Jessica M. Utts

Seeing Through Statistics

Fourth Edition

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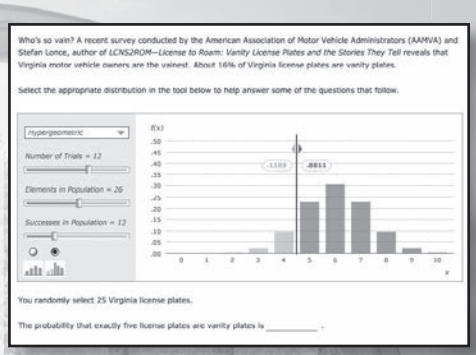

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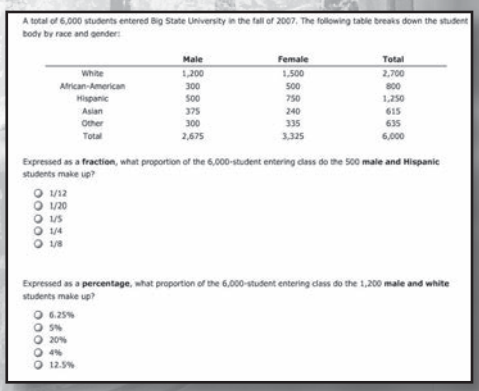

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Fourth Edition

Seeing Through Statistics

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***Seeing Through Statistics*, Fourth Edition**
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To my ancestors, without whom this book would not exist:

Allan
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Gessner/Ghesner
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Highberger/Heuberger
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Simpson
Sprenckel
Stark
Utts/Utz
Wells
Whaley/Whalley
Woods

And many more, some of whom I have yet to discover!

Contents

Preface

If you have never studied statistics, you are probably unaware of the impact the science of statistics has on your everyday life. From knowing which medical treatments work best to choosing which television programs remain on the air, decision makers in almost every line of work rely on data and statistical studies to help them make wise choices. Statistics deals with complex situations involving uncertainty. We are exposed daily to information from surveys and scientific studies concerning our health, behavior, attitudes, and beliefs, or revealing scientific and technological breakthroughs. This book's first objective is to help you understand this information and to sift the useful and the accurate from the useless and the misleading. My aims are to allow you to rely on your own interpretation of results emerging from surveys and studies and to help you read them with a critical eye so that you can make your own judgments.

A second purpose of this book is to demystify statistical methods. Traditional statistics courses often place emphasis on how to compute rather than on how to understand. This book focuses on statistical ideas and their use in real life.

Finally, the book contains information that can help you make better decisions when faced with uncertainty. You will learn how psychological influences can keep you from making the best decisions, as well as new ways to think about coincidences, gambling, and other circumstances that involve chance events.

Philosophical Approach

If you are like most readers of this book, you will never have to *produce* statistical results in your professional life, and, if you do, a single statistics book or course would be inadequate preparation anyway. But certainly in your personal life and possibly in your professional life, you will have to *consume* statistical results produced by others. Therefore, the focus of this book is on understanding the use of statistical methods in the real world rather than on producing statistical results. There are dozens of real-life, in-depth case studies drawn from various media sources as well as scores of additional real-life examples. The emphasis is on understanding rather than computing, but the book also contains examples of how to compute important numbers when necessary, especially when the computation is useful for understanding.

Although this book is written as a textbook, it is also intended to be readable without the guidance of an instructor. Each concept or method is explained in plain language and is supported with numerous examples.

Organization

There are 27 chapters divided into four parts. Each chapter covers material more or less equivalent to a one-hour college lecture. The final chapters of Part 1 and Part 4 consist solely of case studies and are designed to illustrate the thought process you should follow when you read studies on your own.

By the end of Part 1, "Finding Data in Life," you will have the tools to determine whether or not the results of a study should be taken seriously, and you will be able to detect false conclusions and biased results. In Part 2, "Finding Life in Data," you will learn how to turn numbers into useful information and to quantify relationships between such factors as aspirin consumption and heart attack rates or meditation and test scores. You will also learn how to detect misleading graphs and figures and to interpret trends over time.

Part 3 is called "Understanding Uncertainty in Life" and is designed to help you do exactly that. Every day we have to make decisions in the face of uncertainty. This part of the book will help you understand what probability and chance are all about and presents techniques that can help you make better decisions. You will also learn how to interpret common economic statistics and how to use the power of computers to simulate probabilities. The material on probability will also be useful when you read Part 4, "Making Judgments from Surveys and Experiments." Some of the chapters in Part 4 are slightly more technical than the rest of the book, but once you have mastered them you will truly understand the beauty of statistical methods. Henceforth, when you read the results of a statistical study, you will be able to tell whether the results represent valuable advice or flawed reasoning. Unless things have changed drastically by the time you read this, you will be amazed at the number of news reports that exhibit flawed reasoning.

Thought Questions: Using Your Common Sense

All of the chapters, except the one on ethics and those that consist solely of case studies, begin with a series of Thought Questions that are designed to be answered before you read the chapter.

Most of the answers are based on common sense, perhaps combined with knowledge from previous chapters. Answering them *before* reading the chapter will reinforce the idea that most information in this book is based on common sense. You will find answers to the thought questions—or to similar questions—embedded in the chapter.

In the classroom, the thought questions can be used for discussion at the beginning of each class. For relatively small classes, groups of students can be assigned to discuss one question each, then to report back to the class. If you are taking a

class in which one of these formats is used, try to answer the questions on your own before class. By doing so, you will build confidence as you learn that the material is not difficult to understand if you give it some thought.

Case Studies and Examples: Collect Your Own

The book is filled with real-life Case Studies and Examples covering a wide range of disciplines. These studies and examples are intended to appeal to a broad audience. In the rare instance in which technical subject-matter knowledge is required, it is given with the example. Sometimes, the conclusion presented in the book will be different from the one given in the original news report. This happens because many news reports misinterpret statistical results.

I hope you find the case studies and examples interesting and informative; however, you will learn the most by examining current examples on topics of interest to you. Follow any newspaper, magazine, or Internet news site for a while and you are sure to find plenty of illustrations of the use of surveys and studies. If you start collecting them now, you can watch your understanding increase as you work your way through this book.

Formulas: It's Your Choice

If you dread mathematical formulas, you should find this book comfortably readable. In most cases in which computations are required, they are presented step by step rather than in a formula. The steps are accompanied by worked examples so that you can see exactly how to carry them out.

On the other hand, if you prefer to work with formulas, each relevant chapter ends with a section called Focus On Formulas. The section includes all the mathematical notation and formulas pertaining to the material in that chapter.

Exercises and Mini-Projects

Numerous exercises appear at the end of each chapter. Many of them are similar to the Thought Questions and require an explanation for which there is no one correct answer. Answers to every third exercise (3, 6, 9, etc.) are provided at the back of the book. These are indicated with an asterisk next to the exercise number. *Teaching Seeing Through Statistics: An Instructor's Resource Manual,* which is available for download from the companion website (http://www.cengage.com/UttsSTS4e), explains what is expected for each exercise.

In most chapters, the exercises contain many real-life examples. However, with the idea that you learn best by doing, most chapters also contain mini-projects. Some of these ask you to find examples of studies of interest to you; others ask you to conduct your own small-scale study. If you are reading this book without the benefit of a class or instructor, I encourage you to try some of the projects on your own.

Covering the Book in a Quarter, in a Semester, or on Your Own

I wrote this book for a one-quarter course taught three times a week at the University of California at Davis as part of the general education curriculum. My aim was to allow one lecture for each chapter, thus allowing for completion of the book (and a midterm or two) in the usual 29- or 30-lecture quarter. When I teach the course, I do not cover every detail from each chapter; I expect students to read some material on their own.

If the book is used for a semester course, it can be covered at a more leisurely pace and in more depth. For instance, two classes a week can be used for covering new material and a third class for discussion, additional examples, or laboratory work. Alternatively, with three regular lectures a week, some chapters can be covered in two sessions instead of one.

Instructors can download a variety of instructor resources from the companion website www.cengage.com/UttsSTS4e. The website includes additional information on how to cover the material in one quarter or semester. The website also includes tips on teaching this material, ideas on how to cover each chapter, sample lectures, additional examples, and exercise solutions. See below for a full description of the companion website.

Instructors who want to focus on more in-depth coverage of specific topics may wish to exclude others. Certain chapters can be omitted without interrupting the flow of the material or causing serious consequences in later chapters. These include Chapter 9 on plots and graphs, Chapters 16 and 17 on psychological and intuitive misunderstandings of probability, Chapter 18 on understanding economic data, Chapter 25 on meta-analysis, and Chapter 26 on ethics.

If you are reading this book on your own, you may want to concentrate on selected topics only. Parts 1 and 3 can be read alone, as can Chapters 9 and 18. Part 4 relies most heavily on Chapters 8, 12, 13, and 14. Although Part 4 is the most technically challenging part of the book, I strongly recommend reading it because it is there that you will truly learn the beauty as well as the pitfalls of statistical reasoning.

If you get stuck, try to step back and reclaim the big picture. Remember that although statistical methods are very powerful and are subject to abuse, they were developed using the collective common sense of researchers whose goal was to figure out how to find and interpret information to understand the world. They have done the hard work; this book is intended to help you make sense of it all.

A Summary of Changes from the First to Third Editions

In case you are comparing this fourth edition with an earlier edition, here is a summary of changes that were made from the first to second, and second to third editions. For the second edition, over 100 new exercises were added, many based on news stories. In the short time between the first and second editions, Internet use skyrocketed, and so for the second edition many examples from, and references to, websites with interesting data were added. The most substantial structural change from the first to the second edition was in Part 3. Using feedback from instructors,

Chapters 15 and 16 from the first edition were combined and altered to make the material more relevant to daily life. Some of that material was moved to the subsequent two chapters (Chapters 16 and 17 in the second edition). Box plots were added to Chapter 7, and Chapter 13 was rewritten to reflect changes in the Consumer Price Index. Wording and data were updated throughout the book as needed.

There were major changes made from the second to third edition. First, an appendix was added containing 20 news stories, which are used in examples and exercises throughout the book. These are tied to full journal articles, most of which were on a CD accompanying the third edition. The CD (which has now been replaced by a website) contained interactive applets as well. Material was reorganized and expanded, including a new chapter on ethics. New exercises and mini-projects were added, most of which take advantage of the news stories and journal articles in the appendix and on the CD/website.

Again in response to feedback from users, Chapter 12 from the second edition was expanded and divided into Chapters 12 and 13 in the third edition. As a consequence, all of the remaining chapters were renumbered. As mentioned, there was also a new chapter, Chapter 26, called "Ethics in Statistical Studies." As you have probably heard, some people think that you can use statistics to prove (or disprove) anything. That's not quite true, but it is true that there are multiple ways that researchers can naively or intentionally bias the results of their studies. Ethical researchers have a responsibility to make sure that doesn't happen. As an educated consumer, you have a responsibility to ask the right questions to determine if something unethical has occurred. Chapter 26 illustrates some subtle (and not so subtle) ways in which ethics play a role in research. New sections were also added to Chapters 2, 5, 7, 12, and 22 (formerly Chapter 21).

New for the Fourth Edition

There are three major content changes for this edition. First, a new chapter has been added in Part 3, called "Understanding Uncertainty through Simulation" (Chapter 15). The material from that chapter is then used in Part 4 to show how some of the inference procedures can be simulated, expanding the range of problems that can be solved. The former Chapter 14, "Reading the Economic News," has been rewritten and moved to Part 3 with the new title "Understanding the Economic News." And finally, the former Chapter 15, "Understanding and Reporting Trends over Time" has been assimilated into other chapters—the material on time series has been moved to Chapters 9 and 10, and the section on seasonal adjustments to economic data has been moved to the new Chapter 18.

In addition to the major content changes, additional topics have been included in some chapters. The chapters on intuition and probability have been expanded. A section on multiple testing and multiple comparisons has been added to Chapter 24. More information on how to do *t*-tests and confidence intervals has been added in the relevant chapters. Instructions on using the computer to solve problems have been added in many chapters. A summary called "Thinking about Key Concepts" has been added to the end of most chapters. Throughout the book examples, case studies and

exercises have been updated, and new studies have been added. Some of the older examples and case studies have been replaced, but can be found on the companion website.

In previous editions, answers to some homework problems were available in the back of the book, but in this edition that feature has been made more systematic. The answers to every exercise with a number divisible by 3 (3, 6, 9, etc.) are found in the back of the book. In order to implement this feature, the exercises in most chapters have been reordered. In doing so, they also have been rearranged so that the order now more closely follows the order of the content in most chapters.

News Stories and Journal Articles in the Appendix and on the Companion Website

One of the goals of this book is to help you understand news stories based on statistical studies. To enhance that goal, an appendix with 20 news stories was added beginning with the third edition. In this edition, some of the stories have been replaced with instructions on how to find them on the Internet rather than printing the full story in the book. But the news stories present only part of the information you need to understand the studies. When journalists write such stories, they rely on original sources, which in most cases include an article in a technical journal or a technical report prepared by researchers. To give you that same exposure, the companion website for the book contains the full text of the original sources for most of the news stories. Because these articles include hundreds of pages, it would not have been possible to append the printed versions of them. Having immediate access to these reports allows you to learn much more about how the research was conducted, what statistical methods were used, and what conclusions the original researchers drew. You can then compare these to the news stories derived from them and determine whether you think those stories are accurate and complete. In some cases, an additional news story or press release is included on the companion website as well.

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New for the fourth edition, available via Aplia, is **MindTap™ Reader**, Cengage Learning's next generation eBook. MindTap Reader provides robust opportunities for students to annotate, take notes, navigate, and interact with the text (e.g. ReadSpeaker). Annotations captured in MindTap Reader are automatically tied to the Notepad app, where they can be viewed chronologically and in a cogent, linear fashion. Instructors also can edit the text and assets in the Reader, as well as add videos or URLs. Go to http://www.cengage.com/mindtap for more information.

Companion Website for *Seeing Through Statistics*

The companion website (www.cengage.com/UttsSTS4e) has been established for users of this book.

Two of the major features of the website are the **journal articles** mentioned previously and a collection of **computer applets**. The applets will allow you to explore some of the concepts in this book in an interactive way, and the website includes suggestions for how to do so.

This site also includes a variety of resources and information of interest to users of this book:

- Microsoft® PowerPoint® lecture slides and figures from the book
- information on how to cover the material in one quarter or semester
- tips on teaching this material
- ideas on how to cover each chapter
- sample lectures
- additional examples
- exercise solutions

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Jessica M. Utts

PART 1

Finding Data in Life

By the time you finish reading Part 1 of this book, you will be reading studies reported in the news with a whole new perspective. In these chapters, you will learn how researchers should go about collecting information for surveys and experiments. You will learn to ask questions, such as who funded the research, that could be important in deciding whether the results are accurate and unbiased.

Chapter 1 is designed to give you some appreciation for how statistics helps to answer interesting questions. Chapters 2 to 5 provide an in-depth, behind-the-scenes look at how surveys and experiments are supposed to be done. In Chapter 6, you will learn how to tie together the information from the previous chapters, including seven steps to follow when reading about studies.

These steps all lead to the final step, which is the one you should care about the most. You will have learned how to *determine whether the results of a study are meaningful enough to encourage you to change your lifestyle, attitudes, or beliefs*.

CHAPTER 1

The Benefits and Risks of Using Statistics

Thought Questions

1. A news story about drug use and grades concluded that smoking marijuana at least three times a week resulted in lower grades in college. How do you think the researchers came to this conclusion? Do you believe it? Is there a more reasonable conclusion?
2. It is obvious to most people that, on average, men are taller than women, and yet there are some women who are taller than some men. Therefore, if you wanted to "prove" that men were taller, you would need to measure many people of each sex. Here is a theory: On average, men have lower resting pulse rates than women do. How could you go about trying to prove or disprove that? Would it be sufficient to measure the pulse rates of one member of each sex? Two members of each sex? What information about men's and women's pulse rates would help you decide how many people to measure?
3. Suppose you were to learn that the large state university in a particular state graduated more students who eventually went on to become millionaires than any of the small liberal arts colleges in the state. Would that be a fair comparison? How should the numbers be presented in order to make it a fair comparison?
4. In a survey done in September, 2012, employers were asked a series of questions about whether colleges were preparing students adequately for careers in their companies. Of the 50,000 employers contacted, 704 responded. One of the questions asked was "How difficult is it to find recent college graduates who are qualified for jobs at your organization?" Over half (53%) of the respondents said that it was difficult or very difficult. Based on these results, can you conclude that about 53% of all employers feel this way? Why or why not?
(Source: http://chronicle.com/items/biz/pdf/Employers%20Survey.pdf.)

1.1 Why Bother Reading This Book?

If you have never studied statistics, you are probably unaware of the impact the science of statistics has on your everyday life. From knowing which medical treatments work best to choosing which television programs remain on the air, decision makers in almost every line of work rely on data and statistical studies to help them make wise choices.

We are exposed daily to information from surveys and scientific studies concerning our health, behavior, attitudes, and beliefs or revealing scientific and technological breakthroughs. This book's first objective is to help you understand this information and to sift the useful and the accurate from the useless and the misleading. (And there are plenty of both out there!) By the time you finish reading the book, you should be a statistical detective—able to read with a critical eye and to rely on your own interpretation of results emerging from surveys and statistical studies.

Another purpose of this book is to demystify statistical methods. Traditional statistics courses often place emphasis on how to compute rather than on how to understand. This book focuses on statistical ideas and their use in real life. Lastly, the book also contains information that can help you make better decisions. You will learn how psychological influences can keep you from making the best decisions, as well as new ways to think about coincidences, gambling, and other circumstances that involve chance events.

1.2 What is Statistics All About?

If we were all exactly the same—had the same physical makeup, the same behaviors and opinions, liked the same music and movies, and so on—most statistical methods would be of little use. But fortunately we aren't all the same! Statistical methods are used to analyze situations involving uncertainty and natural variation. They can help us understand our differences as well as find patterns and relationships that apply to all of us.

When you hear the word *statistics,* you probably either get an attack of math anxiety or think about lifeless numbers, such as the population of the city or town where you live, as measured by the latest census, or the per capita income in Japan. The goal of this book is to open a whole new world of understanding of the term *statistics,* and to help you realize that the invention of statistical methods is one of the most important developments of modern times. These methods influence everything from life-saving medical advances to the percent salary increase given to millions of people every year.

The word **statistics** is actually used to mean two different things. The better-known definition is that statistics are numbers measured for some purpose. A more appropriate, complete definition is the following:

> *Statistics is a collection of procedures and principles for gaining and analyzing information to educate people and help them make better decisions when faced with uncertainty.*

Using this definition, you have undoubtedly used statistics in your own life. For example, if you were faced with a choice of routes to get to school or work, or to get between one classroom building and the next, how would you decide which one to take? You would probably try each of them a number of times (thus gaining information) and then choose the best one according to criteria important to you, such as speed, fewer red lights, more interesting scenery, and so on. You might even use different criteria on different days—such as when the weather is pleasant versus when it is not. In any case, by sampling the various routes and comparing them, you would have gained and analyzed useful information to help you make a decision.

In addition to helping us make decisions, statistical studies also help us satisfy our curiosity about other people and the world around us. Do other people have the same opinions we do? Are they behaving the way we do—good or bad? Here is an example that may answer one of those questions for you.

EXAMPLE 1.1 **Look Who's Talking!**

Texting or talking on a cell phone (other than hands-free) while driving is illegal in most of the United States and in many other countries. How many law-breakers are there? Does it differ by country? Does it differ by age group? The answers are lots, yes, and yes! Statistical surveys conducted in the United States and Europe in 2011 asked people, "In the past 30 days, how often have you talked on your cell phone while you were driving?" Response choices were "never," "just once," "rarely," "fairly often," and "regularly." The results showed that over two-thirds (68.7%) of adults surveyed in the United States admitted talking on their cell phone at least once in the past 30 days, but just over one-fifth (20.5%) of those in the United Kingdom admitting doing so. In the United States, almost 70% of respondents aged 18 to 24 admitted that they had talked on their phone, but only about 60% of those aged 55 to 64 did so. The age differences were even more striking for those who admitted texting, with slightly over 50% of the youngest age group doing so but under 10% of the oldest age group doing so.

Although it is interesting to know whether others are behaving like we are, these statistics also have implications for public health officials and lawmakers who are studying them to determine why drivers in the United Kingdom are so much more law-abiding than are drivers in the United States in this instance. Or are they? In this book, you will learn to ask other probing questions, such as whether the two groups are equally likely to be telling the truth in their responses and whether the difference could be partially explained by the fact that people in the United States drive more than people in the United Kingdom.

(Source: *Morbidity and Mortality Weekly Report,* March 15, 2013 Vol. 62, No. 10, Centers for Disease Control and Prevention.) ■

1.3 Detecting Patterns and Relationships

How do scientists decide what questions to investigate? Often, they start with observing something and become curious about whether it's a unique circumstance or something that is part of a larger pattern. In Case Study 1.1, we will see how one researcher followed a casual observation to a fascinating conclusion.

CASE STUDY 1.1 Heart or Hypothalamus?

SOURCE: Salk (1973), pp. 26–29.

You can learn a lot about nature by observation. You can learn even more by conducting a carefully controlled experiment. This case study has both. It all began when psychologist Lee Salk noticed that despite his knowledge that the hypothalamus plays an important role in emotion, it was the heart that seemed to occupy the thoughts of poets and songwriters. There were no everyday expressions or song titles such as "I love you from the bottom of my hypothalamus" or "My hypothalamus longs for you." Yet, there was no physiological reason for suspecting that the heart should be the center of such attention. Why had it always been the designated choice?

Salk began wondering about the role of the heart in human relationships. He also noticed that when on 42 separate occasions he watched a rhesus monkey at the zoo holding her baby, she held the baby on the left side, close to her heart, on 40 of those occasions. He then observed 287 human mothers within 4 days after giving birth and noticed that 237, or 83%, held their babies on the left. Handedness did not explain it; 83% of the right-handed mothers and 78% of the left-handed mothers exhibited the left-side preference. When asked why they chose the left side, the right-handed mothers said it was so their right hand would be free. The left-handed mothers said it was because they could hold the baby better with their dominant hand. In other words, both groups were able to rationalize holding the baby on the left based on their own preferred hand.

Salk wondered if the left side would be favored when carrying something other than a newborn baby. He found a study in which shoppers were observed leaving a supermarket carrying a single bag; exactly half of the 438 adults carried the bag on the left. But when stress was involved, the results were different. Patients at a dentist's office were asked to hold a 5-inch rubber ball while the dentist worked on their teeth. Substantially more than half held the ball on the left.

Salk speculated, "It is not in the nature of nature to provide living organisms with biological tendencies unless such tendencies have survival value." He surmised that there must indeed be survival value to having a newborn infant placed close to the sound of its mother's heartbeat.

To test this conjecture, Salk designed a study in a baby nursery at a New York City hospital. He arranged for the nursery to have the continuous sound of a human heartbeat played over a loudspeaker. At the end of 4 days, he measured how much weight the babies had gained or lost. Later, with a new group of babies in the nursery, no sound was played. Weight gains were again measured after 4 days.

The results confirmed what Salk suspected. Although they did not eat more than the control group, the infants treated to the sound of the heartbeat gained more weight (or lost less). Further, they spent much less time crying. Salk's conclusion was that "newborn infants are soothed by the sound of the normal adult heartbeat." Somehow, mothers intuitively know that it is important to hold their babies on the left side. What had started as a simple observation of nature led to a further understanding of an important biological response of a mother to her newborn infant. ■

How to Move From Noticing to Knowing

Some differences are obvious to the naked eye, such as the fact that the average man is taller than the average woman. If we were content to know about only such obvious relationships, we would not need the power of statistical methods. But had you noticed that babies who listen to the sound of a heartbeat gain more weight? Have you ever noticed that taking aspirin helps prevent heart attacks? How about the fact that people are more likely to buy jeans in certain months of the year than in others? The fact that men have lower resting pulse rates than women do? The fact that listening to Mozart improves performance on the spatial reasoning questions of an IQ test? All of these are relationships that have been demonstrated in studies using proper statistical methods, yet none of them are obvious to the naked eye.

Let's take the simplest of these examples—one you can test yourself—and see what's needed to properly demonstrate the relationship. Suppose you wanted to verify the claim that, on average, men have lower resting pulse rates than women do. Would it be sufficient to measure only your own pulse rate and that of a friend of the opposite sex? Obviously not. Even if the pair came out in the predicted direction, the singular measurements would certainly not speak for all members of each sex.

It is not easy to conduct a statistical study properly, but it is easy to understand much of how it should be done. We will examine each of the following concepts in great detail in the remainder of this book; here we just introduce them, using the simple example of comparing male and female pulse rates.

To conduct a statistical study properly, one must:

1. Get a representative sample.
2. Get a large enough sample.
3. Decide whether the study should be an observational study or a randomized experiment.

1. Get a representative sample. Most researchers hope to extend their results beyond just the participants in their research. Therefore, it is important that the people or objects in a study be representative of the larger group for which conclusions are to be drawn. We call those who are actually studied a **sample** and the larger group from which they were chosen a **population.** (In Chapter 4, we will learn some ways to select a proper sample.) For comparing pulse rates, it may be convenient to use the members of your class. But this sample would not be valid if there were something about your class that would relate pulse rates and sex, such as if the entire men's track team happened to be in the class. It would also be unacceptable if you wanted to extend your results to an age group much different from the distribution of ages in your class. Often researchers are constrained to using such "convenience" samples, and we will discuss the implications of this later in the book.

2. Get a large enough sample. Even experienced researchers often fail to recognize the importance of this concept. In Part 4 of this book, you will learn how to detect the problem of a sample that is too small; you will also learn that such a sample can sometimes lead to erroneous conclusions. In comparing pulse rates, collecting one pulse rate from each sex obviously does not tell us much. Is two enough? Four? One hundred? The answer to that question depends on how much *natural variability* there is among pulse rates. If all men had pulse rates of 65 and all women had pulse rates of 75, it wouldn't take long before you recognized a difference. However, if men's pulse rates ranged from 50 to 80 and women's pulse rates ranged from 52 to 82, it would take many more measurements to convince you of a difference. The question of how large is "large enough" is closely tied to how diverse the measurements are likely to be within each group. The more diverse, or variable, the individuals within each group, the larger the sample needs to be to detect a real difference between the groups.

3. Decide whether the study should be an observational study or a randomized experiment. For comparing pulse rates, it would be sufficient to measure or "observe" both the pulse rate and the sex of the people in our sample. When we merely observe things about our sample, we are conducting an **observational study.** However, if we were interested in whether frequent use of aspirin would help prevent heart attacks, it would not be sufficient to simply observe whether people frequently took aspirin and then whether they had a heart attack. It could be that people who were more concerned with their health were both more likely to take aspirin and less likely to have a heart attack, or vice versa. Or, it could be that drinking the extra glass of water required to take the aspirin contributes to better health.

To be able to make a causal connection, we would have to conduct a **randomized experiment** in which we *randomly* assigned people to one of two groups. **Random assignments** are made by doing something akin to flipping a coin to determine the group membership for each person. In one group, people would be given aspirin, and in the other, they would be given a dummy pill that looked like aspirin. So as not to influence people with our expectations, we would not tell people which one they were taking until the experiment was concluded. In Case Study 1.2, we briefly examine the experiment that initially established the causal link between aspirin use and reduction of heart attacks. In Chapter 5, we discuss these ideas in much more detail.

CASE STUDY 1.2 **Does Aspirin Prevent Heart Attacks?**

In 1988, the Steering Committee of the Physicians' Health Study Research Group released the results of a 5-year randomized experiment conducted using 22,071 male physicians between the ages of 40 and 84. The physicians had been randomly assigned to two groups. One group took an ordinary aspirin tablet every other day, whereas the other group took a "placebo," a pill designed to look just like an aspirin but with no active ingredients. Neither group knew whether they were taking the active ingredient.

The results, shown in Table 1.1, support the conclusion that taking aspirin does indeed help reduce the risk of having a heart attack. The rate of heart attacks in the

TABLE 1.1 The Effect of Aspirin on Heart Attacks

Condition	Heart Attack	No Heart Attack	Attacks per 1000
Aspirin	104	10,933	9.42
Placebo	189	10,845	17.13

group taking aspirin was only 55% of the rate of heart attacks in the placebo group, or just slightly more than half as big. Because the men were randomly assigned to the two conditions, other factors, such as amount of exercise, should have been similar for both groups. The only substantial difference in the two groups should have been whether they took the aspirin or the placebo. Therefore, we can conclude that taking aspirin caused the lower rate of heart attacks for that group.

Notice that because the participants were all male physicians, these conclusions may not apply to the general population of men. They may not apply to women at all because no women were included in the study. More recent evidence has provided even more support for this effect, however—something we will examine in more detail in an example in Chapter 27. ■

1.4 Don't Be Deceived by Improper Use of Statistics

Let's look at some examples representative of the kinds of abuses of statistics you may see in the media. The first example illustrates the danger of not getting a representative sample; in the second example, the statistics have been taken out of their proper context; and in the third and fourth examples, you will see how to stop short of making too strong a conclusion on the basis of an observational study.

EXAMPLE 1.2 Robotic Polls and Representative Samples

Methods for polling voters to predict election results have become more complicated as more and more people rely exclusively on cell phones instead of landlines. But some polling firms were slow to change their methods and, consequently, made significant blunders in predicting the outcome of the 2012 Presidential Election. In particular, polling companies that exclusively used "robopolls," which choose their participants using randomized computer dialing and then use an automated script, missed the mark by an average of 4.3 percentage points in favor of the Republican candidate Mitt Romney. One firm even had a 15.7% Republican bias! What went wrong? By 2012, about one-third of Americans relied solely on cell phones and had no landline. But it was illegal to call cell phones using robopolls, so organizations that used them only reached homes with landlines. Younger voters, those less well-off financially and non-Caucasians, were less likely to have landlines and also more likely to vote for the Democratic candidate, Barack Obama. Therefore, the robopolls underestimated the support for Obama.

(*Source:* http://fivethirtyeight.blogs.nytimes.com/2012/11/10/which-polls-fared-best-and-worst-in-the-2012-presidential-race/#more-37396.) ■