Introduction to Statistics

In introducing this book to you, we assume you are a college student who is taking what is perhaps your first course in statistics to fulfill a requirement for your major or a general education requirement. If so, you may be asking yourself two questions:

- What is statistics?
- Why learn statistics?

The ultimate goal of this book is to help you begin to answer these two questions.

1.1 What Is Statistics?

Whether or not you are aware of it, you encounter a variety of “statistics” in your day-to-day activities: the typical cost of going to college, the yearly income of the average college graduate, the average price of a home, and so on. So what exactly is “statistics”? The Merriam-Webster dictionary defines statistics as a branch of mathematics dealing with the collection, analysis, interpretation, and presentation of masses of numerical data. When people think about statistics, they often focus on only the “analysis” aspect of the above definition—that is to say, they focus on numbers that result from analyzing data. However, statistics is not only concerned about how data are analyzed, it recognizes the importance of understanding how data are collected and how the results of analyses are interpreted and communicated. The purpose of this book is to introduce, describe, and illustrate the role of statistics within the larger research process.

1.2 Why Learn Statistics?

We believe there are a variety of reasons why you should learn statistics. First, not only do you currently encounter
A second reason for learning statistics is that you may be asked or required to read and interpret the results of statistical analyses. Many college courses require students to read academic research journal articles. Evaluating published research is complicated by the fact that different people studying the same topic may come up with diverse or even opposing conclusions. Understanding statistics and their role in the research process will help you decide whether conclusions drawn in research articles are appropriate and justified.

Another reason for learning statistics is that it will be of use to you in your own research. College courses sometimes have students design and conduct mini-research studies; undergraduate majors might require or encourage students to do senior honors theses; graduate research programs often require masters' theses and doctoral dissertations. Learning to collect and analyze data will help you address your own questions in an objective, systematic manner.

A final reason for learning statistics is that it may help you in your future career. The website Careercast.com conducts an annual survey in which they evaluate 200 professions on five dimensions: environment, income, employment outlook, physical demands, and stress. In 2013, the highest rated profession in this survey was “actuary,” defined as someone who “interprets statistics to determine probabilities of accidents, sickness, and death, and loss of property from theft and natural disasters.” Talking about his job, one actuary noted, “I can count on one hand the number of days I’ve said, ‘I don’t want to go to work today’ . . . I’ve seen people come in to say thank you for the work I’ve done. That’s pretty powerful.”

It is generally a good idea for students to maintain a healthy level of curiosity or even skepticism in regards to their education. However, we find that when it comes to learning statistics, the frame of mind of some students may be characterized as one of fear and anxiety. Although we understand these feelings, we hope the benefits associated with learning statistics will become clear to you and help you overcome any concerns you may have.

1.3 Introduction to the Stages of the Research Process

Much of scientific research involves asking questions. Throughout this book, we will examine how contemporary researchers have asked and attempted to answer a broad range of questions.
regarding human attitudes and behavior. Below are research questions we will address in this chapter to introduce the stages of the research process:

- Is students’ performance on tests more influenced by their learning strategies (how they learn) or their motivation (why they learn)?
- Do college students and faculty differ in their beliefs about the prevalence of student academic misconduct such as cheating and plagiarism?
- Is the extent to which adolescents are exposed to violence in their community related to how they do in school?
- Is one method of disciplining one’s children more effective than another?
- Does playing online computer games affect one’s interpersonal relationships?
- Does providing substance abuse treatment to drug users have an effect on safety in the workplace?

How might you try to answer questions such as these? You could base your answers on your personal beliefs, or you could adopt the answers given to you by others. But rather than relying on subjective beliefs and feelings, researchers test their ideas using science and the scientific method. The scientific method is a method of investigation that uses the objective and systematic collection and analysis of empirical data to test theories and hypotheses.

At its simplest, this book will portray the scientific method as consisting of five main steps or phases:

- developing a research hypothesis to be tested,
- collecting data,
- analyzing the data,
- drawing a conclusion regarding the research hypothesis, and
- communicating the findings of the study.

Accomplishing each of these five steps requires completing a number of tasks, as shown in Figure 1.1. Because this sequence of steps will be used throughout this book and will serve as the model for the wide assortment of research studies we will review and discuss, each step is briefly introduced below. It is important to understand that the research process depicted in Figure 1.1 represents an ideal way of doing research. The “real” way, as you may discover in your own efforts or from speaking with researchers, is often anything but a smooth ride but rather is filled with starts and stops, dead ends, and wrong turns.

**Developing a Research Hypothesis to Be Tested**

The initial stage—and the first step—of the research process is to develop a research hypothesis to be tested. A **research hypothesis** is a statement regarding an expected or predicted relationship between variables. A **variable** is a property or characteristic of an object, event, or person that can take on different values. One example of a variable is “U.S. state,” a variable with 50 possible values (Alabama, Arkansas, etc.).
Research hypotheses are usually developed through the completion of several tasks:

- identifying a question or issue to be examined,
- reviewing and evaluating relevant theories and research, and
- stating a research hypothesis.

Each of these three tasks is described below.

### Identifying a Question or Issue to Be Examined

Most research starts with a question posed by the researcher. These questions often come from the researcher's own ideas and daily observations. Although this may not seem terribly scientific, there is an advantage in using one's own experience as a starting point: People are generally much more motivated to explore a question or topic that concerns them personally. In teaching statistics, we frequently advise students developing their own research projects to study something that is of interest to them. Conducting research can be tedious, difficult, and frustrating. At various points
during your research, you may ask yourself, “Why am I doing this?” Being able to provide a satisfactory answer to this question will help you overcome whatever obstacles you encounter along the way.

**Reviewing and Evaluating Relevant Theories and Research**

Beyond the researcher's own curiosity, research questions often arise from an examination of the theories, ideas, and research of others. A *theory* is a set of propositions used to describe or explain a phenomenon. The purpose of a theory is to summarize and explain specific facts using a logically consistent framework. Placing a question within a theoretical framework provides guidance and structure to research.

Reviewing and evaluating existing theories and research helps the researcher decide whether it is worth the time and energy required to conduct the study. By seeing what others have done, the researcher may decide that a particular idea has already been investigated and there is no reason to duplicate earlier efforts. On the other hand, the researcher may conclude that the current way of thinking is incomplete or mistaken. By doing this review, researchers are able to ensure that the studies they undertake add to and improve upon an existing body of knowledge.

**Stating a Research Hypothesis: Independent and Dependent Variables**

Understanding and evaluating an existing literature not only helps articulate a question of interest but also may lead to a predicted answer to that question. Within the scientific method, this answer is stated as a research hypothesis, defined earlier as a statement regarding an expected or predicted relationship between variables. Table 1.1 lists the research questions and research hypotheses for the studies listed at the beginning of this section. For example, the first research hypothesis states "students who are taught effective learning skills will perform better on tests than students offered incentives to do well."

One characteristic of research hypotheses such as those listed in Table 1.1 is that they identify the variables that are the focus of their research studies. As mentioned earlier, a variable is a property or characteristic with different values. Variables can be classified in several ways. In specifying a research hypothesis, researchers often speak in terms of “independent” and “dependent” variables. An *independent variable* may be defined as a variable manipulated by the researcher. A *dependent variable*, on the other hand, is a variable measured by the researcher. Researchers are interested in examining the effect of the independent variable on the dependent variable.

Consider the first research hypothesis provided in Table 1.1: “Students who are taught effective learning skills will perform better on tests than students who are offered incentives to do well.” Here the independent variable is the instructional method by which students are taught, which consists of two values: learning skills and incentives. The dependent variable is the test performance that will be measured during the research. In this study, the effect of the independent variable on the dependent variable is that differences in students’ test performance (the dependent variable) may “depend” upon which instructional method (learning skills or incentives) a student receives. Table 1.2 lists the independent and dependent variables for each of the research hypotheses in Table 1.1.

A second characteristic of research hypotheses, in addition to identifying variables, is that they specify with as much precision as possible the nature and direction of the relationship between variables. For example, the first research hypothesis in Table 1.1 states that “students
Table 1.1 Examples of Research Questions and Hypotheses

<table>
<thead>
<tr>
<th>Research Question</th>
<th>Research Hypothesis</th>
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<tbody>
<tr>
<td>Is students' performance on tests more influenced by their motivation (why they learn) or their learning strategies (how they learn)?</td>
<td>Students who are taught effective learning skills will perform better on tests than students offered incentives to do well.</td>
</tr>
<tr>
<td>Do college students and faculty differ in their beliefs about the prevalence of student academic misconduct (i.e., cheating, plagiarism)?</td>
<td>Faculty members' beliefs about the frequency of student academic misconduct will be lower than students' beliefs.</td>
</tr>
<tr>
<td>Is there a relationship between adolescents' exposure to violence in their community and their academic achievement?</td>
<td>The more adolescents are exposed to violence in their community, the lower their levels of academic achievement.</td>
</tr>
<tr>
<td>Is one method of disciplining children more effective than another?</td>
<td>Children will rate a disciplining strategy that emphasizes logic and reason as more effective than one based on rewards and punishment.</td>
</tr>
<tr>
<td>Does playing online games affect one's interpersonal relationships?</td>
<td>Heavy users of online games have less fulfilling interpersonal relationships than users spending little or no time playing online games.</td>
</tr>
<tr>
<td>Does providing substance abuse treatment to drug users have an effect on safety in the workplace?</td>
<td>Drug users are less likely to have work-related accidents after undergoing substance abuse treatment than before the treatment.</td>
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</table>

Table 1.2 Research Hypotheses and Their Independent and Dependent Variables

<table>
<thead>
<tr>
<th>Research Hypothesis</th>
<th>Independent Variable</th>
<th>Dependent Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students who are taught effective learning skills will perform better on tests than students offered incentives to do well.</td>
<td>Instructional method</td>
<td>Test performance</td>
</tr>
<tr>
<td>Faculty members' beliefs about the frequency of student academic misconduct will be lower than students' beliefs.</td>
<td>Member of college community</td>
<td>Beliefs about the frequency of student academic misconduct</td>
</tr>
<tr>
<td>The more adolescents are exposed to violence in their community, the lower their levels of academic achievement.</td>
<td>Exposure to community violence</td>
<td>Academic achievement</td>
</tr>
<tr>
<td>Children will rate a disciplining strategy that emphasizes logic and reason as more effective than one based on rewards and punishment.</td>
<td>Parental discipline strategy</td>
<td>Effectiveness of parental discipline strategy</td>
</tr>
</tbody>
</table>
who are taught effective learning skills will perform better on tests. . . .” The word better indicates the nature and direction of the relationship between the independent variable (instructional method) and the dependent variable (test performance). The direction of the relationship would not have been stated if the hypothesis had included the less specific phrase “will perform differently on tests,” which simply indicates that the two groups are not expected to be the same. Table 1.3 provides directional and non-directional research hypotheses for the research studies from Table 1.1.

The ability to form a directional research hypothesis is dependent on the state of the existing literature on the question of interest. If little or perhaps conflicting research has been conducted, researchers may not be able to form a directional hypothesis before they begin their research. One study, for example, examined the relationship between exercise deprivation (not allowing people to get their exercise) and tension, depression, and anger (Mondin et al., 1996). The researchers for the

<table>
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<tr>
<th>Research Hypothesis</th>
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<th>Dependent Variable</th>
</tr>
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<tr>
<td>Heavy users of online games have less fulfilling interpersonal relationships than users spending little or no time playing online games.</td>
<td>Online game-playing</td>
<td>Quality of interpersonal relationships</td>
</tr>
<tr>
<td>Drug users are less likely to have work-related accidents after undergoing substance abuse treatment than before the treatment.</td>
<td>Time</td>
<td>Occurrence of a work-related accident</td>
</tr>
</tbody>
</table>

Table 1.3 Directional and Non-directional Research Hypotheses

<table>
<thead>
<tr>
<th>Directional Research Hypothesis</th>
<th>Non-directional Research Hypothesis</th>
</tr>
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<tbody>
<tr>
<td>Students who are taught effective learning skills will perform better on tests than students offered incentives to do well.</td>
<td>Students who are taught effective learning skills will perform differently on tests than students offered incentives to do well.</td>
</tr>
<tr>
<td>Faculty members’ beliefs about the frequency of student academic misconduct will be lower than students’ beliefs. The more adolescents are exposed to violence in their community, the lower their levels of academic achievement.</td>
<td>Faculty members’ beliefs about the frequency of student academic misconduct will be different than students’ beliefs. The more adolescents are exposed to violence in their community, the more different their levels of academic achievement.</td>
</tr>
<tr>
<td>Children will rate a disciplining strategy that emphasizes logic and reason as more effective than one based on rewards and punishment.</td>
<td>Children will rate a disciplining strategy that emphasizes logic and reason differently than one based on rewards and punishment.</td>
</tr>
<tr>
<td>Heavy users of online games have less fulfilling interpersonal relationships than users spending little or no time playing online games.</td>
<td>The quality of interpersonal relationships is different for heavy users of online games than users spending little or no time playing online games.</td>
</tr>
<tr>
<td>Drug users are less likely to have work-related accidents after undergoing substance abuse treatment than before the treatment.</td>
<td>The likelihood of drug users having work-related accidents is different after undergoing substance abuse treatment than before the treatment.</td>
</tr>
</tbody>
</table>
study reported, “We did not have a directional hypothesis, and when participants asked what we expected to find in this study, we replied: ‘We really are not sure since the results of earlier work on exercise deprivation are mixed’” (p. 1200).

Collecting Data
Once a research hypothesis has been formulated, researchers are ready to proceed to the second stage in the research process: collecting data relevant to this hypothesis. This step is seen as being composed of three tasks:

• drawing a sample from a population,
• determining how the variables will be measured, and
• selecting a method by which to collect the data.

Learning Check 1:
Reviewing What You’ve Learned So Far

1. Review questions
   a. What are the main steps involved in the research process?
   b. Why is it useful to review and evaluate theories and research before conducting a study?
   c. What are the two main characteristics of research hypotheses?
   d. What is the difference between an independent variable and a dependent variable?

2. Listed below are several research hypotheses from published studies. For each research hypothesis, identify the independent and dependent variable.
   a. “College students will rate instructors who dress formally (i.e., business suit and tie) as having more expertise than instructors who dress casually (i.e., slacks and shirt)” (Sebastian & Bristow, 2008).
   b. “It was expected that . . . greater amounts of television viewing . . . would predict greater . . . posttraumatic stress symptoms” (McLeish & Del Ben, 2008).
   c. “We . . . hypothesized persons who estimated the HSAS level to be red (severe) or orange (high) . . . when the HSAS level was [in fact] yellow (elevated), would report greater worry about terrorism” (Eisenman et al., 2009).
   d. “We hypothesized that prekindergarten children who participated in the 6-week intervention would perform better [on a test of literacy skills] than their peers in a control group who did not participate in the program” (Edmonds, O’Donoghue, Spano, & Algozzine, 2009, p. 214).
Drawing a Sample From a Population

The first step in collecting data is to identify the group of participants to which the research hypothesis applies. The group to which the results of a study may be applied or generalized is called a population. A population is the total number of possible units or elements that could potentially be included in a study. For example, researchers could variously define the population of interest for the first research hypothesis in Table 1.1 as “college students,” “college students in the United States,” “college students in Georgia,” or “college students at the University of Georgia.” Researchers typically try to define their populations as broadly as possible (e.g., “college students in the United States” rather than “college students in Georgia”) to maximize the applications or implications of their research.

It is typically difficult to collect data from all members of a population. Imagine, for example, the time and money that would be needed to collect information from every college student in the United States. For this reason, researchers typically draw conclusions about populations based on information collected from a sample drawn from the population. A sample is a subset or portion of a population. Table 1.4 describes the samples used in the six studies introduced in Table 1.1. As you can see from Table 1.4, samples greatly vary in terms of their targeted population and size (the number of participants).

Determining How Variables Will Be Measured: Levels of Measurement

The research hypotheses described in Table 1.1 involve variables such as instructional method, test performance, online game playing, and quality of interpersonal relationships. To conduct a research study, the researcher must determine an appropriate way to measure the variables stated in the research hypothesis. Measurement is the assignment of categories or numbers to objects or events according to rules.

For example, to measure the variable “height,” a researcher might use “number of inches from the ground in bare feet” as a form of measurement. To measure a variable such as “success in college,” a student’s grade point average (GPA) may be obtained from school transcripts. “Self-esteem” might be measured by having people complete a questionnaire and, on the basis of their responses, be categorized as having either “low” or “high” self-esteem. As these examples demonstrate, the result of measurement is an assignment of a number or a category to each participant in the research study. Different types of variables require different forms of measurement. In recognition of these differences, researchers have identified four distinct levels for measuring variables: nominal, ordinal, interval, and ratio.

The values of variables measured at the nominal level of measurement differ in category or type. The word nominal implies having to do with “names,” such that we use first names and surnames as ways of distinguishing between people. Gender is an example of a nominal variable, in that it consists of categories or types (male and female) rather than numeric values. In the first research hypothesis in Table 1.1, the independent variable, instructional method, is measured at the nominal level, consisting of two categories: learning skills and incentives.

Variables measured at the ordinal level of measurement have values that can be placed in an order relative to the other values. Rankings (such as finishing first, second, or third in a race) and size (small, medium, large, or extra large) are familiar examples of an ordinal scale. Ordinal scales allow researchers to demonstrate that one value represents more or less of a variable than do other values; however, it is not possible to specify the precise size or amount of the difference between values. For example, although you can say that a runner who finishes “first” in a race is...
The values of variables measured at the interval level of measurement are equally spaced along a numeric continuum. One example of an interval variable is the Fahrenheit scale of temperature. Here, a difference of five degrees has the same meaning anywhere along the scale; for example, the difference between 45°F and 50°F is the same as the difference between 65°F and 70°F. Many variables studied in the behavioral sciences (e.g., personality characteristics or attitudes) are considered to be measured at the interval level of measurement. Interval variables not only provide more precise and specific information than do ordinal variables, but they also fulfill the requirements of the most commonly used statistical procedures.

Variables at the ratio level of measurement are identical to interval variables, with one exception: Ratio scales possess what is known as a true zero point, for which the value of zero (0) represents the complete absence of the variable. Variables that describe a physical dimension (such as height, weight, distance, and time duration) typically have a true zero point. In the first research hypothesis in Table 1.1, the researchers in this study measured the variable “test performance” by recording the number of correct answers to a test of reading comprehension. Test performance is a ratio variable because it has a true zero point, where zero would indicate the complete absence of correct answers.
One advantage of ratio measurement versus interval measurement is that ratio variables allow for a greater number of comparisons among values. Consider, for example, the value 6 for the ratio variable “inches.” Not only is the difference between 4 and 6 inches the same as the difference between 6 and 8 inches (thereby involving addition and subtraction), 6 inches is also twice as long as 3 inches and half as long as 12 inches (involving multiplication and division). Multiplication and division comparisons cannot be made with interval variables. You cannot, for example, say that a temperature of 90°F is three times as much temperature as 30°F.

The bold-faced and italicized text in Table 1.5 illustrates how the authors of the six studies described in the earlier tables chose to measure their independent and dependent variables. As you can see, the variables in these studies have been measured in a variety of ways at different levels of measurement.

### Table 1.5 Research Hypotheses and Measurement of Variables

<table>
<thead>
<tr>
<th>Research Hypothesis</th>
<th>Independent Variable</th>
<th>Dependent Variable</th>
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</thead>
<tbody>
<tr>
<td>Students who are taught effective learning skills will perform better on tests than students offered incentives to do well.</td>
<td>Instructional method learning strategy, incentive motivation (nominal)</td>
<td>Test performance number of items correct (ratio)</td>
</tr>
<tr>
<td>Faculty members’ beliefs about the frequency of student academic misconduct will be lower than students’ beliefs.</td>
<td>Member of college community faculty, student (nominal)</td>
<td>Beliefs about the frequency of student academic misconduct 1–5 scale (1 = Never, 5 = Very often) (ordinal)</td>
</tr>
<tr>
<td>The more adolescents are exposed to violence in their community, the lower their levels of academic achievement.</td>
<td>Exposure to community violence 0 times, 1 time, 2 times, 3+ times (ratio)</td>
<td>Academic achievement Grade point average (GPA) (ratio)</td>
</tr>
<tr>
<td>Children will rate a disciplining strategy that emphasizes logic and reason as more effective than one based on rewards and punishment.</td>
<td>Parental discipline strategy power assertion, love withdrawal, induction (nominal)</td>
<td>Effectiveness of parental discipline strategy 1–5 scale (1 = Not at all effective, 5 = Very effective) (ordinal)</td>
</tr>
<tr>
<td>Heavy users of online games have less fulfilling interpersonal relationships than users spending little or no time playing online games.</td>
<td>Online game-playing heavy, light, nonplayer (nominal)</td>
<td>Quality of interpersonal relationships 1–6 scale (1 = Strongly agree, 6 = Strongly disagree) (ordinal)</td>
</tr>
<tr>
<td>Drug users are less likely to have work-related accidents after undergoing substance abuse treatment than before the treatment.</td>
<td>Time before treatment, after treatment (nominal)</td>
<td>Occurrence of a work-related accident Yes, No (nominal)</td>
</tr>
</tbody>
</table>
What difference does the level of measurement make? A variable’s level of measurement has important implications for researchers in that it influences how research hypotheses are stated as well as how data are analyzed. For example, imagine you are interested in studying the variable “success in college.” You could choose to measure this variable at the **nominal** level of measurement by having faculty members classify students into one of two groups: successful or unsuccessful. Researchers typically employ nominal variables when they are interested in questions involving differences between groups, such as, “Do successful and unsuccessful college students differ in their study habits?”

You could instead measure success in college as an **ordinal** variable by having faculty members rank their students from top to bottom. Ranking enables a researcher to study relative differences with less concern for the precise magnitude of these differences. For example, using ranked data, you could ask, “How similar are younger and older faculty members’ rankings of their students?”

To study success in college using the **interval** level measurement, you could have faculty members rate each student on a scale from 1 (low) to 100 (high). You could then use these ratings to address a research question such as, “Is there a relationship between faculty members’ ratings of their students and students’ ratings of themselves?”

Finally, to measure success in college using the **ratio** level of measurement, you could use students’ salary after graduation (in dollars) as an indicator of success. Salary is a ratio variable because it contains a true zero point. In practice, ratio variables can be used to ask many of the same questions as those involving interval variables. For example, you could ask, “Is there a relationship between faculty members’ ratings of students and students’ salaries after graduation?”

As you can see, how researchers choose to measure their variables influences how they state their research questions and research hypotheses. The level of measurement used for a variable has another important implication: It helps determine the statistical procedures researchers use to analyze the data. Certain statistical procedures can be applied only to variables measured at the interval or ratio levels of measurement, whereas other procedures are appropriate for variables measured at the nominal or ordinal level.

**Selecting a Method to Collect the Data:**

**Experimental and Non-experimental Research Methods**

In addition to drawing a sample from a population and determining how the variables in a study may be measured, the third step in collecting data is to determine the type of research method to use to collect the data on these variables. Research methods may be classified into two main types:

- experimental research methods, and
- non-experimental research methods.

**Experimental Research Methods.** Experimental research methods are methods designed to test causal relationships between variables—more specifically, whether changes in independent variables produce or cause changes in dependent variables. To make inferences about cause-effect relationships, researchers conducting an experiment must first eliminate all other possible causes or explanations for changes in the dependent variable besides the independent variable. If it can be claimed that a variable other than the independent variable created the observed changes in the
dependent variable, the research results are said to be confounded. A **confounding variable** is a variable related to an independent variable that provides an alternative explanation for the relationship between the independent and dependent variables.

To understand how confounding variables work, consider the following question: What is the relationship between a mother’s ethnicity and the birth weight of her baby? Although research has shown differences in the birth weights of babies of different ethnicities, one study noted that some of this research did not take into account the possibility that differences in birth weights may be partly due to differences between ethnic groups on such factors as the mother’s average age at time of pregnancy, socioeconomic status, and behaviors such as smoking and drinking (Ma, 2008). These lifestyle characteristics are considered confounding variables in that they provide alternative explanations for any causal relationship between ethnicity and babies’ birth weights.

Researchers minimize the influence of confounding variables in two main ways. First, researchers exercise experimental control by making the research setting (i.e., characteristics of the research participants, location of the experiment, the instruments or measures administered, the instructions given to the research participants) the same for all participants. In the birth weight study, for example, the research design might control for the effect of parental smoking on birth weight by only including nonsmokers in the study sample, excluding those who smoke.

Another way researchers exert control over the research setting is to include a condition known as a **control group**, which is a group of participants in an experiment not exposed to the independent variable the research is designed to test. For example, if you conducted an experiment designed to examine the effects of caffeine on one’s health, one group (the experimental group) might be instructed to drink coffee while a second group (the control group) drinks decaffeinated coffee. By contrasting the results of the two groups, researchers can then assess the impact of caffeinated coffee on the health of those who drink it.
Researchers cannot possibly identify and control for the effects of all potential confounding variables. Consequently, a second strategy used to minimize the influence of confounding variables is **random assignment**, which is assigning participants to each category of an independent variable in such a way that each participant has an equal chance of being assigned to each category. For example, to assign a participant to either the experimental or the control condition of a study, a researcher might simply flip a coin: heads for experimental, tails for control. The purpose of random assignment is to equalize or neutralize the effects of confounding variables by distributing them equally over all levels of the independent variable.

**Non-experimental Research Methods.** Experimental research designs are one of the best tools researchers have for making causal inferences. However, the ability to make causal inferences requires a great deal of control over the situation, control that may not always be possible or desirable. For this reason, researchers often employ non-experimental research methods (sometimes referred to as correlational research methods). **non-experimental research methods** are research methods designed to measure naturally occurring relationships between variables without having the ability to infer cause-effect relationships. Some of the most common types of non-experimental research designs include quasi-experiments, survey research, observational research, and archival research.

**Quasi-experimental research** compares naturally formed or preexisting groups rather than employing random assignment to conditions. For example, suppose a researcher wanted to study the effects of different methods of teaching reading on children’s verbal skills. Ideally, the researcher would randomly assign a sample of schoolchildren to receive the different teaching methods. However, because children are taught together in classes, it would be difficult to have children in the same classroom receive different methods. Implementing multiple methods in a single classroom would not only place an unreasonable burden on the teacher, but children would also see their classmates being treated differently, which might influence their behavior. To address these concerns, a researcher might assign entire classrooms of children to receive a particular method. Comparing the classrooms is an example of quasi-experimental research.

**Survey research** methods obtain information directly from a group of people regarding their opinions, beliefs, or behavior. The goal of survey research, which can involve the use of questionnaires and interviews, is to obtain information from a sample that can then be used to represent or estimate the views of a larger population. Because the researcher does not directly manipulate any variables, survey research is not conducted to make causal inferences but is instead used to describe a phenomenon or predict future behavior. As one example of survey research, political pollsters attempt to predict how people will vote in an election by asking a sample of voters about their preferences.

**Observational research** is the systematic and objective observation of naturally occurring behavior or events. The purpose of observational research is to study behavior or events, with little, if any, intervention on the part of the researcher. Observational research is often used to study phenomena that the researcher either cannot or should not deliberately manipulate. For example, researchers studying aggressive behavior in children would never force children to push or hit each other. By observing playground behavior, however, researchers may be able to record acts of aggression if and when they occur.

Rather than observing or measuring behavior directly, **archival research** is the use of archives (records or documents of the activities of individuals, groups, or organizations) to examine research questions or hypotheses. One example of an archival research study was interested in studying criminal trials—more specifically, whether the race, age, or gender of an offender is related to the
severity of the sentence they receive (Steffensmeier, Ulmer, & Kramer, 1998). To conduct their study, they obtained and analyzed state court records of more than 138,000 criminal trials, recording the severity of the sentences given to the offender as well as the offender's race, age, and gender.

**An Example of Combined Experimental and Non-experimental Research.** Both experimental and non-experimental research methods have strengths and weaknesses. The strength of experimental research is the ability to demonstrate cause-effect relationships between independent and dependent variables; however, the control that experiments require creates situations that may not resemble the real world. Non-experimental research methods do not allow the researcher to make causal inferences because they do not involve experimental manipulation, experimental control, or random assignment; however, they have the advantage of allowing researchers to study variables as they naturally occur. Given the strengths and limitations of both research methods, one solution is to use and compare the findings from both methods for examining the same question.

Does playing violent video games lead to aggressive behavior? Two researchers studied this important question using both experimental and non-experimental research methods, saying, “We chose two different methodologies that have strengths that complement each other and surmount each others’ weaknesses” (Anderson & Dill, 2000, p. 776).

For their experiment, participants were randomly assigned to one of two conditions, playing either a violent video game or a nonviolent game; “type of video game” was their independent variable. Next, they played another type of game in which they could punish their opponent (who was actually a computer) by delivering a loud blast of noise. The loudness and duration of the noise delivered by participants represented the dependent variable of “aggressive behavior.”

For their non-experimental method, the researchers used a survey methodology, asking students to fill out a questionnaire about the number of hours they played violent video games each week (the independent variable). For the dependent variable of aggressive behavior, students reported the number of times in the previous year that they had performed eight different aggressive acts, such as hitting or stealing from other students.

What did the researchers find? In reporting their findings, they wrote, “In both a correlational investigation using self-reports of real-world aggressive behaviors and an experimental investigation using a standard, objective laboratory measure of aggression, violent video game play was positively related to increases in aggressive behavior” (Anderson & Dill, 2000, p. 787). In evaluating their study, they emphasized the advantages of using both types of research methods, explaining that the non-experimental method “measured video game experience, aggressive personality, and delinquent behavior in real life . . . [whereas] an experimental methodology was also used to more clearly address the causality issue” (p. 782).

**Analyzing the Data**

Once data have been collected, the next step in the research process involves analyzing them. This part of the research process addresses the primary topic of this book: statistics. Because this is the first chapter of this book, we will not describe analyzing data in detail. Instead, we introduce the notion that there are two main purposes of analyzing data: (1) to organize, summarize, and describe the data that have been collected and (2) to test and draw conclusions about ideas and hypotheses. These two purposes are met by calculating two main types of statistics: descriptive statistics and inferential statistics.
Calculating Descriptive Statistics

**Descriptive statistics** are statistics used to summarize and describe a set of data for a variable. For example, you have probably heard of crime statistics and unemployment statistics, statistics used to describe or summarize certain aspects of our society. Using a research-related example, Caitlin Abar, a researcher at Brown University, conducted a study examining increases in students’ alcohol-related behaviors after entering college (Abar, 2012). To measure students’ level of alcohol use, she created a variable called “typical weekend drinking,” which “was measured as the sum of drinks consumed on a typical Friday and Saturday within the past 30 days” (p. 22). One way to organize and summarize students’ responses to the typical weekend drinking variable would be to calculate the mean, which is the mathematical average of a set of scores. The mean, described in Chapter 3, is an example of a descriptive statistic. The first part of this book describes a variety of descriptive statistics used by researchers to summarize data they have collected.

Calculating Inferential Statistics

Besides summarizing and describing data, a second purpose of statistics is to analyze data to test hypotheses and draw conclusions. **Inferential statistics** are statistical procedures used to test hypotheses and draw conclusions from data collected during research studies. By using inferential statistics, researchers are able to test the ideas, assumptions, and predictions on which their research is based. Using inferential statistics, researchers are able to make inferences about the existence of relationships between variables in populations based on information gathered from samples of the population.

As an example of an inferential statistic, let’s return to the example of students’ alcohol-related behaviors introduced above (Abar, 2012). This study was interested in seeing whether there was a relationship between these behaviors and students’ perceptions regarding different aspects of their relationships with their parents. One of these aspects was “alcohol communications,” defined as “the extent that they discussed alcohol related topics with their parents at some point during the past several months” (p. 22). To test a hypothesis regarding the relationship between alcohol communications and students’ alcohol use, we may decide to use an inferential statistic known as the Pearson correlation coefficient, which will be discussed in Chapter 13. The chapters in the last half of this book discuss a broad variety of examples of inferential statistics, along with detailed instructions for analyzing and drawing conclusions from statistical data and presenting research findings.

Drawing a Conclusion Regarding the Research Hypothesis

Once statistical analyses have been completed, the next step is to interpret the results of the analyses as they relate to the research hypothesis. More specifically, do the findings of the analyses support or not support the research hypothesis? The word **support** in the previous sentence is very important. Students and researchers are sometimes tempted to conclude that their findings “prove” their hypotheses are either true or false. However, as will be discussed in Chapter 5, because researchers typically do not collect data from the entire population, they cannot know with 100% certainty whether their hypothesis is in fact true or false. Also, given the complexity of the phenomena studied by researchers, it is extremely difficult for one research study to prove a hypothesis or theory is completely true or false.
Communicating the Findings of the Study

Conducting research requires a variety of different skills: conceptual skills to develop research hypotheses, methodological skills to collect data, and mathematical skills to analyze these data. Another integral part of the research process is the communication skills needed to inform others about a study. Researchers must not only be skilled scientists but also effective writers.

For many years, the American Psychological Association (APA), the professional association for psychologists, has recognized the need to provide researchers guidance on how to communicate the results of their research. In 1929, the APA published a seven-page article in the journal *Psychological Bulletin* entitled, “Instructions in Regard to Preparation of Manuscript.” In contrast, the sixth edition of the *Publication Manual of the American Psychological Association*, published in 2010, consists of 272 pages. This increase in length highlights the challenges faced by writers in communicating their research in an effective and efficient manner.

1.4 Plan of the Book

The primary purpose of this chapter was to introduce statistics and place it within the larger research process. The remainder of the book will discuss a number of different statistical procedures used by researchers to examine various questions of interest. Although it is critical for you to be able to correctly calculate statistics, it is equally important to understand the role of statistics within the research process and appreciate the conceptual and pragmatic issues related to the use (and sometimes misuse) of statistics.

The first half of the book (Chapters 2 through 6) will introduce you to conceptual and mathematical issues that are the foundation of statistical analyses. Chapters 2, 3, and 4 discuss how data may be examined, described, summarized, and presented in numeric, visual, and graphic form. Descriptive statistics are introduced and discussed in these chapters. Chapters 5 and 6 introduce critical assumptions about and characteristics of the inferential statistical procedures used to test

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**Learning Check 3: Reviewing What You’ve Learned So Far**

1. Review questions
   a. What are the main differences between experimental and non-experimental research methods?
   b. What are confounding variables? What do researchers do to minimize the effects of confounding variables?
   c. What are the main types of non-experimental research methods?
   d. What are the relative strengths and weaknesses of experimental and non-experimental research?
   e. What are the main purposes of descriptive and inferential statistics?
research hypotheses. The remaining chapters of the book will introduce you to a number of different inferential statistical procedures, along with key issues surrounding the use of these procedures.

In most cases, the chapters in this book share a uniform format and structure, and are centered on the research process. In making our presentation, we will employ various examples of actual published research studies, addressing questions with which you may be familiar. In each case, we will clearly state the research hypothesis, briefly describe how the data in the study were collected, introduce and describe the calculation of both descriptive and inferential statistics, and discuss the extent to which the results of the statistical analyses support the research hypothesis. Finally, we will illustrate how to communicate one's research to a broader audience.

1.5 Looking Ahead

We began our presentation by defining statistics and providing reasons why learning about them may be of value to you. Next, we placed statistics within the stages of the larger research process, a process that will be the foundation of this textbook. As we have explained, the research process is centered on a research hypothesis, a predicted relationship between variables. Once a hypothesis has been stated, the next step is to collect data about the variables included in the research, after which the process of statistical analysis begins. Analyzing data involves the calculation of two main types of statistics, one designed to describe and summarize the data for a variable (descriptive statistics) and one designed to test research hypotheses (inferential statistics). However, before conducting analyses on a set of data, there is preliminary work that must be completed. The next chapter will focus on methods used by researchers to examine data.

1.6 SUMMARY

Statistics may be defined as a branch of mathematics dealing with the collection, analysis, interpretation, and presentation of masses of numerical data. As such, statistics is not only concerned about how data are analyzed but also recognizes the importance of understanding how data are collected and how the results of analyses are interpreted and communicated.

There are a variety of reasons why students should learn statistics: Statistics are encountered in a wide variety of daily activities, students may be asked or required to read and interpret the results of statistical analyses in their courses, students may use statistics in conducting their own research, and statistics may help one's career.

Researchers conduct research using the scientific method of inquiry, a method of investigation that uses the objective and systematic collection and analysis of empirical data to test theories and hypotheses. The research process used within the scientific method of inquiry consists of five main steps: developing a research hypothesis to be tested, collecting data, analyzing the data, drawing a conclusion regarding the research hypothesis, and communicating the findings to the study.

A research hypothesis is a statement regarding an expected or predicted relationship between variables. Developing a research hypothesis involves identifying a question or issue to be examined, reviewing and evaluating relevant theories and research, and stating
the research hypothesis to be tested in the study. A theory is a set of propositions used to describe or explain a phenomenon. A research hypothesis contains variables, which are properties or characteristics of some object, event, or person that can take on different values. More specifically, a research hypothesis states the nature and direction of a proposed relationship between an independent variable (a variable manipulated by the researcher) and a dependent variable (a variable measured by the researcher).

Collecting data involves drawing a sample from a population, determining how the variables will be measured, and selecting a method to collect the data. A population is the total number of possible units or elements that could potentially be included in a study; a sample is a subset or portion of a population. Variables can be measured at one of four levels of measurement: nominal (values differing in category or type), ordinal (values placed in an order relative to the other values), interval (values equally spaced along a numeric continuum), or ratio (values equally spaced along a numeric continuum with a true zero point).

There are two main types of methods used to collect data: experimental research methods, designed to test whether changes in independent variables produce or cause changes in dependent variables, and non-experimental research methods, designed to examine the relationship between variables without having the ability to infer cause-effect relationships.

In experimental research, researchers are concerned about possible confounding variables, which are variables related to independent variables that provide an alternative explanation for the relationship between independent and dependent variables. To minimize the impact of confounding variables, a research study may exercise experimental control over various aspects of the situation, including the use of a control group, which is a group of participants not exposed to the independent variable the research is designed to test, or random assignment, which involves assigning participants to each category of an independent variable in such a way that each participant has an equal chance of being assigned to each category.

Examples of non-experimental research methods are survey research, in which information is directly obtained from a group of people regarding their opinions, beliefs, or behavior; observational research, which involves the systematic and objective observation of naturally occurring events; and archival research, which uses archives (records or documents of the activities of individuals, groups, or organizations) to examine research questions or hypotheses.

Once data have been collected, the next step is to analyze them using two main types of statistics: descriptive statistics, which summarize and describe a set of data, and inferential statistics, which are statistical techniques used to test hypotheses and draw conclusions from data collected during research studies.

Once the statistical analyses have been completed, the results of the analyses are interpreted regarding whether they support or not support the study’s research hypothesis. The final step in the research process is to communicate the study to a broader audience.

1.7 IMPORTANT TERMS

<table>
<thead>
<tr>
<th>statistics (p. 1)</th>
<th>research hypothesis (p. 3)</th>
<th>theory (p. 5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>scientific method (p. 3)</td>
<td>variable (p. 3)</td>
<td>independent variable (p. 5)</td>
</tr>
</tbody>
</table>
dependent variable (p. 5)
population (p. 9)
sample (p. 9)
measurement (p. 9)
level of measurement (nominal, ordinal, interval, ratio) (p. 9-10)
experimental research methods (p. 12)
confounding variable (p. 13)
control group (p. 13)
random assignment (p. 13)
non-experimental research methods (p. 14)
quasi-experimental research (p. 14)
survey research (p. 14)

observational research (p. 14)
archival research (p. 14)
descriptive statistics (p. 16)
inferential statistics (p. 16)

1.8 EXERCISES

1. Listed below are a number of hypothetical research hypotheses. For each hypothesis, identify the independent and dependent variable.
   a. Male drivers are more likely to exhibit “road rage” behaviors such as aggressive driving and yelling at other drivers than are female drivers.
   b. The more time a student takes to finish a midterm examination, the higher his or her score on the examination.
   c. Men are more likely to be members of the Republican political party than are women; women are more likely to belong to the Democratic political party than are men.
   d. Students who receive a newly designed method of teaching reading will display higher scores on a test of comprehension than the method currently used.
   e. The more time a child spends in daycare outside of the home, the less he or she will be afraid of strangers.

2. Listed below are a number of research questions and hypotheses from actual published articles. For each hypothesis, identify the independent and dependent variable.
   a. “The use of color in a Yellow Pages advertisement will increase the perception of quality of the products for a particular business when compared with noncolor advertisements” (Lohse & Rosen, 2001, p. 75).
   b. “We hypothesized that parents who use more frequent corporal and verbal punishment . . . will report more problem behaviors in their children” (Brenner & Fox, 1998, p. 252).
   c. “It was hypothesized that adolescents with anorexia nervosa would . . . be more respectful when compared with peers with bulimia nervosa” (Pryor & Wiederman, 1998, p. 292).
   d. “The purpose of the present research was to assess brand name recognition as a function of humor in advertisements. . . . It was predicted that participants would recognize product brand names that had been presented with humorous advertisements more often than brand names presented with nonhumorous advertisements” (Berg & Lippman, 2001, p. 197).
   e. “The purpose of this study was to explore the relation between time
spent in daycare and the quality of exploratory behaviors in 9-month-old infants . . . it was hypothesized that . . . infants who spent greater amounts of time in center-based care would demonstrate more advanced exploratory behaviors than infants who did not spend as much time in center-based care” (Schuetze, Lewis, & DiMartino, 1999, p. 269).

f. “It was hypothesized that students would score higher on test items in which the narrative contains topics and elements that resonate with their daily experiences versus test items comprised of material that is unfamiliar” (Erdodi, 2012, p. 172).

3. Listed below are additional research questions and hypotheses from actual published articles. For each hypothesis, identify the independent and dependent variable.

a. “It is expected that achievement motivation will be a positive predictor of academic success” (Busato, Prins, Elshout, & Hamaker, 2000, p. 1060).

b. “Men are expected to employ physical characteristics (particularly those that are directly related to sex) more often than women in selecting dating candidates” (Hetsroni, 2000, p. 91).

c. The purpose of our study was to gain a better understanding of the relationship between social functioning and problem drinking. . . . We predicted that problem drinkers would endorse more social deficits than nonproblem drinkers” (Lewis & O’Neill, 2000, pp. 295–296).

d. “We predicted that people in gain-framed conditions would show greater intention to use sunscreen . . . than those people in loss-framed conditions” (Detweiler et al., 1999, p. 190).

e. “Students with learning disabilities who received self-regulation training would obtain higher reading comprehension scores than students (with learning disabilities) in the control group” (Miranda, Villaescusa, & Vidal-Abarca, 1997, p. 504).

f. “We hypothesized that consumers would think that a ‘sale price’ presentation would generate a greater monetary savings than an ‘everyday low price’ presentation” (Tom & Ruiz, 1997, p. 403).

g. “We hypothesize that physical coldness (vs. warmth) would activate a need for psychological warmth, which in turn increases consumers’ liking of romance movies” (Hong & Sun, 2012, p. 295).

4. Name the scale of measurement (nominal, ordinal, interval, ratio) for each of the following variables:

a. The amount of time needed to react to a sound

b. Gender

c. Score on the Scholastic Aptitude Test (SAT)

d. Political orientation (not at all conservative, conservative, very conservative)

e. Political affiliation (Democrat, Republican, Independent)

5. Name the scale of measurement (nominal, ordinal, interval, ratio) for each of the following variables:
a. One’s age (in years)
b. Size of soft drink (small, medium, large, extra large)
c. Voting behavior (in favor vs. against)
d. IQ score
e. Parent (mother vs. father)

6. A faculty member wishes to assess the relationship between students’ scores on the Scholastic Aptitude test (SAT) and their performance in college.
   a. What is a possible research hypothesis in this situation?
   b. What are the independent and dependent variables?
   c. How could you measure the variable “performance in college” at each of the four levels of measurement?

7. A researcher hypothesizes that drivers who use cellular phones will get into a greater number of traffic accidents than drivers who do not use these phones. For this example,
   a. What are the independent and dependent variables?
   b. How could you measure the dependent variable?
   c. How could you conduct this study using an experimental research method? How could you conduct this study using a non-experimental method?

Answers to Learning Checks

Learning Exercise 1

2. a. IV: Instructors’ dress;
   b. IV: Amount of television viewing;
   c. IV: Estimation of HSAS level;
   d. IV: Use of humor;
   e. IV: Participation in intervention program;
   DV: Expertise
   DV: Posttraumatic stress symptoms
   DV: Worry about terrorism
   DV: Product recognition
   DV: Literacy skills

Learning Exercise 2

2. a. Nominal
   b. Ratio
   c. Ordinal
   d. Ratio

Answers to Odd-Numbered Exercises

1. a. Independent variable (IV): Gender; Dependent Variable (DV): “Road rage” behaviors
    b. IV: Time;
    c. IV: Gender;
    DV: Exam score
    DV: Political affiliation
d. IV: Method of teaching; DV: Comprehension test scores
e. IV: Time in daycare; DV: Fear of strangers
3. a. IV: Achievement motivation; DV: Academic success
   b. IV: Gender; DV: Emphasis on physical characteristics
   c. IV: Alcohol drinking; DV: Social deficits
d. IV: Framing; DV: Intention to use sunscreen
e. IV: Training program; DV: Reading comprehension scores
f. IV: Price presentation; DV: Perception of savings
g. IV: Physical temperature; DV: Liking of romance movies
5. a. Ratio
   b. Ordinal
   c. Nominal
d. Interval
e. Nominal
7. a. IV: Cellular phone use; DV: Number of traffic accidents
   b. Example: Determine the number of traffic accidents each person has experienced in the past year.
c. Example of experimental: Use a driving simulation with the “driver” talking on a phone and measure the number of potential driving mistakes or accidents.
   Example of non-experimental: Take a survey of the number of accidents people have been in and whether or not they were using a phone during the accident.

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