Why Do I Have to Learn Statistics? The Value of Statistical Thinking in Life

After reading this chapter, you will be able to

Identify reasons why people tend to ignore information about probability in everyday life

Identify reasons why people tend to misunderstand connections between events in everyday life

Differentiate research methods for each of the four goals of research

Differentiate basic concepts in statistical thinking

"Statistical thinking will one day be as necessary a qualification for efficient citizenship as the ability to read and write."

H. G. Wells

When I was in high school and college, I took a math-based class (e.g., algebra, geometry, statistics, and calculus) every semester. I did fairly well in these classes because I worked hard and usually earned decent grades, never spectacular but not bad either. Playing around with numbers was a fun intellectual exercise for me back then. During that same time, I took writing-based classes (e.g., composition, creative writing, business communications, and literature). At the risk of being arrogant, I usually earned solid "A"s in those classes (and even some "A + "s because we could get those at my high school). Candidly, I did not work nearly as hard in my writing classes as I did in my math classes. I was by no means a gifted writer, but thanks in large part to my parents, I always understood the importance of writing and communication abilities even when I was in middle school. Indeed, how can good writing and other communication skills do anything but help a person in a job or many other life situations, such as developing personal relationships? I took more writing classes than my high school and college required just because they were so much fun and easy for me. Math classes? Not so much. Until I was in graduate school, I never saw the relevance of math classes outside of the classroom. Then, in my third
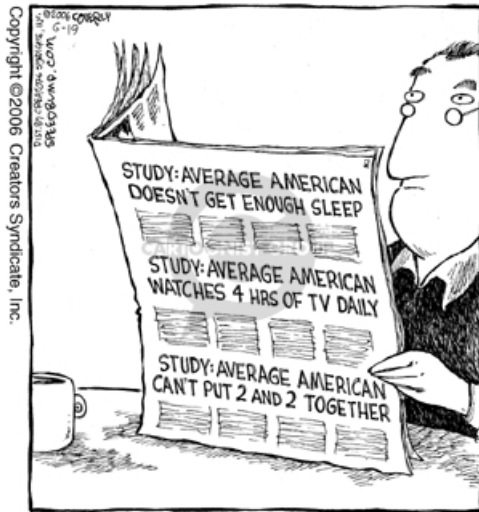
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Photo 1.1   Statistical information is everywhere. Understanding it is essential for success not just in school, but also in life more generally.

graduate-level statistics class (yes, you read that correctly, my *third graduate-level statistics class*), something clicked. Even now, 19 years later, I don't know what it was that clicked. But something clicked, and I began understanding the relevance of the numbers I was using. When I began to see the logic of each statistic that I was calculating, all I wanted to do was learn more about statistics. And as I did so, I understood the logic of statistics, even fairly high-level statistics, more quickly and became much better able to use such logic not only in research but in "real-life" situations as well.

Maybe I was not very smart in high school or college, but I look back at that time and cannot understand what took me so long to see the logic behind statistics. When I started teaching statistics more than 15 years ago, I swore that my students would leave the class understanding the logic of statistics. Some have gone on and used statistics in research careers; most have not. Those who are not using technical statistics in their work are still dealing with situations that require the same logical thinking that statistics requires. If you are interested in doing research or are already enthusiastic about dealing with quantitative information, you probably don't need to be sold on the idea that statistics will be important to you. However, before we dive into specific statistical information, I want to take some time to discuss the general importance of statistics, both to researchers and to nonresearchers alike. For those of you taking this class solely because you have to take it, I hope it will give you some idea of why you are here and the benefits you should expect to gain while you are here. It is my hope that by the time you complete this class, you will understand the importance of statistics in making sense of research, in addition to using the logic of statistical thinking in more everyday situations.

In the first part of this chapter, we will discuss why a lot of people are not good at using statistical logic in their daily lives. I do not want you to be like a lot of people in this regard as it can be costly in many ways. We will highlight the reasons most people are not good at dealing with statistical information in daily life and, in doing so, detail some of these everyday situations, describing how statistical logic is (or should be) used in each one. The second section will discuss some basic goals of research and the role that statistics play in achieving each of these goals. Finally, we will introduce some basic statistical information we will see throughout this course and, in doing so, highlight how such information can improve our ability to think about the world.

STATISTICAL THINKING AND EVERYDAY LIFE

We easily can get our hands on information via the Internet for any situation we may be in. However, we need to know how to interpret and make use of such information, especially as not all of it is objective or even correct. The world is full of statistical information, much of it we hardly ever notice or pay much attention to (until now). In addition to potential value in the workplace, learning about statistics and the logic behind them will help you navigate everyday situations you will encounter, some of which we'll discuss in this section.

Before we begin this section in detail, let me say that, in general, the human mind works magnificently well. We rarely notice how well it works until something goes wrong. I say this because as you read this section of the chapter, you might think people are generally stupid, but that is just not the case. But here, I want to draw your attention to some flaws in our ability to process information as they relate to statistical thinking. By learning about statistics

in subsequent chapters, I hope that you will be able to spot these shortcomings in your thinking and in the thinking of other people.

I have classified these flaws in human thinking loosely into two categories: failing to use information about probability and misunderstanding connections between events. However, in practice, they are more interrelated than I will present them here.

Failing to Use Information About Probability

Last night, I put my life in great jeopardy. I did so voluntarily. What did I do, you ask? I carried dirty clothes downstairs and did laundry.

If you are wondering what the risk was, more than 8 million visits to the emergency room each year are due to falls at home, and more than 17,000 people in the United States die each year from such falls and resulting complications (National Safety Council, 2015). Now, I said I put my life in "great jeopardy." Almost anything we do (e.g., walking, exercising, or eating) carries some risk. While walking, we could trip and fall. While exercising, we could dislocate a joint. While eating, we could choke or ingest something poisonous. So, I need to clarify what I meant by "great jeopardy." I am guessing the risks associated with these everyday behaviors have not crossed your mind unless, of course, they have happened to you. However, other risks may well have crossed your mind. Terrorism is in the news a lot. There is a chance you could be a victim of terrorism. However, how great is that risk? The U.S. Department of State (2014) reported that worldwide, 16 Americans died from terrorist-related activity worldwide in 2013. Another 12 Americans were kidnapped and another 7 were injured from terrorism. Compare that total (35 Americans) with the 17,000 Americans who die from falling each year. I have a 485 times greater chance of dying trying to do my laundry than I do of dying in a terrorist attack. Based on these statistics, should we be more concerned about falling at home or about terrorism?

Even with this statistical information, you may not be convinced that terrorism is less of a threat than is falling at home, and that is understandable. We tend to ignore probabilities for a very good reason. We need to make a lot of decisions in our lives. We make decisions all of the time. What class to study for first? Go running or go to yoga (or, in my case, what TV show to watch)? What to eat for a snack? What to wear today? We make many of our decisions using heuristics, which are mental shortcuts, based on prior experience, that allow us to make decisions quickly. Let's take a simple example. Suppose you are at the grocery store needing to buy toothpaste;

> "What has been very successful for me through my whole life is to not be arrogant about knowing, but to embrace the fact that I have weaknesses, that I don't know a lot about this, that and the other thing. The more you learn, the more you realize you don't know."
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> **Ray Dalio,** *Founder and Co–Chief Investment Officer, Bridgewater Associates, the world's largest hedge fund*
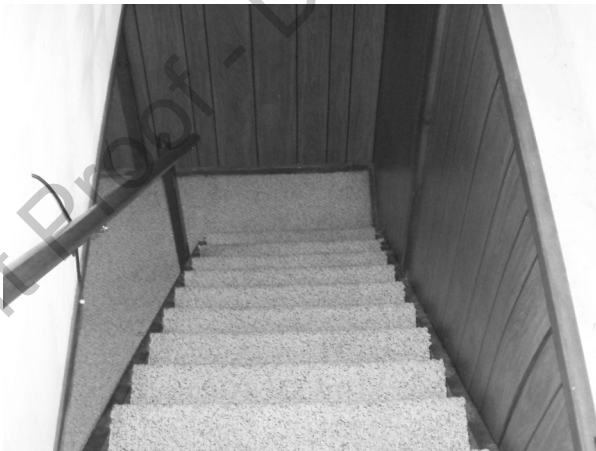
Photo 1.2   Stairs to the basement. A killer in plain sight?

you probably would not look in the fresh produce section. Likewise, if you want to buy fresh strawberries, you probably would not look on the baking supply isle. Did you ever notice those signs above the various isles in the grocery store (and many other types of stores)? Those signs are heuristics in that they give shoppers a general idea of the products contained on that isle. They do not guarantee that the product you are looking for will be there, but in all likelihood (i.e., probability), it will be. We can contrast heuristics with **algorithms**, which are step-by-step procedures that guarantee, eventually, that we will solve a problem correctly. In the grocery store example, you could walk up and down each isle looking for the toothpaste, and eventually, you would indeed find it. However, who wants to spend their time that way? Most people prefer to navigate the world as quickly and efficiently as possible, and heuristics, not algorithms, make that possible.

> **Heuristic**: mental shortcut that allows us to make decisions quickly.
>
> **Algorithm**: step-by-step procedure that guarantees a correct solution to a problem.

So it is with making many, if not most, of our decisions in life. Last night, I made a decision to go downstairs and do laundry, and no, the risk I was taking never crossed my mind. I bet that the notion of being a victim of terrorism scares people more than being the victim of a fall despite the overwhelming odds of dying from a fall. Let's examine why this is the case.

Availability heuristic

Which of these two headlines do you think will capture people's attention more? First, "Statistics Teacher Dies Carrying Laundry Downstairs." Or second, "Civilian Killed in Terrorist Attack." I am betting more people will read the story that accompanies the second headline. In fact, would the first headline even make the news? I doubt it would. The **availability heuristic** involves estimating the frequency of some event happening, based on how easily we can think of examples of that event (Tversky & Kahneman, 1974). When there is an act of terrorism, it is much more likely to be on the news than when a person dies falling in his or her home. Perhaps the local news would make mention of a person dying in a fall, but even if that is the case, hearing about a terrorist act is more frightening to people and more likely to stick in their minds. Let's discuss one reason we rely on the availability heuristic, and then we'll discuss a couple of applications of it.[1]

At some point, I bet you have had to do a group project. One characteristic of a functional work group is that each member has an assigned role and responsibilities (West, Borrill, & Unsworth, 1998). Even if this task was done in your groups, did you ever get the feeling that as the project moved along, you were doing more than other members of your group? If so, there is a reason why we, at least in Western cultures, tend to think this way. How does the availability heuristic work in this situation? Because we are **egocentric**, we have difficulty seeing the world from other people's perspectives. We are each fully aware of the work we are doing, how challenging that work is, the time we invested in that work, and so on. However, that information about the work other people have done is not so readily available to us; hence, it is why most people in this culture tend to overestimate their individual contribution to a group project.

> **Egocentrism**: tendency to perceive the world from our individual, unique perspective.
>
> **Availability heuristic**: estimating the frequency of some event happening, based on how easily we can think of examples of that event.
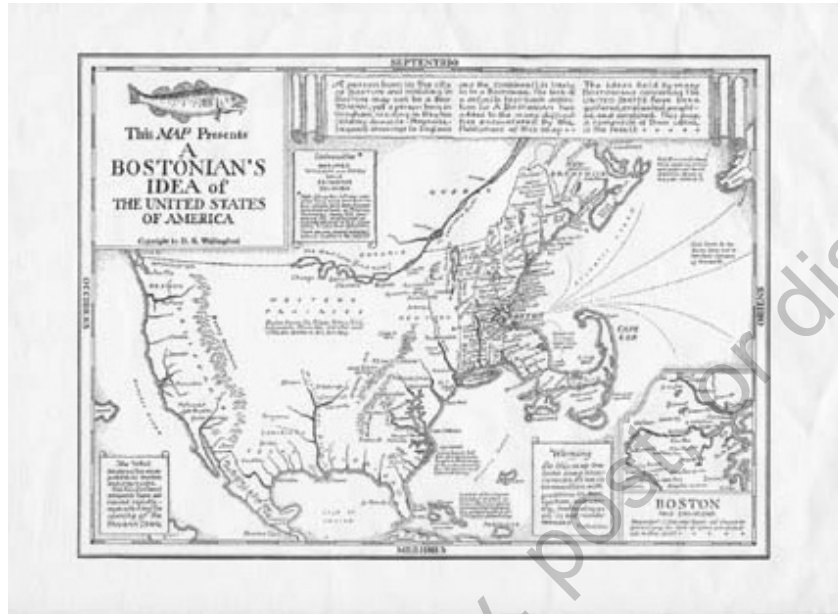
Photo 1.3   An example of egocentrism, Boston style.

Indeed, egocentrism is an important reason why we rely on the availability heuristic. It takes a lot of time and effort to perceive the world from a perspective other than our own. Take another example. In this culture, we often say, "The run rises in the morning," and "The sun sets in the evening." In reality, the sun does not go anywhere; we on Earth are moving, but we cannot see or feel that motion. Therefore, what is available to us is whether we can see the sun. Thanks to our egocentrism, it seems the sun is moving, but it is not. Although being egocentric is normally not a problem to our daily functioning, it can require some altering of our thinking when presented with information, especially quantitative information that may feel impersonal and that counters our perspectives. For

Photo 1.4   Winning at the casino seems so easy on TV.

instance, one of my best friends from high school grew up in Massachusetts before moving to Plano, Texas, where we met. A few months after he moved, his family decided to vacation in the Rio Grande Valley in South Texas. They were shocked at how long a drive it would be from Plano (about 9 hours). After all, it was all in the same state. However, states in the northeastern United States are geographically smaller than they are in the southwestern United States. So to get from one end of a state in the Northeast to the other end of that same state

requires far less time than it does in Texas. What was available to my friend and his family was their perspective on the geographic size of a "state," which varies greatly across regions of the country.

So now that we understand why we rely on availability, let's see it in action. Advertisers make good use of the availability heuristic in trying to persuade people to buy their products and services. For example, casinos will create commercials in which people who won money are proudly displaying their winnings, saying how much fun they had at the casino, and how it is the best place to spend a weekend, all with huge smiles on their faces.

If someone happens to win a lot of money at the casino, why would they not be in a commercial (which they are perhaps getting paid to do on top of their gambling winnings)? If it is that easy to win money, we should all go the casino as it seems everybody is a winner there. Of course, there is some information that is missing. That is, those commercials never show the people who lost their money gambling at that casino. And, in fact, most people have to lose money gambling as it is one way that the casinos make money to stay in business! But by only making available to viewers the people who won money, casinos make available in our minds that they exist just to hand us cash. So naturally, why would we not go there and gamble? Of course, the casinos neglect to make available the reality of gambling for most people.

Photo 1.5a and 1.5b

Another specific application of the availability heuristic is the framing effect, in which people are persuaded by the way information is presented rather than by the value of the information itself (Hardisty, Johnson, & Weber, 2010). Let's take an example from a food that I tend to eat too much of potato chips.

Let's look at RUFFLES® Original Potato Chips (hereafter, "Original Ruffles") and RUFFLES® Oven Baked Original Potato Chips (hereafter, "Baked Ruffles"), made by Frito-Lay® (Purchase, NY). As you might have guessed, Baked Ruffles are baked. The Original Ruffles are fried. So if one type is called "Baked" Ruffles, why not call the other type "Fried" Ruffles to signify how the chips were made? What image does "fried" make available in your mind? It is likely not one of health food. "Baked," on the other hand, sounds like it might be healthy, so therefore it is included on that package. This is an example of the framing effect. Health-conscious consumers might not buy Original Ruffles because there is no real health value in them. However, by baking the chips instead of frying them, it does reduce the fat content, so this benefit gets advertised on the package. Original Ruffles do not advertise that they were fried on the package because most people perceive fried foods to be unhealthy.

Framing effect: tendency to be persuaded by the way information is presented.

You might be asking at this point whether Baked Ruffles are healthier than Original Ruffles. Let's look at the nutritional information to see whether that is the case.

In looking at the nutritional labels for each type of Ruffles, indeed, the Baked Ruffles have more than 50% less fat than Original Ruffles. However, the Original Ruffles have more potassium than do Baked Ruffles. Examining the protein, vitamin, and mineral contents of each bag, they are both low on all dimensions. When we look at the data regarding nutritional content of both types of Ruffles, we see that in terms of vitamins and minerals, there is no big health advantage to Baked Ruffles (maybe less of a "health disadvantage"), no matter how healthy an image such a label may create in our minds. If I want to eat something healthy, data suggest eating snacks such as peppers, bananas, and apples.

Photo 1.6a and 1.6b   Are baked chips really better for you?

Representativeness heuristic

The availability heuristic is one barrier to using statistical information. There is another heuristic we use that also makes it difficult to use statistical information. To start this discussion, let me to tell you about my cousin Adam. When he was a toddler, he lived in a house with two dogs. So when Adam saw any four-legged, furry creature, he called it "doggie." One day when we were at a petting zoo, he saw what I, as a teenager, knew was a horse. But to him, it was a "big doggie." And indeed, dogs and horses do share some outward similarities (e.g., four legs, fur, and a tail). One difference between dogs and horses is that whereas dogs bark, horses neigh.

So when this "big doggie" neighed, Adam looked most perplexed. That sound did not fit in his mental notion of "dog." He was forced to change his mental picture of what a dog was, and in addition, he needed to create a new, distinct mental category for this creature he had encountered called a "horse." In this example, Adam was using the representativeness heuristic (Gilovich & Savitsky, 2002). That is, he had created a mental category of "dog" that included all animals with four legs, fur, and a tail.

> **Representativeness heuristic**: judging how likely something or someone is to the typical instance of a mental category that we hold; can lead us to ignore other relevant information.

So what's the problem that representativeness plays in our thinking? Those mental categories had to come from somewhere, and indeed, they are often correct or else we would stop using them. In Adam's situation, the sound that the horse made forced him to redefine his mental category of "dog." This may not be too difficult to
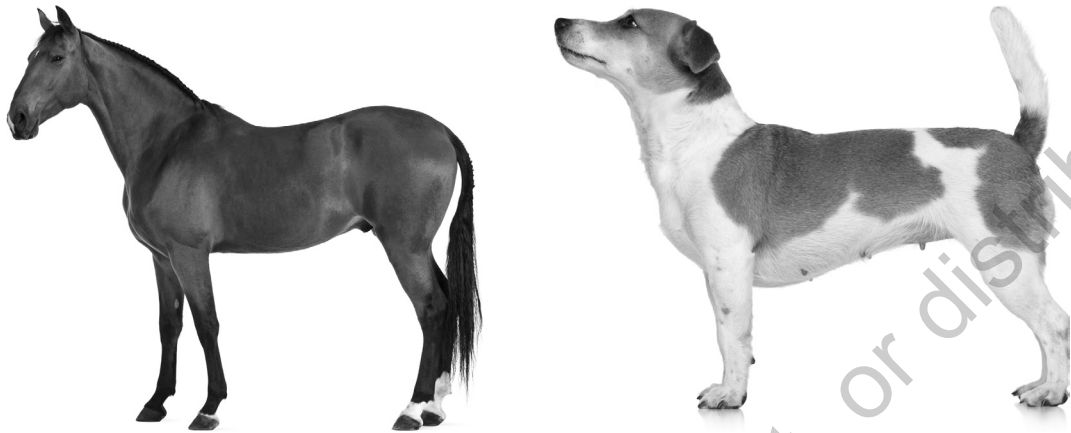
Photo 1.7   They look similar, don't they?

do at least in theory. But remember, I want you to be aware of when our thinking goes awry and how such missteps are rooted in statistical thinking.

There are two potentially problematic results of using representativeness that we will discuss. First, the **base-rate fallacy** is the tendency to ignore information that describes (i.e., represents) most people or situations. Rather, we rely on information that fits a mental category we have formed (Bar-Hillel, 1980). To take a simple example, approximately 90% of the students at my college are from Michigan, Indiana, and Ohio. At first-year orientation this fall, I talked with a tall, athletic-looking, suntanned student who had long blond hair and was wearing a Ron Jon Surf Shop® (Cocoa Beach, FL) T-shirt. Where was he from? California? Florida? Perhaps. But without knowing any additional information, you have a 90% chance of being correct (assuming you say "Michigan," "Indiana," or "Ohio"). Even though the description seems to fit someone from California or Florida, those states are sparsely represented in our student body. Thus, there was minimal chance he was from one of those places despite fitting our mental category of "Californian" or "Floridian." Let's explore the base-rate fallacy in a little more detail.

> **Base-rate fallacy**: tendency to prefer information derived from one's experience and ignore information that is representative of most people or situations.

When we started this chapter, I lamented that we as humans often have difficulty thinking statistically. Again, 90% of the student population at my college is from three states. Therefore, the probability of a student being from any of the other 47 states or another country is low. That probability is even lower for any one specific state of those 47. However, in this instance, the only thing I "saw" is that one student I talked with at orientation. He was a sample of the entire student body at my college. The entire study body at my college consists of people primarily from three states. Therefore, even though he fit my mental representation of "Californian" or "Floridian," the odds are that he was from Michigan, Indiana, or Ohio.

One danger, in terms of statistical thinking, of our everyday experiences is that rarely, if ever, do we have all of the information about a given situation (we are egocentric, remember). Much as we can rarely, if ever, be familiar with everyone in a large group of people, we rely on our personal experiences to draw conclusions about the world. An extension of the base-rate fallacy is the **law of small numbers**, which is the second potential problem with using representativeness. The law of small numbers holds that results based on a small

number of observations are less likely to be accurate than are results based on a larger number of observations (Asparouhova, Hertzel, & Lemmon, 2009; Taleb, 2004). We assume that our experiences are representative of the larger world around us when, in fact, that is not always the case. For instance, when you toss a coin, there is a 50% chance the coin will land on heads and a 50% chance it will lands on tails. If you flip that coin four times, you would expect it to land on heads twice and on tails twice. That would be 50/50, just the way coin tosses should turn out. However, with only four flips of the coin, weird things might happen. You might flip three tails but only one heads. Or maybe all four flips will be heads. Does this mean the coin is "fixed"? No. Rather, with such a small number of flips (i.e., a small sample), you might get outcomes that are markedly different than what you would expect to find (i.e., all coin flips in history). Flip a coin 20 times. I bet you will not get exactly 10 heads and 10 tails, but overall, it should be closer to 50/50 than 75/25. Now flip the coin 40 times, and again, you are likely to be closer to 50/50 than you were with 20 flips.[2]

Law of small numbers: results based on small amounts of data are likely to be a fluke and not representative of the true state of affairs in the world.

Let's take another, more mundane example of the law of small numbers. You are thinking about where to go for dinner tonight. Your roommate said a friend of hers really liked the local pizza place. Based on this information, you decide to have dinner at the local pizza place. How is this instance an example of the law of small numbers? Let me ask you, how much information did you gather to make your decision? You have a suggestion from one friend of your roommate; that is all. So, with one piece of data, you drew your conclusion of where to eat dinner. Let's hope your food preferences are similar to those of your roommate's friend. Had you read reviews of this restaurant, you would have had more data on which to base your decision of where to eat.

As one real-world example of the law of small numbers, many people are afraid to invest their money in stocks because they think bonds are a safer investment. However, a great deal of research (e.g., Index Fund Advisors, 2014) has demonstrated that over the long term, investing in stocks is the best way to grow one's money. Since 1928, the U.S. stock market's average annual return has been about 9.6%. During that same time span, U.S. government long-term bonds have grown on average by only about 5.4% each year. So, when deciding where to invest our money, clearly it should go into the stock market, right? Maybe. Keep in mind that 1928 was a long, long time ago. Over a long period of time, then yes, the stock market has indeed been the best investment available. However, you know enough about history to know what happened in October 1929, again in October 1987, and in the fall of 2008. There are comparatively small pockets of time during which stocks do poorly, sometimes disastrously so. These time periods are the exceptions, but if it is your money being lost when stocks decline in value, you probably will not take comfort in this knowledge. Therefore, money you need in the near future probably should not be invested too heavily in stocks because during brief (i.e., small) periods of time, the value of stocks can decline, sometimes precipitously. However, money you do not need for a longer period of time probably is better invested in stocks than in bonds.

Now that we have learned some reasons why we tend not to incorporate statistical information into our thinking, let's distinguish among three concepts that we've already implicitly touched on and that are foundational for statistical thinking: a population, a variable, and a sample. These are not complicated distinctions, but they are critical in this course and in being better consumers of statistical information. A **population** is the entire group of people you want to draw conclusions about. In our example of stock market and bond market gains, the population would be every year since 1928. In our example of where to eat on Friday night, the population would be every person who's eaten at that restaurant. All members of a population must have some characteristic in common. In research, such a characteristic is called a **variable.** A variable is a quality that has different values or changes in the population. For instance, qualities such as height, age, personality, happiness, and
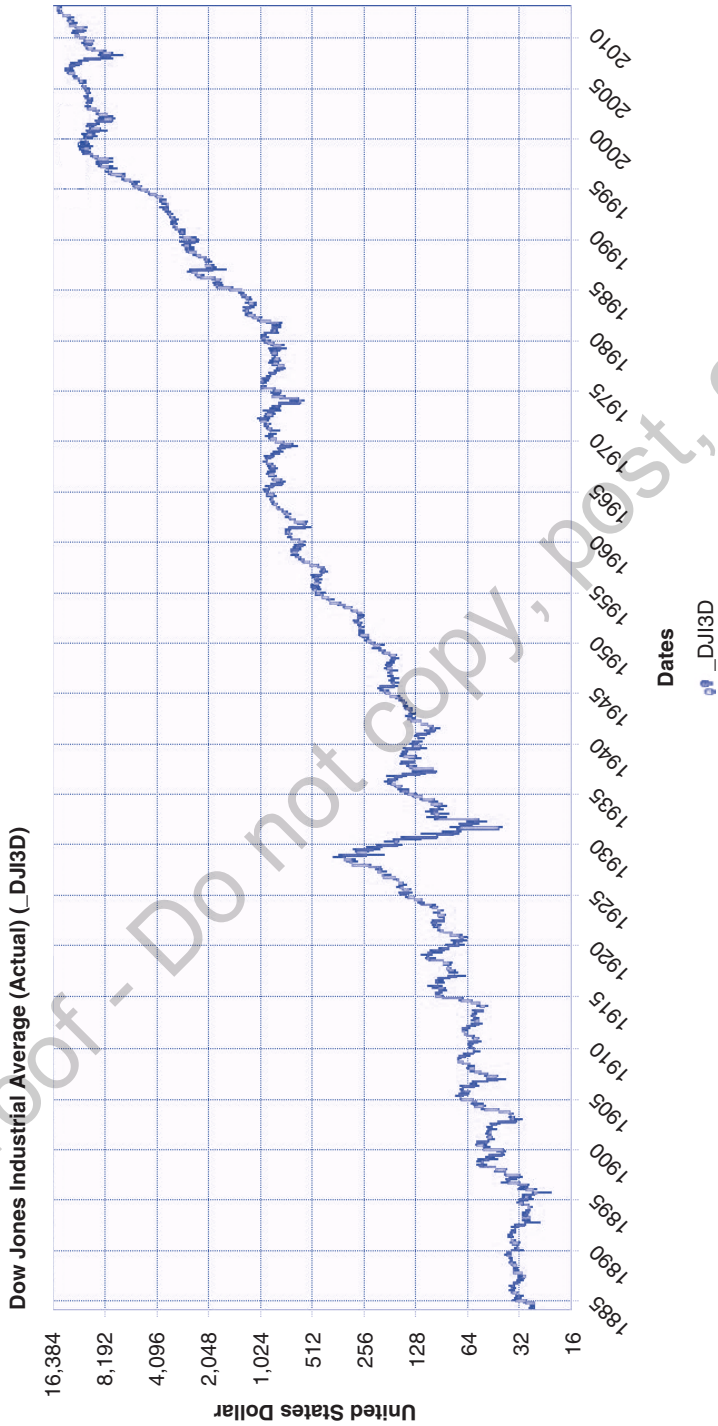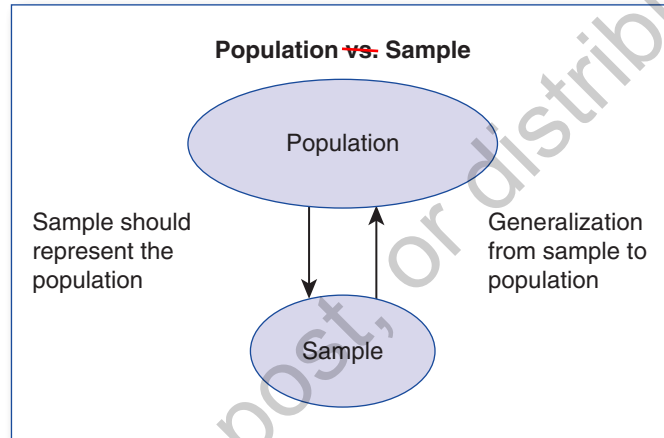
Photo 1.8 Stocks generally rise in value. The highlighted pockets of time note the exceptions to this historical trend.

intelligence each differ among people; hence, each is a variable. Variables can also be environmental features, such as classroom wall color or investment returns.

For most research studies, and for most situations in life more generally, it is impossible to examine or be familiar with each and every member of the population. Therefore, we make particular observations from the population, and based on that **sample**, we draw conclusions about the population. One year could be a sample of stock market and bond market gains (or depending on the one year in question, losses). Your roommate's friend is the sample in that example. Had you read reviews of the restaurant, doing so would have provided a larger sample of data on which to base your decision on where to eat dinner.

Figure 1.1   Relationship Between and Purposes of a Population and a Sample

Population ~~vs.~~ **Sample**

Population

Sample

Sample should represent the population

Generalization from sample to population

Population: entire group of people you want to draw conclusions about.

Variable: characteristic that has different values or changes among individuals.

Sample: subset of people from the population that is intended to represent the characteristics of the larger population.

Let's return to two other previous examples. Regarding casinos advertising the people who won money gambling at their facilities, the population would be all people who gamble in casinos. The sample would be the winners that are in the advertisements. Based only on this sample, it appears that winning money in casinos is normal (which of course it is not; it is just the opposite, actually). In our example of the base-rate fallacy and the "surfer-looking" student at my college, the population would be all students at my college, 90% of whom are from either Michigan, Ohio, or Indiana. The sample is the one student who looks like he is a surfer, which is something we associate with people from California or Florida more than with people from these other three states. He was one of about 1,500 students in the population. Given his appearance, it would be easy to assume he was from somewhere other than what is indicative of the population he was a member of.[3]

LEARNING CHECK

1. Because algorithms guarantee a correct solution to a problem, why do people tend to prefer heuristics in their thinking?

    A: Heuristics provide us with answers to our problems more quickly than do algorithms. In addition, heuristics are not necessarily going to lead us astray (despite the tone of much of what you're reading). So, we keep using them because they are efficient and sometimes correct.

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(Continued)

2. We are far more likely to die in a car accident than in an airplane accident. Yet, people tend to fear flying more than driving. Explain why people fear flying more than driving even though driving is more dangerous.

   A: When a plane crashes, especially a commercial passenger plane, we hear about it on the news perhaps for several days after it happened. However, we are less likely to hear about car accidents on the news. Therefore, because of the availability heuristic, flying is often feared more than is driving even though driving is far more dangerous.

3. Vicks® VapoRub™ (Procter & Gamble, Cincinnati, OH) is medicine you can spread on your chest to help break up congestion. To me, it smells a lot like menthol cough drops. So as a kid when I had a cold, I ate the Vicks VapoRub. Use the representativeness heuristic to explain why I ate the VapoRub instead of spreading it across my chest as the product is supposed to be used.

   A: We make mental categories of things that seem to "go together." Here, both cough drops and VapoRub have a menthol smell (at least to me), so given that one is supposed to eat cough drops, I figured anything with a similar smell is supposed to be eaten as well.

4. Explain why people are more likely to carry their umbrellas when they hear there is a "20% chance of rain" than when there is an "80% chance it will be dry." Both phrases contain the same information, so why is there a difference in how people respond to them?

   A: This is an example of the framing effect. By hearing the word "rain," people think about getting wet. By hearing the word "dry," people do not think about getting wet. Therefore, the image of being wet prompts people to carry their umbrellas.

5. LeBron James, one of the best players in professional basketball, has challenged me to a game of one-on-one basketball. By using information about the law of small numbers, explain how I could maximize the likelihood that I beat James at his sport.

   A: Even the best basketball players will sometimes miss a shot. Even the worst basketball players will sometimes make a shot. Therefore, to maximize my chances of winning, which on the surface seem nonexistent, I would want to play just one shot against LeBron James. This is an application of the law of small numbers. Perhaps he'll miss his shot and I will make mine and, thus, win. The longer the game goes, the more likely I am to lose because he is the better basketball player.

6. Suppose I made you the following offer: You pay me $4, and I will flip a legitimate coin for which you call "heads" or "tails." If you call the flip correctly, I'll pay you $10. If you call it incorrectly, you get nothing. How many times, if any, would you play this game with me? Explain your reasoning.

   A: If you want to make a lot of money, you should play this game as often as possible. On average, you will call the flip correctly 50% of the time. When you do, you win $10. When you don't, you lose $4. Suppose you played this game twice, winning once and losing once. To play twice costs $8 ($4 each time). If you win only once, you walk away with $10, so you made $2. The more you play this game, the more money you will make. However, we know from the law of small numbers that you want to play it more than once or twice because it is possible you could end up losing money with a small number of flips. But over the course of many flips, you will win money.

7. What is the difference between a population and a sample?

   A: The population is larger than the sample. The sample is used to draw conclusions about the population, which is the entire group you want to learn about in a research study.

8. Why is blood pressure a variable?

   A: A variable is a characteristic that differs among members of a population. People have different blood pressure levels, so therefore it is a variable (and one of great interest to medical researchers).

Misunderstanding Connections Between Events

In addition to not using information about probability, we as human beings also have a need to perceive order in the world. Think about being at a party, and you suddenly find yourself around people you do not know. You know almost nothing about them (other than they are at the same party you are), so what do you say to them? You have almost no idea where to begin to strike up a conversation. Maybe you look at their clothes for some hint of what they are like. If someone is wearing a University of Florida T-shirt, you might ask them if they are from the state of Florida and perhaps mention you visited there (assuming that you did). You look for something, anything, to break the uneasiness of that situation. Even for the most socially outgoing among us, it is an awkward situation. So, you start looking to make connections with these people.

Our need to make connections is powerful. The world is much less stressful when it is predictable. Therefore, our minds seek to make connections between events in the world. We will highlight two of these tendencies now. The first tendency concerns perceiving connections that in fact do not exist. The second of these tendencies is a result of the first and concerns the misinterpretation of future events based on prior events.

Figure 1.2   Two Equally Likely Outcomes

Illusory correlations

To start a discussion of the first of these two tendencies, take a look at these two poker hands of cards in Figure 1.2. Which one is a player more likely to be dealt? A hand of 10 through ace, all of the same suit, feels highly unlikely. However, in reality, the odds of getting that hand are no lower than the odds of getting the other, seemingly random, hand of cards. We are wired as human beings to detect patterns in the world, and so it is here. We feel as though the 10 through ace is a more unusual hand than the other hand of cards. Statistically, however, the odds of getting either one are the same. This is an example of an **illusory correlation**. By "illusory," we mean "not real" or an "illusion." By correlation, we mean an "association" or "connection" between two behaviors or events. Much as an optical illusion is seeing something that is not present, an illusory correlation is perceiving a relationship when no relationship exists (Fiedler, 2000). We want the world to be a predictable, orderly place. So our minds impose order and logic even when order and logic do not exist.

> **Illusory correlation**: tendency to perceive a relationship when no relationship really exists.

Let's discuss some additional examples of illusory correlations. In college, I had a roommate, Alex, who was not only a nice guy, but smart, too. Alex worked hard and never took his natural intellectual ability for granted. He did well in all of his classes, and he went on to become an immigration lawyer in South Florida. We were roommates for our entire college careers, and he is still a good friend to this day. I am sure this information does not impress you. But here is what might impress you. Take a guess as to why Alex did so well in college and beyond. His intelligence? His hard work? Those would be reasonable guesses. Ask Alex, however, and he will tell you something different. Let me explain. In our first year of college, we had our first round of tests
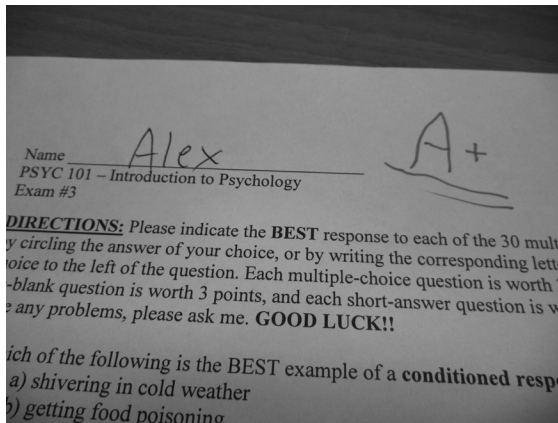
Photo 1.9a and 1.9b   Does a "lucky" charm really help us get good grades?

about five weeks into the semester. We both had two or three tests that week. Of course, as would become the norm, Alex did well on these assessments. About five weeks later, we had our second round of tests and papers coming due. Because Alex had done so well on tests and papers earlier in the semester, I asked him for some study tips. Here is what he told me: *He told me that I could not wear his pair of "lucky socks."* They were his lucky socks, and no one else could wear them. He had worn them every day during the week of our first round of tests and papers, and because he did so well, he was going to wear them again when tests and papers came due. Of course, I thought he was joking, but no, it quickly became clear that in his mind, the reason he did well on tests was because of his lucky pair of socks. By believing, albeit erroneously, that his pair of socks aided his performance on his tests, Alex was able to feel as though he had gained some control over his environment. The next time he had a test, he just needed to wear that same pair of socks again, and he would do well.[4]

If you have ever played a sport or been involved in the performing arts, did you ever have some sort of pre-performance routine that you felt you had to follow? Just like my college roommate and his belief that wearing a certain pair of socks contributed to his academic success, some highly accomplished professional athletes have pre-performance routines that they follow. For instance, three-time Ironman champion Chrissie Wellington wrote the Rudyard Kipling poem "If" on her water bottles before each event. Similarly, professional baseball player Justin Verlander reportedly used to eat Taco Bell® (Yum! Brands Inc., Louisville, KY) the night before the games in which he was the starting pitcher. Is there really a relationship between writing a poem on a water bottle and performance in an Ironman event? How about between eating Taco Bell and pitching a baseball? I doubt it; however, for these athletes, they have come to make these connections in their minds.

Illusory correlations arise in part, as we said previously, from our need to detect order in the world. To satisfy this need, we tend to pay attention to instances that confirm this connection and disregard those instances that disconfirm that connection. Did my roommate ever do poorly on a test? Yes, actually, a few times he did. But in his mind, those exceptions had nothing to do with his socks. Did Chrissie Wellington win every race she competed in? No, but in her mind, she likely would have done even worse had she not written that poem on her water bottles. Indeed, once we establish relationships between events in our mind, they are difficult to dislodge.

Gambler's fallacy

Our second obstacle in understanding connections between events is closely related to the illusory correlation. The **gambler's fallacy** is a thinking tendency that involves making a connection between prior outcomes and future outcomes when those outcomes are independent of each other (Nickerson, 2002). Let's discuss some examples of the gambler's fallacy.

Gambler's fallacy: tendency to think that two mutually exclusive outcomes are somehow related.

After graduating from high school in Texas, I went to college in a small town in Florida. At that time, Texas did not have a lottery, but Florida did have one. So, a few weeks after starting college, I decided to buy a lottery ticket for the weekly drawing on Saturday nights. I did so each week during my first year in college. By late April of that school year, I had won nothing. I figured I was overdue to win something, so instead of buying one ticket that week, I bought five tickets. After all, with such a long losing streak, I was bound to win something at some point, right? If you are shaking your head at my logic, good for you. My logic is an example of the gambler's fallacy. That is, I thought that a previous outcome (not winning lottery money) was somehow connected to a future event (likelihood of winning lottery money) when in fact there was no connection between the prior outcome and the future outcome.

To take another example of the gambler's fallacy, consider the game of roulette. The dealer spins the wheel and a ball lands in one of the slots, each of which has a number and color associated with it. Players can bet on what color the ball lands on (red, black, or green), which specific number or set of numbers (e.g., evens or odds) the ball lands on, and so on. I have this game, and I decided to spin the wheel 50 times. Here are the outcomes of those spins. The color of the number represents whether it is a "red" or "black" number (or a "green" number in a few outcomes). The first column is the first 10 spins, the second column is the second 10 spins, and so on.

8	20	24	34	18
26	2	19	14	0
16	00	21	6	22
26	31	18	23	16
13	3	9	13	21
10	30	15	34	21
24	8	21	5	35
20	33	16	29	26
0	12	21	13	17
20	28	6	34	14

Look at the first 10 spins. There were 8 black numbers that came up. So, on the 11th spin, it would just seem I was overdue for a red number. But of course, the 11th outcome had nothing to do with the first 10 outcomes, and indeed, the 11th outcome was another black number. The odds of the ball landing on a red number or a black number are the same for the 12th spin as they were for each of the first 11 spins.

You might be thinking at this point that these examples of the gambler's fallacy involve small numbers of observations (e.g., one spin of the roulette wheel). And indeed, you are correct. As we said at the outset of this section of the chapter, these issues in statistical thinking are closely related. With the gambler's fallacy, it is more likely to manifest itself in our thinking when we have only a limited number of observations available. Take a look back at the outcomes of my 50 spins of the roulette wheel. If you take only my first 10 spins, it looks like the wheel
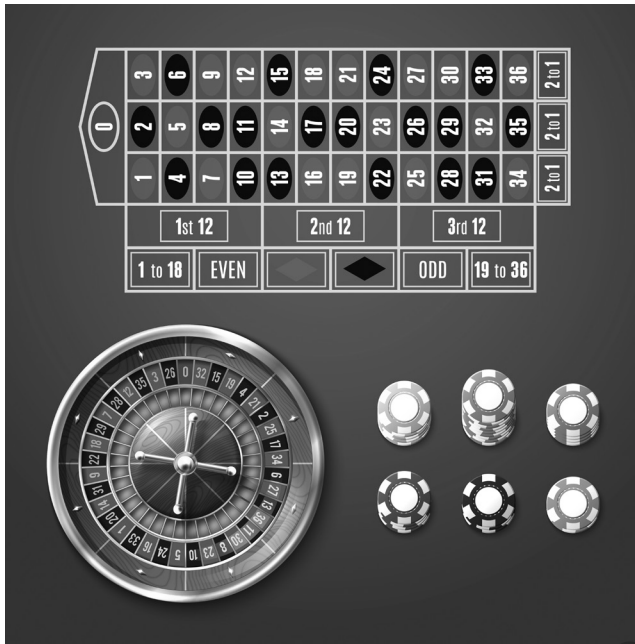
is somehow "fixed" because so many black numbers emerged. But then consider the middle 10 spins; here, we have disproportionately more red numbers emerge. However, on average across the 50 spins, the emergence of red and black numbers is close to 50% each (24 black numbers and 23 red numbers).

Let's consider a nongambling example of the gambler's fallacy. In well-known research, Thomas Gilovich and his colleagues (Gilovich, Vallone, & Tversky, 1985) examined the belief that basketball players have "hot streaks" when shooting the ball. That is, if basketball players have made a few shots consecutively, are they more likely to make their next shot than if they had missed their previous shot? In other words, is there a connection between the prior outcome (i.e., making a previous shot) and a future outcome (i.e., making one's next shot)? Gilovich and his colleagues examined shooting statistics for the Philadelphia 76ers and the Boston Celtics for the 1980–1981 season. For the 76ers, it was found that players were slightly *less likely* to make a shot after making their previous shot (51%) than

Photo 1.10 A roulette table and a roulette wheel.

after missing their previous shot (54%). Furthermore, the odds of making a shot after making the previous three or four shots (50%) were slightly lower than the odds of making a shot after missing the previous three or four shots (57%). For the Celtics, it was found that players are no more likely to make a second free throw attempt after making the previous free throw attempt or missing that first attempt. In fact, the team as a whole made 75% of its second free throw attempts after making the first free throw, and it made 75% of its second free throws after missing the first one. Taken together, these data strongly suggest that there is no "hot hand" in shooting a basketball even though it may feel that way when playing or watching a game.

LEARNING CHECK

1. In college, it sometimes seemed as though the harder I studied for a test, the worse I did on it. Explain how my thinking could be an example of an illusory correlation.

   A: If I study hard, I should do well on tests. If I don't study hard, I should do poorly on tests. Those are normal states of affairs. What I recall, though, are the "weird" instances in which I studied hard but did poorly on a test. Because such instances are rare, they stand out and are easier to recall. Thus, I've made a false (illusory) connection between my study habits and test scores.

2. If a couple has had three children who were all girls, they might assume their fourth child is likely to be a boy. Explain why the couple might think their fourth child is likely to be a boy.

   A: There should be an "evening out" that occurs eventually (or so it feels to this couple). Of course, the sex of their fourth child has nothing to do with the sex of their first three children. This is an example of the gambler's fallacy.

3. Explain why some people have a "lucky charm" that they like to carry with them wherever they go.

   A: People have established a connection in their mind between an object and desirable outcomes that resulted from that object. That's how it became a "lucky charm" to them. For instance, some students have a "lucky pen" that they like to write with. For whatever reason, they have developed an illusory correlation that the pen is associated with good things, so they keep it with them. Likewise, some people may have a "lucky coin" that they keep in their possession at all times, figuring it will bring them good luck (or at least avoid bad luck). Indeed, illusory correlations are pervasive!

GOALS OF RESEARCH

As we have discussed, we as humans tend to have "efficient flaws" in our thinking. They are efficient because they allow us to navigate the world quickly and prevent us from exhausting our cognitive capacities. They are flaws, though, because they allow for mistakes in how we think about the world. When conducting scientific research, we want to do what we can to minimize mistakes. This is where statistics can help. I find it helps students to approach classes in statistics with the mind-set that statistics are tools we need to understand research. Just as we need a screwdriver to tighten a loose screw or scissors to cut paper, we need statistics to understand scientific research. The goal of a research study will guide the type of statistic (or tool) that the researcher needs to use. We now examine four goals of scientific research.

Scientific research in psychology has four overriding goals: (1) to describe, (2) to predict, (3) to explain, and (4) to apply behavioral and cognitive phenomena. The first three goals have different statistical tools associated with them, which we will discuss as we present each goal in turn now.

Goal: To Describe

Descriptive research aims to communicate variables as they exist in the world. To conduct descriptive research, we need to make observations and measurements of the phenomena we want to study. If you want to know the temperature outside, a thermometer located outside can provide this information. The temperature is descriptive information. If we want to describe the health-related behaviors of college students, we can take measurements of how much sleep they get each night, how many times per week they exercise, and their daily fruit and vegetable consumption. We could then describe the health-related behaviors of college students along these dimensions.

How might we go about collecting data to describe the health behaviors of college students? First, we can conduct observational studies. By using *naturalistic observation*, we could sit in the student cafeteria and record what students eat. Likewise, we can go to the student recreational facility and see how many students work out there, including the types of exercises that they perform. Naturalistic observation will be more difficult to use to record sleep habits; however, we might use *laboratory observations*, in which we observe behavior in a more controlled setting, such as a research laboratory. In this case, we could have a bed available and record how long students sleep.

In addition to observational research, we can use case studies to describe behavior. A case study involves studying one or more people in great depth. We could examine the health behaviors of a small number, perhaps three or four, college students. An advantage of using the case study method over observational studies is that we can go into great detail on the behaviors of this small sample. In addition, case studies are particularly useful when studying rare phenomena, such as certain diseases that occur in only a few people. The disadvantage, though, is that it is extremely time-consuming to conduct a large number of case studies, especially if we want the research to be representative of the college student population.

Finally, surveys can be used to describe behavior. In our case, we would ask questions of college students about their health-related behaviors. Surveys can be administered through *questionnaires* via campus mail, over

the Internet, or in a research lab setting. Likewise, surveys can be administered as *interviews* either in person or over the phone. Questionnaires are advantageous because the researcher asks respondents to provide the same information. Interviews are advantageous because the researchers can ask follow-up questions depending on a respondent's answers. Surveys are particularly helpful because it is easier to collect more data than with case studies or most observational research. However, researchers must pay close attention to the wording of the questions to make sure respondents are interpreting them correctly. We must also be sure that the sample of survey respondents is representative of the population we want to study. In this case, it might only be the more health-conscious students who complete a survey. If that happens, our sample data will not reflect the population of college students.

Descriptive research: depicts variables as they exist in the world.

Observational studies: consist of watching behaviors in naturalistic and laboratory settings.

Case studies: examine in depth one or more people with a certain characteristic.

Surveys: series of questions to which people respond via a questionnaire or an interview.

Description is typically the first step in conducting predictive and explanatory research. In the next section of this chapter, we will preview what are called descriptive statistics. In Chapters 2 through 5, we will look extensively at these types of statistics. Their overriding purpose is to help researchers describe data from a sample.

Goal: To Predict

Predictive research aims to make forecasts about future events. In the case of the weather, if we know the time of year it is, wind flow patterns, and barometric pressure, we can predict the temperature and likelihood of precipitation. Returning to our health-behaviors research, if we have data on college students' health behaviors, we can use those data to predict outcomes such as grade-point average and satisfaction with college, both of which most colleges are keenly interested in. There are two methods of conducting predictive research. First, using the **correlational method**, researchers measure the extent to which two or more variables are related to each other (i.e., co-related). In our example, if we know how much sleep a college student gets each night, how many times per week he or she exercises, and his or her daily fruit and vegetable consumption, we can predict, to some extent, outcomes such as GPA and satisfaction with college.

We will explore correlational research in more detail in Chapters 12 and 13. For now, understand that there are **positive correlations**, in which increases (or decreases) in the frequency of one behavior tend to be accompanied by increases (or decreases) in the frequency of a second behavior. To illustrate what a positive correlation looks like, consider Figure 1.3, which displays the nature of the

Figure 1.3 What a Positive Correlation Looks Like
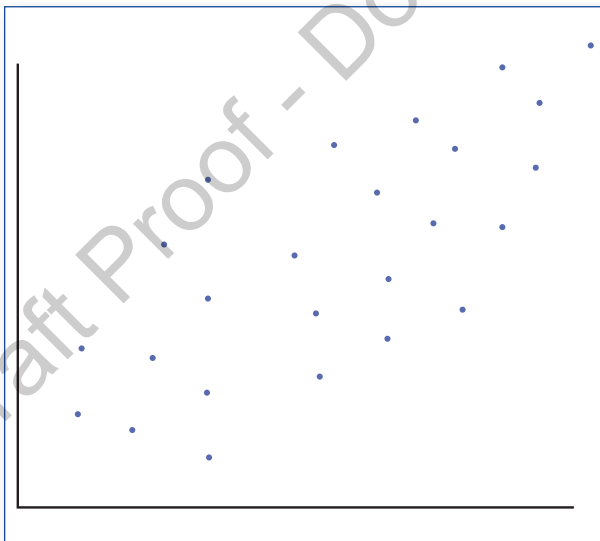
relationship between weekly exercise habits and GPA (Bass, Brown, Laurson, & Coleman, 2013). Each dot on this scatterplot represents one student's weekly aerobic exercise time (*x*-axis) and the student's corresponding GPA (*y*-axis). In general, as weekly aerobic exercise time increases, GPA increases. This does not happen for every student, but *in general*, this is the case. Therefore, weekly aerobic exercise and GPA are positively correlated.

In addition, the second type of correlation is a **negative correlation**, which results when increases in the frequency of one behavior tend to be accompanied by decreases in the frequency of a second behavior. To illustrate what a negative correlation looks like, consider Figure 1.4, which displays the hypothetical relationship between weekly alcohol consumption and GPA. In general, as weekly alcohol consumption increases, GPA decreases (Singleton & Wolfson, 2009).

Finally, the third type of correlation is a **zero**

Figure 1.4 What a Negative Correlation Looks Like

correlation. As you might have guessed, a zero correlation exists when there is no pattern between the frequency of one behavior and the frequency of a second behavior. I am aware of no research that suggests any relationship between physical height and frequency of flossing one's teeth. I doubt that taller people floss more often than shorter people (which would have been a positive correlation) or that shorter people floss more often than taller people (which would have been a negative correlation).

In addition to the correlational method, predictive research makes use of **quasi-experiments**. A quasi-experiment compares naturally occurring groups of people. We could compare whether first-years, sophomores, juniors, or seniors have higher GPAs and higher levels of college satisfaction. Here, year-in-school is a *quasi-independent variable* in the sense that people tend to fall into one of these four types of students. Realize, as with correlational methods, we cannot conclude that being a senior causes students to do better or worse in school (or anything else) than being a first-year. However, such data could still be of interest. For instance, suppose we find the somewhat counterintuitive result that first-years earn higher GPAs and are more satisfied with college than are sophomores. College faculty and administrators would likely want to do more research to understand this relationship (and perhaps do something to facilitate the sophomore experience on their campuses).

Prediction is more powerful than description. Although prediction is never perfect (just think about weather forecasts), it does provide insights into the world around us. Chapters 12 and 13 will provide us with tools that allow us to make predictions from our data.
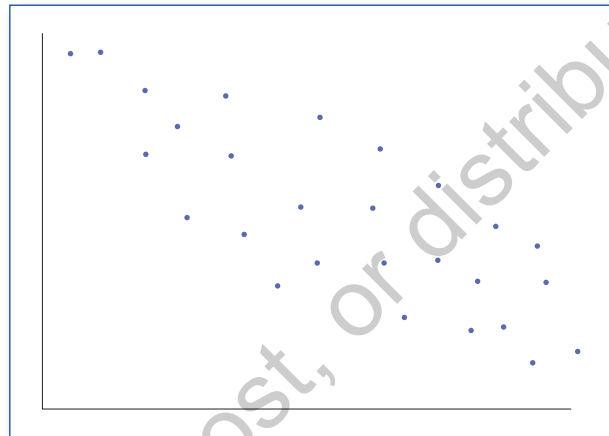
> **Predictive research**: makes forecasts about future events.
>
> **Correlational method**: examines how and the extent to which two variables are related to each other.
>
> **Positive correlation**: increases (or decreases) in one variable tend to be accompanied by increases (or decreases) in a second variable. In other words, the two variables tend to relate in the same direction.
>
> **Negative correlation**: increases in one variable tend to be accompanied by decreases in a second variable. In other words, the two variables tend to relate in the opposite direction.
>
> **Zero correlation**: no relationship exists between two variables.
>
> **Quasi-experiment**: compares naturally existing groups, such as socioeconomic groups.

Goal: To Explain

Explanatory research takes descriptive and predictive research one step further; that is, explanatory research (also called *experimental research*) allows researchers to draw cause-and-effect conclusions between phenomena of interest. The researcher uses "control" to establish cause-and-effect conclusions. By "control" in the context of explanatory research, a researcher must manipulate (i.e., control) some aspect of behavior. The behavior that is controlled is called the **independent variable**. In this example, the independent variable is level of aerobic exercise. It is "independent" because the researchers can decide, within ethical boundaries, what to expose participants to in the experiment. It is called "variable" because some participants engaged in aerobic exercise, and others did not. Had all participants engaged in aerobic exercise, there would be nothing that varied. There must be at least two groups created by manipulating (controlling) an independent variable. Without at least two groups, you would have no way to make a comparison on how people's behavior was affected.[5]

Of course, we want to know an outcome of the independent variable. That outcome is called the **dependent variable**. That is, are there differences in academic performance based on whether people engaged in aerobic exercise? Such potential differences "depend" on the independent variable.

You might well be wondering at this point how we can draw cause-and-effect conclusions from the independent variable's effect on the dependent variable. Researchers use **random assignment** of participants in the sample either to engage in aerobic exercise or not to engage in aerobic exercise. Think about the many ways people differ from one another. For instance, I grew up during the relative economic boom years of the 1980s in the North Dallas suburbs, raised by parents from the northeastern United States. Such an upbringing may well differ from yours, likely in more than one way. And that's just a couple of ways we might differ from each other. Not that such differences are unimportant, but in this context, they are not of interest to the researchers. Therefore, we want to control for their influence on how people in the sample behave, so that we can isolate the effect of the independent variable. *Through the process of random assignment, we can minimize the influences of variables (e.g., where people grew up, when people grew up, and socioeconomic status) other than the independent variable. In doing so, any effects we find can be linked to the independent variable.*

Suppose we find that students who engaged in aerobic exercise throughout the semester had higher grades at the end of that semester. By using experimentation, which involves manipulating at least one variable, and by using random assignment of participants to groups created by that manipulation, we can draw cause-and-effect conclusions between behaviors. We will explore statistical tools that are often used with experimental data in Chapters 7 through 11.

Explanatory research: draws cause-and-effect relationships between variables.

Independent variable: variable that a researcher manipulates (changes) to create experimental groups (conditions). It should affect subsequent behavior or mental processes.

Dependent variable: behavior that results from the independent variable.

Random assignment: uses a random process, such as flipping a coin, to put members of a sample in one of the groups (conditions) in an experiment. Its purpose is to minimize preexisting differences among members of the sample so that researchers can be confident of the effects of the independent variable.

Goal: To Apply

Finally, **applied research** does not have specific research methods associated with it. Rather, it makes use of the findings from the methods described previously and uses them in specific contexts. For instance, when you listen to the weather forecast (a prediction) for the next day, you will apply that information by dressing accordingly. Likewise, we already know that the manner in which information is presented influences how people

respond to that information (called the framing effect). The makers of Ruffles potato chips were clearly aware of the framing effect when they labeled the cooking method of "baked" on those bags of chips, but they did not label the cooking method of the "fried" chips.

To continue our example of health-related behaviors in college students, many colleges and universities are keenly interested in promoting physical and psychological well-being in their student populations. Like all organizations, these schools face budgetary constraints. Therefore, they want to maximize the desired outcomes (well-being in their student populations) within those financial limitations. To do so, many schools rely on the sorts of research studies we have described in this part of the chapter. For instance, one college wanted to update its aerobic exercise machines. It first conducted a survey of its students and faculty by asking these people to complete a questionnaire. Based on the results of this survey, the college invested a portion of available funds and updated some of the aerobic exercise equipment. Then, after this new equipment was available for use, it conducted naturalistic observation to learn if in fact the equipment was being used as indicated it would be used on the questionnaire. When those naturalistic observations suggested heavy use of the new equipment, the college immediately invested the remaining portion of its funds for this purpose.

> **Applied research**: uses descriptive, predictive, and explanatory research methods to answer specific research questions in specific contexts.

LEARNING CHECK

1. What is the difference between naturalistic and laboratory observations?

   A: Naturalistic observations occur in the normal environment in which a behavior occurs. Laboratory observations occur in a more controlled setting. For instance, if we want to study driving behaviors, we could conduct naturalistic observation by watching and recoding driving behaviors on the interstate. We could conduct laboratory observation by using a driving simulator in a research lab.

2. Case studies are not used as much as other descriptive research methods. Why is this the case?

   A: Case studies tend to be used to study rare phenomena. For instance, much of what we know about the effects of strokes we gained through case studies of people who have actually experienced a stroke. Depending on where precisely in the brain a stroke occurred, a case study allows us to learn what happens when that part of the brain is damaged.

3. Explain the difference between a positive correlation and a negative correlation.

   A: A positive correlation exists when two variables tend to "move in the same direction." A negative correlation exists when two variables tend to "move in opposite directions." For example, there is a positive correlation between the number of hours that students study for tests and their scores on those tests. There is a negative correlation between the amount of alcohol consumed the night before a test and scores on that test.

4. I do a study in which I compare students' political beliefs at the start of their first year of college and again when they graduate from college. Explain why this study is a quasi-experiment.

   A: As year-in-school is a participant variable, I cannot randomly assign people to be first-years or seniors. These are naturally occurring groups to which people belong.

(Continued)

(Continued)

5. How does random assignment allow an experimenter to claim that an independent variable influenced a dependent variable?

A: Random assignment minimizes preexisting differences between people who are in an experiment. Therefore, with these differences minimized, researchers can isolate the effects of the independent variable on the dependent variable.

6. A college registrar did a research project and found the typical 18- to 22-year-old college student is mentally more alert later in the morning than earlier in the morning. Therefore, her college decides not to schedule any classes before 11 a.m. How is this an example of applied research?

A: The college is taking a research finding (that students aren't as mentally alert early in the morning) and then using it to implement a policy in a specific situation.

STATISTICAL THINKING: SOME BASIC CONCEPTS

One commonalty in the flaws in our thinking is that they all, to varying extents, rely on our personal experiences to learn about the world. Personal experiences can sometimes be helpful. For instance, when I was three years old, I touched a hot stove burner. I learned right then and there never to do it again. However, just because our experiences may provide us with information, it does not mean that such information is necessarily correct or true of people in general. We use statistics not to learn about any one person but to learn about people (and animals, chemicals, and many other topics of study) in general. Let's discuss, and in some cases, reinforce, some extremely important statistical concepts that will appear throughout this class.

Parameters Versus Statistics

We discussed the notions of population and sample previously in this chapter. We will expand on them here. Recall that a population is the entire group of people we want to learn about, and a sample is a subset of people drawn from that population that is intended to represent the characteristics of its population. In research, the purpose of the sample is to learn about characteristics of the population. As we said, when we say "characteristics of the population," we are talking about variables, which again, are qualities that have different values or change among individuals.

P for Population, **P** for Parameter

S for Sample, **S** for Statistic

Caption: A nice heuristic to remember these concepts

As we discussed in this chapter, in most walks of life, we must operate with information about a sample from our personal experiences, and that can be problematic when drawing conclusions about the world. Variables, typically expressed quantitatively, that describe a population are called **parameters**. An example of a parameter would be the odds of dying in a terrorist attack and the odds of dying from a fall at home. However, we rarely, if ever, know and use parameters in our daily thinking. Rather, we rely on samples. This can be a problem when our goal is to be objective. When we want to be objective, we need some help. Therefore, we make use of **statistics**, which are accepted quantitative procedures that allow us to organize, summarize, and interpret information (called data) to draw conclusions about the world (i.e., the population). At this point and throughout the remainder of the book, we want to learn how to interpret and use statistics correctly.

Parameter: number that expresses a value in the population.

Statistic: number that expresses a value in the sample.

Descriptive Statistics Versus Inferential Statistics

There are two different broad categories of statistics, and each one has a specific purpose. With **descriptive statistics,** we are organizing and summarizing a body of information. We will discuss descriptive statistical tools at length in Chapters 2 through 5. Descriptive statistics are useful for learning about the characteristics of our sample. For instance, Pam Mueller and Daniel Oppenheimer (2014) conducted a study to learn whether college students (the population) retain more information when taking notes in class with a computer or with a pen and paper. They sampled college students and measured their performance on test questions based on which note-taking method they used. They calculated certain statistics, such as those we will encounter in the next four chapters, to compare the performance of students using the two different note-taking methods in their sample.

Although descriptive statistics are vital to research, we tend to be more interested in drawing conclusions about a population based on information from our sample. And, again, most always we cannot collect information from everyone in our population, so we rely on our sample to make inferences about the population. In that situation, we use **inferential statistics**. The purpose of inferential statistics is to draw an inference about conditions that exist in a population by studying a sample drawn from the population. We will learn about different inferential statistical tools in Chapters 6 through 14. Mueller and Oppenheimer (2014) were interested in learning about how note-taking was related to academic performance in a population of college students. Not being able to test all college students, they sampled students from Princeton University and UCLA. From this sample, they drew conclusions about college students and the effects of how they take notes on test performance.

> **Descriptive statistics**: quantitative procedures that are used to organize and summarize (describe) information about a sample.
>
> **Inferential statistics**: quantitative procedures that are used to learn if we can draw conclusions (inferences) about a population based on a sample.

Sampling Error

Of course, samples are not always (and hardly ever are) perfect representations of populations. The extent to which a sample doesn't reflect the population is called **sampling error**. Sampling error occurs when there is a difference between the characteristics of the population and the characteristics of the sample. Let's consider an example of sampling error. Let's again consider Mueller and Oppenheimer's (2014) research. They drew their sample of college students from two schools, Princeton and UCLA. From this sample, they wanted to learn about the population of college students. Let's list some parameters for the population of college students in the United States (National Center for Education Statistics, 2014). These parameters for three variables appear in the top portion of Figure 1.5. How well does the sample that Mueller and Oppenheimer (2014) used map onto the population? The statistics for the same variables appear in the lower portion of Figure 1.5.

> **Sampling error**: discrepancy between characteristics of the population and characteristics of the sample.

As you can see, there are some discrepancies between the population parameters and the sample statistics. For example, the sample did not contain any students from two-year schools. Does such sample error make Mueller and Oppenheimer's (2014) work pointless? Absolutely not. We just need to remember the sample characteristics when drawing conclusions from this research. For instance, it might be a worthwhile idea to conduct this study again using a sample of students from two-year colleges as no such students were included in this sample.

Figure 1.5 Population Parameter and Sample Statistics in Mueller and Oppenheimer's (2014) Research

Population (*N* = 21 million)

Parameters:

57% female, 43% male

62% full-time, 38% part-time

65% at four-year colleges/universities; 35% at two-year colleges/universities

Sample (*n* = 327)

Statistics:

71% female, 29% male

99% full-time

100% at four-year universities
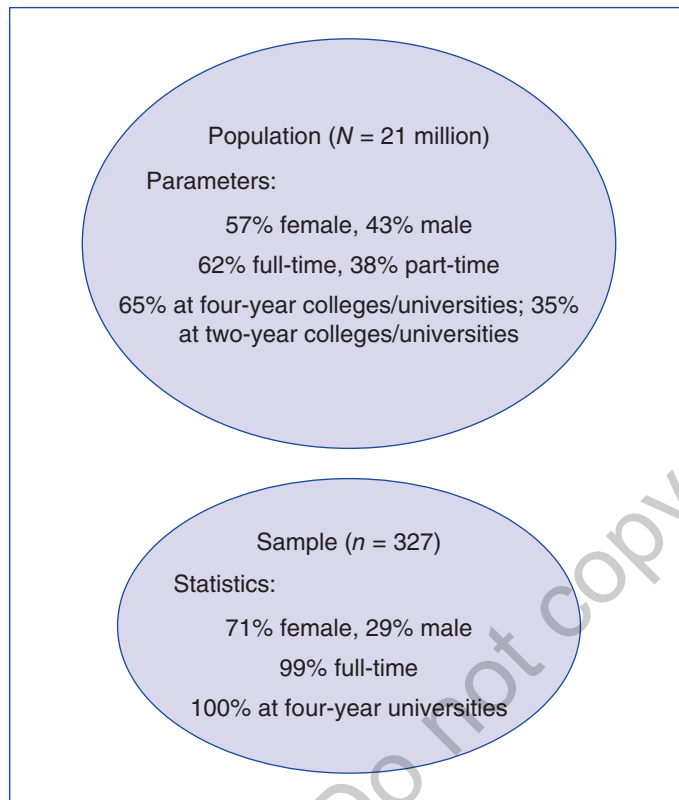
Indeed, learning about the world around us through research is a process that can never be accomplished in a single research study. Indeed, one could argue correctly that the population in this research was in fact college students at four-year universities. Would the results of this research apply to my school, which is a four-year liberal arts college that serves only undergraduate students? Would the results apply to your school? Without conducting the research with a sample of students from my school and a sample of students from your school, we cannot know.

To take another example of sampling error, suppose the average SAT score at your college or university is 1700 (if your college or university required the ACT, suppose that the average ACT score is 22). The population in this instance is students at your school. Now, if you take two samples of 10 students each, do you think each sample will have an average SAT of 1700 (or average ACT of 22)? Probably not; in fact, I bet neither sample will have precisely that average. One sample may have an average SAT of 1684 (20 ACT), and the second sample may have an average SAT of 1733 (23 ACT). The discrepancy is the sampling error.

You may often hear on the news about public opinion surveys that various polling groups (e.g., the *Wall Street Journal* or CNN) conduct on different topics (e.g., feelings about the economy or Congressional approval ratings). To conduct such surveys, the polling agencies do not (and realistically cannot) ask every member of the population for their input. So, they sample the population of interest. As you know, we now have to consider sampling error. That is what is meant when you hear about this "margin of error" the news is (or should be) reporting. If the president has a 54% approval rating, there should be a margin of error reported. That 54% is based on the sample, so there will be some variability around that number in the larger population. A 54% approval rating with a "plus or minus 3% margin of error" means that the presidential approval rating in the population is between 51% and 57%.

LEARNING CHECK

1. Explain the difference between a parameter and a statistic.

    A: A parameter is a population value, whereas a statistic is a sample value.

2. Explain the difference between descriptive statistics and inferential statistics.

A: Descriptive statistics organize and summarize information about a sample. They are the first step toward using inferential statistics, which are procedures used to learn whether we can make conclusions about a population based on data from a sample.

3. Why is it the case that in almost any research study, there will be some degree of sampling error?

A: Unless everyone in the population is included in the sample, there will be some discrepancy between the population characteristics and the sample characteristics.

NOTES

1. If you've ever suffered a serious fall in your home, you may well fear this event more than a terrorist attack. However, if you are basing this relative fear on your experience and not on statistical information, you are still making use of the availability heuristic.

2. The expression "A broken clock is correct twice each day" is making use of the law of small numbers. At two times out of the 1,440 possible times (60 minutes × 24 hours) each day, the broken clock will tell the correct time. Of course, the other 1,438 times, the clock is incorrect, but if you looked at it those 2 other times, it would appear to be functioning correctly.

3. This student was indeed from Michigan.

4. If you are interested, Alex continued to keep that same pair of socks and wear them every time he had a test as an undergraduate. Again, he isn't a dumb person. It is not a lack of intelligence that makes one susceptible to illusory correlations.

5. The difference between an independent variable and a quasi-independent variable is that an independent variable is controlled by the researcher. A quasi-independent variable is not controlled by the researcher. In our example of a quasi-independent variable, the researchers cannot assign people to be first-years, sophomores, juniors, or seniors. These are naturally occurring groups.

CHAPTER APPLICATION QUESTIONS

1. Holly resisted changing her answer on a test question because she reminded herself that "it's always best to stick with your first answer." Holly's decision best illustrates:

   a) an algorithm.   c) egocentrism.

   b) a heuristic.   d) the gambler's fallacy.

   A: "b"

3. Reliance on the representativeness heuristic is *beneficial/helpful* when it:

   a) simplifies a complex social world.

   b) is selectively applied.

c) is reserved for ambiguous situations.

d) minimizes differences within a group of people.

A: "a"

5. The law of small numbers states that:

a) we are more influenced by information that contradicts our beliefs than by information that supports our beliefs.

b) we like to categorize people, places, and events to simplify a complex world.

c) conclusions drawn from a limited number of observations are likely to be a fluke.

d) we pay conscious attention to a limited amount of information at any given point in time.

A: "c"

7. Which of the following set of outcomes is **MOST** probable?

a) flipping 6 or more heads in 10 coin flips.

b) flipping 60 or more heads in 100 coin flips.

c) flipping 600 or more heads in 1,000 coin flips.

d) All of the above are equally probable.

A: "a"

9. In an experiment, the behavior being measured as a *result* of the manipulated/changed variable is called the _____ variable.

a) independent   c) spurious

b) dependent   d) illusory

A: "b"

11. You would probably find **NO correlation** between:

a) height and weight.

b) shoe size and scores on an intelligence test.

c) ACT scores and SAT scores.

d) distance from the equator and average daily high temperature.

A: "b"

QUESTIONS FOR CLASS DISCUSSION

2. The use of phrases such as "federal revenue enhancement" when the government announces a "tax increase" is making use of:

a) the framing effect.   c) illusory correlation.

b) the representativeness heuristic.   d) spurious correlation.

4. The tendency to conclude that a person who is athletic is more likely to be a cross-country runner than a master piano player illustrates use of:

    a) the law of small numbers.

    b) egocentrism.

    c) the availability heuristic.

    d) the representativeness heuristic.

6. Which of the following is **NOT** an example of the gambler's fallacy?

    a) A number will not be drawn in the lottery on a particular day because it was drawn on the two preceding days.

    b) A fifth child in a family will be a boy because the first four children were girls.

    c) Carl is more likely to carry his umbrella to work when there is a "20% chance of rain" than when there is an "80% chance of dry weather."

    d) All of the above are examples of the gambler's fallacy.

8. Drew erroneously believes that his test grades are **NEGATIVELY** correlated with the amount of time he studies for tests. Research on illusory correlation suggests that he is most likely to notice instances in which:

    a) poor grades follow either brief or lengthy study.

    b) either poor grades or good grades follow lengthy study.

    c) good grades follow lengthy study and poor grades follow brief study.

    d) poor grades follow lengthy study and good grades follow brief study.

10. The purpose of random assignment in an experiment is to:

    a) reduce the likelihood that participants within any group know each other.

    b) increase the likelihood that research participants are representative of the population being studied.

    c) reduce the influence of any preexisting differences between people assigned to the conditions of the experiment.

    d) ensure that the independent variable will have a strong influence on the dependent variable.