1

Introduction

OBJECTIVES FOR CHAPTER 1

After studying the text and working the problems in this chapter, you should be able to:

1. Identify strategies you can use to set yourself up for success in learning statistics
2. Distinguish between descriptive and inferential statistics
3. Define population, sample, parameter, statistic, and variable as they are used in statistics
4. Distinguish between quantitative and categorical variables
5. Distinguish between continuous and discrete variables
6. Identify the lower and upper limits of a continuous variable
7. Identify four scales of measurement and distinguish among them
8. Distinguish between statistics and research design
9. Distinguish between correlational and experimental research designs
10. Define independent variable, dependent variable, and extraneous variable and identify them in research studies
11. Describe statistics' place in epistemology
12. Identify ways in which statistics is a dynamic and controversial field

WELCOME TO THE world of statistics! We are excited to begin our exploration of this important, useful discipline with you. Before we jump into content, let's start with two things: 1) an overview of what to expect throughout this book and 2) a review of approaches you can take throughout our time together to maximize your likelihood of success as you learn statistics. In other words, don't skip this chapter! If you meaningfully engage with this chapter, you will have a good idea of how to approach the rest of the chapters. If you meaningfully engage with the rest of the chapters, you will develop statistical skills that will prove useful in your professional life and your personal life.

Looking at the Map

Let's first preview the route that we will take on our exploration of statistics. We will start here at base camp (Chapter 1), where we will collect our gear and learn some key terms that will be important for our journey. As we start along the path, we will first learn how to organize data (Chapter 2) and then learn about statistics that help us describe data sets (Chapters 3-6)—the foothills, if you will. We will then reach the steeper part of our climb, where we'll learn how to select, conduct, and interpret statistical analyses that help us answer more advanced research questions (Chapters 7-15). When we finally reach the top, we'll look back on where we have been and practice what we have learned along the way (Chapter 16).

Collecting our Gear

If you have never explored statistics before, you might be wondering what gear you'll need to navigate this course. This list might differ slightly depending on your trail guide (your instructor), but here is an overview of the major categories of supplies you'll need:

Your Guide Book

Instructors assign textbooks for several reasons, most of which come down to this: *they are helpful*. As with any tool, though, textbooks are only helpful in so far as you know how to use them. Here are some tips for maximizing the utility of this book:

1. *Read assigned chapters before class*. This will give you a frame of reference for the information covered in class. Each chapter begins with a list of skills the chapter is designed to help you acquire. Read this list of objectives first to find out what you are to learn to do. Then thumb through the chapter and read the headings. Try to anticipate questions this chapter should answer for you. Take notes on the content as you read. These are what we call "active reading" strategies.[1]
2. *Work through practice problems*. As you study each chapter, work the problems *as you come to them*. We encourage you to work them all—both the computational ones and the conceptual ones. Testing your knowledge through practice problems is a great way to differentiate between the topics that are clicking for you and the ones you need to engage with more. Here are additional tips for completing practice problems:
   - Never, ever look up an answer before you have worked the problem (or at least tried twice to work the problem). Looking up the answer before you've worked the problem yourself can give you a false sense of understanding the material.
   - For each set of problems, work the first one and then immediately check your answer against the answer in **Appendix G**. If you make an error, find out why you made it—faulty understanding, arithmetic error, or whatever—before moving on.
   - Don't be satisfied with just doing the math. If a problem asks for an interpretation, write out your interpretation.
   - When you finish a chapter, go back over the problems immediately, reminding yourself of the various techniques you have learned.
3. *At the end of a chapter, re-read the objectives*. Can you meet each one? If so, put a check mark beside that objective. If not, plan for how you will continue to work toward that objective. Do you need to make an office hours appointment, stop by class tutoring

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[1] If you've ever been "reading" and realized you lost focus at some point and couldn't recall what you had just read, that's passive reading. Passive reading eats up a lot of time and doesn't result in meaningful learning.

times? Do you need additional practice problems? (If so, check out the Study Guide that is available at **www.exploringstatistics.com**.)

Your engagement in statistics matters. Active participation is *necessary* to learn statistics, so we've organized and written this book in a way that encourages active participation. Here are features we've included to enhance the value you get out of actively reading the book:

1. *Trail Tips, On the Horizons,* and *Tripping Hazards*. Throughout the book, we highlight three types of important information. With *Trail Tips* and *Tripping Hazards*, we draw upon our own experiences teaching statistics to offer advice on what to do and what *not* to do as you learn the basics of statistics. With *On the Horizons*, we preview the ways in which content will be important in future chapters.
2. *Revisited problems*. On occasion, problems or data sets are used again, either later in that chapter or in another. If you do not work the problem when it is first presented, you are likely to be frustrated when it appears again. To alert you, we have put an asterisk (*) beside problems that are used in future problem sets in the book.
3. *Summit Problems*. Many chapters end with a comprehensive problem, called a Summit Problem. Working these problems requires knowledge of most of the material in the chapter. It is best to work all problems but be *sure* you can work summit problems.
4. *jamovi output*. Once we reach Chapter 5, you will begin to see output from a popular, freely-available statistical software program, *jamovi*. If your course uses a different statistical software program, don't worry: output across different programs contains very similar information. If your course does not use a statistical software program, it's still helpful to your learning to see statistical output presented in an organized fashion.
5. *Glossaries*. This book has three separate glossaries of words, symbols, and formulas.
   - *Words*. The first time an important word is used in the text, it appears in boldface type accompanied by a definition in the margin. **Appendix D** is a complete glossary of these words (p. 434). We suggest you mark this appendix.
   - *Symbols*. Statistical symbols are defined in **Appendix E** (p. 439). Mark that appendix, too. It is a good idea to memorize new symbols as you come to them. Having them in your working vocabulary will help reduce frustration as many symbols are used at multiple places throughout the book.
   - *Formulas*. Formulas for all the statistical techniques used in the text are printed in **Appendix F** (p. 441), in alphabetical order according to the name of the technique.

Computers, Calculators, Pencils, and Organization

Computer software, calculators, and pencils (with erasers!) are all tools used at one time or another by statisticians. Any or all of these devices may be part of the course you are taking. Regardless of the calculating aids that you use, however, your task will be the same:

1. Read a problem.
2. Decide what statistical procedure to use.
3. Apply that procedure using the tools available to you.
4. Write an interpretation of the results.

Pencils, calculators, and software represent, in ascending order, tools that are less and less error-prone. People who routinely use statistics routinely use computers. You may or may not use one at this point. Remember, though, whether you are using a software program or not, your principal task is to understand and describe.

Finally, because our exploration of statistics will naturally build upon itself, keeping an organized notes system will pay off. Buy yourself a notebook or establish a folder on your computer to organize and save your statistics work. When you make an error, don't remove that work—note the error and rework the problem correctly underneath. Seeing your error later serves as a reminder of what *not* to do on a test. If you find that we have made an error, write us with a reminder of what not to do in the next edition.[2]

But I'm Not a Hiker!

Okay, we'll drop the hiking metaphor for a second to make this point as clearly as possible, because it is that important: *You do not need to be a "math person" to succeed in statistics*. Yes, you will need to rely on some math skills (e.g., arithmetic, order of operations)[3] as you learn how to calculate the statistics in this book by hand, but that ability to hand-calculate statistics is not the end goal itself. To us, the biggest benefit of learning how to calculate statistics by hand is to better understand the concepts behind the calculations and what the resulting answers mean. Indeed, if you continue your study of statistics beyond the introductory level, it is likely you will rely more and more on computer software programs to do the calculations for you, rather than calculating by hand. What you will need to know, then, is what statistical analyses are most appropriate for a data set or research question and how to interpret the resulting statistical output.

To put it another way, which of the below problems do you think is the better to have?

1. You can work through the math of a statistical analysis with little to no trouble, but you don't know why you did it or what the end result means.
2. You can identify the appropriate statistical test and understand what the result means, but you struggle with some of the mathematical computations.

We would argue that the second problem is the better one to have. Being able to calculate a statistic is almost worthless if you cannot explain what it means in writing. Writing reveals how thoroughly you understand. To emphasize the importance of explanations, we've highlighted **Interpretation** in the answers in Appendix G.

Are you concerned about whether your background skills are adequate for a statistics course? For most students, this is an unfounded worry. **Appendix A**, Getting Started, should help relieve your concerns. But if you end up needing a little extra help working through the calculations, that's fine! Lots of people need help with math. Recognizing when you need a

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[2] Seriously, please write us at info@outcroppublishers.com if you find an error in this book. If you are the first person to detect that error, we will put your name up on the website as the person who discovered the error and pay you $5. Who says it doesn't pay to read your textbook?

[3] If you feel like you need to brush up on some of the math skills you will need for this course, engage with Appendix A.

little extra help (and then asking for that help) is a sign of self-awareness and strength, not weakness. And if you start to feel like your math anxiety is getting the best of you, try a little reframing exercise: Because so many people have doubts about their math and statistical abilities, this course is an opportunity for you to set yourself apart from your peers by mastering a skillset that is very marketable across a wide range of professions. You can do this. We believe in you.

Do you feel a little more prepared to embark on our exploration of statistics? (We're back to the metaphor.) We hope so. Throughout the rest of this chapter, we will provide an overview of the field of statistics and introduce to you some foundational key terms.

What Do You Mean, "Statistics?"

The *Oxford English Dictionary* says that the word *statistics* came into use almost 250 years ago. At that time, *statistics* referred to a country's quantifiable political characteristics—characteristics such as population, taxes, and area. Statistics meant "state numbers." Tables and charts of those numbers turned out to be a very satisfactory way to compare different countries and to make projections about the future. Later, tables and charts proved useful to people studying trade (economics) and natural phenomena (science). Statistical thinking spread because it helped. Today, two different sets of techniques are called *statistics*: descriptive statistics and inferential statistics[4].

Descriptive statistic: A number that conveys a particular characteristic of a set of data, meant to organize and summarize a set of data.

Mean: Arithmetic average; sum of scores divided by number of scores.

Descriptive statistics[5] produce a number or a figure that summarizes or describes a set of data. You are already familiar with some descriptive statistics. For example, you know about the arithmetic average, called the **mean** in statistics. You have probably known how to compute a mean since elementary school—just add up the numbers and divide the total by the number of entries. The mean describes the central tendency of a set of numbers. We'll learn more about the mean and other measures of central tendency in Chapter 3. The basic idea of descriptive statistics is simple: They summarize a set of data with one number or graph. This book covers about a dozen descriptive statistics.

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[4] A more complete answer to what is meant by "statistics" is Chapter 6 in *21st Century Psychology: A Reference Handbook* (Spatz, 2008). This 8-page chapter summarizes in words (no formulas) the statistical concepts usually covered in statistics courses. This chapter can orient you as you begin your study of statistics and later provide a review after you finish your course.

[5] Boldface words and phrases are defined in the margin and also in Appendix D, Glossary of Words.

Inferential statistic: Method that uses sample evidence and probability to reach conclusions about unmeasurable populations.

Population: All measurements of a specified group.

Sample: Measurements of a subset of a population.

The other statistical technique is **inferential statistics**. Inferential statistics use measurements from a **sample** to reach conclusions about a larger, *unmeasured* **population**. A population consists of all the scores of some specified group whereas a sample is a subset of a population. The population is the thing of interest. It is defined by the investigator and includes all cases. The following are some populations:

- Family incomes of college students
- Depression scores of Alaskans
- Gestation times for human beings
- Memory scores for U.S. adults[6]

Investigators are always interested in populations. However, as you can determine from these examples, populations can be so large that not all the members can be studied. The investigator must often resort to measuring a sample that is small enough to be manageable. A sample taken from the population of incomes of families of college students might include only 40 students. Most authors of research articles carefully explain the characteristics of the samples they use. Often, however, they do not identify the *population*, leaving that task to the reader.

The answer to the question "What is the population?" depends on the specifics of a research area, but many researchers generalize generously. For example, for some topics it is reasonable to generalize from the results of a study on rats to "all mammals." In all cases, however, the reason for gathering data from a sample is to generalize the results to a larger population even though sampling introduces some uncertainty into the conclusions.

There is, of course, a problem with samples. Samples always depend *partly* on the luck of the draw; chance helps determine the particular measurements you get, because chance determines *who* ends up in your sample. We'll learn more about the risks and rewards of sampling in Chapter 8.

If you have the measurements for the entire population, chance doesn't play a part—all the variation in the numbers is "true" variation. But with samples, some of the variation is the true variation in the population and some is just the chance ups and downs that go with a sample. Inferential statistics were developed as a way to account for the effects of chance that come with sampling. This book will cover about a dozen and a half inferential statistics.

Here is a textbook definition: Inferential statistics are methods that take chance factors into account when samples are used to reach conclusions about populations. Like most textbook definitions, this one condenses many elements into a short sentence. Because the idea of using samples to understand populations is perhaps the *most important concept* in this course, please pay careful attention when elements of inferential statistics are explained.

Inferential statistics have proved to be very useful in scientific disciplines. Many fields use inferential statistics, so we've selected examples and problems from a variety of disciplines

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[6] We didn't pull these populations out of thin air; they are all populations that researchers have gathered data on. Studies of these populations will be described in this book.

for this text and its auxiliary materials. *Null hypothesis significance testing* (NHST), a technique we'll spend a lot of time with in future chapters, is an inferential statistics technique.

Here is an example from psychology that uses the NHST technique. Today, there is a lot of evidence that people remember the tasks they fail to complete better than the tasks they complete. This is known as the *Zeigarnik effect*. Bluma Zeigarnik asked participants in her experiment to do about 20 tasks, such as work a puzzle, make a clay figure, and construct a box from cardboard.[7] For each participant, half the tasks were interrupted before completion. Later, when the participants were asked to recall the tasks they worked on, they listed more of the interrupted tasks (average about 7) than the completed tasks (about 4).

One good question to start with is, "Did interrupting make a big difference or a small difference?" In this case, interruption produced about three additional memory items compared to the completion condition. This is a 75% difference, which seems like a big change, given our experience with tests of memory. The question of "How big is the difference?" can often be answered by calculating an *effect size index* (introduced in Chapter 5).

So, should you conclude that interruption improves memory? Not yet. It might be that interruption actually has no effect but that several *chance factors* happened to favor the interrupted tasks in Zeigarnik's particular experiment. One way to meet this objection is to conduct the experiment again. Similar results would lend support to the conclusion that interruption improves memory. A less expensive way to meet the objection is to use inferential statistics such as NHST.

NHST begins with the actual data from the experiment. It ends with a probability—the estimated probability of obtaining data like those actually obtained if it is true that interruption has *no* effect on memory. If the probability is very small, you can conclude that interruption *does* affect memory. For Zeigarnik's data, the probability was tiny. Once we reach Chapter 9, this will all make a lot more sense to you.

Now for the conclusion. One version might be, "After completing about 20 tasks, memory for interrupted tasks (average about 7) was greater than memory for completed tasks (average about 4). The approximate 75% difference is unlikely due to chance because chance by itself would rarely produce a difference between two samples as large as this one." The words *chance* and *rarely* tell you that probability is an important element of inferential statistics.

ON THE HORIZON

We will review the process of NHST beginning in Chapter 9. In short, NHST is a statistical approach for drawing, essentially, yes/no conclusions about research questions based on probability: yes, there seems to be an effect present or no, there does not seem to be an effect present. Throughout Chapters 9 to 15, you will learn to apply this process to different types of research designs (e.g., two-group designs, three-group designs). Although the actual statistics calculated will be different for different types of research designs, the general process of NHST will be the same.

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[7] A summary of this study can be found in Ellis (1938). The complete reference and all others in the text are listed in the References section at the back of the book.

Some Additional Terminology

Like most courses, statistics introduces you to many new words. In statistics, most of the terms are used over and over again. Your best move, when introduced to a new term, is to *stop, read* the definition carefully, and *memorize* it. As the term continues to be used, you will become more and more comfortable with it. Making notes is helpful. In this section, we'll introduce some additional foundational terminology in the discipline of statistics.

Parameters versus Statistics

Parameter: Numerical or nominal characteristic of a population.

Statistic: Numerical or nominal characteristic of a sample.

A **parameter** is some numerical (number) or nominal (name) characteristic of a *population*. An example is the mean reading readiness score of all first-grade pupils in the United States. A **statistic** is some numerical or nominal characteristic of a *sample*. The mean reading readiness score of 50 first-graders is a statistic, and so is the observation that 45% are girls. A parameter is constant; it does not change unless the population itself changes. The mean of a population is exactly one number. Unfortunately, the parameter often cannot be computed because the population is unmeasurable. So, a statistic is used as an estimate of the parameter, although, as suggested before, statistics tend to differ from one sample to another. If you have five samples from the same population, you will probably have five different sample means. In sum, parameters are constant; statistics are variable across samples. Parameters characterize populations; statistics characterize samples that (hopefully) are representative of the population.

Variables

A **variable** is something that exists in more than one amount or in more than one form. Height and eye color are both variables. The notation *67 inches* is a numerical way to identify a group of persons who are similar in height. Of course, there are many other groups, each with an identifying number. Blue and brown are common eye colors, which might be assigned the numbers *0* and *1*. All participants represented by *0* have the same eye color. We will often refer to numbers like *67* and *0* as *scores* or *test scores*. A score is simply the result of measuring a variable.

What makes something a variable is context dependent. For example, gender identity varies across individuals. Gender identity is a variable. If, in a given situation, gender identity does *not* vary across individuals (say, a study that only included women), then gender identity is not a variable *in that context*. In that situation, we would instead call it a constant.[8] In short, if something can assume multiple values or forms in a given situation, then it is a variable. There are two kinds of variables: quantitative variables and categorical variables.

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[8] There are also things that are *always* constants, regardless of the situation. For example, the circumference of a circle is determined by multiplying the diameter of the circle by pi. Though diameter can vary across circles, pi does not. Pi is a mathematical constant.

QUANTITATIVE VARIABLES

Scores on **quantitative variables** tell you the *degree* or *amount* of the thing being measured. At the very least, a larger score indicates more of the variable than a smaller score does. There are two kinds of quantitative variables: continuous variables and discrete variables.

Continuous variables. Continuous variables are quantitative variables whose scores can be any value or intermediate value over the variable's possible range. The continuous memory scores in Zeigarnik's experiment make up a quantitative, continuous variable. *Number of tasks recalled* scores come in whole numbers such as 4 or 7, but it seems reasonable to assume that the underlying "thing" being measured, memory, is a continuous variable. Thus, of two participants who both scored 7, one's "true" memory score may be at the low end of the 7 range (true score of 6.6) and the other's "true" memory score may be at the high end of the 7 range (true score of 7.4). Picture the continuous variable, *recall*, as **Figure 1.1**.

If that explanation feels a bit circular, consider this: With continuous variables, more sensitive measurement instruments can pick up on smaller differences in the variable. For example, many household scales show the weight in pounds (perhaps out to one decimal place), but scales also exist that report weight in grams. With a more sensitive scale, you can obtain a more precise measurement of weight because weight is a continuous variable.

Variable: Something that exists in more than one amount or in more than one form.

Quantitative variable: Variable whose scores indicate different *amounts*.

Continuous variable: A quantitative variable whose scores can be any amount.

Lower limit: Bottom of the range of possible values that a measurement on a continuous variable can have.

Upper limit: Top of the range of possible values that a measurement on a continuous variable can have.

Figure 1.1 shows that a score of 7 is used to represent a range of possible recall values—the range from 6.5 to 7.5. The number 6.5 is the **lower limit** and 7.5 is the **upper limit** of the score of 7. The idea is that recall can be any value between 6.5 and 7.5, but that all the recall values in this range are expressed as 7. Similarly, a charge indicator value of 62% on your cell phone stands for all the power values between 61.5% (the lower limit) and 62.5% (the upper limit).

Sometimes scores are expressed in tenths, hundredths, or thousandths. Like integers, these scores have lower and upper limits that extend halfway to the next value on each side on the quantitative scale.

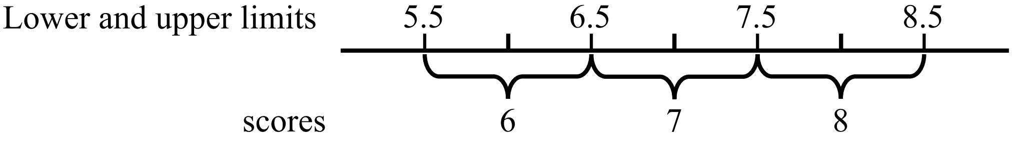

Figure 1.1 The lower and upper limits of recall scores of 6, 7, and 8

Discrete variable: Variable for which intermediate values between scores are not meaningful.

Discrete variables. Some quantitative variables are classified as **discrete variables** because intermediate values are not possible. The number of siblings people have is a discrete variable because it can't have intermediate values. Maybe you have 2 siblings or maybe you have 3 siblings, but you certainly don't have 2.5 siblings and no difference in your measurement approach would change that. Things like the number of pets you have, the number of times you've been hospitalized, and how many pairs of shoes you have are other examples of discrete variables. Intermediate scores such as 2.5 just don't make sense.

CATEGORICAL VARIABLES

Categorical variables (also called qualitative variables) produce scores that differ in *kind* and not *amount*. College major is a categorical variable. Eye color is another categorical variable. Scores might be expressed as *blue* and *brown* or as *0* and *1*, but substituting a number for a name does not make eye color a quantitative variable.

Categorical (or *qualitative*) variable: Variable whose scores differ in *kind*, not amount.

American political affiliation is a categorical variable with values of Democrat, Republican, Independent, and Other. Again, we could assign numbers to these categories, but those numbers would not convey a quantitative meaning; that is, assigning 1 to represent Democrats and 2 to represent Republicans does not mean that Republicans are *"more"* than Democrats. All categorical variables produce discrete scores, but not all discrete scores are from a categorical variable.

Engagement Check

At the beginning of this chapter, we encouraged you to engage in active reading of this book. Have you been doing that? Have you read the footnotes? Have you looked up any words you weren't sure of? Have you read a paragraph, wrinkled your brow in concentration, made notes in the book margin, or promised yourself to ask your instructor or another student about something you aren't sure of? *Engagement* shows up as activity. Best of all, the activity at times is a nod to yourself and a satisfied, "Now I understand."

Throughout each chapter, we will use our best engagement tactic: We'll give you a set of problems so that you can practice what you have just been reading about. Working these problems correctly is additional evidence that you have been engaged and helps you test your knowledge. You will find the answers at the end of the book in Appendix G. If you notice themes in the problems you struggle with, go back to that section of the textbook, review your notes, and seek out answers to questions that you have.

Now, here is your first opportunity to see how actively you have been reading.

PROBLEMS

1.1 Identify each number below as coming from a quantitative variable or a categorical variable.

- **a.** 65, number of seconds to work a puzzle
- **b.** 300.02, the identification number for generalized anxiety disorder in the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders
- **c.** 3, the group identification number for small-cup daffodils
- **d.** 4, a student's score on a high school Advanced Placement exam
- **e.** 81, milligrams of aspirin

1.2 Identify which of the below variables are continuous variables and which are discrete variables. For all continuous variables, identify their upper and lower limits.

- **a.** 20, number of seconds to work a puzzle
- **b.** 14, number of concerts attended
- **c.** 3, someone's birth order
- **d.** 10, speed in miles per hour

1.3 Write a paragraph that gives the definitions of *population, sample, parameter,* and *statistic* and describes the relationships among them.

1.4 Fill in the blanks for the following statements:

- **a.** Two kinds of statistics are ____________ statistics and ____________ statistics.
- **b.** To reach a conclusion about an unmeasured population, use ____________ statistics.
- **c.** ____________ statistics take chance into account to reach a conclusion.
- **d.** ____________ statistics are numbers or graphs that summarize a set of data.

Scales of Measurement

Numbers mean different things in different situations. Consider three answers that appear to be identical but are not:

What number were you wearing in the race?	"5"
What place did you finish in?	"5"
How many minutes did it take you to finish?	"5"

The three 5s all look the same. However, the three variables (identification number, finish place, and time) are quite different. Because of the difference in what the variables measure, each 5 has a different interpretation.

To illustrate this difference, consider another person whose answers to the same three questions were 10, 10, and 10. If you take the first question by itself and know that the two people had scores of 5 and 10, what can you say? You can say that the first runner was different from the second, but *that is all*. (Think about this until you agree.) On the second question, with scores of 5 and 10, what can you say? You can say that the first runner was faster than the second and, of course, that they are different. Comparing the 5 and 10 on the third question, you can say that the first runner was twice as fast as the second runner (and, of course, was faster and different).

The point of this discussion is to draw the distinction between the *thing* you are interested in and the *number* that stands for the thing. Much of your experience with numbers has been with pure numbers or quantitative measures such as time, length, and amount. Four and two have a relationship of *twice as much* and *half as much*. And, for distance and seconds, four *is* twice two; for amounts, two *is* half of four. But these relationships do not hold when numbers are used to measure some things. For example, for political race finishes, *twice* and *half* are not helpful. Second place is not half or twice anything compared to fourth place.

S. S. Stevens (1946) identified four different *scales of measurement*, each of which carries a different set of information. Each scale can use numbers, but the information that can be inferred from the numbers differs. The four scales are *nominal, ordinal, interval,* and *ratio*.

Nominal scale: Measurement scale in which numbers serve only as labels and do not indicate any quantitative relationship.

In the **nominal scale**, when numbers are used, they are used simply as names and have no real quantitative value. Numerals on sports uniforms are an example. Thus, 45 is *different* from 32, but that is all you can say. The person represented by 45 is not "more than" the person represented by 32, and certainly it would be meaningless to calculate the mean of the two numbers. Examples of nominal variables include psychological diagnoses, personality types, and political parties. Each of these variables contains multiple categories and these categories can be assigned corresponding numbers. For example, psychological diagnoses, like other nominal variables, consist of a set of categories. People are assessed and then classified into one of the categories. The categories have both a name (such as posttraumatic stress disorder or autism spectrum disorder) and a diagnostic number (309.81 and 299.00, respectively) assigned to them. Because psychological diagnoses is a nominal scale, these numbers mean only that the categories are different. For a nominal scale variable, the numbers could even be assigned to categories at random, so long as all things that are alike must have the same number.

The **ordinal scale** has the characteristic of the nominal scale (different numbers mean different things) plus the characteristic of indicating *greater than* or *less than*. In the ordinal scale, the object with the number 3 has less or more of something than the object with the number 5. Finish places in a race are an example of an ordinal scale. The runners finish in rank order, with 1 assigned to the winner, 2 to the runner-up, and so on. Here, 1 means less time than 2 and 2 means less time than 3, but these numbers tell you nothing about *how* *much less* time. Judgments about quality and recovery (from, say, an illness) often correspond to an ordinal scale. "Much improved," "improved," "no change," and "worse" are levels of an ordinal recovery variable. Ordinal scales are characterized by *rank order*.

The third kind of scale is the **interval scale**, which has the properties of both the nominal and ordinal scales plus the additional property that *intervals between the numbers are equal*. "Equal interval" means that the distance between the things represented by 1 and 2 is the same as the distance between the things represented by 2 and 3. Temperature is measured on an interval scale. The difference in temperature between 10°C and 20°C is the same as the difference between 40°C and 50°C. The Celsius thermometer, like all interval scales, has an arbitrary[9] zero point—that is, the zero point was chosen when creating the measurement. On the Celsius thermometer, the chosen zero point is the freezing point of water at sea level. Zero degrees on this scale does not mean the complete absence of heat; it is simply a convenient starting point. With interval data, there is one restriction: You may not make simple ratio statements. This is precisely because the zero point is arbitrary. You may not say that 100° is twice as hot as 50° or that a person with an IQ of 60 is half as intelligent as a person with an IQ of 120.[10] We often find that understanding what an interval scale is becomes easier after learning about the ratio scale.

The fourth kind of scale, the **ratio scale**, has all the characteristics of the nominal, ordinal, and interval scales plus one other: It has a *true zero point*, which indicates a complete absence of the thing measured. On a ratio scale, zero means "none." Height, weight, and time are measured with ratio scales. Zero height, zero weight, and zero time mean that no amount of these variables is present. If you slept 0 hours last night, you did not sleep at all last night (which we hope isn't actually true for you). With a true zero point, you can make ratio statements such as 16 kilograms is four times heavier than 4 kilograms.[11] **Table 1.1** summarizes the major differences among the four scales of measurement.

Ordinal scale: Measurement scale in which numbers indicate the order of scores and serve as *ranks*; equal differences between numbers do not represent equal differences between the things measured.

Interval scale: Measurement scale in which equal differences between numbers represent equal differences between the things measured. The zero point is arbitrarily defined.

Ratio scale: Like interval scales, equal differences between numbers represent equal differences between the things measured; but zero means that none of the thing measured is present.

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[9] When talking about scales of measurement, the word "arbitrary" does not necessarily mean that the 0 point was chosen at random. Instead, this term is used to indicate that the zero point is not a "true" zero. Keep reading in the main text for the definition of a true zero.

[10] Convert 100°C and 50°C to Fahrenheit (F = 1.8C + 32) and suddenly the "twice as much" relationship disappears.

[11] Convert 16 kilograms and 4 kilograms to pounds (1 kg = 2.2 lbs) and the "four times heavier" relationship is maintained.

TABLE 1.1
Characteristics of the four scales of measurement

	Scale Characteristics			
Scale of Measurement	**Different numbers for different things**	**Numbers convey greater than and less than**	**Equal differences mean equal amounts**	**True zero point**
Nominal	✓	×	×	×
Ordinal	✓	✓	×	×
Interval	✓	✓	✓	×
Ratio	✓	✓	✓	✓

Knowing the distinctions among the four scales of measurement will help you in two tasks in this course. The kind of *descriptive statistics* you can compute from numbers depends, in part, on the scale of measurement the numbers represent. For example, it is senseless to compute a mean of numbers on a nominal scale. Calculating a mean Social Security number, a mean telephone number, or a mean psychological diagnosis is nonsensical and evidence of misunderstanding numbers.

Understanding scales of measurement is sometimes important in choosing the kind of *inferential statistic* that is appropriate for a set of data. If the dependent variable (see next section) is a nominal variable, then a chi square analysis is appropriate (Chapter 14). If the dependent variable is a set of ranks (ordinal data), then a nonparametric statistic is required (Chapter 15). Most of the data analyzed with the techniques described in Chapters 7-13 are interval and ratio scale data.

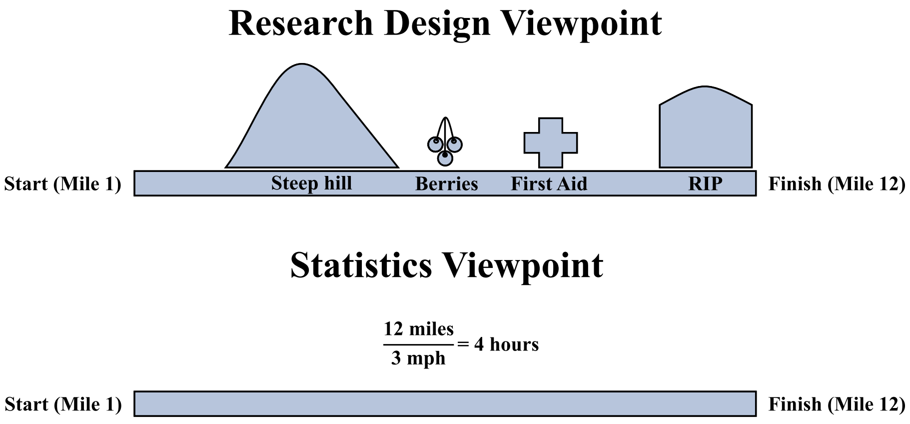
The topic of scales of measurement is controversial among statisticians. Part of the controversy involves viewpoints about the underlying thing you are interested in and the number that represents the thing (Wuensch, 2005). In addition, it is sometimes difficult to classify some of the variables used in the social and behavioral sciences. Often, they appear to fall between the ordinal scale and the interval scale. For example, a score may provide more information than simply rank, but equal intervals cannot be proven. Examples include aptitude and ability tests, personality measures, and intelligence tests. In such cases, researchers generally treat the scores as if they were interval scale data.

Statistics and Research Design

Here is a story that will help you distinguish between statistics (applying straight logic) and research design (observing what actually happens). This is an excerpt from a book by E. B. White, *The Trumpet of the Swan* (1970, pp. 63–64).

> The fifth-graders were having a lesson in arithmetic, and their teacher, Miss Annie Snug, greeted Sam with a question.
>
> “Sam, if a man can walk three miles in one hour, how many miles can he walk in four hours?” “It would depend on how tired he got after the first hour,” replied Sam. The other pupils roared. Miss Snug rapped for order.
>
> “Sam is quite right,” she said. “I never looked at the problem that way before. I always supposed that man could walk twelve miles in four hours, but Sam may be right: that man may not feel so spunky after the first hour. He may drag his feet. He may slow up.”
>
> Albert Bigelow raised his hand. “My father knew a man who tried to walk twelve miles, and he died of heart failure,” said Albert.
>
> “Goodness!” said the teacher. “I suppose *that* could happen, too.”
>
> “Anything can happen in four hours,” said Sam. “A man might develop a blister on his heel. Or he might find some berries growing along the road and stop to pick them. That would slow him up even if he wasn’t tired or didn’t have a blister.”
>
> “It would indeed,” agreed the teacher. “Well, children, I think we have all learned a great deal about arithmetic this morning, thanks to Sam Beaver.”
>
> Everyone had learned how careful you have to be when dealing with figures.

Statistics involves the manipulation of numbers and the conclusions based on those manipulations (Miss Snug). Research design deals with all the things that influence the numbers you get (Sam and Albert). **Figure 1.2** illustrates these two approaches to getting an answer. This text could have been a “pure” statistics book, from which you would learn to analyze numbers without knowing where they came from or what they referred to. You would learn about statistics, but without providing the broader research question and methodology, such a book would be dull, dull, dull. On the other hand, to describe procedures for collecting numbers is to teach research design—and this book is for a statistics course. Our solution to this conflict is generally to side with Miss Snug, but to include some aspects of research design throughout the book. Knowing research design issues is especially important when it comes time to interpret a statistical analysis. Here’s a start on research design.



Research Design Viewpoint

Statistics Viewpoint

Figure 1.2 Travel time from a research design viewpoint and a statistical viewpoint

Types of Research Designs and Variables

Correlational study: Research design wherein all variables are measured variables.

Experimental study: Research design wherein at least one variable is a manipulated variable.

Independent variable: Variable controlled by the researcher; changes in this variable may produce changes in the dependent variable.

Dependent variable: Observed variable that is expected to change as a result of changes in the independent variable in an experiment.

Level: One value of the independent variable (also called *condition*; in some experiments it is appropriate to call levels *treatments*).

The overall task of a researcher is to discover relationships among variables. As you've already read in this chapter, variables are things that vary, and researchers have studied personality, health, gender, anger, caffeine consumption, memory, beliefs, age, skill.... (you get the picture—almost anything can be a variable).

If all of the variables of interest in a study are *measured*—for example, year in school and time spent studying—and their relationship is assessed, then the study design is what we call a **correlational study.** We'll talk more about correlations and correlational studies in Chapter 6. If at least one variable in the study is *manipulated*—that is, the variable levels are created or determined by the researcher, such as whether a participant completes a task alone or in the presence of another person—then the study design is what we call an **experimental study.** Which study design you use will depend on your research question, but many of the examples throughout this text will refer to experimental designs.

Independent and Dependent Variables

A simple experiment has two major variables, the **independent variable** and the **dependent variable**. In the simplest experiment, the researcher selects two values of the independent variable for investigation. Values of the independent variable are usually called **levels** or **conditions** and sometimes called **treatments**.[12]

The basic idea is that the researcher creates two groups of participants that are similar in every way except for the independent variable. These individuals are then measured on the dependent variable. The question is whether the data will allow the researcher to claim that the values on the dependent variable *depend* on the level of the independent variable.

The values of the dependent variable are found by *measuring* or *observing* participants in the investigation. The dependent variable might be scores on a personality test, number of items remembered, or whether or not a passerby offered assistance. For the independent variable, the researcher might have produced the difference in the two groups by an experimental manipulation such as creating

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[12] Sometimes an experiment is literally comparing the effects of different treatment options [e.g., comparing the effect of a new drug treatment to a placebo (an inert substance)]. In that case, levels of the independent variable are called treatments.

different amounts of anxiety or providing different levels of practice. This would result in a true experimental design. However, if the researcher selected two groups of participants because they were already different—in age, gender, personality, and so forth—this would then be a correlational study.

Let's walk through an example of a simple experimental design. Suppose for a moment that as a budding gourmet cook you want to improve your spaghetti sauce. One of your buddies suggests swapping brown sugar for white sugar. To investigate, you serve spaghetti sauce at two different gatherings. For one group of guests, the sauce includes brown sugar; for the other, it includes white sugar. At both gatherings, you count the number of favorable comments about the spaghetti sauce. *Stop reading; identify the independent and the dependent variables.*

The dependent variable is the number of favorable comments, which is a measure of the taste of the sauce. The independent variable is sugar type, which has two levels: brown sugar and white sugar. This would be an experimental design because you, the researcher, created the difference between the two groups.

Extraneous Variables

Extraneous variable: Variable other than the independent variable that may affect the dependent variable.

One of the pitfalls of research studies is that every situation has other variables besides the independent variable that might possibly be responsible for the changes in the dependent variable. These other variables are called **extraneous variables**. In the story, Sam and Albert noted several extraneous variables that could influence distance traveled in 4 hours.

Are there any extraneous variables in the spaghetti sauce example? Oh yes, there are many, and just one is enough to raise suspicion about a conclusion that relates the taste of spaghetti sauce to the type of sugar used. Extraneous variables include the amount and quality of the other ingredients in the sauce, the spaghetti itself, the "party moods" of the two groups, and how hungry everyone was. If any of these extraneous variables was actually operating, it weakens the claim that a difference in the comments about the sauce is the result of the type of sugar used. The simplest way to remove an extraneous variable is to be sure that all participants are equal on that variable. For example, you can ensure that the sauces are the same except for the type of sugar used by mixing up the ingredients, dividing it into two batches, adding white sugar to one batch and brown sugar to the other, and then cooking. The "party moods" variable can be controlled (equalized) by conducting the taste test in a laboratory. Controlling extraneous variables is a complex topic covered in courses that focus on research methods and experimental design.

In many experiments, it is impossible or impractical to control all the extraneous variables. Sometimes researchers think they have controlled them all, only to find that they did not. The effect of an uncontrolled extraneous variable is to prevent a simple cause-and-effect conclusion. Even so, if the dependent variable changes when the independent variable changes, something is going on. In this case, researchers can say that the two variables are *related*, but that other variables may play a part, too.

At this point, you can test your understanding by engaging yourself with these questions: What were the independent and dependent variables in the Zeigarnik experiment reviewed on page 7? How many levels of the independent variable were there?[13]

How well did Zeigarnik control extraneous variables? For one thing, each participant was tested at both levels of the independent variable. That is, the recall of each participant was measured for interrupted tasks and for completed tasks. One advantage of this technique is that it naturally controls many extraneous variables. Thus, extraneous variables such as age and motivation were exactly the same for tasks that were interrupted as for tasks that were not because the same people contributed scores to both levels.

At various places in the following chapters, we will explain experiments and the statistical analyses using the terms *independent* and *dependent variables*. These explanations usually assume that all extraneous variables were controlled; that is, you may assume that the researcher knew how to design the experiment so that changes in the dependent variable could be attributed correctly to changes in the independent variable. However, we'll also present a few investigations (like the spaghetti sauce example) that we hope you recognize as being so poorly designed that conclusions cannot be drawn about the relationship between the independent variable and dependent variable. Be alert.

Here's a summary of the relationship between statistics and research design: Researchers start with a research question. They then design and conduct a research study; in a true experimental design, they choose the levels of the independent variable (treatments), control the extraneous variables, and then measure the participants on the dependent variable. The measurements (data) are analyzed using statistical procedures. Finally, the researcher tells a story that is consistent with the results obtained and the procedures used.

Statistics and Philosophy

The two previous sections reviewed the relationship between statistics and experimental design; this section will review the place of statistics in the grand scheme of things.

Explaining the grand scheme of things is the task of philosophy and, over the years, many schemes have been advanced. For a scheme to be considered a grand one, it has to address **epistemology**—that is, to propose answers to the question: How do we acquire knowledge?

Epistemology: The study or theory of the nature of knowledge.

Both *reason* and *experience* have been popular answers among philosophers.[14] For those who emphasize the importance of reason, mathematics has been a continuing source of inspiration. Classical mathematics starts with axioms that are assumed to be true. Theorems are thought up and are then proved by giving axioms as reasons. Once a theorem is proved, it can be used as a reason in a proof of other theorems.

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[13] Try for answers. Then, if need be, here's a hint: First, identify the dependent variable; for the dependent variable, you don't know values until data are gathered. Next, identify the independent variable; you can tell what the levels of the independent variable were from the description of the design. Ask yourself: How many groups were present?

[14] In philosophy, those who emphasize reason are rationalists and those who emphasize experience are empiricists.

Statistics has its foundations in mathematics; thus, statistical analysis is based on reason. As you go about calculating means and standard deviations, finding confidence intervals, and telling the story of what they mean, know that you are engaged in logical reasoning. (Experimental design is more complex; it includes experience and observation as well as reasoning.)

Let's move from formal descriptions of philosophy to a more informal one. A very common task of most human beings can be described as *trying to understand*. Statistics has helped many in their search for better understanding, and it is such people who have recommended (or demanded) that statistics be taught in school. A reasonable expectation is that you, too, will find statistics useful in your future efforts to understand and persuade.

Speaking of persuasion, you have probably heard it said, "You can prove anything with statistics." The implied message is that a conclusion based on statistics is suspect because statistical methods are unreliable. It isn't true that statistical methods are unreliable, but it is true that people can misuse statistics (just as any tool can be misused). One of the great advantages of studying statistics is that you get better at recognizing statistics that are used improperly.

Statistics: A Dynamic, Controversial, and Useful Discipline

Many people think of statistics as a collection of techniques that were developed long ago, have not changed, and will be the same in the future. That view is mistaken. Statistics is a dynamic discipline characterized by more than a little controversy.[15] New techniques in both descriptive and inferential statistics continue to be developed. Controversy continues, too. For example, ongoing controversy exists over the utility of NHST,[16] which we discussed earlier in this chapter and will unpack in more detail in Chapter 9. Part of this controversy is that NHST is often misunderstood *and mistaught*. Indeed, one study found that in a sample of popular introductory psychology textbooks that review NHST, 89% did so inaccurately (Cassidy et al., 2019).

How will we address NHST in light of this controversy? First, we will be as clear as possible when we explain what NHST is, how to use it, and what inferences to draw from it. Second, we will make understanding the controversy around this technique part of your exploration of statistics. Finally, we will highlight the utility of alternative or complementary approaches to NHST. Although the field of statistics may one day fully discard the usage of NHST, it hasn't done so yet. Therefore, learning NHST remains an important part of your statistical journey.

In addition to controversy over techniques, attitudes toward data analysis have shifted in recent years toward the idea of exploring data to see what it reveals and away from using statistical analyses to nail down a conclusion. This shift owes much of its impetus to John Tukey (1915–2000), who promoted exploratory data analysis (Lovie, 2005) and invented techniques such as the boxplot (Chapter 5) that reveal several characteristics of a data set simultaneously.

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[15] For a slightly longer walk through some of the history of statistics, additional information is presented under "Free Materials" at exploringstatistics.com.

[16] To get a feel for the issues when the controversy entered the mainstream, see Cohen (1994), Dillon (1999) or Spatz (2000) for nontechnical summaries. For more technical explanations, see Nickerson (2000). To read about current approaches, see Erceg-Hurn and Mirosevich (2008), Kline (2013), or Cumming (2014).

Another important source of controversy in statistics has to do with prominent figures and the purposes for which they invented and used statistical techniques. Sir Frances Galton (1822-1911), Karl Pearson (1857-1936), and Ronald Fisher (1890-1962), are credited with a long list of contributions to statistics, many of which we will encounter later in this book. However, their work had a dark motivation, as all three were vocal proponents of eugenics and used statistics as a way to promote eugenics. We will use this point as an opportunity to emphasize that, although statistical techniques themselves cannot be judged as moral or immoral, the way in which we use statistics and the research questions we test very much can.

Today, statistics is used in a wide variety of fields. Researchers start with a phenomenon, event, or process that they want to understand better. They make measurements that produce numbers. The numbers are manipulated according to the rules and conventions of statistics. Based on the outcome of the statistical analysis, researchers draw conclusions and then write the story of their new understanding of the phenomenon, event, or process. Statistics is just one tool that researchers use, but it is often an essential tool.

Whatever your current interests or thoughts about your future as a statistician, we believe you will benefit from this course. A successful statistics course teaches you to identify questions a set of data can answer; determine the statistical procedures that will provide the answers; carry out the procedures; and then, using writing and graphs, tell the story the data reveal. Kirk (2008) identifies four levels of statistical sophistication:

- Category 1: those who understand statistical presentations
- Category 2: those who understand, select, and apply statistical procedures
- Category 3: applied statisticians who help others use statistics
- Category 4: mathematical statisticians who develop new statistical techniques and discover new characteristics of old techniques

We hope that by the end of your statistics course, you will be well along the path to becoming a Category 2 statistician.

Concluding Thoughts

This book is a fairly complete introduction to basic statistics. When you finish this course (but before any final examination), engage with Chapter 16, the last chapter in this book. It is an integrative chapter. Of course, there is a lot more to statistics, but there is a limit to what you can do in one term. Exploration of paths not covered in a textbook can be fun. Encyclopedias, both general and specialized, often reward such exploration. Try the *Encyclopedia of Statistics in Behavioral Sciences* or *the International Encyclopedia of the Social and Behavioral Sciences.*

Most students find that this book works well as a textbook in their statistics course. We recommend that you keep the book after the course is over to use as a *reference* book. In future courses and even after school, many find themselves looking up a definition or reviewing a procedure. A familiar textbook can be a valued guidebook that serves for years into the future.

For us, exploring statistics and using them to understand the world is satisfying and illuminating. Though your first time on this trail may involve a few stumbles, we hope you have a similar experience.

PROBLEMS

1.5 Name the four scales of measurement identified by S. S. Stevens and give the properties of each.

1.6 Identify the scale of measurement used in each of the following cases:

- **a.** Geologists have a “hardness scale” for identifying different rocks, called Mohs’ scale. The hardest rock (diamond) has a value of 10 and will scratch all others. The second hardest will scratch all but the diamond, and so on. Talc, with a value of 1, can be scratched by every other rock. (A fingernail, a truly handy field-test instrument, has a value between 2 and 3.)
- **b.** The volumes of three different cubes are 40, 64, and 65 cubic inches.
- **c.** Three different highways are identified by their numbers: 40, 64, and 65.
- **d.** Republicans, Democrats, Independents, and Others are identified on the voters’ list with the numbers 1, 2, 3, and 4, respectively.
- **e.** The winner of the race was from New York; the two runners-up were from Ohio and California. (Hint: There are *two* variables in this case)
- **f.** The prices of the three items are $3.00, $10.00, and $12.00.
- **g.** She earned three degrees: B.A., M.S., and Ph.D.

1.7 Undergraduate students conducted the three studies that follow. For each study, identify the dependent variable, the independent variable, the number of levels of the independent variable, the names of the levels of the independent variable, and whether the study design is correlational or experimental in nature.

- **a.** Becca had students in a statistics class rate a résumé, telling them that the person had applied for a position that included teaching statistics at their college. The students rated the résumé on a scale of 1 (not qualified) to 10 (extremely qualified). All the students received identical résumés, except that the candidate’s first name was Jane on half the résumés and John on the other half.
- **b.** Michael wondered if birth order could be used to predict narcissism. Michael’s participants filled out the Selfism scale, which measures narcissism. (Narcissism is neurotic self-love.) In addition, students were classified as first-born, second-born, and later-born.
- **c.** Johanna had participants read a description of a crime and “Mr. Anderson,” the person convicted of the crime. For some participants, Mr. Anderson was described as a janitor. For others, he was described as a vice president of a large corporation. For still others, no occupation was given. After reading the description, participants recommended a jail sentence (in months) for Mr. Anderson.

1.8 Researchers who are now well known conducted the classic studies that follow. For each study, identify the dependent variable, the independent variable, and the number and names of the levels of the independent variable. Complete items i and ii for each.

a. Theodore Barber hypnotized 25 people, giving each a series of suggestions. The suggestions included arm rigidity, hallucinations, color blindness, and enhanced memory. Barber counted the number of suggestions the participants complied with (the mean was 4.8). For another 25 people, he simply asked them to achieve the best score they could (but no hypnosis was used). This second group was given the same suggestions, and the number complied with was counted (the mean was 5.1). (See Barber, 1976.)

i. Identify a nominal variable and a statistic.
ii. In one sentence, describe what Barber's study shows.

b. Elizabeth Loftus had participants view a film clip of a car accident. Afterward, some were asked, "How fast was the car going?" and others were asked, "How fast was the car going when it passed the barn?" (There was no barn in the film.) A week later, Loftus asked the participants, "Did you see a barn?" If the barn had been mentioned earlier, 17% said yes; if it had not been mentioned, 3% said yes. (See Loftus, 1979.)

i. Identify a population and a parameter.
ii. In one sentence, describe what Loftus's study shows.

1.9 Stanley Schachter and Larry Gross gathered data from male students for about an hour in the afternoon. At the end of this time, a clock on the wall was correct (5:30 p.m.) for 20 participants, slow (5:00 p.m.) for 20 others, and fast (6:00 p.m.) for 20 more. The actual time, 5:30, was the usual dinnertime for these students. While participants filled out a final questionnaire, crackers were freely available. The weight of the crackers each student consumed was measured. The means were as follows: 5:00 group—20 grams; 5:30 group—30 grams; 6:00 group—40 grams. (See Schachter & Gross, 1968.)

i. Identify a ratio scale variable.
ii. In one sentence, describe what this study shows.

1.10 For the study that is described at the top of the next page, identify the dependent and independent variables and indicate whether the design is correlational or experimental in nature. Additionally, there are uncontrolled extraneous variables in the study described here. Name as many as you can.

An investigator concluded that Textbook A was better than Textbook B after comparing the exam scores of two statistics classes. One class met MWF at 10:00 a.m. for 50 minutes, used Textbook A, and was taught by Dr. X. The other class met for 2.5 hours on Wednesday evening, used Textbook B, and was taught by Dr. Y. All students took the same comprehensive test at the end of the term. The mean score for Textbook A students was higher than the mean score for Textbook B students.

1.11 In philosophy, the study of the nature of knowledge is called ___________.

1.12 The two approaches to epistemology identified in the text are ___________ and ___________. Statistics has roots in ___________.

1.13 One reason why controversy exists over the use of NHST is that it is often ___________.

1.14 Read the objectives at the beginning of this chapter and respond to them. Getting in the habit of responding to chapter objectives will help you consolidate and assess what you have learned.

KEY TERMS

- **Categorical variable (p. 10)**
- **Continuous variable (p. 9)**
- **Correlational study (p. 16)**
- **Dependent variable (p. 16)**
- **Descriptive statistics (p. 5)**
- **Discrete variable (p. 10)**
- **Epistemology (p. 18)**
- **Experimental study (p. 16)**
- **Extraneous variable (p. 17)**
- **Independent variable (p. 16)**
- **Inferential statistics (p. 6)**
- **Interval scale (p. 13)**
- **Level (p. 16)**
- **Lower limit (p. 9)**
- **Mean (p. 5)**
- **Nominal scale (p. 12)**
- **Ordinal scale (pp. 12-13)**
- **Parameter (p. 8)**
- **Population (p. 6)**
- **Qualitative variable (p. 10)**
- **Quantitative variable (p. 9)**
- **Ratio scale (p. 13)**
- **Sample (p. 6)**
- **Statistic (p. 8)**
- **Treatment (p. 16)**

Chapter 1, a haiku

First, definitions,
history, and the book's features.
After that – explore!
- Chris Spatz