CHAPTER

Making Sense of Variability: An Introduction to Statistics

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h that blasted alarm,” you mutter as you push the snooze button for a second time. What a short night! As you stumble out of bed, you realize that only a quick shower and a fast breakfast will let you be on time for your 8:00 A.M. class. As you walk to your car, you notice what a pleasant, warm day seems to be in store for this early spring day, much nicer than yesterday’s cold rain and drizzle. As you pull onto the expressway, the traffic is heavier than usual, and it’s not moving as fast as you had expected. Will you be late for your class? Fortunately, you make your class on time; the lecture today is one of the best of the semester. But you dread your 9:00 A.M. science lab; often it runs so long you don’t have time for lunch. Yet, today is different. Everything goes smoothly, and you get out in time to have a leisurely, fun lunch with two of your best friends, as well as time to respond to a few text messages. After lunch, it’s off to work at the Big Bargain Department Store. The customers today seem very pleasant in contrast to yesterday—you think maybe it’s because of the nice weather. The pleasant customers make the afternoon pass quickly, and soon you are again on the expressway heading for home. Traffic now is lighter than most days; maybe everyone left work earlier today. You have a great deal of schoolwork to do, so after dinner you settle at your desk, hoping for a productive night of studying. But first you read your e-mail. Surprisingly, only few messages are spam in comparison to the typical number you receive each day. Your studying seems to go well, at least compared to many of your attempts to study after dinner. You really feel prepared for that statistics exam coming up at the end of the week. To reward yourself, you text a few friends and then go to bed. Maybe if you go to bed a bit earlier, the night will seem longer.

Perhaps this short vignette represents a typical day in your life, perhaps it does not. In any event, you are probably wondering what this vignette has to do with statistics. Well, for one, it illustrates that you have recognized certain regularities or consistencies in the events of your life: the typical amount of time you have for a shower or breakfast, the normal weather for an early spring day, the characteristic amount of traffic on your drive to college and how long it takes you to get there, the general interest level of a class, the average length of a science lab, the normal amount of fun you have at lunch, the typical behavior of a department store customer, the average number of spam e-mail messages you receive each day, and the normal productivity of a night of studying. The fact that you recognize there are consistencies or regularities in the occurrences of your life indicates you also recognize that there is variability or variation in these regularities. Some nights seem longer than others, showers and breakfasts vary in length from day to day, the weather rarely is normal for the time of the year, traffic may be lighter or heavier, classes vary in interest level from day to day (and from course to course), science labs are sometimes longer and other times shorter than average, the behavior of shoppers is quite variable from person to person, and some study sessions are more productive than others.

This variation among events implies the existence of variables in the environment. A variable is any environmental condition or event, stimulus, personal characteristic or attribute, or behavior that can take on different values at different times or with different people. The amount of sleep you obtain, the length of your shower, the amount of traffic on the expressway, the interest level of a class, the length of a science lab, the mood of shoppers, and the productivity of study sessions are all variables. Statistics is the discipline that quantifies the consistency found in a variable and the variability about this consistency. Although this definition of statistics is informal and incomplete, it will serve for the moment.

You, of course, are not the only person to note the regularity of events in the world. Lambert Adolphe Jacques Quetelet (1796–1874), a Belgian professor with wide-ranging
interests, believed that such regularities in variables have causes and that if he could identify the regularities, he could then identify their causes. He thus set out to identify these regularities. His initial work was to characterize what he called an “average man.” To do so, he obtained anthropometric data (that is, bodily measurements) on variables such as height and weight from a large number of French soldiers (Stigler, 1986). His hope was that by characterizing an average person, he could find regularities in human attributes and then compare these averages between males and females or across nationalities, localities, ages, or races. Quetelet’s interest in the average person extended also to what he called “moral statistics,” regularities in variables such as suicide rates or crime and conviction rates. For example, Quetelet studied conviction rates in French courts over a period of years and categorized the rate of conviction by the accused’s ability to read and write. His results are presented in Table 1.1. The numerical values in Table 1.1 represent probabilities. For example, if you were being tried in a French court in 1829 and you were able to read and write only imperfectly, the probability of your being convicted would be 0.60 (or 6 chances out of 10). Notice there appears to be a clear relationship between the accused’s reading and writing abilities and the likelihood that he or she would be convicted of a crime. Quetelet often is called the father of social science for initiating these statistical studies (Dudycha & Dudycha, 1972).

### TABLE 1.1

Conviction rates in French courts as a function of year and the ability of the defendant to read and write.

<table>
<thead>
<tr>
<th>Ability of Accused to Read or Write</th>
<th>1828</th>
<th>1829</th>
<th>1830</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unable to read or write</td>
<td>0.63</td>
<td>0.63</td>
<td>0.62</td>
<td>0.627</td>
</tr>
<tr>
<td>Able to read and write imperfectly</td>
<td>0.62</td>
<td>0.60</td>
<td>0.58</td>
<td>0.600</td>
</tr>
<tr>
<td>Able to read and write well</td>
<td>0.56</td>
<td>0.55</td>
<td>0.52</td>
<td>0.543</td>
</tr>
<tr>
<td>Has a superior education</td>
<td>0.35</td>
<td>0.48</td>
<td>0.37</td>
<td>0.400</td>
</tr>
</tbody>
</table>

As the introduction illustrates, the study of statistics deals with both the regularities and variability of events that all of us have noticed in our lives. Thus, in one sense, although we are new to the study of statistics, we are all experienced statisticians finding consistency in variability. Nevertheless, many people are intimidated by the idea of statistics and dread the thought of an entire course in the subject. This fear need not be the case, however. Learning statistics is similar to learning a new language. The language of statistics is composed of words, symbols, and formulas. As with any new language, statistics requires time and effort to master its components. Throughout this text, we will provide you with information about how to maximize your success in understanding statistics. With practice and experience, statistics will become as natural to you as your native language. Several features of this text will help you with your study of statistics to achieve that goal.
Important Terms and Symbols

Terms and symbols that are especially important for understanding the concepts of a chapter are **boldfaced** in the text. The most important terms are also highlighted in a marginal definition. When you encounter a boldfaced term, you should recognize that it is important for your understanding of statistics. We suggest you come up with a plan for how to learn and understand the definitions of terms and the meaning of symbols, not merely memorize them. It often helps if after reading a section, you immediately attempt to define terms without looking at the definition provided in the book. Many students have also found that writing down the symbols, what they are called, and their definition helps them become more comfortable with the symbols. Other students have found that flash cards are helpful for learning terms and symbols. Regardless of your plan, it is important that you learn the terms and symbols as soon as they are introduced and that you continue to review them throughout the semester. If you cannot recall the meaning of a term or statistical symbol, a glossary of terms is provided in Appendix F and a glossary of statistical symbols is provided in Appendix B.

Self-Testing Questions

Self-testing is critical for success in understanding statistics. To help you test your knowledge of the material covered in the text, we have provided three types of self-test questions.

**Testing Your Knowledge.** Each chapter contains several Testing Your Knowledge sections. These sections provide an opportunity for you to review and test your understanding of the material you have just studied before you move on to the next section of the chapter. Many of the questions focus on actual research problems and provide examples of how the statistical methods you are studying are used. Answers for many of the Testing Your Knowledge questions are given in Appendix E, “Answers for Computational Problems.”

**Review Questions.** Review questions are provided at the end of each chapter. These questions provide a review of the material presented in the chapter. As with the Testing Your Knowledge questions, we encourage you to complete the chapter review questions and then compare your answers to those given in Appendix E, “Answers for Computational Problems.”

**Integrating Your Knowledge.** Many of the questions in Testing Your Knowledge and Review Questions are structured to help you focus on pieces of the statistical information presented in the chapter. The real world, however, is not going to present you with nice, compartmentalized statistical challenges. Integrating Your Knowledge problems are designed to assist you in practicing integrating information across multiple topics and chapters. Answers to Integrating Your Knowledge also appear in Appendix E, “Answers for Computational Problems.” The first Integrating Your Knowledge occurs in Chapter 3.

Mathematics Review

The mathematics used in this text is elementary, requiring only the operations of addition, subtraction, multiplication, and division. Mathematical symbols and operations are explained as they are needed. If you encounter difficulties with any of the mathematical operations, a mathematics review is provided in Appendix A. This review provides a summary of basic mathematical symbols and operations.
Before You Begin

You Hold the Key to Success

You hold the key to your own success in this course because two of the most important predictors of your success are linked to your attitude and your behavior. Psychologists know that attitudes can affect behavior and that certain attitudes and behaviors are associated with mastery of information such as statistics. This book uses that knowledge in its design, and we will also pass this knowledge on to you. Thus, as you study this text, you will learn about the attitudes and behaviors that will help maximize your success in understanding statistics. Before you read further, please think carefully about the statement below. Then, select the number that best corresponds to the way you feel about the statement.

<table>
<thead>
<tr>
<th>Some people are simply born smart, others are not so lucky.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 2 3 4 5 6</td>
</tr>
<tr>
<td>Strongly Agree  Strongly Disagree</td>
</tr>
</tbody>
</table>

Research by Dweck (1999, 2006) has found that students who strongly disagree with a statement similar to this example believe that intelligence is changeable. These students are also more likely to (1) attend class, (2) think about what the professor is presenting during class, (3) complete all homework assignments, (4) seek out study groups, and (5) seek out help from the professor when needed. Students who strongly agree with the above statement, however, believe that intelligence is fixed and cannot be changed. These students are (1) more likely to say things like, “I was never good in math anyway, I’m not going to be good in this class”; (2) less likely to attend class; (3) less likely to try to solve problems when they do attend class; (4) less likely to complete all homework assignments; and (5) less likely to seek out help when struggling in the class. Building upon these findings, several undergraduate students designed and completed a series of studies demonstrating that students who believe that they cannot become smarter do not do as well in class as students who believe that, with effort, they can become smarter. We will be discussing more about the relationship of attitudes and behaviors in future chapters. For now, recognize that if you adopt a “growth mindset,” that is, if you believe your intellectual skills can grow, you are more likely to behave in a manner that will cause you to improve in statistics. However, if you do not believe that you can grow intellectually, why would you act as if you were able to improve your performance in statistics? So, start thinking about having an attitude of success for this class and putting into place the types of behaviors that will lead to that success. Believe that, with the right effort, you can learn statistics and be successful in this course.

Some Further Suggestions for Achieving Success

We have a few other tips to help you maximize your success with statistics.

Do not look ahead in the text. The material in the text can look scary and confusing, just like listening to someone speak in a foreign language that you do not know. No benefit will come from looking ahead in the text to see how difficult the material appears to be. As a woman who had five children once said when asked how she handled the challenges
of her children, “I got used to one child at a time. Since each child came one at a time, with some chance for me to get acclimated before the next child arrived, it really wasn’t that difficult.” The material in this class will come at you one piece at a time. You will have a chance to become acclimated before you progress to the next piece. Before you know it, you’ll be at the end of the book. There is no benefit in rushing it.

Read and study the textbook. It is critical that you read and study this book because it will help you understand the material when it is presented in class. Students who have anxiety related to statistics sometimes adopt the practice of ignoring the textbook as a method of decreasing anxiety. This approach may decrease your anxiety temporarily, but this short-term fix will hurt you in the long term. If you find reading the text to be anxiety provoking, seek a pleasant internal state (e.g., eat comfort food) and an external state (e.g., a comfortable chair and clean desk) that will improve your mood and decrease your anxiety. It often helps to start by just reading the headings and the terms in a section. Get comfortable with that information, then begin to read the entire chapter. It will be well worth your time.

Studying the textbook is critical, but how you study is equally critical. When you study, try to rid yourself of other distractions. Turn off the music, the TV, and the videogame. Unplug the iPod. Don’t read your email, text your friends, or try to study with friends around. And give up the Internet for the duration of your studying. All these activities, enticing as they may be, have been shown to be related to lower exam performance (Gurung, 2005). Time is a precious commodity; make your study time effective!

Complete the various self-testing questions. Self-testing will help you discern whether you truly understand the material you are studying. This testing will help you target your studying and become more efficient. Moreover, there is real benefit in the act of self-testing, as it increases your understanding and long-term memory of the material. There is even reason to believe that self-testing will help decrease math or test anxiety that may otherwise interfere with your performance in this class. We understand that you have a limited amount of time to spend on academic pursuits. Skipping the self-testing questions in this book, however, is not a wise way to save time.

Be intellectually engaged. You hold the power of your mind. Use it to think about what is being covered in this book and in your class. Actively begin to examine results and conclusions of reported research studies. Do you agree? Does it make sense? Is there a flaw in the method or interpretation? Try to think of examples from your own experience. Often, forming study groups is a good way to become more intellectually engaged with this material, as you will find talking about statistics helpful for increasing your understanding. A study group is a particularly helpful strategy for someone who is experiencing some anxiety related to this material, because being around other people often decreases that fear while increasing positive emotions related to the material; but be sure it’s a study group and not just a bunch of friends hanging out.

Finally, attend class and take careful notes. Be prepared for class, and ask questions about material that you do not understand. Study your class notes, and compare them to the material in the text. This recommendation may seem like a “no-brainer,” but preparation for class and intellectual engagement in class activities and discussion is strongly related to academic success. In the hurry of our everyday lives, it’s sometimes easy to forget this fact.

What Is Statistics?

Data ➞ The scores or measurements of behavior or characteristics obtained from observations of people or animals.

Following in the footsteps of Quetelet, behavioral scientists attempt to understand and explain human and animal behavior. They do so by collecting data. Data (data is plural, datum is singular) are the scores or measurements of behavior or characteristics obtained
from observations of people or animals. To identify both the consistencies and variability in these data, procedures called statistics are applied to it. Statistics thus refers to the methods or procedures used to summarize, analyze, and reach conclusions from a set of data.

Using Statistics: Four Examples

Statistical procedures are used in many different ways in behavioral science. The remainder of this chapter provides examples of four uses of statistical methods in behavioral science. A number of terms are introduced, and you should study and learn these terms, for you will encounter them throughout the text. Don’t worry, however, if you don’t understand all the details of the examples provided; the use of each approach is discussed more fully in later chapters.

Plain yet Mighty: Descriptive Statistics

There are probably many questions you have about the statistics class in which you are now enrolled. One of them may be how much time will you have to study each week? While we can’t answer this question for you, many studies have been done on the amount of time college students spend studying. For example, Adams (2005) found that students believed that 6.2 hours of study per week indicated superior effort in a course, whereas faculty members believed that 8.5 hours per week of studying were indicative of superior effort. These numerical values illustrate the use of descriptive statistics. A descriptive statistic, often simply called a statistic, is a single number that may be used to describe or analyze a set of data from a sample. A sample is a small part of anything. In statistics, a sample is a subset, or subgroup, selected from a population. A population is a complete set of people, animals, objects, or events that share a common characteristic. For example, all students who are taking a college-level statistics class this semester could be considered a population. The common characteristic of this population is that all the individuals included in it are taking a similar class at the same time. They share something in common. Other examples of populations are all the college students in Canada, all the households in Bermuda, all the adult females in North Carolina, all the farmers in Nebraska, and all the people who have at least one bank credit card; each set comprises a population. Any group of individuals may be thought of as a population as long as all those possessing the characteristic common to the population are included in the group. For our example on study time, the numerical values were obtained from a sample of 159 college students from a population of college students and a sample of 59 faculty members from a population of college professors.

We encounter such descriptive statistics every day in our reading or from the media. For example, it was reported that married mothers currently spend 14.1 hours a week on child care, whereas in 1965 married mothers typically spent 10.1 hours per week on child care (St. George, 2007). Again, these descriptive statistics were obtained from a sample of married mothers and are intended to be typical of the amount of time that the married mothers in that sample devote to child care.

Descriptive statistics help provide basic information about the sample from which you have collected data. Most likely, you are already familiar with some common descriptive statistics such as the mode, the median, or the mean, which we will discuss in following chapters. Descriptive statistics, however, have limitations; they cannot give you a cause or an explanation for what was observed. Why do married mothers currently spend more time on child care per week in comparison to 1965? Did they cut back on
other activities? Do they perceive child care as being more important than did the mothers of 1965? Does society place a greater emphasis on child care now than it did in 1965? Are mothers of today more likely to overestimate how much time they spend with their children? Simple descriptive statistics such as those we have presented here cannot provide answers for these questions. We do not know what caused the difference in amount of time devoted to child care just from looking at the descriptive statistics. Yet, descriptive statistics are important for they provide us with an objective summary of information that has been collected.

Testing Your Knowledge 1.1

1. Define: data, descriptive statistic, population, sample, statistic, statistics, variable.
2. On the first day of statistics class, a professor conducted a brief survey asking students to rate their level of math anxiety. She determined that 24 percent of her class could be classified as possessing a high level of math anxiety, whereas 39 percent could be classified as having some math anxiety. The remainder of the class had either low or very low levels of math anxiety.
   a. What data were collected in this example?
   b. Was there variability in the data collected?
   c. Explain why descriptive statistics are necessary to summarize the results of this research.
   d. What percentage of the class had low or very low levels of math anxiety?
   e. Although the professor could determine what percentage of her class experiences math anxiety, what couldn’t she determine from the percentages?

Making Sense of the World from a Little Piece: Inferential Statistics

Descriptive statistics tell us what is going on with the measurements we gather from a sample of people. However, as we have indicated, scientists often want to reach conclusions that go beyond the sample to the population from which the sample was selected. Behavioral scientists often want to characterize populations with statements such as “the typical married working mother devotes 14.1 hours per week to child care.” It should be obvious that in most instances these characterizations cannot be obtained from measuring all members of the population; we cannot measure all married working mothers. Rather, scientists typically use information obtained from only a sample of the population to reach these conclusions.

Often, but not always, samples are selected from a population by following a set of rules to ensure that the sample is representative of the population. One common form of selecting a sample is random sampling. In a simple random sample, individuals are selected in such a way that each member of the population has an equal chance of being selected for the sample and the selection of one member is independent of the selection of any other member of the population. Data are then obtained from members of the sample, and a descriptive statistic is calculated to describe the data. This descriptive statistic is then used to infer a characteristic of the population. The word infer implies reasoning from something known to something unknown. Thus, statistical inference is
the process of reaching conclusions about unknown population values (e.g., how much
time does the typical married working mother devote to child care per week?) called
parameters from descriptive statistics obtained from a sample (e.g., the typical mar-
ried working mother in the sample devoted 14.1 hours per week to child care). Charac-
teristics of populations are called parameters rather than statistics to distinguish them
from the statistics calculated on data from a sample.1

There are numerous common examples of descriptive statistics used to infer characteris-
tics of populations. For example, the U.S. Census Bureau collects a variety of information
about life in the United States and each year publishes summaries of some of this information
in the Statistical Abstract of the United States. The 2007 Statistical Abstract revealed that

1. 25.1 percent of the population played cards within the last 12 months.
2. the typical female commuter spent 23.1 minutes traveling to work each day.
3. the average family income was $56,194.
4. 60.4 percent of males and 56.9 percent of females were married.

Each of these numerical values is a parameter estimated from a descriptive statistic
obtained from a sample. Realize that it is impossible to ask every person whether or not he
or she played cards within the past year or to ask each female commuter how much time
she spends in traveling to work each day. Thus, each of these values is an estimate of a
population value. How well these individual descriptive statistics estimate population val-
ues depends on how the sample was chosen and how representative it is of the population.
The procedures involved in the selection and description of samples and inference to a
population are discussed more fully in Chapters 3 through 7.

Testing Your Knowledge 1.2

1. Define: parameter, random sample, statistical inference.
2. In a recent election, 600 potential voters of a congressional district were polled to
discover whom they planned to vote for in an upcoming election. The results indicated
that 312 voters, or 52 percent of the sample, planned to vote for candidate A, 240 voters,
or 40 percent, planned to vote for candidate B, and 48 voters, or 8 percent, said they did
not plan to vote or had no preference among the candidates. Based on the results of the
poll, the researchers estimated that candidate A would win the election with about
52 percent of the total vote.
   a. Explain why descriptive statistics are necessary to summarize the results of this
      research.
   b. What inferences to a population were made from the statistics obtained?
   c. What type of statistic helps us make generalizations from the sample to the population?
   d. Thinking ahead: although we haven’t discussed the selection of samples in detail,
      what aspects of selecting this sample would make you trust the results of the poll
      that candidate A is going to win the election?
   e. What aspects of selecting this sample would make you distrust this result?

Of course, not all statisticians adhere to this usage, and some use the term statistic to refer to both samples and
populations. In this text, however, we will use the term statistic to refer to values obtained from a sample and
parameter to refer to values obtained from a population.
Behavioral scientists are interested not only in describing and characterizing samples and populations, but they also want to find the causes for individual or group behaviors. One approach to this task is to perform an experiment. To conduct an experiment, a researcher identifies a variable, called an independent variable, that he or she thinks affects a person’s behavior. The behavior that is expected to be affected by this independent variable is called the dependent variable.

For example, we might expect alcohol consumption to affect a person’s response to violence: People under the influence of alcohol are expected to be more accepting of violence than people who are not under the influence of alcohol (Gustafson, 1987). In this instance, alcohol consumption is the independent variable. An experimenter has control over whether a person does or does not consume alcohol, and he or she expects it to affect the acceptance of violence. A measure of the person’s acceptance of violence is the dependent variable. Acceptance of violence is presumed to depend on whether or not a person has consumed alcohol. The statement of the researcher’s expectation that alcohol consumption will affect the acceptance of violence is called a research hypothesis. A research hypothesis is a statement of an expected, or predicted, relationship between two or more variables. In an experiment, a research hypothesis is a predicted relationship between an independent variable and a dependent variable.

The simplest experiment that could be performed to test a research hypothesis relating alcohol consumption to acceptance of violence begins by creating two equivalent groups of people. Scientists refer to the people who participate in research studies as subjects or participants. Although these terms are sometimes used interchangeably, we will use subjects in the chapters that follow. Equivalent groups are groups of subjects that are not expected to differ in any consistent or systematic way prior to receiving the independent variable of the experiment. Notice that we are saying the groups are equivalent, but we are not saying that the groups are equal. Subjects differ, so groups of subjects will also differ. However, psychologists have a technique called random assignment to obtain equivalent groups. Random assignment requires that all subjects selected for an experiment have an equal chance of being in any of the treatment groups and the assignment of one subject to a treatment group is independent of the assignment of any of the other subjects. If all subjects have been randomly assigned to the treatment groups, then there is no reason to believe one group will be different from another group in a consistent or systematic manner before the treatment is given. As such, we have equivalent, though not equal, groups. Random assignment and the creation of equivalent groups is discussed more fully in Chapter 9.

An experiment in which two or more groups are created is called a between-subjects design. After equivalent groups are created, the researcher manipulates or varies the independent variable and measures the dependent variable, while controlling all other variables that may affect the dependent variable. In this example, the experimenter might give people in the first group 0.8 milliliter of alcohol per kilogram of body weight mixed with an equal amount of orange juice. Subjects in the second group might be given 1.6 milliliters of plain orange juice per kilogram of body weight. The difference in the drink is the only way in which the two groups are allowed to vary. The dependent variable may be measured by having the subjects watch a violent movie and then rate the movie on the acceptability of the violence shown. A score on the rating task is obtained for each person. A score is the measurement obtained on the subject’s performance of a task. This score is the dependent variable, for we expect it to depend on whether or not the person had consumed

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**Independent variable**
A variable manipulated in an experiment to determine its effect on the dependent variable.

**Dependent variable**
The variable in an experiment that depends on the independent variable. In most instances, the dependent variable is some measure of a behavior.

**Research hypothesis**
A statement of an expected or predicted relationship between two or more variables. In an experiment, a research hypothesis is a predicted relationship between an independent variable and a dependent variable.

**Subject or participant**
The person who participates in an experiment.

**Equivalent groups**
Groups of subjects that are not expected to differ in any consistent or systematic way prior to receiving the independent variable of the experiment.

**Random assignment**
A method of assigning subjects to treatment groups so that any individual selected for the experiment has an equal probability of assignment to any of the groups and the assignment of one person to a group does not affect the assignment of any other individual to that same group.

**Between-subjects design**
A research design in which two or more groups are created.

**Score**
The measurement obtained on the subject’s performance of a task.