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## UNCOMMON SENSE AND THE SCIENTIFIC METHOD

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### LEARNING OBJECTIVES: FAST FACTS

Why scientific method?

- 1.1 Our minds are susceptible to systematic errors of thinking, reasoning, decision making, and judgment, known as heuristic biases.
- 1.2 To combat heuristic biases, the scientific method identifies a set of rules, procedures, and techniques that together form a unified conceptual framework—a formal way of thinking about a problem, idea, or question.
- 1.3 Scientific questions are commonly framed in reference to a particular theory, which in turn generates a hypothesis that is tested by collecting empirical data from unbiased samples.
- 1.4 A research study aims to measure the effects of an independent variable on a dependent variable and often includes control variables to reduce effects of unwanted confounds.
- 1.5 Psychological research today plays a critical role in rooting out error and myth, and it is used to combat pseudoscientific beliefs. Pseudoscience preys on our naturally evolved and universal tendency for confirmatory bias.

## TESTING BEFORE LEARNING

Here is the answer. You come up with the question.

1. A mental shortcut that can lead to systematic errors in reasoning.
  - a. What is a parameter?
  - b. What is a heuristic?
  - c. What is a statistic?
  - d. What is sample bias?
2. A scientific hypothesis should be open to this kind of evidence.
  - a. What is testimonial?
  - b. What is falsifiable?
  - c. What is intuitive?
  - d. What is expert?
3. An attribute such as height, weight, or happiness that is measurable and that is assigned changing values.
  - a. What is a heuristic?
  - b. What is a statistic?
  - c. What is a variable?
  - d. What is a sample?
4. A variable that is manipulated.
  - a. What is a control variable?
  - b. What is a dependent variable?
  - c. What is an independent variable?
  - d. What is a confounding variable?
5. A variable that measures the effect of a manipulated variable.
  - a. What is a control variable?
  - b. What is a dependent variable?
  - c. What is an independent variable?
  - d. What is a confounding variable?
6. The enemy of the scientific method, the veritable reason for its existence.
  - a. What is empiricism?
  - b. What is theory?
  - c. What is measurement?
  - d. What is bias?
7. Information that is described as empirical because it can be measured and evaluated statistically.
  - a. What are data?
  - b. What are research participants?
  - c. What is error?
  - d. What is description?
8. A researcher wants to maximize the extent to which findings that are derived from a sample can be applied to a wider population.
  - a. What is generalizability?
  - b. What is sample bias?
  - c. What is probability?
  - d. What is error?
9. A formal way of thinking that relies exclusively on empirical evidence to create and evaluate knowledge.
  - a. What is a heuristic?
  - b. What is pseudoscience?
  - c. What is probability?
  - d. What is the scientific method?
10. Used to measure an unwanted source of influence that could invalidate the conclusions of a study.
  - a. What is a dependent variable?
  - b. What is an independent variable?
  - c. What is a control variable?
  - d. What is a confound?

## BIASES IN THINKING

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Imagine that your neighbor asks you to help figure out someone she has just met named Steve:

Steve is very shy and withdrawn, invariably helpful but with little interest in people or in the world of reality. A meek and tidy soul, he has a need for order and structure, and a passion for detail.

Your neighbor also explains that Steve is just some random guy, picked from the larger population. She asks you, “Is Steve more likely to be a librarian or a farmer?” How do you answer? Of course, we can’t know for sure, but write your best guess here:

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### Intuition

If you are like most people, you answered that Steve is more likely to be a librarian. Why? His personality seems to be such a natural match with that of a stereotypical librarian, doesn’t it? (With apologies to Russ’s wife, who is a librarian and is nothing like that stereotype!) Indeed, in reading the above question, this personality resemblance comes to mind immediately, and it is both too striking and too difficult to ignore—the answer just feels right. This is what psychologists define as **intuitive thinking**—that is, judgments and decisions that come to mind automatically, without explicit awareness of the triggering cues, and with total acceptance of the accuracy of those cues (Kahneman & Klein, 2009). In our example, the answer of Steve as a librarian reflects intuitive thinking because it arose automatically, without effort, and without explicit awareness of the cues that triggered it, namely the striking resemblance of his personality description with that of a stereotypical librarian.

What likely did not occur to you was a statistical fact that is highly relevant to the question: There are 20 times more male farmers than male librarians in the United States. With so many more farmers than librarians, the likelihood is far greater for “meek and tidy” men to be farmers than librarians. However, studies have consistently shown that when asked about Steve, most people ignore relevant statistical facts and instead base their answers exclusively on personality resemblance (Kahneman, 2011). We call this reliance on resemblance a **heuristic**, which is defined as a simplifying mental shortcut that people use to make a difficult judgment (Kahneman & Tversky, 1973). The work of Kahneman and his late colleague Amos Tversky identified some 20 distinct heuristics, each of which causes systematic errors in thinking and judgments, known as cognitive **biases**.

These **heuristic biases** of intuitive thinking are evident when we judge Steve to be a librarian based exclusively on his personality description, ignoring the statistical fact that we surely know that there are more male farmers than male librarians. However, when told the correct answer to questions like this, many research participants expressed strong emotions of disbelief that were comparable to those produced by familiar optical illusions.

What if you had been told in advance how many more male farmers there are than male librarians? Would that have affected your answer? In another study, Tversky and Kahneman (1974) described Dick:

Dick is a 30-year-old man. He is married with no children. A man of high ability and high motivation, he promises to be quite successful in his field. He is well liked by his colleagues. (p. 1125)

They then told some research participants that Dick had been drawn from a group of 70 engineers and 30 lawyers and asked them whether Dick was more likely to be a lawyer or an engineer. What would your answer be? \_\_\_\_\_.

This time there was a twist: Tversky and Kahneman gave some of the research participants the same information you received (70 engineers, 30 lawyers), but they told others that the group had 30 engineers and 70 lawyers. We call these proportions the **base rates** for these occupations. But it didn't matter! The research participants in the Tversky and Kahneman studies simply ignored the base rates (Kahneman & Tversky, 1973; Tversky & Kahneman, 1974). Put simply, even if a personality sketch conveys little or no information to help in making a decision like this, people ignore base rates when they decide. Did *you* take the base rate into account?

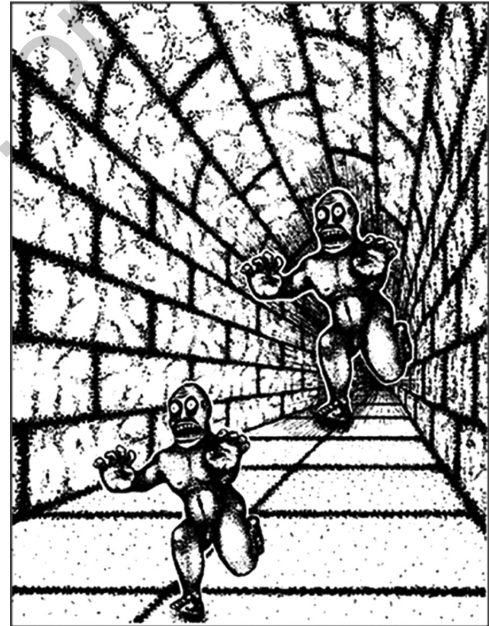
Do you understand the problem? Consider the optical illusion in Exhibit 1.1. Your visual system deceives you so that the figure in the background seems larger, even though the two figures are exactly the same size. In the same way, **cognitive illusions** occur when our thinking deceives us, and this happens because of curious blind spots, or mental tunnels in our minds (e.g., Piatelli-Palmarini, 1994). This is what happens when people think about Steve or about Dick.

Our intuitive thinking is automatic, effortless, efficient, and often adaptive. But can we count on intuition to produce the right answer? Enter psychology, broadly defined as the scientific study of people. The scientific process starts with an idea and then proceeds to a methodology to test that idea. The next step is to statistically analyze results and draw conclusions from those results. Our goal is to describe the fundamental nature of the topic, to explain how it works, and to predict when it occurs. This is a scientific understanding of the topic of study. Hence we have fast and frugal versus disciplined and systematic; intuitive judgments versus scientific thinking. Understanding scientific research methods begins with the tale of these two ways of thinking.

What happens when intuitive and scientific thinking clash? Who wins, and why does it matter for us as we learn research methods? As we will see, psychological studies clearly show that intuitive thinking is often difficult to resist, even when there are objective statistical

### EXHIBIT 1.1 ■ Cool Brain Trick: In Depth

Which monster is larger?



**Note:** To most people, the one in the background seems larger, though in fact the two monsters are exactly the same size. The depth cues in the picture (the receding tunnel) give the 2D image a 3D feel. Although both monsters create the same size image in our eyes, our brains take the depth cues into account, which results in a perception of the upper monster as farther away—making it seem larger.

**Source:** From *Mind Sights* by Roger Shepard. Copyright © 1990 Roger Shepard. Published by W. H. Freeman & Company. Reprinted by permission of the author.

data. In fact, the research tells us that we resist particular scientific findings that defy our intuitions and our common sense (Gilovich & Ross, 2015). And we do so naturally without even knowing that our intuitions can deceive us (Kahneman, 2011). In this book, we show you how to think scientifically—that is, to apply scientific research methods to topics in psychology. You will have to decide whether you think the use of scientific research methods helps to improve our understanding of human behavior.

### Curiosity and Imagination

However, we do not want to leave you with a negative view of intuition. In fact, there is considerable evidence that a certain type of intuition can be quite effective (Kahneman & Klein, 2009). This intuition is gained through expertise, the most classic example being the ability of chess grand masters to recognize complex patterns and identify the most promising moves. This expert intuition arises from experience and demonstrated skill. Intuition arising from experience and skill is different from the intuition that comes from simplifying heuristics like those evident in the case of “Steve.” Intuitions based on simplifying heuristics are likely to be wrong and are prone to predictable, systematic biases (Kahneman & Klein, 2009).

Intuitions can also be important sources of creative thinking. Creative intuitions allow for uncovering patterns and connections of images and ideas that exist, but only a few people can discover them without prompting (Kahneman & Klein, 2009). A prepared yet intuitive and open mind increases the chances of accidentally discovering something fortunate. This is known as the **serendipity** effect. The history of science and technology is marked by a long list of very important but serendipitous discoveries and inventions. For example, in 1954 the Austrian scientist Dr. Leo Sternbach accidentally discovered Librium, used to treat anxiety, while cleaning up his lab. Astronomer William Herschel accidentally discovered the planet Uranus while looking for comets, and in fact originally identified Uranus as a comet. Lore also has it that the seeds of Isaac Newton’s law of universal gravity can be traced to his observations of the famed apple falling out of a tree. The point of these observations taken from the history and sociology of science is that serendipity teaches us the value of keeping our minds and hearts open to unexpected, unlikely, and counterintuitive events.

### The Power of Observation

Suppose you have no formal experience in research but you have always been curious about the human face. In many ways, you have chosen a wonderful topic for research that can be studied by the power of simple *observation*. Science often begins with simple observation, which can serve as a source of both evidence and ideas. Charles Darwin, for example, generated the theory of evolution by natural selection exclusively on the basis of simple observation. In his later 1872 book *The Expression of the Emotions in Man and Animals*, and again relying exclusively on observation, Darwin made the case that all mammals regularly display emotion in their faces. For us mere mortals, we might look for the “agony of defeat and the thrill of victory” etched on the faces of the athletes when watching our favorite sport. But in modern psychology, using simple observation, Paul Ekman, inspired by Darwin, has discovered a set of seven basic emotions that are universally expressed across all cultures from the most remote villages to the most populated urban settings (see Exhibit 1.2).

**EXHIBIT 1.2 ■ Universal Expression of Seven Major Categories of Facial Emotions**


Source: Paul Ekman, PhD/Paul Ekman Group LLC

## THE SCIENTIFIC METHOD

As you will learn throughout the book, the **scientific method** is the cornerstone of research. We will flesh out various key features of the scientific method throughout the book. But as a starting point, let's think of the scientific method as the veritable rules of the game of research. These rules reflect procedures and techniques for conducting and evaluating psychological research. Together, these rules, procedures, and techniques form a unified conceptual framework—a formal way of thinking about a problem, idea, or question. Just as any game will have a set of rules, procedures, and techniques to govern play, so too does the scientific method lay out a foundation for how information is collected, measured, examined, and evaluated. In this sense, then, the scientific method serves as a playbook or toolbox for psychological research.

For many historians and philosophers, the roots of the scientific method can be traced to **natural philosophy**, which focused on the study of nature and the physical universe. Traditionally understood as the precursor of modern science, natural philosophy with Aristotle as its founding figure represented the dominant school of thought for the study of nature and the physical universe from ancient times continuing to the 17th century. However, the 16th and 17th centuries saw the rise of **experimentation**, marked by precise calibration and systematic observation, best illustrated by the invention of the telescope in 1608. In the ensuing scientific revolution of the 17th century, mathematical description and computation along with empirical evidence took center stage as essential tools for understanding nature and the physical world. Philosophical argument and theological

explanation, though still powerful, no longer had exclusive domain in the scientific discourse of the 17th century. With the advent of experimentation, the seeds of modern science had been sown.

Galileo's 1612 treatise, *Bodies That Stay Atop Water or Move in It*, is often cited as one of the key historical, watershed events in the birth of modern science. Indeed, Galileo's calculations regarding the positioning and dynamics of the planets and stars of our solar system proved that the *earth revolved around the sun*. This proof of the **heliocentric** model of the solar system, originally proposed by the Polish astronomer Nicolaus Copernicus in 1543, stood in direct opposition to the dominant **geocentric** view of the universe with the earth at the center.

The theocracy of the 17th century viewed Galileo as blasphemous for his scientific proof of heliocentricism and his scientific refutation of geocentricism. In 1633, the Roman Catholic Church Inquisition condemned Galileo, rejecting heliocentricism and declaring geocentricism as sacred dogma. More than 350 years later, in 1992, the Roman Catholic Church offered a formal apology to Galileo announcing that he was indeed correct. However, as early as the 1600s, the ascendancy of science had begun, and its methods were firmly entrenched by the time of Galileo's death in 1642 (see Exhibit 1.3).

The origins of the scientific method may thus be traced to the 17th century and the school of philosophy known as **empiricism**. Empiricists believe that knowledge is gained through experience, observation, and experiment. In science, the term *empirical* is used to denote information gained from observation or experimentation. This information,

#### EXHIBIT 1.3 ■ Galileo Galilei Before Members of the Holy Office in the Vatican in 1633



Source: Robert-Fleury, J. N. (1847). *Galileo before the Holy Office* [Painting]. Paris, France: Musée de Luxembourg.

commonly referred to as **data**, is described as empirical because it can be measured and evaluated statistically. Data constitute empirical evidence against which all scientific knowledge is tested. Empirical evidence differs from anecdotal evidence, which refers to the subjective impressions of one or more people that are not translated into a quantifiable form. Investigative journalism often uses anecdotal evidence.

As empiricism takes center stage in the philosophy of the 17th century, so too do we see the seeds are sown for psychology's transformation from its humble beginnings as a field devoted to the metaphysics of the soul to a flourishing science of behavior and mental processes. Yet it was not until the 19th century that psychology, now understood as the study of thoughts, feelings, and actions of human beings, adopted an experimental focus incorporating the scientific method (Brown, 1992). In 1879, Wilhelm Wundt established the world's first experimental psychology laboratory in Leipzig, Germany. Wundt's focus on both experimental and physiological psychology effectively banished the notion of the soul as a legitimate topic of study, while at the same time expanding the scope of research to include animals. Four years later in 1883, G. Stanley Hall established the first psychological laboratory in the United States at the Johns Hopkins University. Over the next decade, close to two dozen psychological laboratories would be established in the United States (Brown, 1992).

In the 1920s, the seminal work of statistician Sir Roger Fisher provided the key tools for the quantitative foundation of psychological research. Indeed, Fisher's work on statistical reasoning and data analytic tools has remained central to 21st-century psychological research. Perhaps his most prominent contribution is the ***p* value**, a common metric used throughout science to determine the strength of empirical evidence, or, as we will learn, the probability that the obtained results from psychological studies are due to chance (Nuzzo, 2014). The smaller the *p* value, the more likely it is that results of a study are considered statistically significant, which makes a researcher very happy! By convention, *p* values of less than .05 are considered statistically significant.

Now let us learn how Kahneman and Tversky's approach to studying cognitive illusions provides a simple but elegant example of using the scientific method to investigate a problem. They devised a set of questions, each of which can be viewed as a small experiment. They then tabulated responses to the set of questions; these answers constituted their data. Then Kahneman and Tversky calculated the percentages of participants who selected either librarian or farmer for Steve's occupation and the percentages of participants who selected either engineer or lawyer for Dick's profession. These percentages are the statistics—the empirical evidence—that Kahneman and Tversky used in answering their scientific question.

### What Is a Scientific Question?

Not every question we can ask is a **scientific question** that can be investigated with empirical evidence. Philosophers often distinguish two types of questions: “is” questions and “ought” questions. This philosophical distinction (known as **is–ought**) may help us understand what is meant by a scientific or “researchable” question. “Is” questions can be answered by facts or empirical data, and these answers are independent of social, cultural, political, and religious preference. These so-called “is” questions, many would argue, are the exclusive domain of scientific research. These are questions that can be best addressed through scientific research.

“Ought” questions call upon cultural values and ethical considerations and cannot be answered solely on the basis of scientific evidence. These include questions of religion and



faith that fall well beyond the realm of science and for which empiricism would be considered inappropriate. Does God exist? Should capital punishment be overturned? Should same-sex marriage be legalized? “Ought” questions address the values inherent in laws and customs and are influenced by beliefs that can reflect ideology, politics, and interpretation of rights. Science may contribute to the debate, but science alone certainly cannot provide any direct, definitive answers to these questions. We will leave such questions that are not researchable to philosophers, theologians, and constitutional scholars. The scientific method is really moot for the topics these questions deal with.

The scientific method aims to answer scientific questions. Scientific questions and their answers are commonly framed in reference to a particular theory. In psychology, **theory** is defined as a coherent set of propositions that are used as principles to describe, understand, and explain psychological or behavioral phenomena. Theories often address questions of “how,” as in the case of Kahneman and Tversky, who studied the cognitive rules of intuitive reasoning. Theories also address questions of “why” as in the case of Kahneman’s work that shows an overreliance on heuristic shortcuts can lead to errors in decision making. Ideas for a research study often spring from psychological theories. We use the scientific method to assess the quality of any psychological theory. In psychology, theory often influences all aspects of a study, continuing through the final interpretation of the study’s results (Kuhn, 1962).

Thus, Kahneman and Tversky proposed a general theory of the cognitive processes involved in intuitive predictions and judgments. The major contribution of their approach, called the “heuristic and biases approach,” is the discovery of systematic errors in our thinking and reasoning. A sound theory explains psychological or behavioral phenomena. As you have already seen, their theory does just that: It explains a distinct set of mental shortcuts, which are defined as heuristics and which cause systematic errors in probability judgments.

A sound theory also identifies boundary conditions under which the phenomenon under study does *not* hold. Here too the theory of Kahneman and Tversky passes with flying colors. For example, consider the base-rate neglect heuristic demonstrated in the question of whether Dick is more likely to be an engineer or a lawyer. Kahneman and Tversky found that this problem does not occur when there is no other descriptive information presented. So if there is no description of Dick’s personality, motivation, or ability, people use the base rates to answer the question of whether Dick is more likely to be a lawyer or an engineer. However, the presentation of the slightest inkling of evidence describing Dick’s personality leads to ignoring base rates and so to the mistake of judging probability by similarity or resemblance.

### From Theory to Testable Hypothesis

A theory generates testable **hypotheses**, which are evaluated empirically with the scientific method. A **testable hypothesis** is framed as a statement, often in the form of a prediction that is made prior to the actual collection of data. A testable hypothesis is therefore described as **a priori**, meaning that it is developed before experimentation or observation. A priori hypotheses constitute a key feature of the scientific method. By formulating hypotheses before data collection and analysis, a scientist is less likely to be prone to error and bias by bending the theory to fit the numbers.

In direct contradistinction are hypotheses that are formulated after the data are collected and analyzed. These hypotheses, described as **post hoc** (in Latin, “after this”), pose serious problems for the scientific method. Post hoc hypotheses increase the likelihood of error and bias. The notion is the more you look, the more likely it is you will find something—the

more hypotheses you test post hoc, the more likely it is that one of these will by chance be wrongly accepted as true. Formulating hypotheses post hoc is therefore not a good idea; those who use them should at least make statistical adjustments that make it harder to conclude that they have “found something.”

Kahneman and Tversky developed specific, testable a priori hypotheses from their general theory of heuristics and biases in judgment. For example, they hypothesized that the “representativeness heuristic” would cause participants to make systematic errors in evaluating the probability of Steve as a librarian or a farmer. They tested this hypothesis by presenting a description of Steve and asking research participants to answer the question of whether Steve is more likely to be a librarian or farmer. Their results were the percentages of participants who judged Steve more likely to be a librarian or farmer. These results provided empirical evidence that could either support or not support their hypothesis; in fact, their hypothesis was supported. Kahneman and Tversky specifically predicted that the representativeness heuristic would cause participants to ignore relevant statistical facts and make their judgment exclusively on the extent to which the personality sketch of Steve as a “meek and tidy soul” meets that of the stereotypical librarian.

### Variables as the Language of Research

Variables are the language of research. A **variable** is simply defined as any characteristic that can take on different values or that can vary across research participants. Variables can include age, gender, weight, height, education, attitude, income, use of a medication, and virtually any other attribute that can assume multiple values or can vary in people. A researcher will identify, often based on theory, key variables to investigate scientifically.

In research, a critical lesson to learn is the concept of **independent variable** and **dependent variable**. The independent variable is defined as an element of a study that you as a researcher systematically manipulate, change, or select. By contrast, the effects of the manipulation of the independent variable are examined and measured by the dependent variable. That is, the dependent variable is the observed effect, result, or outcome that is measured in response to a systematic change of or variation in the independent variable.

Let’s illustrate how Kahneman and Tversky used variables in their work on base-rate neglect with regard to the question of whether Dick is more likely to be an engineer or a lawyer. In this study, participants were assigned to either one of two conditions. In one condition, participants were told Dick’s personality description had been drawn from a group of 70 engineers and 30 lawyers. In the other condition, they were told Dick’s personality description had been drawn from a group that consisted of 30 engineers and 70 lawyers. So in this study, the researchers manipulated the base rates provided to the research participants for the group from which Dick’s personality sketch was drawn: either 70 engineers/30 lawyers or 30 engineers/70 lawyers. So in this study, the independent variable was the base rates presented to participants, with the two conditions. The effect of this manipulation in this independent variable of base rates was evaluated on the dependent variable, the percentages of participants who predicted Dick to be an engineer or a lawyer.

The same variable can be used differently depending upon the study. Take the variable stress at work. In one study, stress at work may be used as an independent variable. For example, let’s say employees are selected on the basis of their level of reported stress at work, and then the brain activity of employees with different stress levels is recorded. Here the effects of the independent variable, stress at work, on the dependent variable, brain activity, are studied. In

a different study, stress at work is used as a dependent variable, as, for example, a researcher wants to compare the level of stress at work experienced by people who have more and less authoritarian bosses. Here the experimenter does nothing to alter the number of people at different stress levels in the experiment, but rather measures the differences in stress at work between the two groups with different types of bosses. So depending on the role it plays in the hypothesized relationship, the same variable can be either independent or dependent.

## Sampling and Populations

Often in research, our observations are collected systematically and quantified by sampling a population. A population is defined as any entire collection of people, animals, plants, or things, all of which can be referred to as units, from which we may collect information (for more on population, see Chapter 6). Because a population is too large to study in its entirety, a sample is generally selected for study. A sample is defined as a group of units selected from a larger group that is known as the *population* (see Chapter 6).

How a researcher selects a sample from a larger population is critically important for the scientific method. Ideally, a researcher uses a random process to select members from a population. This is known as **random sampling**. It is called “random” to indicate that every member from the larger population has an equal chance of being in the sample. Statistical theory assumes random samples, but in reality, a purely random sample in psychological research is often impractical. We will learn in Chapter 6 that there are specific sampling techniques that can provide an unbiased selection of members from a larger defined group even though they are not purely random. The goal is to use an unbiased method of selecting a sample.

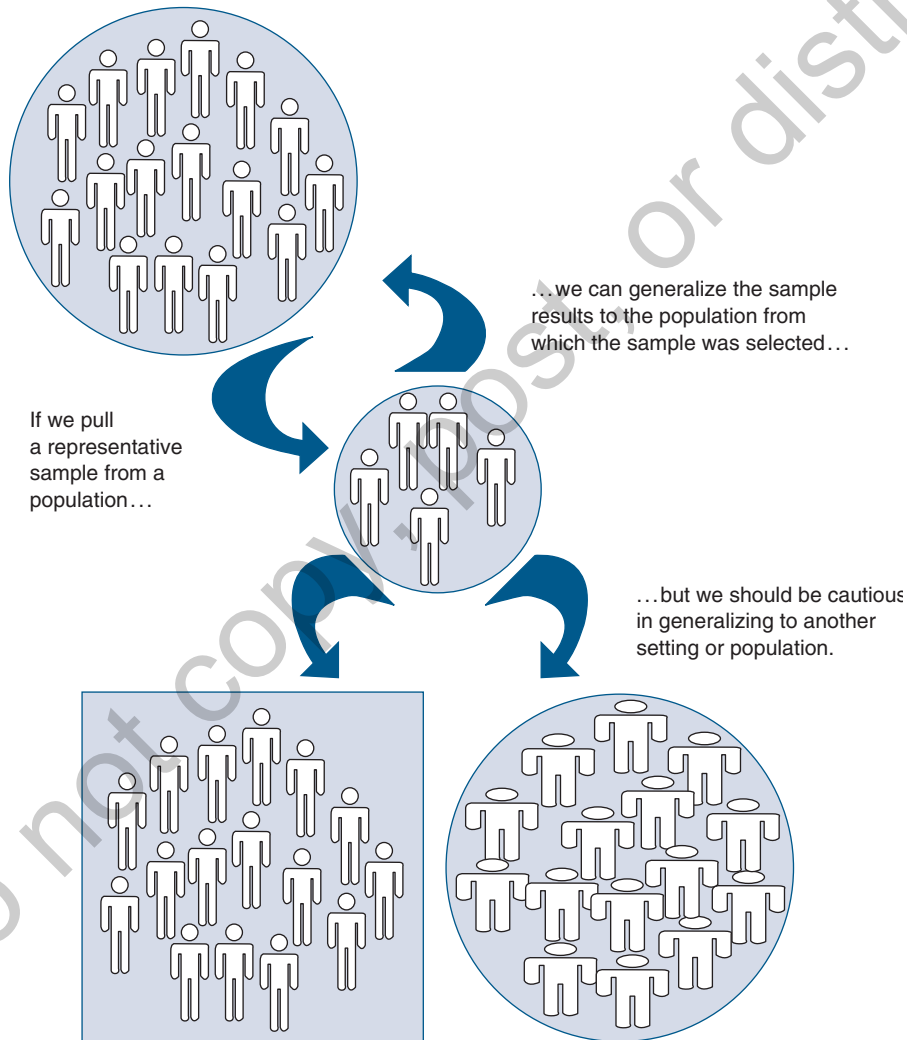
Why is the gold standard for an unbiased sample one that is formed via a random process? The closer the process for creating a sample is to purely random, the greater likelihood that the sample will be representative of a larger group. The objective is to maximize what is referred to as **generalizability**, which means the extent to which findings that are derived from a sample can be applied to a wider population. Remember, a major reason for the scientific method is to combat bias, and a key source of potential bias can originate from how a sample is selected. For example, case studies, examining one or only a few preselected participants, can be seriously if not fatally flawed by selecting only those cases that fit preconceived ideas. This sort of “cherry-picking”—that is, deliberately picking only cases that support your view while ignoring those opposing your view—is an anathema to the scientific method. This can lead to a particular form of bias, **sample bias**, which means that some members of the population are less likely than others to be included in the study (Trochim, 2006). Such exclusion of certain members or subgroups of a population under study can sometimes produce misleading results (see Exhibit 1.4).

The issue of sample bias is extremely relevant in heuristic and bias research like Kahneman and Tversky’s that aims to examine the nature and limitations of human thinking. One important question is whether these cognitive biases generalize across different cultures. For example, a researcher in the field of **cultural psychology** studies how culture shapes thinking and how thinking shapes culture (e.g., Nisbett, Peng, Choi, & Norenzayan, 2001). A researcher in the related field of **cross-cultural psychology** studies the universality of psychological processes across different cultures. Researchers in both of these fields of psychology would be interested in sampling persons from different cultures to examine the generalizability of cognitive biases. Overall, then, sampling reminds us of the importance of understanding and appreciating culture in research in psychology. Ensuring

that our samples of research participants are representative of the diversity of the population is an important consideration in designing research.

Sampling bias is less a concern in studies of fundamental processes that operate the same across people within and between different populations. For example, as previously noted, Charles Darwin generated the theory of evolution by natural selection exclusively on the basis of simple observation of species in particular locations. He could not draw a representative sample of species, and he could not compare all different populations of animals. However,

#### EXHIBIT 1.4 ■ Sample and Cross-Population Generalizability



Source: Schutt, R. K. (2012). *Investigating the social world: The process and practice of research* (7th ed., p. 50). Thousand Oaks, CA: Pine Forge Press.

he believed that the basic process of evolution by natural selection occurred across all species, and so once he had figured out that process, it could be applied to species and populations he had not studied. Research after Darwin continued to support this belief. In a similar vein, Darwin made the case that all mammals regularly display emotion in their faces. Again, subsequent research supported this conclusion, even though Darwin had not studied a representative sample or examined facial expressions across all populations of mammals.

## Evaluating Evidence and Theory

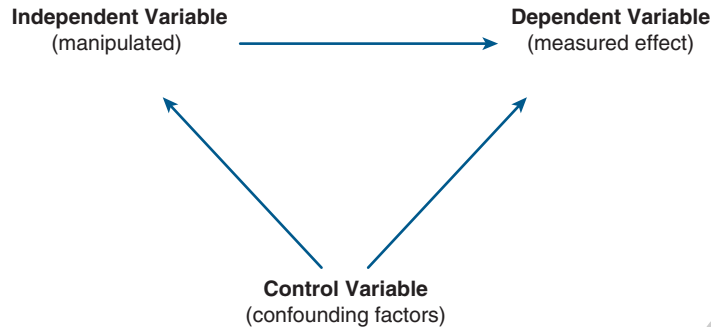
You now know that the scientific method requires the collection of observations, such as responses to questions, test scores, or ratings. These observations are then categorized or quantified systematically, and numeric values are either assigned or computed. These numeric values are the data that constitute empirical evidence. The scientific method uses statistics to test or analyze relationships between and among objective, quantifiable measures of variables that are derived from either experimentation or observation. The sample statistics are assumed to provide estimates of the population. All statistics are based on the logic of probability, and they all use the same criterion for evaluation, as represented by the  $p$  value. The question asked and answered by statistical tests may be stated as follows: In light of the data, what is the probability that the obtained results are due to chance? If the statistical analyses of the data show that the obtained results are highly unlikely due to chance, then the predicted relationship is considered to be highly likely. If, on the other hand, the statistical analyses of the data show that the obtained results are likely due to chance, then there is no empirical evidence in support of the expected relationship. The statistical evidence therefore provides a means to test a specific hypothesis and to evaluate a theory.

## Reliability and Validity

All sound research studies rely on the scientific method. However, different areas of psychology often pose and answer scientific research questions differently. As we will learn in Chapter 2, psychologists use a research “toolbox” consisting of a variety of methods and techniques to investigate these questions. Each method and technique has its own advantages and disadvantages, but they all have to meet scientific standards. Not all data are created equal, as wise psychologists have often noted. Two standards are most important when judging the scientific quality of these methods and techniques as well as the results that they produce.

The first standard is **reliability**, which simply means *consistency*. A reliable study is one that produces data that can be **replicated**—that is, repeated with the same results. Whenever you read about a result of a study, always find out if it has been replicated; if it has, then you can have greater confidence in its reliability.

Equally important in evaluating research is **validity**, which is defined as the extent to which a study provides a true measure of what it is *meant* to investigate. We will learn that there are different types of validity, all of which, however, address the same question: “How true are our conclusions?” or “Are we measuring what we think we are measuring?” In evaluating validity, you will learn to look for what are known as **confounds** or **confounding variables**, which are unwanted sources of influence or variability that can be viewed, much to the dismay of the researcher, as viable alternative explanations for the result of a study. “Those darn confounds” is a damning phrase that can make researchers cringe, as it cuts to the heart or validity of a study. In many studies, researchers use what is referred to as a

**EXHIBIT 1.5 ■ Three Key Variables**

*Source:* From *Designing and Conducting Health Systems Research Projects: Volume 1. Proposal Development and Fieldwork*, by Corlien M. Varkevisser, Inda Pathmanathan, and Ann Brownlee. Published by Canada's International Development Research Centre.

**control variable** in order to measure an unwanted source of influence that could invalidate the conclusions of a study (see Exhibit 1.5). The aim is to be able to rule out the effect of a control variable on the results of a study.

Think of reliability and validity as two related but distinct standards that you should use to evaluate research. A reliable study may not necessarily be valid, but a valid study has to be reliable. As a simple principle, think of reliability as an essential condition for validity. That is, an unreliable finding, which by definition is a finding that is not reproducible or replicable, cannot be valid. However, the concept of validity extends beyond the idea of reliability. It speaks to meaningfulness of theoretical conclusions. For example, the findings of heuristics and biases in human thinking have been widely replicated and are extremely reliable. The validity of the theory of systematic errors in cognition is perhaps even more impressive, as evidenced in its impact across so many different fields of study. In fact, this work earned psychology professor Daniel Kahneman the Nobel Prize in Economics! Scholars have applied the theory of heuristics and biases to a wide variety of fields of study, including medical diagnosis, legal judgment, philosophy, finance, and statistics (Kahneman, 2011; M. Lewis, 2017).

**STAT CORNER****"A PLEDGE TO THE SCIENTIFIC METHOD"**

When we conduct psychological research, we in effect contract in both practice and principle to uphold standards of reliability, validity, transparency, and empiricism. We further pledge to design studies from carefully recruited samples of considerable size

that allow for clear and rigorous statistical examination of target variables, while controlling for extraneous confounds, with the aim of producing results that can be generalized to the wider population. This is our oath—our allegiance to the scientific method!

## PSYCHOLOGICAL RESEARCH IN THE PUBLIC SQUARE

We have now learned about the cultural history and evolution of the scientific method as applied in psychological research. We can conclude from this literature that the scientific method allowed psychology to become a true empirical science of behavior and mental processes. It incorporated the scientific method from the natural sciences, modifying and refining it for designing reliable and valid research studies whose ultimate aim is to build knowledge to benefit society.

Beyond the laboratory, however, psychological research today plays a critical role in rooting out error and myth in contemporary society. This is perhaps not surprising given what we have learned in this chapter. That is, we need the scientific method to curtail our natural cognitive biases, as reflected in our propensity to be deceived by our intuitions and to be fooled by single-case anecdotes. Moreover, we know from a historical perspective the critical role the scientific method plays in debunking cultural myths. Galileo is perhaps the most well-known example of scientific evidence clashing with religious belief in which empiricism ultimately refuted dogma. Still in contemporary society, notwithstanding our sophisticated technology, there is a growing body of research demonstrating the lay public's continued beliefs in "myths" about psychology, education, and neuroscience (e.g., Lilienfeld, Lynn, Ruscio, & Beyerstein, 2010; MacDonald, Germine, Anderson, Christodoulou, & McGrath, 2017). In the following section, we briefly examine some of these myths, defined as pervasive and persistent misunderstandings and misconceptions of psychological science and related fields (Lilienfeld et al., 2010; MacDonald et al., 2017).

### Pervasiveness of Psychological Myths

Every day, we are bombarded by claims regarding a host of topics in psychology. These claims can range from traditional topics of empirical psychological research, such as brain functioning, learning, memory, and attention, to unusual subjects that by their very nature are not suitable for controlled scientific experimentation, such as paranormal experiences, alien abduction, psychic readings, and mind control. In their 2010 book, eponymously titled *50 Great Myths of Popular Psychology: Shattering Widespread Misconceptions About Human Behavior*, psychologists Scott Lilienfeld, Steven Jay Lynn, John Ruscio, and Barry Beyerstein provide a compelling and engaging account of how each one of these myths can be debunked by scientific evidence.

Along the same lines is a 2017 study by Kelly MacDonald and colleagues published in *Frontiers in Psychology*, titled "Dispelling the Myth: Training in Education or Neuroscience Decreases but Does Not Eliminate Belief in Neuromyths." As way of background, the MacDonald study is part of a growing body of research inspired by the Brain and Learning Project of the UK's Organisation for Economic Co-operation and Development (OECD), which first called attention to the issue of neuromyths in 2002. In this study, MacDonald and colleagues adopted the OECD definition of a **neuromyth** as "a misconception generated by a misunderstanding, a misreading, or a misquoting of facts scientifically established (by brain research) in education or other contexts." As these researchers noted, the existence of neuromyths has become an increasing concern for educators committed to developing evidence-based practices for learning, as multinational studies have shown these mistaken beliefs to be quite pervasive among teachers. But whether this would also be true for other groups, and if so why this might be the case, had yet to be investigated.

As shown in Exhibit 1.6, the two most commonly endorsed neuromyths across the three groups were false beliefs about learning styles and dyslexia. That is, participants regardless of their training responded incorrectly, answering true to item 14, “Individuals learn better when they receive information in their preferred learning style,” and item 17, “A common sign of dyslexia is seeing letters backwards.” Other popular misconceptions included believing that listening to classical music increases children’s reasoning ability. This is known as the **Mozart effect**, which has been roundly unsupported by scientific studies. Also included in the seven classic neuromyths are false beliefs about the impact of sugar on attention and using 10% of our brains.

### EXHIBIT 1.6 ■ Brain Survey

Please choose one answer only; check either true or false for each question.	True	False
1. We use our brains 24 hours a day		
2. It is best for children to learn their native language before a second language is learned		
3. Boys have bigger brains than girls, on average		
4. If students do not drink sufficient amounts of water, their brains shrink		
5. When a brain region is damaged, other parts of the brain can take up its function		
6. We only use 10% of our brain		
7. The left and right hemispheres of the brain work together		
8. Some of us are “left brained” and some are “right brained,” and this helps explain differences in how we learn		
9. The brains of boys and girls develop at different rates		
10. Brain development has finished by the time children reach puberty		
11. There are specific periods in childhood after which certain things can no longer be learned		
12. Information is stored in the brain in networks of cells distributed throughout the brain		
13. Learning is due to the addition of new cells to the brain		
14. Individuals learn better when they receive information in their preferred learning style (e.g., auditory, visual, or kinesthetic)		

(Continued)



**EXHIBIT 1.6 ■ (Continued)**

Please choose one answer only; check either true or false for each question.	True	False
15. Learning occurs through changes to the connections between brain cells		
16. Academic achievement can be negatively impacted by skipping breakfast		
17. A common sign of dyslexia is seeing letters backwards		
18. Normal development of the human brain involves the birth and death of brain cells		
19. Mental capacity is genetic and cannot be changed by the environment or experience		
20. Vigorous exercise can improve mental function		
21. Children must be exposed to an enriched environment from birth to three years, or they will lose learning capacities permanently		
22. Children are less attentive after consuming sugary drinks and/or snacks		
23. Circadian rhythms (“body clock”) shift during adolescence, causing students to be tired during the first lessons of the school day		
24. Exercises that rehearse coordination of motor perception skills can improve literacy skills		
25. Extended rehearsal of some mental processes can change the structure and function of some parts of the brain		
26. Children have learning styles that are dominated by particular senses (i.e., seeing, hearing, or touch)		
27. Learning problems associated with developmental differences in brain function cannot be improved by education		
28. Production of new connections in the brain can continue into old age		
29. Short bouts of motor coordination exercises can improve integration of left- and right-hemisphere brain function		
30. There are specific periods in childhood when it’s easier to learn certain things		
31. When we sleep, the brain shuts down		
32. Listening to classical music increases children’s reasoning ability		

Source: MacDonald, K., Germine, L., Anderson, A., Christodoulou, J., & McGrath, L. (2017). Dispelling the myth: Training in education or neuroscience decreases but does not eliminate beliefs in neuromyths. *Frontiers in Psychology*. <https://doi.org/10.3389/fpsyg.2017.01314>

## Science Versus Pseudoscience

In philosophical terms, the scientific method represents a specific **epistemology**, or way of knowing. The scientific way of knowing is exclusively reliant upon objective, empirical investigation. Its techniques must be **transparent** so that the methods, procedures, and data analyses of any study can be easily reproduced. This transparency allows for other researchers to see if the same study can be repeated in a different sample with the same finding. As we have learned in this chapter, when a result is replicated, we have greater confidence that the finding is both reliable and valid. Reliable and valid knowledge is thus knowledge that has a high probability of being true because it has been systematically acquired and empirically tested; that is, it has been produced and evaluated by the scientific method.

Now let us consider knowledge gained not through the scientific method but through other means, such as intuition, impression, gut reactions, or experience. We may be convinced that this knowledge is also true and valid. However, it is not based on empirical evidence generated by the scientific method. Instead, it might be based on authoritarian or expert evidence of what a person tells you to believe, or it might be based on testimonial or anecdotal evidence offered by a person who believes the knowledge to be true because of personal subjective experience.

The crux of the problem arises when the methods of establishing evidence and the body of knowledge generated from these techniques are claimed to represent a legitimate scientific field of study. Consider the well-known case of astrology that uses horoscopes to predict personality and behavior; many people swear by astrology and believe it to be scientific. However, astrology, along with extrasensory perception, alien abduction reports, out-of-body experiences, the lunar lunacy effect, rebirthing therapy, and handwriting analysis, is just one example of what is referred to as **pseudoscience**. In popular psychology, pseudoscientific beliefs are dubious but fascinating claims that are touted as “scientifically proven” and bolstered by fervent, public testimonials of believers who have experienced firsthand or who claim to have witnessed the phenomenon (Lilienfeld, 2005). Many of the myths that people hold may also be viewed as an example of pseudoscientific thinking.

## Recognizing Pseudoscience

History tells us that as knowledge develops over time, some fields of study that initially are seen as scientific come to be seen as pseudoscientific: Today’s pseudoscience could be yesterday’s science. Take for example, **phrenology**, a now defunct field of study that was considered a science in the 19th century. The major, unified belief of phrenology held that bumps and fissures of the skull determined the character and personality of a person. Phrenologists believed that various psychological attributes, including personality traits, intellectual faculties, and moral character, could all be assessed by running their fingertips and palms over the skulls of a patient to feel for enlargements or indentations (see Exhibit 1.7). Advances in neurology would relegate phrenology to the dustbin of pseudoscience.

This porcelain head for sale in a New Orleans antique store shows the sections of the brain, as detailed by 19th-century phrenologists. They believed that each section was responsible for a particular human personality trait. If a section were enlarged or shrunken, the personality would be likewise abnormal. Doctors, particularly those doing entry examinations at American prisons, would examine the new inmate’s head for bumps or

## EXHIBIT 1.7 ■ Phrenology: Yesterday's Science, Today's Pseudoscience



Source: ©iStockPhoto/Photojope.

cavities to develop a criminal profile. For example, if the section of brain responsible for “acquisitiveness” was enlarged, the offender probably was a thief. Criminologist Cesare Lombroso (1911) and his school combined phrenology with other models that included external physical appearance traits that they believed could single out criminals from the general population.

Psychology professor Scott Lilienfeld of Emory University has identified “The 10 Commandments of Helping Students Distinguish Science From Pseudoscience in Psychology,” and he proposes these rules as a way for us to understand better what science is and what science isn’t. Just as we cannot grasp fully the concept of cold without understanding hot, we cannot grasp fully the concept of scientific thinking without an understanding of pseudoscientific beliefs—specifically those beliefs that at first blush appear scientific but are not (Lilienfeld, 2005). Among the warning signs of pseudoscience laid out by Lilienfeld (2005) are

- A tendency to invoke ad hoc hypotheses, which can be thought of as “escape hatches” or loopholes, as a means of immunizing claims from falsification
- An absence of self-correction and an accompanying intellectual stagnation
- An emphasis on confirmation rather than refutation
- A tendency to place the burden of proof on skeptics, not proponents, of claims
- Excessive reliance on anecdotal and testimonial evidence to substantiate claims
- Evasion of the scrutiny afforded by peer review
- Absence of “connectivity” (Stanovich, 1997)—that is, a failure to build on existing scientific knowledge
- Use of impressive-sounding jargon whose primary purpose is to lend claim to a facade of scientific respectability
- An absence of boundary conditions (Hines, 2003)—that is, a failure to specify the settings under which claims do not hold

Now none of these warning signs alone is sufficient to render a discipline as pseudoscientific. But the more warning signs that are present, the more reason to suspect pseudoscientific machinations are at work.

### Why Pseudoscience?

Why are we so susceptible to pseudoscience? Recall that theories help us to understand how a particular phenomenon works. In this case, we want to understand how, in theory, pseudoscience might work. We have learned in this chapter that humans commonly reason with unseen and persistent biases. Pseudoscience preys on these biases. Among the key warning signs of pseudoscience listed by Emory psychologist Scott Lilienfeld (2005) is an “emphasis on confirmation rather than refutation.” This is known as **confirmatory bias**. We are all subject to this bias to believe and to confirm. It reflects a natural tendency of the human mind to actively seek out and assign more weight to any kind of evidence that favors existing beliefs, expectations, or a hypothesis in hand (Gilovich & Ross, 2015; Nickerson, 1998). As psychological studies have shown (D. Gilbert, 1991), believing is always easier than disbelieving and highly evolutionarily adaptive because “false positives (believing there is a connection between A and B when there is not) are usually harmless, whereas false negatives (believing there is no connection between A and B when there is) may take you out of the gene pool” (Shermer, 2008, p. 42).

In research as well as in real life, other examples of confirmatory bias include preferential treatment of that which supports existing beliefs, looking only or primarily for positive cases, a form of “cherry-picking” and overweighting positive confirmatory instances (Nickerson, 1998). Thus, a common mistake, confirmatory bias reflects both selective thinking and selective observation—choosing to look only at things that are in line with our preferences or beliefs.

## RESEARCH IN THE NEWS

### COMBATING CONFIRMATION BIAS

Emory University psychologist Scott Lilienfeld (2007, cited in Gilovich & Ross, 2015) dubbed confirmation bias the “mother of all biases” because it is so deeply and naturally ingrained into our psyches yet it can so powerfully and deceptively distort both everyday judgments and scientific reasoning. Even in research, confirmatory bias can influence the questions we ask, the hypothesis that we formulate, the literature we review, the evidence we collect and weigh, and the conclusions we draw. In their 2015 book *The Wisest One in the Room*, social psychologists Gilovich and Ross write that

to combat our natural impulse to look for mainly supportive evidence, we must adopt the “consider the opposite” strategy. Citing studies by Milkman, Chugh, and Bazerman (2009), Gilovich and Ross (2015) write, “Studies have shown that when people are encouraged to ask themselves, ‘Why might my initial impressions be wrong?’ or ‘Why might the opposite be true?’” (p. 147), they tend to show less of a confirmation bias and, as a result, make far more accurate assessments. Pick a topic for which you have a strong opinion and ask, how might the opposite be true?

Philosophers of science have long viewed confirmatory bias as a major threat or danger to research. Sir Karl Popper (1959) proposed the **doctrine of falsification**, which often is seen as the holy grail of science. As Nobel Prize winner Eric R. Kandel writes in his autobiography, *In Search of Memory* (2006), “Being on the wrong side of an interpretation was unimportant, Popper argued. The greatest strength of the scientific method is its ability to disprove a hypothesis” (p. 96). As we will learn in this book, falsification fits with the **self-correcting** nature of science in which information accumulates with new advances and discoveries. In stark contrast is pseudoscience, which is neither self-correcting nor cumulative in building knowledge (Exhibit 1.8).

Lilienfeld (2005) also identified the lure of anecdotal evidence in pseudoscience. And this of course is entirely consistent with what we learned about how personality sketches often lead us to ignore objective base rates and deceive us into making errors in judgment and reasoning (Tversky & Kahneman, 1974).

Developmental psychology also helps us to understand the appeal of pseudoscience. Consider that even before the development of language, one-year-old babies possess a rich understanding of the physical world and the social world, with the former referred to as a “naïve physics” and the latter as a “naïve psychology” (P. Bloom & Weisberg, 2007). This evolved adaptation gives children a head start for understanding and learning about objects and people. By the same token, however, it inevitably conflicts with scientific discoveries, sowing the seeds of resistance in children to learning and accepting certain scientific facts. As S. Carey (2000) noted, the challenge in teaching science to children is “not what the student lacks, but what the student *has*, namely alternative conceptual frameworks for the phenomena covered by the theories we are trying to teach” (p. 14). A similar point is made by P. Bloom and Weisberg (2007), who proposed that people come to “resist certain scientific findings because many of these findings are unnatural and unintuitive” (p. 997). Thus, we can see that pseudoscience can be appealing on many fronts. It often preys on inherent biases in our thinking, capitalizing on our evolved and developed resistance to the uncommon sense of science.

**EXHIBIT 1.8 ■ Disconfirmation of “All Swans Are White”**

Source: ©iStockphoto.com/CraigRJD.

## CONCLUSION

We naturally and often unconsciously use mental shortcuts or heuristics that can lead to systematic errors in thinking, reasoning, decision making, and judgments, known as cognitive biases. These deeply ingrained cognitive biases make the scientific method critical for studying research questions in psychology. The scientific method identifies a set of rules, procedures, and techniques that together form a conceptual framework—a formal way of thinking about a problem, idea, or question. The scientific method lays out a foundation for how information is collected, measured, examined, and evaluated. Scientific questions are commonly framed in reference to a particular theory that in turn leads to a testable hypothesis that specifies key variables to be investigated. Objective measurement of these variables is critical, because if something in psychology cannot be measured, then it cannot be investigated scientifically. Observations can then be collected systematically and quantified by sampling a population. These observations, translated into numeric values, are what constitute empirical evidence. Statistics are computed to test hypothesized relationships between and among objective, quantifiable measures. Statistics allow the researcher to assess the likelihood that the obtained results are due to chance; a finding that is unlikely due to chance is typically interpreted as supportive of the hypothesis of the study. Reliability and validity are two important standards that are used to judge the scientific quality of any research study. Today, psychological research plays a critical role in rooting out error and myth in contemporary society.

## KEY TERMS

A priori	Generalizability	Pseudoscience
Base rate	Geocentric	Random sampling
Bias	Heliocentric	Reliability
Cognitive illusions	Heuristic	Replication
Confirmatory bias	Heuristic bias	Sample bias
Confounds or confounding variables	Hypothesis	Scientific method
Control variable	Independent variable	Scientific question
Cross-cultural psychology	Intuitive thinking	Self-correcting
Cultural psychology	Is–ought	Serendipity
Data	Mozart effect	Testable hypothesis
Dependent variable	Natural philosophy	Theory
Doctrine of falsification	Neuromyth	Transparent
Empiricism	$p$ value	Validity
Epistemology	Phrenology	Variable
Experimentation	Post hoc	
	Probability	

## ACTIVITY QUESTIONS

- As a cross-cultural psychologist, you have been hired to help researchers design studies that have greater generalizability. What would you recommend in terms of sampling? What kinds of measures might be most helpful? What kind of study design would you recommend?
- In a May 9, 2010, article in the *Chronicle of Higher Education*, titled “The New War Between Science and Religion,” Mano Singham writes about “the new war that pits those who argue that science and ‘moderate’ forms of religion are compatible worldviews against those who think they are not” (paragraph 1). The prestigious National Academy of Sciences endorses the position for the compatibility of science and religion. Weigh both the pros and cons of this debate. How can the philosophical distinction between questions of *ought* versus *is* be used to shed light on this debate?
- Suppose you have been hired as a developmental psychologist to help design a curriculum to teach science and the scientific method to elementary school children. Organize a formal discussion, first addressing people’s commonsense intuitive understanding of psychology (“naïve psychology”) and why it comes so naturally to us. How could it contribute to scientific resistance for understanding the workings of the brain and mind?
- Examples abound of new pseudoscientific disciplines. Perhaps there is no better example than the best-selling tome *The Secret* by television producer Rhonda Byrne. It became a blockbuster, number one on *The New York Times* best-seller list when it was featured not once but twice by television personality Oprah Winfrey’s popular show. What is so evidently alluring about *The Secret* is its central idea, known as the Law of Attraction, which states that wishing can make things come true, something very young children could resonate with in their beliefs about the Tooth Fairy and Santa Claus. Whether you want money, a new home, or even a regular parking space, just ask, believe you will get it, and you will get it, guaranteed! *The Secret*’s mantra is a simple and ancient idea: Ask. Believe. Receive. This is positive thinking with a guarantee, and of course, there are no guarantees in psychology. How does *The Secret* meet the seven warning signs of pseudoscience?

## REVIEW QUESTIONS

1. Describe the heuristics and biases research approach and its theory. Use the findings of this research to make the case for the scientific method.
2. What is a scientific question? Compare and contrast scientific questions and legal questions.
3. Describe how the scientific method uses statistics to test hypotheses and evaluate theories. Be sure to address statistical reasoning in relation to probability, randomness, sampling, and law of large numbers.
4. How can you tell the difference between pseudoscience and real science? Why do you think pseudoscience is often so appealing? According to cognitive psychologists, how do our minds make us susceptible to pseudoscience?
5. Describe the relationship of independent variable, dependent variable, and control variable. Be sure to define the function of each in research.

## CHAPTER 1 TESTING BEFORE LEARNING ANSWERS

**ANSWER KEY:** 1. b; 2. b; 3. c; 4. c; 5. b; 6. d; 7. a; 8. a; 9. d; 10. c



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