devore, J., and R. Peck (1993). *Statistics: The Exploration and Analysis of Data,* 2nd ed., Belmont, CA: Duxbury Press.

Diaconis, P., and F. Mosteller (1989). "Methods for studying coincidences," *Journal of the American Statistical Association,* Vol. 84, pp. 853–861.

Eddy, D. M. (1982). "Probabilistic reasoning in clinical medicine: Problems and opportunities," Chapter 18 in D. Kahneman, P. Slovic, and A. Tversky (eds.), *Judgment under Uncertainty: Heuristics and Biases,* Cambridge, U.K.: Cambridge University Press.

Edwards, Gary, and Josephine Mazzuca (2000). "About four-inten Canadians accepting of same sex marriages, adoption," Gallup Poll Release, March 7, 2000 (www.gallup.com).

Elias, Marilyn (2001). "Web use not always a downer. Study disputes link to depression," *USA Today,* July 23, 2001, p. 1D.

Ellsworth, P. C., J. M. Carlsmith, and A. Henson (1972). "The stare as a stimulus to *Journal of Personality and Social Psychology,* Vol. 21, pp. 302 –311.

Faigenbaum, A. D., W. L. Westcott, R. LaRosa Loud, and C. Long (1999). "The effects of different resistance training protocols on muscular strength and endurance development in children,"

Pediatrics Electronic Article, Vol. 104, No. 1 (July), p. e5.
Fichtenberg, C. M., and S. A. Glantz (2000). "Association of the California Tobacco Control program with declines in cigarette consumption and mortality from heart disease," *New England Journal of Medicine,* Vol. 343, No. 24, 1772 –1777.
Fletcher, S. W., B. Black, R. Harris, B. K. Rimer, and S. Shapiro (1993). "Report of the international workshop on screening for breast cancer," *Journal of the National Cancer Institute,* Vol. 85, No. 20, Oct. 20, 1993, pp. 1644 –1656.
Freedman, D., R. Pisani, R. Purves, and A. Adhikari (1991). *Statistics,* 2nd ed., New York: W. W. Norton.
Freinkel, A. (1998). Letter to the editor, *Journal of the American Medical Association,* Vol. 280, No. 22, p. 1905.
French, J. R. P (1953). "Experiments in *Research Method in the Behavioral Sciences,* New York: Holt, pp. 98–135.

Gastwirth, J. L. (1988). *Statistical Reasoning in Law and Public Policy,* New York: Academic Press.
Gastwirth, J. L. (1988). *Statistical Reasoning in Law and Public Policy, Vol. 2: Tort Law, Evidence and Health,* Boston: Academic Press.
Gehring, W. J., and A. R. Willoughby (2000). "The medial frontal cortex and the rapid processing of monetary gains and losses," *Science,* Vol. 295, pp. 2279 –2284.
Gillespie, Mark (1999). "Local schools get passing grades: Americans support higher pay for teachers," Gallup Poll Release, Sept. 8, 1999.
Gustafson, R., and H. Kallmen (1990). "Alcohol and Color Word Test," *Perceptual and Motor Skills,* Vol. 71, pp. 99–105.

Hand, D. J., F. Daly, A. D. Lunn, K, J. McConway, and E. Ostrowski (1994). *A Handbook of Small Data Sets,* London: Chapman and Hall.
Harmon, Amy (1998). "Sad, lonely world discovered in cyberspace," *New York Times,* August 30, 1998, p. A3.
Hedges, L. V., and I. Olkin (1985). *Statistical Methods for Meta-Analysis,* New York: Academic Press.
Hite, Shere (1987). *Women and Love,* New York: Knopf.
Holbrook, M. B., and R. M. Schindler (1989). "Some explorator *Journal of Consumer Research,* Vol. 16, pp. 119–124.
Horne, J. A., L. A. Reyner, and P. R. Barrett (2003). "Driving impairment due to sleepiness is exacerbated by low alcohol intake," *Journal of Occupational and Environmental Medicine,* Vol. 60, pp. 689–692.
Howell, David C. (1997). *Statistical Methods for Psychology,* 4th ed., Belmont, CA: Duxbury.
Hurt, R., L. Dale, P. Fredrickson, C. Caldwell, G. Lee, K. Offord,
G. Lauger, Z. Maruisic, L. Neese, and T. Lundberg (1994). "Nicotine patch therapy for smoking cessation combined with physician advice and nurse follow-up," *Journal of the American Medical Association,* Vol. 271, No. 8, (Feb. 23), pp. 595–600.

Ichimaya, M. A., and M. I. Kruse (1998). "The social contexts of binge drinking among university freshmen," *Journal of Alcohol and Drug Education,* Vol. 44, pp. 18–33.
Iman, R. L. (1994). *A Data-Based Approach to Statistics,* Belmont, CA: Wadsworth.

Jorenby, D. E., S. J. Leischow, M. A. Nides, S. I. Rennard, J. A. Johnston, A. R. Hughes, S. S. Smith, M. L. Muramoto, D. M. Daughton, K. Doan, M. C. Fiore, and T. B. Baker (1999). "A controlled trial of sustained-release bupropion, a nicotine patch, or both for smoking cessation," *New England Journal of Medicine,* Vol. 340, No. 9, pp. 685 –691.

Kalichman, S. C. (1986). "Horizontality as a function of sex and academic major," *Perceptual and Motor Skills,* Vol. 63, pp. 903–908.
Kawachi, I., D. Sparrow, A. Spiro III, P. Vokonas, and S. T. Weiss (1994). "A prospective study of anger and coronary heart disease: The normative aging study," *Circulation,* Vol. 94, pp. 2090–2095.
Kiener, Robert (accessed June 3, 2005). "How honest are we?" *Reader's Digest Canada* (http://www.readersdigest.ca/mag/1997/03/think_01.html).
Kitchens, L. J. (1998). *Exploring Statistics: A Modern Introduction to Data Analysis and Inference,* 2nd ed., Boston: Dux-bury Press.
Kohlmeier, L., G. Arminger, S. Bartolomeycik, B. Bellach, J. Rehm, and M. Thamm (1992). "Pet birds as an independent risk factor for lung cancer: Case-control study," *British Medical Journal,* Vol. 305, pp. 986 –989.
Koopmans, L. H. (1987). *An Introduction to Contemporary Statistical Methods,* 2nd ed., Boston: Duxbury Press.
Krantz, Les (1992). *What the Odds Are,* New York: Harper-Perennial.
Kraut, R., V. Lundmark, M. Patterson, S. Kiesler, T. Mukopadhyay, and W. Scherlis (1998). "Internet paradox: A social technology that reduces social involvement and psychological well-being?" *American Psychologist,* Vol. 53, No. 9, pp. 1017–1031.

Lang, Susan (2003). "CU nutritionists: Junk food, all-you-caneat make 'freshman 15' a reality," Cornell Chronicle, http://www.news.cornell.edu/Chronicle/03/8.28.03/freshman_15.html, posted August 28, 2003.
Lau, Edie (2005). "Autism study *The Sacramento Bee,* 7 May 2005, pp. A1 and A26.
Lawrence, T. R. (1993). "Gathering in the sheep and goats. A Meta-analysis of forced choice sheep–goat ESP studies, 1947–1993," *Proceedings of Presented Papers: The 36th Annual Convention of the Parapsychological Association,* pp. 75–86.
Lesko, S. M., L. Rosenberg, and S. Shapiro (1993). "A case-control study of baldness in relation to myocardial infarction in men," *Journal of the American Medical Association,* Vol. 269, No. 8 (Feb. 24), pp. 998 –1003.
Levin, Alan (1999). "Planes get closer in midair as traf?•c control errors rise," *USA Today,* February 24, 1999, p. 1A.
Levy, S. (2005). "Does Your iPod Play Favorites?" *Newsweek,* January 31, 2005, p. 10.
Liss, Susan (1997). "The Effects of Survey Methodology Changes in the NPTS," Technical Report, Of Loftus, E. F., and J. C. Palmer (1974). "Reconstruction of automobile destruction: An example of the interaction between language and memory," *Journal of Verbal Learning and Verbal Behavior,* Vol. 13, pp. 585–589.
Lotufo, P. A., C. U. Chae, U. A. Ajani, C. H. Henneken, and J. E. Manson (2000). "Male pattern baldness and coronary heart disease: The physicians' health study," *Arch. Intern. Med.,* Vol. 160, pp. 165–171.

Mackowiak, P. A., S. S. Wasserman, and M. M. Levine (1992). "A critical appraisal of 98.6 degrees F, the upper limit of the normal body temperature, and other legacies of Carl Rein-hold August Wunderlich," *Journal of the American Medical Association,* Vol. 268, No. 12 (Sep. 23), pp. 1578–1580.
Martin, M. E., M. L. Straf, and C. F. Citro (eds.) (2001). *Principles and Practices for a Federal Statistical Agency,* 2nd ed., Washington, D.C.: National Academy Press.
Maugh, Thomas H., II. "Study says calcium can help ease PMS," *Sacramento Bee,* 26 August 1998, pp. A1 and A9.
Mazzuca, Josephine (2004). "Do U.S. parents rule with an iron
Mervis, Jeffrey (1998). "Report deplores science-media gap," *Science,* Vol. 279, p. 2036.
Milgram, Stanley (1983). *Obedience to Authority: An Experimental View,* New York: Harper/Collins.
Moore, David S. (1997). *Statistics: Concepts and Controversies,* 4th ed., New York: W. H. Freeman.
Morin, Richard (1995). "What informed public opinion?" *The Washington Post National Weekly Edition,* April 10 –16, 1995, p. 36.
Newcomer, Clarence (1994). Judgment in the Civil Action No. 93–6157, *Bruce S. Marks et al.* v. *William Stinson et al.,* United States District Court for the Eastern District Court of Pennsylvania, entered April 26, 1994.

Answers to Selected Exercises

The following are partial or complete answers to the exercises numbered in bold in the text.

Chapter 1

1.2 a. .00043
1.5 a. 400
1.7 c. Randomized experiment. d. Observational study.
1.11 189/11,034, or about 17/1000, based on placebo group.
1.15 a. 150 mph. b. 55 mph. c. 95 mph. d. 1/2 e. 51
1.19 No.
1.22 The base rate for that type of cancer.
1.26 a. 212/1525 = .139. b. 1/ = .026. c. .113 to .165.
1.28 a. Self-selected or volunteer. b. No. Readers with strong opinions will respond.

Chapter 2

2.1 a. 4 b. State in the United States. c. $n = 50$.
2.3 a. Whole population. b. Sample.
2.5 a. Population parameter. b. Sample statistic. c. Sample statistic.
2.11 a. Categorical. b. Quantitative. c. Quantitative. d. Categorical.
2.12 a. Categorical. b. Ordinal.
2.14 a. Not continuous.
2.15 a. Explanatory is amount of walking or running; response is lung function.
2.16 a. Support ban or not; categorical. b. Gain on verbal and math SATs after program; quantitative. c. Smoker or not and Alzheimer sufferer or not; both categorical.
2.17 a. Pulse rate and gender.
2.19 Example: Letter grades (A, B, etc.) converted to GPA.
2.22 a. 1427/2530 = .564, or 56.4%. b. 100% = 56.4% = 43.6%.
2.23 a. 1700/2470 = .688, or 68.8%. b. 1056/1700 = .621, or 62.1%.
2.24 c. Overweight = 26.57%; about right = 69.23%; underweight = 4.20%.
2.26 a. Explanatory is smoked or not; response is developed Alzheimer's disease or not.
2.30 Either could be justified as being more informative.
2.33 a. 150 mph. b. 55 mph. c. 95 mph. d. 1/2 e. 51
2.34 a. Median is greater for males. b. Spread between extremes is about the same; spread between quartiles is slightly greater for males.
2.37 a. Skewed to the right. b. 13 ear pierces may be an outlier. c. 2 ear pierces; about 45 women had this number. d. About 32 or so.
2.39 a. Roughly symmetric. b. Highest = 92.
2.44 Yes. Values inconsistent with the bulk of the data will be obvious.
2.46 a. Shape is better evaluated by using a histogram.
2.48 Skewed to the left.
2.50 a. Median = (72 + 76)/2 = 74; mean = 74.33. b. Median = 7; mean = 25.
2.52 a. Range = 225 – 123 = 102. b. IQR = 35. c. 50%
2.53 a. Median = 12.
2.54 d. There are no outliers.
2.59 The median is 16.72 inches. The data values vary from 6.14 to 37.42 inches. The middle 1/2 of the data is between 12.05 and 25.37 inches, so "typical" annual rainfall covers quite a wide range.
2.60 The shape is somewhat skewed to the right; this increases the value of the mean compared to the median.
2.62 Median is located between 21 and 25 words.
2.64 a. 110
2.67 32, 45.5, 50, 57, 74.
2.71 Example: The age of a person who is 80 years old would be an outlier at a traditional college but not at a retirement home.
2.72 Whether it is the male author (then not an outlier) or the female author (then an outlier)
2.76 a. Between 5.3 and 8.7 hours. b. Between 3.6 and 10.4 hours.
2.78 a. $z = (200– 170)/20 = 1.5$.
2.79 a. $x = 20$; $s = 1.581$.
2.80 a. Range = 98 – 41 = 57. b. $s = 57/6 = 9.5$.
2.82 The Empirical Rule predicts about 68%, 95%, 99.7% within 1, 2, and 3 standard deviations of the mean, respectively. Data show 72%, 97%, 98%, so the set of measurements fits well.
2.83 b. $s^2 = 208.857$.
2.86 a. Somewhat unusual. Only about 2.5% of adult males will have a smaller measurement because 52 cm is two standard deviations below the mean.
2.90 a. Population. b. Population, 14.77.
2.94 a. Would hold without the two outliers; should still be close. b. Yes, range is 10.75 cm, close to 6 standard deviations. Expect between 4 and 6 standard deviations.
2.98 a. $z = –0.5$; .3085. b. $z = 2.5$; .9938.
2.100 50, 50, 50, 50, 50, 50, 50; no.
2.103 a. Mean = 51.47 years; standard deviation = 8.92 years (population standard deviation – 8.85). b. Range is 42 years, 4.7 standard deviations, so it holds. c. z for youngest CEO is –2.18, z for oldest CEO is 2.53; about as expected from the Empirical Rule.
2.110 a. This is a personal preference; some may prefer a large family. b. An outlier in the high direction.
2.111 a. Categorical. b. Quantitative.
2.113 a. Yes; night light use, for example. b. No.
2.117 a. Set 2—it covers a much wider range of heights.
2.119 a. Amount of beer consumed per unit of time (week, etc.) and systolic blood pressure. b. Calories of protein consumed per day on average and whether or not they had colon cancer.
2.122 Do the students who studied the most last week tend to be the students with the highest grade point averages?

Chapter 3

3.3 a. Yes. The heights of women in the class probably are simi-

lar to the heights of all women at the college. b. No. The sample of daycare parents is likely to be more supportive than the general population.
3.4 a. All registered voters in the community.
3.9 c. Nonresponse bias.
3.11 For example, testing manufactured parts and the test damages the products.
3.13 a. Selection bias. b. Nonresponse bias.
3.15 a. Does not hold. Professional basketball players do not represent any larger population. b. Probably holds. Students taking statistics most likely have representative pulse rates.
3.17 No. All possible sets of four songs do not have the same probability to be a sample. For example, a sample consisting of the first four songs on the first CD is impossible.
3.19 .014 or 1.4%.
3.24 b. 40% + 3.15% or 36.85% to 43.15%.
3.28 a. .49 + .03 = .46 to .52. b. .47 + .03 = .44 to .50.
3.37 a. Use 01 to 49 as is and subtract 50 from 51 to 99 to get 15, 23, 20, 21, 29, 5. b. It doesn't matter.
3.40 Simple random sample.
3.43 a. Stratified sample: Use the three types of schools as strata. Create a list of all students for each of the three strata; draw a simple random sample from each of the three lists. b. Cluster sample: Use individual schools or individual classes as clusters. Take a random sample of clusters; measure all students in those clusters. c. Simple random sample: Obtain a list of all students in the classes at all schools; take a simple random sample from that combined list.
3.46 Cluster sample because a sample of exchanges is found and then only numbers within those exchanges are sampled.
3.48 a. All taxpayers. b. Parents of all the school children.
3.52 a. Dentists who subscribe to one of two dental magazines. Yes, because not all dentists subscribe to those two magazines. b. Nonresponse. c. Send a reminder or call those who didn't respond.
3.61 Anonymous testing.
3.64 Any two questions in which one changes the way respondents would think about the other. An example: "Are you aware that over 30% of homeless people in this city are mothers with children?"î and "ìDo you think more public money should be used to help homeless people?"
3.66 Desire to please; confidentiality and anonymity.
3.69 a. Open-form question. b. Yes, because of all the publicity he had just received. c. Probably lower.
3.76 Any list that contains the two-digit strings in any order: 00, 07, 15, 19, 24, 33, 44, 51, 65, 99. For instance, 24190 03351 99076 54415.
3.79 a. Put an ad in the local paper asking people to fill out the survey. b. Ask "Don't you agree that there is too much trash in our streets and that more public trash containers are needed?"
3.85 a. All students at the university. b. All students enrolled in statistics classes. c. The 500 students to whom the survey was mailed.
3.87 The sample sizes or margin of error. The 20% versus 25% may be within the margin of error for the surveys.
3.89 The quickie poll would probably be most representative.
3.91 Nonresponse.
3.92 b. Send the survey to a legitimate random sample, but make the questions so outrageous that only those who support the position would respond; others would not take it seriously.
3.96 No, only those who are likely to vote should be used.
3.99 Larger; the sample size for Republicans only would be smaller.
3.101 a. .078; .66 + .078 or 58.2% to 73.8%. b. .066; .38 – .066 or 31.4% to 44.6%. c. Yes, intervals do not overlap.

Chapter 4

4.3 c. Observational study.
4.4 a. Response variable is daughter's height.
4.7 c. Randomized experiment. d. Observational study.
4.9 a. Probably not, because long-term meditation is a matter of choice, not easily randomly assigned. b. Yes, volunteers could be randomly assigned to attend the program or not.
4.10 a. The explanatory variable is long-term practice of meditation; the response is blood pressure.
4.11 a. Amount of salt and sodium in the diet or other dietrelated factors.
4.20 a. Yes b. No
4.25 Completely randomized design.
4.29 a. Single-blind; customers knew what plan they had, but the technician did not.
4.30 a. Matched pairs.
4.31 a. The explanatory variable is the rate plan; the response is usage during peak hours.
4.32 a. A control group was used (matched with the treatment group); a placebo was not.
4.38 a. Yes. b. No. c. No.
4.42 a. Observational study. b. The explanatory variable was whether or not the couple owned a pet, and the response variables were marriage satisfaction and stress levels. c. An example is the amount of business travel they do. Couples who travel frequently may be less likely to own pets and also have more stress.
4.46 a. Interacting variable.
4.49 The explanatory variable is taking the new medication or not; the response variable is weight gain or loss; the interacting variable is gender.
4.53 a. Yes. b. Yes. c. No.
4.57 c. Confounding variables and the implication of causation (e.g., current diet). Relying on memory; it would be hard for people to remember how high in fat their childhood diet was.
4.60 Observational study.
4.63 Postmenopausal women who did not use hormone therapy at all.
4.67 Extending results inappropriately. If women today take lower levels of hormones than the women in the study, these results might not apply to women currently on hormone therapy.
4.72 This is an example of an interacting variable, since the effect on self-esteem of thinking about their bad hair is different for men than for women.
4.78 a. Individual unit is a tomato plant. Two variables were the number of tomatoes produced and whether the tomato plant was raised in full sunlight or partial shade.
4.80 a. Yes. b. Yes. c. No.
4.87 a. A random sample was used, so results can be extended to all customers.

Chapter 5

5.1 a. Negative association. b. No association.
5.2 a. Negative association. b. Roughly linear. c. Highest average math SAT is about 600; fewer than 5% took the test. d. Lowest average math SAT is about 475; about 60% took the test.
5.3 a. Yes, both variables are quantitative.
5.7 a. The speed of the car is the explanatory variable, and the stopping distance is the response variable. b. Positive association, somewhat linear but possibly curvilinear.
5.9 a. Average weight =–250 + 6(70) = 170 lb. b. On average, weight increases 6 pounds per each 1-inch increase in height.
5.11 b. Predicted average = 575 – 1.11(8) = 566.12. c. Residual _ 573 – 566.12 = 6.88.
5.12 Deterministic relationship.
5.14 a. Height increases an average of 0.7 inch for each centimeter increase in handspan. b. 65.1 in. c. Residual = 66.5 – 65.1 = 1.4 in.
5.19 a. For line 1, SSE = 10; for line 2, SSE = 4. b. Line 2 is better because SSE is smaller.

Credits

This page constitutes an extension of the copyright page. We have made every effort to trace the ownership of all copyrighted material and to secure permission from copyright holders. In the event of any question arising as to the use of any material, we will be pleased to make the necessary corrections in future printings. Thanks are due to the following authors, publishers, and agents for permission to use the material indicated.

Photos

xxvi © DiMaggio/Kalish/Corbis; **12** © Tony Dizinno/Allsport Concepts/Getty Images; **70** ©Roy Morsch/zefa/Corbis; **116** © Royalty-free/Corbis; **150** © Royalty-free/Corbis; **192** © Simon Wilkinson/The Image Bank/Getty Images; **228** © Mario Tama/Getty Images; **278** © Ron Sherman/Stone/Getty Images; **330** © Joos Mind/Stone/Getty Images; **400** © Peter Scholey/Photographer's Choice/Getty Images; 442 © Geoffrey Clifford/The Image Bank/ Getty Images; **494** © Laurence Mouton/PhotoAlto/Getty Images; **550** © Photodisc/Getty Images; **598** © Royalty-free/Corbis; **634** © John Giustina/Iconica/Getty Images; **668** © Nick Daly/Photonica/Getty Images; **704** © Photodisc/Getty Images; **S1-1** © Rudy Gutierrez/ America 24-7/Getty Images; **S2-1** © Ian Shaw/Stone/Getty Images; **S3-1** © Royalty-free/ Corbis; **S4-1** © Wide Group/Iconica/Getty Images; **S5-1** © Zia Soleil/Iconica/Getty Images

Text

Chapter 1 **6** Case Study 1.7 (excerpt): "Sad, Lonely World Discovered in Cyberspace," by

A. Harmon, *New York Times,* August 30, 1998, p. A3. Reprinted with permission of the New York Times Company.

Chapter 2 **38** Example 2.11 (excerpt): From Amy Goldwitz, *The Davis Enterprise,* March 4, 1998, p. A1. Reprinted by permission of *The Davis Enterprise*.

Chapter 3 **100** Example 3.18 (excerpt): Reprinted by permission of *The Davis Enterprise*.

Chapter 4 **125** (excerpt): *Sacramento Bee,* July 7, 1999, p. G5. Reprinted by permission of the *Sacramento Bee*. **137** Example 4.4 (excerpt): From "Study: Age doesn't sap memory," *Sacramento Bee,* Kathryn Doré Perkins, July 7, 1999, pp. A1 and A10. Reprinted by permission of the *Sacramento Bee*. **122–123** Case Study 4.1 (excerpt): From Sternberg, Steve, "Lead Exposure Linked to Bad Teeth in Children," *USA Today,* 23 June 1999, Internet. Reprinted with permission.

Chapter 10 **421** Example 10.7 (excerpt): Copyright © 1997 The Gallup Organization. **433** Exercise 10.7: Copyright © 2000 The Gallup Organization.

Chapter 12 **537** Case Study 5.1 (excerpt): From "Probability experts may decide Pennsylvania vote," by P. Passell, *New York Times,* April 11, 1994, A15. Reprinted with permission of the New York Times Company. **537** Case Study 5.1 (excerpt): From "Sad, Lonely World Discovered in Cyberspace," by A. Harmon, *New York Times,* August 30, 1998, p. A3. Reprinted by permission of the New York Times Company. **544** Exercise 12.65: Copyright © 2000 The Gallup Organization. **547** Exercise 12.100: Copyright © 2000 The Gallup Organization. 548 Exercise 12.106: Copyright © 2000 The Gallup Organization.

Chapter 15 **660** Exercise 15.13: Copyright ©© 1999 The Gallup Organization. 666 Exercise

15.54: Copyright ©© 1999, 2000 The Gallup Organization.

Index

A

Addition rule for probability, 244– 45, 250
Additive model for two-way ANOVA, S4-7–9
  defined, S4-7
  for each observation, S4-8
  hypotheses about, S4-10
a-level (level of significance), 501, 503
  probability of type 1 error and, 508, 510
  probability of type 2 error and, 509, 510
  p-values close to .05 and, 651–52
Alternative hypothesis, 497–98
  defined, 497
  for Kruskal–Wallis Test, S2-16
  for one-sample t-test, 554
  one-sided, 498
  for paired t-test, 562
  p-value areas for types of, 517
  for regression coefficient, S3-9–10
  for sign test, S2-3
    with discrete random variable, S2-7
  for two-sample rank-sum test, S2-8
  for two-sample t-test, 566
  two-sided, 498
  for two-way ANOVA, S4-10
  for two-way contingency table, 208, 636–38
  for Wilcoxon signed-rank test, S2-13
  for z-test for one proportion, 513
  for z-test of differences in two proportions, 528, 530
American Psychological Association, S5-2, S5-3, S5-4, S5-9
American Statistical Association, S5-2
Analysis of variance (ANOVA), 669–703
  defined, 669
  one-way, 669–85
    analysis of variance table, 679–80, 682
    assumptions and necessary conditions for, 672–74
    comparing two-way ANOVA and, S4-3– 4
    defined, 669
    family of F-distributions, 674–75
    F-test for comparing means, 669–79
    measuring total variation, 681–82
    measuring variation between groups, 680
    measuring variation within groups, 680–81
    model, S4-4
    multiple comparisons, 676–79
    95% confidence intervals for population means in, 684
    notation for summary statistics, 672
    p-value, 670, 675–76
    steps in, 685
    transforming response variable for, 689
  other methods for comparing populations, 685–89
    hypotheses about medians, 686
    Kruskal–Wallis Test for comparing medians, 687–88, S2-16–19
    Mood's Median Test, 688–89
  two-way, 669, 689–93, S4-2–23
    assumptions and conditions for, S4-3– 4
    balanced versus unbalanced design, S4-9–10, S4-11
    defined, 689
    F-tests and, 692–93
    hypothesis testing in, S4-9–20
    interaction effects, 689–90, 692, S4-3, S4-7, S4-8
    main effect, 690, 692, S4-3, S4-7, S4-8
    models, S4-5–9
    nonsignificant results, cautions about, S4-19–20
    notation for, S4-6
Analysis of variance table, 679–80
  for multiple regression, S3-10–11
  one-way, general format of, 682
  two-way, S4-13
Animal research, ethics in, S5-8–9
Anonymity of survey, 98–99
Appropriate statistical analyses, S5-14–16
  for inference, 576–580
Approximate 95% confidence intervals, 77, 460–61
  defined, 77, 460
  for difference in population means, 472
  for large samples, 460–61
  for proportion p, 420–21
  using multiplier z, 460–61, 472
Association
  negative, 152, 153
  no, 152
  observed, interpretation of, 176–77
  positive, 152, 152–53
Attitudes, measuring, 101
Automated data recording, S5-12

B

Balanced ANOVA (balanced design), S4-9, S4-11
Bar graphs, 22, 23–24
Baseline risk, 3, 198, 203
Base rate, 3
  confusion of the inverse and, 262, 263
Bayesian statistics, 502
Bayes Rule, 252
Bell-shaped curves, 33, 49–57. See *also* Normal curve (normal distribution)
  Empirical Rule for, 52–57, 279, 303
    in action, example of, 56–57
    applied to z-scores, 54–55
Bell-shaped curves (continued) defined, 55
    range and standard deviation and, 54
  interpreting standard deviation for, 52–53
Bell-shaped dataset, 33
Bernoulli random variable, 295
Beta coefficients/parameters (regression coefficients), S3-3, S3-5, S3-9–10
Beta (probability of type 2 error), 509, 510
Bias
  defined, 74
  experimenter effects, 139, S5-12–13
  nonresponse, 4–5, 74, 91, 92
  personal, S5-12–13
  randomization to protect against, 126
  response, 75, 95–99
  selection, 74, 90
  in surveys, 74–75, 91–92
  systematic sampling and, 87–88
Big Five parameters, 335– 44
  computing confidence intervals for, 407–10
  examples of, 336– 43
  hypothesis tests for, 496–504
Bimodal dataset, 33, 34
Binomial distribution, 296
  multinomial distributions and, S1-12
  normal approximation to, 311–14
Binomial experiments, 294–95, 339, 348–49
  finding exact p-value for binomial proportion, 521–23
Binomial random variable(s), 281, 294–300, 349
  binomial experiments and, 294–95, 339, 348– 49
  cumulative probabilities for, approximating, 312–14
  expected value (mean) for, 298–99, S1-6
  independent, combining, 318–20
  Poisson approximation for, S1-11
  probabilities for, 295–98

standard deviation for, 298–99
variance of, 299
Blinding, 128, 129
Block designs, 130–31, 132
Blocks, 130
number of units per, 133
Boxplot (box-and-whisker plot), 29, 33–35, 43–46
comparative, 34, 35, 36
outlier detection on, 33, 34, 43–46
picturing location and spread with, 33–35
strengths and weaknesses, 36
Bureau of Transportation Statistics (BTS), S5-11
data collection principles from, S5-10–11

C

Case-control studies, 134–35, 136
advantages of, 135
example of, 134
Categorical data, estimating probabilities from observed, 234–35
Categorical variable(s), 15–16, 17, 336–37
case study involving, 657
defined, 15, 193, 635
explanatory and response variables for, 21
forming two groups using, 365–66
frequency distribution for, 20
hypothesis testing about one, 652–56
chi-square goodness-of-fit test, 652–56
parameters for, 336
examples of, 336–40
questions to ask about, 17–18
raw data from, 15, 17
sample proportions of, 348–54, 382
summarizing one or two, 19–24
numerical summaries, 19–20
visual summaries, 22–24
Categorical variables, relationship between, 193–227, 635–67
case study involving, 657
chi-square test for two-way tables, 208–16, 635–46
alternative hypothesis, 208, 636–38
critical values, 643–45
expected counts, interpreting and calculating, 208–9, 639–40, 646
necessary conditions and, 209, 638–40
notation for, 640
null hypothesis, 208, 636–38
p-value for, 210, 213, 215, 216, 641–43
supporting analysis, 645
column percentages, 194, 195, 196, 197, 636, 639
conditional percentages, 194, 196
displaying, 193–97
risk, 198–204
row percentages, 194, 195, 196, 197, 636, 639
third variable, effect of, 204–6
Simpson's Paradox caused by, 205–6
2 2 table, analyzing, 206–16, 646–52
chi-square statistic, 208–10, 646–47
chi-square test vs. z-test for difference in two proportions, 647–49
Fisher's Exact Test for, 650–52
shortcut for computing chi-square statistics for, 646–47
Cause-and-effect relationship, 117, 720
correlation vs. causation, 176–77
nonstatistical considerations to assess, using, 707–8
in observational studies, 5, 118, 136–37, 706–7, 708
randomized experiments and, 5–6, 118, 124, 176–77, 706–7
Rule for Concluding Cause and Effect, 137, 176, 706–7
Cells of two-way contingency table, 194, 635
Census, 73, 74
advantages of sample survey over, 74
data, 718
decennial United States, S5-11
defined, 73
Central Limit Theorem, 374–76
Certificate of Confidentiality, S5-6
Chi-square distribution, 641
Chi-square statistic, 208–11, 638–40
calculating, 210, 640
for goodness-of-fit test, 652
statistical significance and, deciding on, 210–11, 216
for 2 2 tables, 208–11, 216, 646–47
for two-way tables, 208–9, 638–39, 640
Chi-square test, 635–46
for goodness-of-fit, 652–56
mathematical notation for, 655
steps in, 653–54
for two-way tables, 208–16, 635–46
alternative hypothesis, 208, 636–38
critical values, 643–45
expected counts, 208–9, 638–40, 646
homogeneity hypothesis, 638
independence hypothesis, 638
making decision and reporting conclusions, 643–45
necessary conditions and, 209, 640
notation for, 640
observed counts, 638, 640, 647
p-value for, 210–11, 213, 215, 216, 641–43
rejection region, 643–45
steps in, 208–13, 645–46
supporting analysis, 645
z-test vs., for difference in two proportions, 647–49
Closed questions, 101–2
Clusters, 85–86, 89
Cluster sampling, 85–87
stratified sampling vs., 86
Codes of ethics, S5-2, S5-3, S5-17
Coefficient(s)
correlation. See Correlation
of determination, multiple, S3-8
regression, S3-3
estimating, using sample data, S3-5
testing null and alternative hypotheses for, S3-9–10
Coherent probabilities, 236
Coincidences, 264–67
Column percentages, 194, 195, 196, 197, 636, 639
Complement, 239, 243, 252
rule to find probability of, 243–44, 250, S1-8
Complementary events, 239, 240, 243
Completely randomized design, 131, 132
Complexity of survey questions, 97
Computer, reading results for regression on, 170–71
Computer-assisted information collection, S5-10–11
Computer-assisted self-interviews, 98–99
Computer-assisted telephone interviewing system (CATI), 89
Concepts in survey questions, illdefined, 101
Conclusions, making stronger or weaker than justified, S5-19
Conditional percentages, 194, 196
Conditional probability, 241–42, 243, 246
defined, 242
determining, 247–49, 251, 252
p-value, 501, 502
tree diagram and, 256–58
type 1 or type 2 errors, 507–8
Confidence interval(s), 76–79, 206–7, 332–33, 401–93, S5-16
in action, example of, 480–82
approximate 95%, 460–61, 472
defined, 460
for difference in population means, 472
for large samples, 460–61
for proportion p, 420–21
case studies, 429–31, 478–79
curiosity and, 401–2
decisions and, 428–29
defined, 332, 401, 403, 405, 443
for difference between two population means, 466–77
equal variance assumption of, 473–76
general format for, 467
interpreting, 470–72
pooled, 473–475, 477
pooled standard error for, 473–76
pooled vs. unpooled, 475–76
calculating, 210, 640
for goodness-of-fit test, 652
statistical significance and, deciding on, 210–11, 216
for 2 2 tables, 208–11, 216, 646–47
for two-way tables, 208–9, 638–39, 640
Chi-square test, 635–46
for goodness-of-fit, 652–56
mathematical notation for, 655
steps in, 653–54
for two-way tables, 208–16, 635–46
alternative hypothesis, 208, 636–38
critical values, 643–45
expected counts, 208–9, 638–40, 646
homogeneity hypothesis, 638
independence hypothesis, 638
making decision and reporting conclusions, 643–45
estimating, using sample data, S3-5
testing null and alternative hypotheses for, S3-9–10
Coherent probabilities, 236
Coincidences, 264–67
Column percentages, 194, 195, 196, 197, 636, 639
Complement, 239, 243, 252
rule to find probability of, 243–44, 250, S1-8