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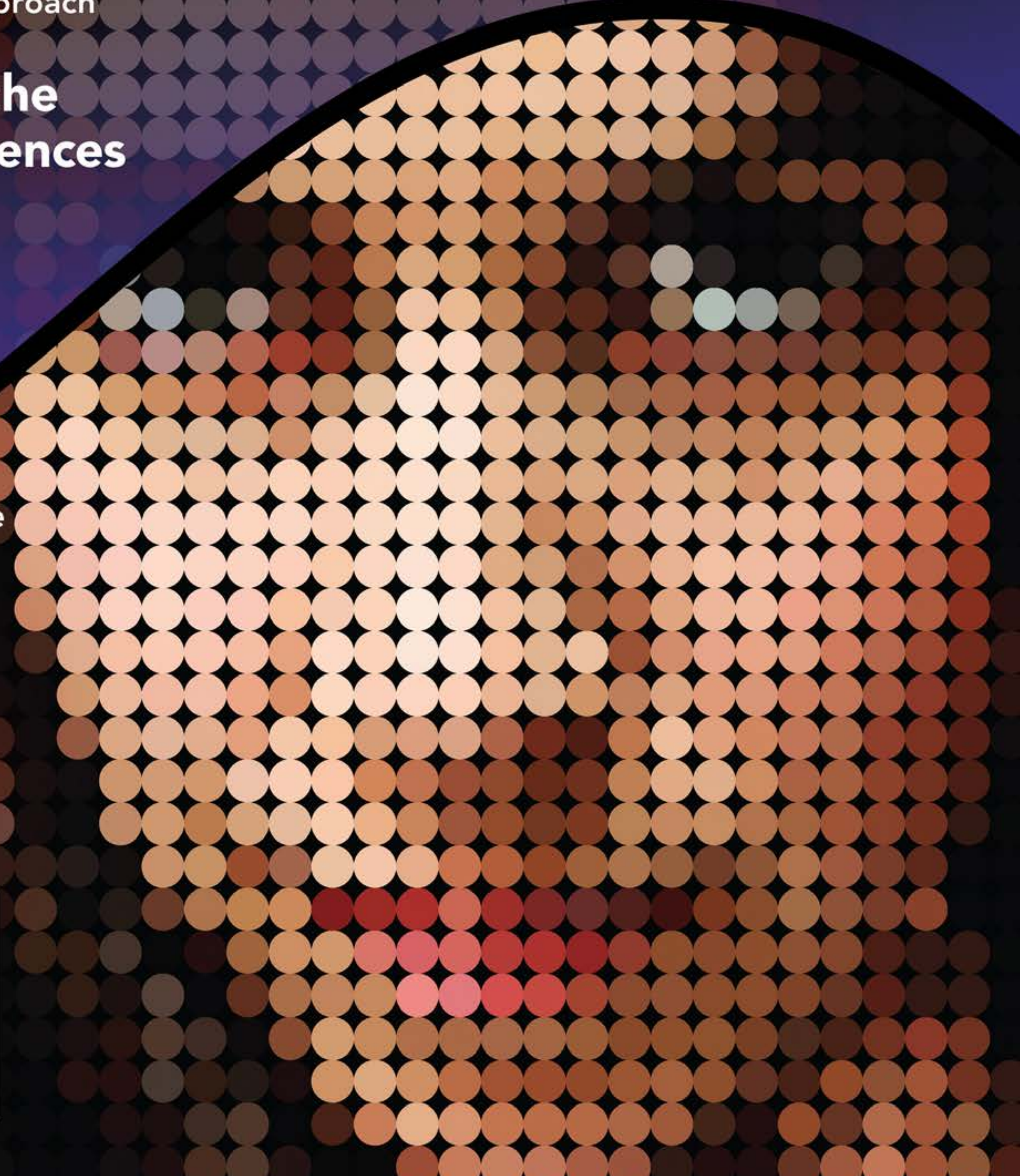

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ISBN-13: 978-1-285-45814-4
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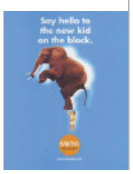

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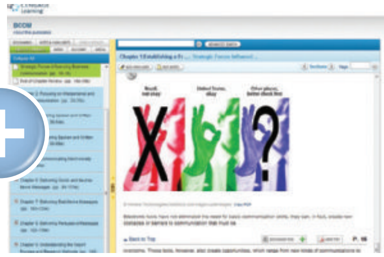

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Library of Congress Control Number: 2013936603

ISBN-13: 978-1-285-45814-4

ISBN-10: 1-285-45814-1

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200 First Stamford Place, 4th Floor
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Printed in the United States of America
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For my wife Karen, the love of my life

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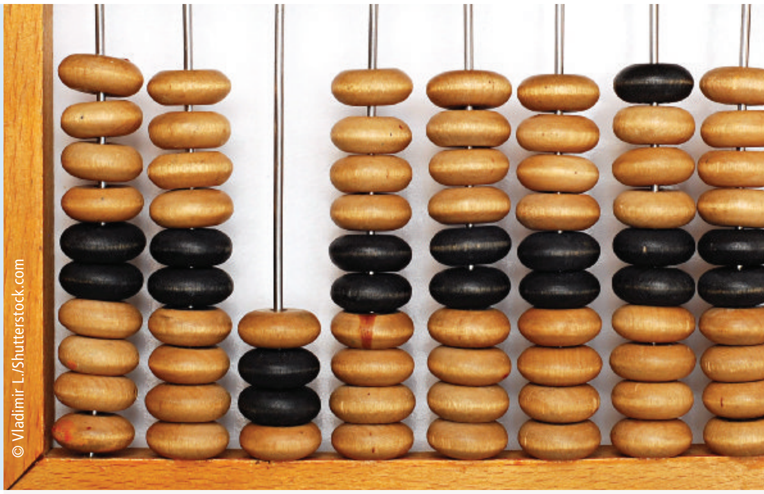

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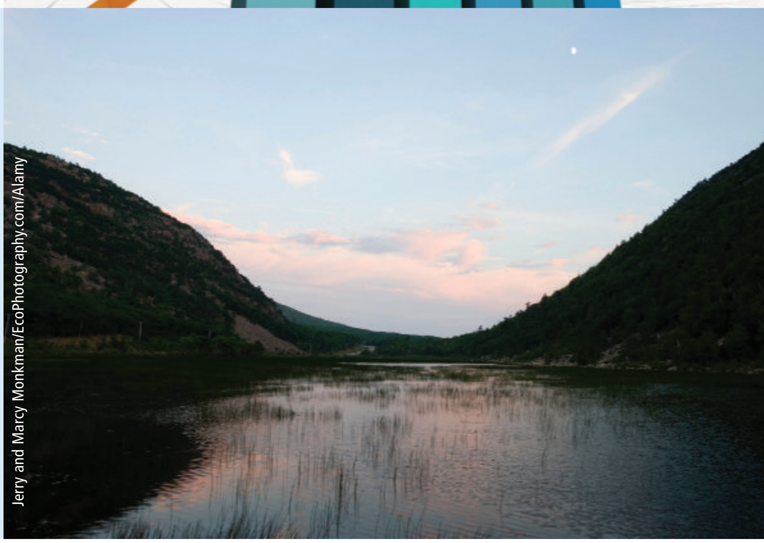

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Chapter 1

INTRODUCTION TO STATISTICS AND RESEARCH

GOING FORWARD

Your goals in this chapter are to learn:

- The logic of research and the purpose of statistical procedures.
- What a relationship between scores is.
- When and why descriptive and inferential procedures are used.
- What the difference is between an experiment and a correlational study, and what the independent variable, the conditions, and the dependent variable are.
- What the four scales of measurement are.

Sections

1-1 Learning about Statistics

1-2 The Logic of Research

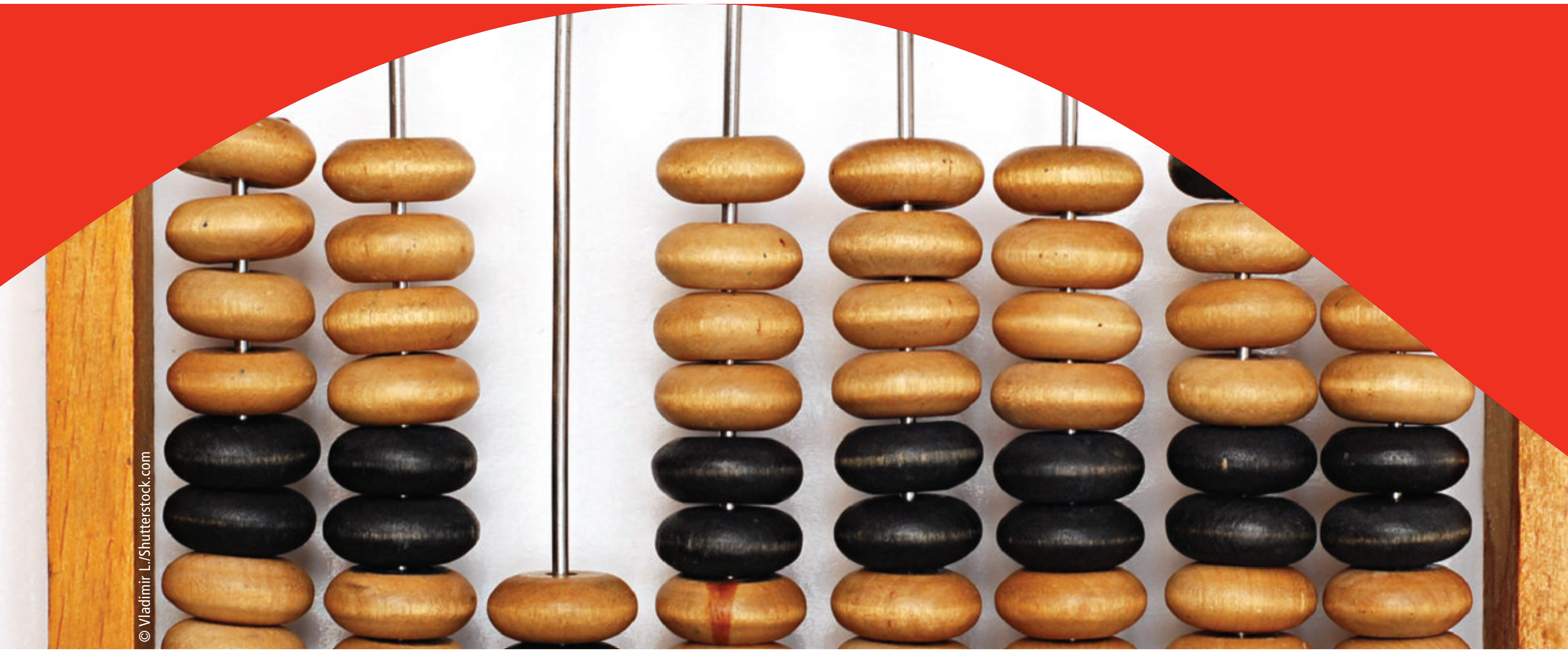
1-3 Understanding Relationships

1-4 Applying Descriptive and Inferential Statistics

1-5 Understanding Experiments and Correlational Studies

1-6 The Characteristics of Scores

Okay, so you're taking a course in statistics. What does this involve? Well, first of all, statistics involve math, but if that makes you a little nervous, you can relax: You do not need to be a math wizard to do well in this course. You need to know only how to add, subtract, multiply, and divide—and use a calculator. Also, the term *statistics* is often shorthand for *statistical procedures*, and statisticians have already developed the statistical procedures you'll be learning about. So you won't be solving simultaneous equations, performing proofs and derivations, or doing other mystery math. You will simply learn how to select the statistical procedure—the formula—that is appropriate for a given situation and then compute and interpret the answer. And don't worry, there are not that many to learn, and these fancy-sounding "procedures" include such simple things as computing an average or drawing a graph. (A quick refresher in



math basics is in Appendix A.1. If you can do that, you'll be fine.)

Instead of thinking of statistics as math problems, think of them as tools that psychologists and other behavioral researchers employ when "analyzing" the results of their research. Therefore, for you to understand statistics, your first step is to understand the basics of research so that you can see how statistics fit in. To get you started, in this chapter we will discuss (1) what learning statistics involves, (2) the logic of research and the purpose of statistics, (3) the two major types of studies that researchers conduct, and (4) the four ways that researchers measure behaviors.

1-1 LEARNING ABOUT STATISTICS

Why is it important to learn statistics? Statistical procedures are an important part of the research that forms the basis for psychology and other behavioral sciences. People involved with these sciences use statistics and statistical concepts every day. Even if you are not interested in conducting research yourself, understanding statistics is necessary for comprehending other people's research and for understanding your chosen field of study.

How do researchers use statistics? Behavioral research always involves measuring behaviors. For example, to study intelligence, researchers measure the IQ scores of individuals, or to study memory, they measure the number of things that people remember or forget. We call these scores the *data*. Any study typically produces a very large batch of data, and it is at this point that researchers apply statistical procedures, because ***statistics help us to make sense out of the data***. We do this in four ways.

1. First, we *organize* the scores so that we can see any patterns in the data. Often this simply involves creating a table or graph.
2. Second, we *summarize* the data. Usually we don't want to examine each individual score in a study, and a summary—such as the average score—allows us to quickly understand the general characteristics of the data.
3. Third, statistics *communicate* the results of a study. You will learn the standard techniques and symbols we use to quickly and clearly communicate results, especially in published research reports.
4. Finally, we use statistics to *interpret* what the data indicate. All behavioral research is designed to answer a question about a behavior and, ultimately, we must decide what the data tell us about that behavior.

THE PURPOSE OF
STATISTICAL
PROCEDURES IS
TO MAKE SENSE OUT OF DATA.

You'll see there are actually only a few different ways that behavioral research is generally conducted, and for each way, there are slightly different formulas that we use. Thus, in a nutshell, the purpose of this course is to familiarize you with each research approach, teach you the appropriate formulas for that approach, and show you how to use the answers you compute to make sense out of the data (by organizing, summarizing, communicating, and interpreting).

Along the way, it is easy to get carried away and concentrate on only the formulas and calculations. However, don't forget that statistics are a research tool that you must learn to apply. Therefore, more than anything else, your goal is to learn *when* to use each procedure and how to *interpret* its answer.

1-1a Studying Statistics

The nature of statistics leads to some "rules" for how to approach this topic and how to use this book.

- You will be learning novel ways to think about the information conveyed by numbers. You need to carefully read and study the material, and often you will need to read it again. Don't try to "cram" statistics. You won't learn anything (and your brain will melt). You must translate the new terminology and symbols into things that you understand, and that takes time and effort.
- Don't skip something if it seems difficult because concepts and formulas build upon previous ones. Following each major topic in a chapter, test yourself with the in-chapter "Quick Practice." If you have problems with it, go back—you missed something. (Also, the beginning of each chapter lists what you should understand from previous chapters. Make sure you do.)
- Researchers use a shorthand "code" for describing statistical analyses and communicating research results. A major part of learning statistics is learning this code. Once you speak the language, much of the mystery of statistics will evaporate. So learn (memorize) the terminology by using the glossary in the page margins and the other learning aids that are provided.
- The *only* way to learn statistics is to *do* statistics, so you must practice using the formulas and concepts. Therefore, at the end of each chapter are study questions that you should complete. Seriously work on these questions. (This is the practice test before the real test!) The answers to the odd-numbered problems are in Appendix C, and your instructor has the answers to the even-numbered problems.
- At the end of this book are two tear-out "Review Cards" for each chapter. They include: (1) a Chapter Summary, with linkage to key vocabulary terms; (2) a Procedures and Formulas section, where you can review how to use the formulas and procedures (keep it handy when doing the end-of-chapter study questions); and (3) a Putting It All Together fill-in-the-blank exercise that reviews concepts, procedures, and vocabulary. (Complete this for all chapters to create a study guide for the final exam.)
- You cannot get too much practice, so also visit the *CourseMate* website as described on the inside cover of this book. A number of study tools are provided for each chapter, including printable flashcards, interactive crossword puzzles, and more practice problems.

1-1b Using the SPSS Computer Program

In this book we'll use formulas to compute the answers "by hand" so that you can see how each is produced. Once you are familiar with statistics, though, you will want to use a computer. One of the most popular statistics programs is called SPSS. At the end of most chapters in this book is a brief section relating SPSS to the chapter's procedures, and you'll find step-by-step instructions on one of the Chapter Review Cards. (Review Card 1.4 describes how to get started by entering data.) These instructions are appropriate for version 20 and other recent versions of SPSS. Establish a routine of using the data from odd-numbered study problems at the end of a chapter and checking your answers in Appendix C.

TO BRUSH UP ON YOUR MATH SKILLS, CHECK OUT THE REVIEW OF BASIC MATH IN APPENDIX A.1 ON PAGE 234.

But remember, computer programs do only what you tell them to do. SPSS cannot decide which statistical procedure to compute in a particular situation, nor can it interpret the answer for you. You really must learn *when* to use each statistic and what the answer *means*.

1-2 THE LOGIC OF RESEARCH

The goal of behavioral research is to understand the "laws of nature" that apply to the behaviors of living organisms. That is, researchers assume that specific influences govern every behavior of all members of a particular group. Although any single study is a small step in this process, our goal is to understand every factor that influences the behavior. Thus, when researchers study such things as the mating behavior of sea lions or social interactions among humans, they are ultimately studying the laws of nature.

The reason a study is a small step is because nature is very complex. Therefore, research involves a series of translations that simplify things so that we can examine a specific influence on a specific behavior in a specific situation. Then, using our findings, we *generalize* back to the broader behaviors and laws we began with. For example, here's an idea for a simple study. Say that we think a law of nature is that people must study information in order to learn it. We translate this into the more specific *hypothesis* that "the more you study statistics, the better you'll learn them." Next, we will translate the hypothesis into a situation where we can observe and measure specific people who study specific material in different amounts, to see if they *do* learn differently. Based on what we observe, we have evidence for working back to the general law regarding studying and learning.

The first part of this translation process involves samples and populations.

population The large group of individuals to which a law of nature applies

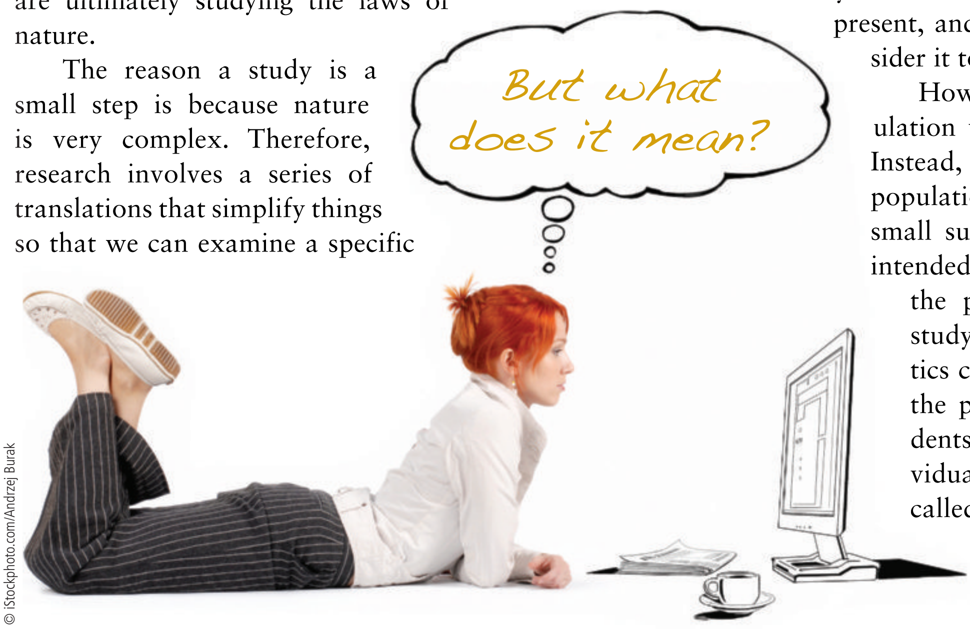
sample A relatively small subset of a population intended to represent the population

participants The individuals who are measured in a sample

1-2a Samples and Populations

When researchers talk of a behavior occurring in nature, they say it occurs in the population. A **population** is the entire group of individuals to which a law of nature applies (whether all humans, all men, all 4-year-old English-speaking children, etc.). For our example, the population might be all college students who take statistics. A population usually contains all possible members—past, present, and future—so we usually consider it to be infinitely large.

However, to study an *infinite* population would take roughly forever! Instead, we study a sample from the population. A **sample** is a relatively small subset of a population that is intended to represent, or stand in for, the population. Thus, we might study the students in your statistics class as a sample representing the population of all college students studying statistics. The individuals measured in a sample are called the **participants** and it is their scores that constitute our data.



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Although researchers ultimately discuss the behavior of individuals, in statistics we often go directly to their scores. Thus, we will talk about the population of scores as if we have already measured the behavior of everyone in the population in a particular situation. Likewise, we will talk about a sample of scores, implying that we have already measured our participants. Thus, a population is the complete group of scores that would be found for everyone in a particular situation, and a sample is a subset of those scores that we actually measure in that situation.

The logic behind samples and populations is this: We use the scores in a sample to *infer*—to estimate—the scores we would expect to find in the population if we could measure it. Then by translating the scores back into the behaviors they reflect, we can infer the behavior of the population. By describing the behavior of the population, we *are* describing how nature works, because the population *is* the entire group to which the law of nature applies. Thus, if we observe that greater studying leads to better learning for the sample of students in your statistics class, we will infer that similar scores and behaviors would be found in the population of all statistics students. This provides evidence that, in nature, more studying does lead to better learning.

Notice that the above assumes that a sample is *representative* of the population. We discuss this issue in later chapters, but put simply, the individuals in a representative sample *accurately* reflect the individuals that are found in the population. This means that then our inferences about the scores and behaviors found in the population will also be accurate. Thus, if your class is representative of all college students, then the scores the class obtains are a good example of the scores that everyone in the population would obtain.

variable Anything about a behavior or situation that, when measured, can produce two or more different scores

On the other hand, any sample can be *unrepresentative* and then it *inaccurately* reflects the population. The reason this occurs is simply due to random chance—the "luck of the draw" of who we happen to select for a sample. Thus, maybe, simply because of who happened to enroll in your statistics class, it contains some very unusual, atypical students who are not at all like those in the population. If so, then their behaviors and scores will mislead us about those of the typical statistics student. Therefore, as you'll see, researchers always consider the possibility that a conclusion about the population—about nature—might be incorrect because it might be based on an unrepresentative sample.

Researchers study the behavior of the individuals in a sample by measuring specific *variables*.

1-2b Understanding Variables

We measure aspects of the situation that we think influence a behavior, and we measure aspects of the behavior itself. The aspects of the situation or behavior that we measure are called variables. A **variable** is anything that can produce two or more different scores. A few of the variables found in behavioral research include characteristics of an individual, like your age, race, gender, personality type, political affiliation, and physical attributes. Other variables measure your reactions, such as how anxious, angry, or aggressive you are, or how attractive you think someone is. Sometimes variables reflect performance, such as how hard you work at a task or how well you recall a situation. And variables also measure characteristics of a situation, like the amount of noise, light, or heat that is present; the difficulty or attributes of a task; or

Erik Isakson/Getty Images

how many others are present and the types of interactions you have with them.

Variables fall into two general categories. If a score indicates the amount of a variable that is present, the variable is a **quantitative variable**. A person's height, for example, is a quantitative variable. Some variables, however, cannot be measured in amounts, but instead classify or categorize an individual on the basis of some characteristic. These variables are called **qualitative variables**. A person's gender, for example, is qualitative because the "score" of male or female indicates a quality, or category.

For our research on studying and learning statistics, say that to measure "studying," we select the variable of the number of hours that students spent studying for a particular statistics test. To measure "learning," we select the variable of their performance on the test. After measuring participants' scores on these variables, we examine the *relationship* between them.

Table 1.1

Scores Showing a Relationship between the Variables of Study Time and Test Grades

FYI: The data presented in this book are fictional. Any resemblance to real data is purely a coincidence.

Student	Study Time in Hours	Test Grades
Gary	1	F
Bo	1	F
Sue	2	D
Tony	2	D
Sidney	3	C
Ann	4	B
Rose	4	B
Lou	5	A

1-3 UNDERSTANDING RELATIONSHIPS

If nature relates those mental activities we call *studying* to those mental activities we call *learning*, then different amounts of learning should occur with different amounts of studying. In other words, there should be a *relationship* between studying and learning. A **relationship** is a pattern in which, as the scores on one variable change, the scores on the other variable change in a consistent manner. In our example, we predict the relationship in which the longer you study, the higher your test grade will be.

Say that we ask some students how long they studied for a test and their subsequent grades on the test. We obtain the data in Table 1.1. To see the relationship, first look at those people who studied for 1 hour and see their grade. Then look at those who studied 2 hours, and see that they had a different grade from those studying 1 hour. And so on. These scores form a relationship because as the study-time scores change (increase), the test grades also change in a consistent fashion (also increase). Further, when study-time scores do not change (e.g., Gary and Bo both studied for 1 hour), the grades also do not change (they both received Fs). We often use the term *association* when talking about relationships: Here, low study times are associated with low test grades and high study times are associated with high test grades.

Remember:

In a *relationship*, as the scores on one variable change, the scores on the other variable change in a consistent manner.

Because we see a relationship in these sample data, we have evidence that in nature, studying and learning do operate as we hypothesized: The amount someone studies does seem to make a difference in test grades. In the same way, whenever a law of nature ties behaviors or events together, then we'll see that particular scores from one variable are associated with particular scores from another variable so that a relationship is formed. Therefore, most research is designed to investigate relationships, because relationships are the tell-tale signs of a law at work.

A major use of statistical procedures is to examine the scores in a relationship and the pattern they form. The simplest relationships fit one of two patterns. Let's call one

quantitative variable A variable for which scores reflect the amount of the variable that is present

qualitative variable A variable for which scores reflect a quality or category that is present

relationship A pattern between two variables where a change in one variable is accompanied by a consistent change in the other variable X and the other Y. Then, sometimes the relationship fits the description "the more you X, the more you Y." Examples of this include the following: The more you study, the higher your grade; the more alcohol you drink, the more you fall down; the more often you speed, the more traffic tickets you receive; and even that old saying "The bigger they are, the harder they fall."

At other times, the relationship fits the description "the more you X, the *less* you Y." Examples of this include the following: The more you study, the fewer the errors you make; the more alcohol you drink, the less coordinated you are; the more you "cut" classes, the lower your grades; and even that old saying "The more you practice statistics, the less difficult they are."

Relationships may also form more complicated patterns where, for example, more X at first leads to more Y, but beyond a certain point, even more X leads to *less* Y. For example, the more you exercise the better you feel, until you reach a certain point, beyond which more exercise leads to feeling less well, due to pain and exhaustion.

Although the above examples involve quantitative variables, we can also study relationships that involve qualitative variables. For example, gender is a commonly studied qualitative variable. If you think of being male or female as someone's "score" on the gender variable, then we see a relationship when, as gender scores change, scores on another variable also change. For example, saying that men tend to be taller than women is actually describing a relationship, because as gender scores change (going from men to women), their corresponding height scores tend to decrease.

1-3a The Consistency of a Relationship

Table 1.1 showed a perfectly consistent association between hours of study time and test grades: All those who studied the same amount received the same grade. In a *perfectly consistent relationship*, a score on one variable is always paired with one and only one score on the other variable. This makes for a very clear, obvious pattern when you examine the data. In the real world, however, not everyone who studies for the same amount of time will receive the same test grade. (Life is not fair.) A relationship can be present even if there is only some *degree* of consistency. Then, as the scores on one variable change, the scores on the other variable *tend* to change in a consistent fashion. This produces a less obvious pattern in the data.

Table 1.2

Scores Showing a Relationship between Study Time and Number of Errors on Test

Student	X Hours of Study	Y Errors on Test
Amy	1	12
Karen	1	13
Joe	1	11
Cleo	2	11
Jack	2	10
Maria	2	9
Terry	3	9
Manny	3	10
Chris	4	9
Sam	4	8
Gary	5	7

For example, Table 1.2 presents a less consistent relationship between the number of hours studied and the number of *errors* made on the test. Notice that the variables are also labeled X and Y. When looking at a relationship, get in the habit of asking, "As the X scores *increase*, do the Y scores change in a consistent fashion?" Answer this by again looking at one study-time score (at one X score) and seeing the error scores (the Y scores) that are paired with it. Then look at the next X score and see the Y scores paired with it. Two aspects of the data in Table 1.2 produce a less consistent relationship: First, not everyone who studies for a particular time receives the same error score (e.g., 12, 13, and 11 errors are all paired with 1 hour). Second, sometimes a particular error score is paired with *different* studying scores (e.g., 11 errors occur with both 1 and 2 hours of study). These aspects cause overlapping groups of different error scores to occur at each study time, so the overall pattern is harder to see. In fact, the greater the differences among the group of Y scores at an X and the more the Y scores overlap between groups, the less consistent the relationship will be. Nonetheless, we still see the pattern where more studying *tends* to be associated with lower error scores, so a relationship is present. Essentially, one batch of error scores occurs at one study-time score, but a *different* batch of error scores tends to occur at the next study-time score.

Notice that the less consistent relationship above still supports our original hypothesis about how nature operates: We see that, at least to some degree, nature does relate studying and test errors. Thus, we will always examine the relationship in our data, no matter how consistent it is. A particular study can produce anywhere between a perfectly consistent relationship and no relationship. In Chapter 10 we will discuss in depth how to describe and interpret the consistency of a particular relationship. (As you'll see, the degree of consistency in a relationship is called its *strength*, and a less consistent relationship is a *weaker* relationship.) Until then, it is enough for you to simply know what a relationship is.

Remember:

A relationship is present (though not perfectly consistent) if there tends to be a different group of Y scores associated with each X score. A relationship is not present when virtually the same batch of Y scores is paired with every X score.

1-3b When No Relationship Is Present

At the other extreme, sometimes the scores from two variables do not form a relationship. For example, say that we had obtained the data shown in Table 1.3.

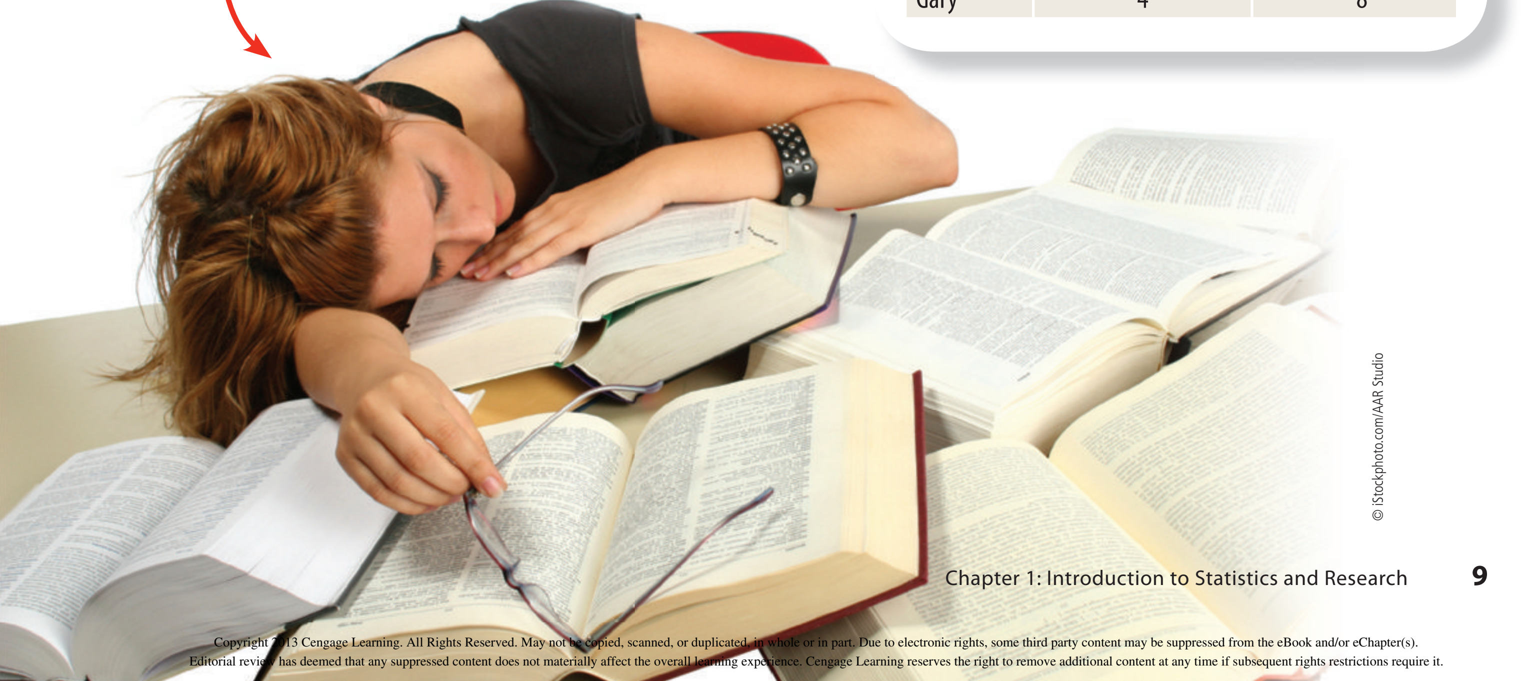
Here, no relationship is present because the error scores paired with 1 hour are essentially the same as the error scores paired with 2 hours, and so on. Thus, virtually the same (but not identical) batch of error scores shows up at each study time, so no pattern of increasing or decreasing errors is present. These data show that how long people study does not make a consistent difference in their error scores. Therefore, this result would not provide evidence that studying and learning operate as we think.

Table 1.3

Scores Showing No Relationship between Hours of Study Time and Number of Errors on Test

Student	*X* Hours of Study	*Y* Errors on Test
Amy	1	12
Karen	1	10
Joe	1	8
Cleo	2	11
Jack	2	10
Maria	2	9
Terry	3	12
Manny	3	9
Chris	3	10
Sam	4	11
Jane	4	10
Gary	4	8

Less studying may lead to more errors ...



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