TENTH EDITION

EXPERIMENTAL Psychology

BARRY H. KANTOWITZ • HENRY L. ROEDIGER III • DAVID G. ELMES

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Experimental Psychology

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To three outstanding psychologists who shared the
fun and excitement of experimental psychology with us,
David A. Grant, William M. Hinton, and L. Starling Reid

ABOUT THE AUTHORS

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BARRY H. KANTOWITZ is professor emeritus of psychology, professor emeritus of industrial and operational engineering, and former director of the Transportation Research Institute at the University of Michigan. Prior to that, he was chief scientist of the Human Factors Transportation Center of the Battelle Memorial Institute in Seattle. He received the Ph.D. degree in experimental psychology from the University of Wisconsin in 1969. From 1969 to 1987 he held positions as assistant professor, associate professor, and professor of psychological sciences at Purdue University, West Lafayette, Indiana. Dr. Kantowitz was elected a fellow of the American Psychological Association in 1974. He has been a National Institute of Mental Health postdoctoral fellow at the University of Oregon, a senior lecturer in ergonomics at the Norwegian Institute of Technology, Trondheim, Norway, and a visiting professor of technical psychology at the University of Lulea, Sweden. He has written and edited more than two dozen books. His research on human attention, mental workload, reaction time, human–machine interaction, and transportation human factors has been supported by the Office of Education, the National Institute of Mental Health, the National Aeronautics and Space Administration, the Air Force Office of Scientific Research, and the Federal Highway Administration. He has served as editor of the *Transportation Human Factors Journal*, Associate Editor of *Human Factors*, and edited the book series *Human Factors in Transportation*.

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HENRY L. ROEDIGER III is the James S. McDonnell distinguished university professor and dean of academic planning at Washington University in St. Louis, where he has taught since 1996. He received a B.A. degree in psychology from Washington and Lee University in 1969 and a Ph.D. in cognitive

psychology from Yale University in 1973. He has taught at Purdue University (1973–1988) and Rice University, where he was the Lynette S. Autrey professor of psychology. He also spent three years as a visiting professor at the University of Toronto. His research interests lie in cognitive psychology, particularly in human learning and memory. Dr. Roediger has published over 250 articles, chapters, and reviews, as well as coauthoring or editing ten other books. These include *Research Methods in Psychology* (with D. G. Elmes and B. H. Kantowitz) that came out in its ninth edition in 2012. Dr. Roediger has served as editor of the *Journal of Experimental Psychology: Learning, Memory and Cognition* (1984–1989) and was the founding editor of *Psychonomic Bulletin & Review* (1994–1997). He is currently a consulting editor for ten journals. He has served as president of the Association for Psychological Science, the Midwestern Psychological Association, and the Experimental Psychology Division of the American Psychological Association. Roediger's current research is supported by grants from the Institute of Education Sciences of the Department of Education, Dart Neuroscience, and the James S. McDonnell Foundation. He was a member of the governing board of the Psychonomic Society for five years and its chair in 1989–1990. He has been named a Highly Cited Researcher by the Institute of Scientific Information and also received a Guggenheim Fellowship. Roediger has been elected to membership in the Society of Experimental Psychologists and the American Academy of Arts and Sciences, as well as being elected fellow of the American Association for the Advancement of Science, the American Psychological Association, the Association for Psychological Science, and the Canadian Psychological Association. He has received the Howard Crosby Warren Medal from the Society of Experimental Psychologists for his research on false memories and the William James Lifetime Achievement Award from the Association for Psychological Science.

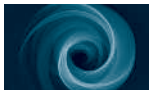
Courtesy, David Elmes; Photo by Patrick Hinely

DAVID G. ELMES is professor emeritus of psychology at Washington and Lee University, where he taught for forty years. He earned his B.A. with high honors from the University of Virginia and completed the M.A. and Ph.D. degrees in psychology there. Dr. Elmes was an adjunct professor at Hampden-Sydney College, was a research associate for a year in the Human Performance Center of the University of Michigan, and was a visiting fellow of University College at the University of Oxford. At Washington and Lee, he codirected the Cognitive Science Program for fourteen years and chaired the Department of Psychology for ten years. Professor Elmes edited *Readings in Experimental Psychology*, *Directory of Research in Psychology at Primarily Undergraduate Institutions*, and is coauthor of the ninth edition of *Research Methods in Psychology* (2012, with B. H. Kantowitz and H. L. Roediger III). Dr. Elmes has published numerous articles concerned with human and animal learning, memory, and the sense of smell. The smell research has been supported by the National Institute of Environmental Health Sciences. He frequently referees papers submitted to technical journals and was a consulting

editor for the *Journal of Experimental Psychology: Learning, Memory and Cognition* for several years. Professor Elmes is passionate about the educational value of undergraduate research. For a number of years he was active in the Council of Undergraduate Research, for which he has served as psychology councilor, Psychology Division chair, and president. Dr. Elmes is a fellow of the Association for Psychological Science and the Virginia Academy of Science.

CONTENTS IN BRIEF

CONTENTS



PREFACE

The term *experimental psychology* used to denote only a few selected topics in psychology. In, say, 1930, experiments were conducted to understand sensation, perception, learning, memory, and a few other topics. The situation is quite different today: Experimental methods are used to investigate social psychology, developmental psychology, individual differences, and many other topics (such as environmental psychology) that were not considered in psychology's vision eighty years ago. The use of experimental methods has expanded to include most topics in the field. Writing a textbook aimed at this increasing ambit has therefore become an increasing challenge.

This textbook is the tenth edition of a book first published in 1978. The thirty-five years spent revising the book have gone by rather quickly. Our collaboration has endured longer than many careers and many marriages. Despite changes in research interests, new jobs, different locations, personal transitions, medical traumas, and mandatory migrations between merging publishing firms, we have continued to explain the wonders of experimental psychology to thousands of students. The tremendous feedback we have received from students and faculty has been a constant source of inspiration and motivation for us. But times' arrow only moves forward: A majority of the authors have received their final promotion to emeritus status. Furthermore, this implies that many of the faculty who have used this text and given us sage advice for decades are also on the cusp of retirement. Thus, there is a high probability that the tenth edition you are holding may be our last edition. If so, we take this opportunity to thank our readers one final time for joining us on our voyage of discovery.

Psychology today has evolved considerably from the discipline we began to master as eager graduate students about to commence a marvelous

journey. Each of the revised editions has seen both major and minor changes in response to students' and professors' comments, and this edition is no exception. Readers familiar with the previous edition will find changes in every chapter. We have tried to blend the best aspects of the previous nine editions with new features to make the book even more appealing. (We describe the changes in more detail below.) We are pleased that the continued popularity of this text has permitted us to produce this new edition, because we think we have been able to improve it, and we have enjoyed working on it again.

The title *Experimental Psychology* has appeared on many textbooks that have become classics, beginning with E. B. Titchener's pair in the early 1900s, through Woodworth's 1928 text and its revision (Woodworth & Schlossberg, 1954), and finally to those books by Osgood (1953) and Underwood (1966). All these books provided an introduction to research methodology, but they did so in the context of fundamental research in experimental psychology. The books were primarily about the content of experimental psychology, with an emphasis on the research methods used to acquire the knowledge. We see our textbook as firmly within this tradition, even if much less encyclopedic than the great books mentioned above.

Today this approach is unique; during the 1970s and the 1980s, many "research methods" texts appeared that organize the subject matter quite differently. Instead of providing methodology in the context in which it is used, these books treat methodological topics (e.g., between-subjects designs, small-*n* designs) as chapter titles and introduce content examples to flesh out the discussion of the methods. This is also an excellent approach, and we have produced another text that embodies this method (*Research Methods in Psychology*, by Elmes, Kantowitz, and Roediger, also published by Cengage). However, *Experimental Psychology* seeks to provide an integrated blend of content and methodology, with methods discussed in the context of actual research. Primary differences between our text and those of our predecessors in this tradition are that our approach is to select particular examples that best illustrate the methodological point under consideration and that our book is intended mostly for an undergraduate audience with only a first course in psychology as a background.

We should note one point about terms in our book. In 1994, the *Publication Manual of the American Psychological Association* recommended that the traditional term *subjects*, which had been used for over a century to refer to people who were tested in psychological research, be changed to *participants*. This change received a mixed reaction in the research community, and some other organizations that publish psychology journals did not go along. For example, the Psychonomic Society permitted use of either term in papers published in their journals. In addition, the copyeditors of the American Psychological Association journals do not insist that participants be used as the favored term, but rather encourage its use. The recent sixth edition of the APA Publication Manual has clarified the situation by explicitly stating that both participants and subjects are approved terms to refer to people in

experiments. (The term subjects is always used in research with animals.) We have followed the convention of using both *subjects* and *participants* when referring to people in psychological research in this book. We always use subjects when referring to non-human animals in research, but we use both terms when referring to humans. The usage in our text therefore reflects current practice in the field at large.

TEXT ORGANIZATION

The philosophy of the text remains unchanged. As with the first nine editions, we have striven to achieve an integrated treatment of experimental psychology with a seamless link binding methodology and content. The book includes two main parts. The first five chapters constitute Part One, Fundamentals of Research, and discuss some basic methodological preliminaries that students need. In these chapters we describe some general aspects of science and theory construction; the features of (and differences among) observational, correlational, and experimental methods (with an emphasis on the last); ethical issues in research; and how to read and write research reports.

In the remaining ten chapters, which make up Part Two, Principles and Practices of Research, we flesh out the bare bones provided in Part One by illustrating methodological topics in the context of actual research problems. The chapters are provided with content titles (e.g., Perception), and some content is covered in its own right, but the main purpose of the chapters is to present methodological topics in the context of actual research. This organization reflects our belief that the best way to provide students with an understanding of methodology is to embed it in the context of real problems that occur in conducting research. Methodology does not exist in a vacuum, but is devised to solve concrete research problems. We hope that presenting methods in the context of important content issues will help students to see the importance of considering research methods.

Chapter Format

The chapters in Part Two all share a common format. This parallel structure should help orient students to important features of the text that facilitate learning.

Chapter Opening The chapters begin with an outline and quotation. Following a brief orientation to the content area explored in the chapter, the student will come across the first of several boxed inserts, which readers of the previous editions have found to be helpful and which have therefore been carried over to the tenth edition.

Introducing the Variables This feature quickly orients the student to those independent, dependent, and control variables commonly used in particular

research areas. Our coverage of these variables does not exhaust the possibilities, but does include some of the most common ones.

Experimental Topics and Research Illustrations This feature represents the main part of the chapter, in which two or three methodology issues are presented in the context of an actual research problem. Thus, for example, in Chapter 10 we discuss the difficulty of ceiling and floor effects in the context of a memory experiment in which this problem actually arose. Many of these experimental topics have been introduced in Part One and are covered in more detail in Part Two. Some crucial topics are discussed more than once in Part Two to ensure better comprehension. The content topics were chosen to be good vehicles for discussing the particular methodological point under consideration. Thus, the content topics may not represent the most important topics in the subject under discussion, nor do we intend our chapters to represent a complete summary of contemporary work in the area. Our intent is to illustrate issues of methods in the context of actual research problems that are of interest. Two other unique features appear toward the end of each chapter in Part Two.

From Problem To Experiment: The Nuts and Bolts In this section, we present the rationale behind experimental design decisions—how many subjects should be used, why variable X is selected instead of variable Y, and so on—when hypotheses are taken from a general form to the specifics of an experiment. These decisions are the "nuts and bolts" of experimental research. They are second nature to practicing experimenters and hence seldom articulated in journal articles, but they may represent puzzles to those new to research.

Psychology in Action This feature suggests safe and simple experimental demonstrations that require little or no equipment and that can be used in or out of class. For example, Chapter 7 includes a demonstration of the Stroop effect and Chapter 14 presents methods to measure the effects of noise on memory.

End-of-Chapter Features Each chapter contains a summary in which the main points of the chapter are reviewed, a set of key terms for review and study, and several discussion questions.

Chapter Sequence

Although students will be best served by reading Part One in correct serial order (especially the first three chapters), those professors and students more interested in methodology than in content can ignore the chapter numbers in Part Two. The table that cross-lists chapter numbers and experimental topics (to be found after the Preface) can be used to determine the order in which chapters in Part Two are assigned. Thus, the instructor has the option of following a more- or less-traditional order or of creating a unique ordering better suited to his or her educational goals. Two lesser-used chapters that,

however, may be quite necessary for some are located in appendixes. Appendix A provides a brief sketch of the history of experimental psychology, and Appendix B contains a review of basic statistics. Appendix C provides some frequently used statistical tables described in Appendix B.

Companion Web Site Resources

The companion Web site for this edition, available at www.cengagebrain.com, contains several helpful features for both instructors and students. Instructors will be able to find teaching activities, chapter outlines, and chapter summaries. To aid students, the Web site contains a glossary, flashcards, crossword puzzles to help learn key terms, web links, and sample quizzes. The Web site also includes the following features:

Instructor's Manual with Test Bank Resources for instructors include chapter outlines, key terms, answers to discussion questions, lecture suggestions, demonstration suggestions, and "experimental dilemmas." The test bank contains multiple-choice, true-false, and essay questions for each chapter. In addition the new Cengage Learning Testing powered by Cognero allows you to author, edit, and manage test bank content from multiple Cengage Learning solutions, create multiple test versions in an instant, and deliver tests from your LMS, classroom, or wherever you want

Electronic Slides Many of the figures from the text are available as PowerPoint® slides that can be downloaded and used in the classroom.

Changes in the Tenth Edition

Users of the previous edition will discover many changes in the current edition. Web references have been updated for all chapters; while these were working in June 2013, some will undoubtedly change during the life of this edition. These references guide readers to relevant discussions online, including the Wadsworth Online at The Wadsworth Psychology Study Center. In addition, instructors in North America who have specified that InfoTrac College Edition be packaged with this text have been provided four months of free access to this extensive virtual library for their students.

New coverage and more recent references have been added in every chapter, and some chapters have been rebuilt to reflect the most recent findings and topics, even though this meant removing substantial amounts of text dearly cherished by the authors. Chapter 1 tells how to determine if you are a fox or a hedgehog and which of these two cognitive styles results in more accurate prediction. Chapter 2 introduces the methodology of interobserver reliability and updates results on the relationship between violent media and games upon aggressive behavior. Chapter 3 adds a new topic, researcher degrees of freedom, and discusses its implications for analyzing data. Chapter 4 adds more information on animal welfare, scientific fraud,

and APA Standards 8.10 and 8.11. Chapter 5 has been heroically rewritten because of the new edition of the APA Publication Manual and now includes a new sample journal article and a new sample manuscript. Chapter 6 was condensed following suggestions from reviewers but still contains the essential information on psychophysics found in previous editions. Chapter 7 expands discussion of blindsight to add two new sub-categories. Chapter 8 adds a new topic, researcher degrees of freedom, and contrasts a basic research study with an applied study; a previous topic was deleted. Chapter 9 has been substantially revised to emphasize human learning, creating a balance between early examples of conditioning and contemporary research on human learning. Chapter 10 has been updated with nine recent references on memory research. Chapter 11 has been updated with new studies on analogy in educational settings, Duncker's box problem, and fMRI and feeling of knowing. Chapter 12 has added recent information about the smart Balamurali Krishna Ambati. Chapter 13 contains new discussion of Milgram's obedience study and the role of norms on mate selection. Chapter 14 adds a new section on the ethics of benevolent deception in virtual environments. Chapter 15 expands the section on pilot workload in response to reviewer suggestions by adding a new subsection on cockpit automation. It also adds new findings on driver distraction and discusses selecting the best dependent variable. Appendix B has expanded the discussion of type 1 errors to include work on false positives now included in Chapter 3. Please continue to let the authors know how you and your students react to these substantial changes.

ACKNOWLEDGMENTS

It takes many more people than authors to create a text that has endured for ten editions, and the authors are pleased to acknowledge with gratitude the assistance of numerous others. Our greatest debt is to the readers of previous editions who continue to offer many useful comments. Without their helpful suggestions, this new edition would not exist.

Sara Estle at Washington University in St. Louis provided invaluable help, especially in checking the material in Chapter 5. Wendy Langerud and Nicole Richards provided valuable assistance in manuscript preparation and proofreading among other things, and we thank them all. We also thank Michelle Clark at Cengage, Brenda Carmichael and Dewanshu Ranjan at PreMediaGlobal for their substantial efforts guiding our book through the production process.

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ORGANIZATION OF THE BOOK

Experimental Topics	6	7	8	9	10	11	12	13	14	15
Choosing the dependent variable								X		
Confounding			X							
Converging operations		X								
Counterbalancing				X						
Demand characteristics								X		
Ethical issues									X	
Experimental control/ extraneous variables						X		X		
Field research								X		X
Generalization of results					X				X	
Interaction effects					X					
Measurement scales	X									
Operational definition	X						X			
Quasi-experiments									X	
Regression artifacts							X			
Reliability of measures						X	X			
Researcher degrees of freedom			X							
Scale attenuation					X					
Selection of dependent variable			X					X		X
Small-*n* design	X			X						X
Verbal report		X				X				
Within and between-subjects designs				X						

PART

1

Fundamentals of Research

CHAPTER

1

Explanation in Scientific Psychology

Ask any scientist what he conceives the scientific method to be, and he will adopt an expression that is at once solemn and shifty-eyed; solemn, because he feels he ought to declare an opinion, shifty-eyed because he is wondering how to conceal the fact that he has no opinion to declare. If taunted he would probably mumble something about "Induction" and "Establishing the Laws of Nature," but if anyone working in a laboratory professed to be trying to establish Laws of Nature by induction, we should begin to think he was overdue for leave. (P. B. MEDAWAR)

The goal of scientific psychology is to understand why people think and act as they do. In contrast to nonscientists, who rely on informal and secondary sources of knowledge, psychologists use a variety of well-developed techniques to gather information and develop theoretical explanations. As one example of this scientific approach to understanding, consider the following case study of the research process.

MAKING SENSE OF THE WORLD

Social Loafing

A common observation—one you probably have made yourself on many occasions—is that people working in a group often seem to "slack off" in their effort. Many people in groups seem willing to let a few do the work. Bibb Latané, a social psychologist, noticed this tendency and decided to study it experimentally. Initially, Latané examined the research literature for evidence of this phenomenon of people working less hard in groups, which he named **social loafing**. One of the earliest studies of social loafing was conducted by a French agricultural engineer (Kravitz & Martin, 1986; Ringelmann, 1913) who asked people to pull on a rope as hard as they could. The subjects pulled by themselves or with one, two, or seven others. A sensitive gauge was used to measure how hard they pulled the rope. If people exert the same amount of effort in groups as when alone, then the group performance should be the sum of the efforts of all individuals. Ringelmann discovered that groups of two pulled at only 95 percent of their capacity, and groups of three and eight sank to 85 percent and 49 percent, respectively. So, it is probably not just our imaginations when we notice others (and ourselves?) seeming to put forth less effort when working in groups: Ringelmann's research provides us with a good example of social loafing.

Latané and his colleagues went on to perform a systematic series of experiments on the phenomenon of social loafing (Latané, 1981; Latané, Williams, & Harkins, 1979). They first showed that the phenomenon could be obtained in other experimental situations besides that of rope pulling. They also demonstrated that social loafing occurs in several different cultures (Gabrenya, Latané, & Wang, 1983) and even holds for young children. Thus, social loafing seems to be a pervasive characteristic of working in groups.

Latané has related this work to a more general theory of human social behavior (Latané, 1981). The evidence from the experimental studies points to **diffusion of responsibility** as a possible reason for social loafing. People working by themselves think they are responsible for completing the task; when they work in groups, however, this feeling of responsibility diffuses to others. The same idea accounts for behavior in other group situations: If one of your professors asks a question in a class containing only two other people, you would probably feel responsible for trying to answer. However, if there were 200 other people in the class, you would likely feel much less responsible for answering. Similarly, people are more likely to help in an emergency when they feel the burden of responsibility than when there are several others about who could help.

One possible benefit of such basic research into a phenomenon is that the findings may be applied later to solve some practical problem. A great problem in American society is the difficulty of keeping worker productivity high. Although social loafing is, at best, only one factor involved in this complicated issue, Marriott (1949) showed that factory workers working in large groups produce less per individual than do those working in small groups. Thus, basic research that would show a way to overcome the problem of social loafing may be of great practical import. In fact, Williams, Harkins, and Latané (1981) found conditions that eliminated the effect of social loafing. When individual performance (rather than just performance of the entire group) could be monitored within the group situation, the individuals worked just as hard as they did when they worked alone. Certainly more research must be done, but it may be that simply measuring individual performance in group situations could help eliminate social loafing and increase productivity. The proposed solution may seem simple, but in many jobs only group performance is measured and individual performance is ignored.

We have discussed Latané's studies of social loafing as an example of psychological research to illustrate how an interesting problem can be brought into a laboratory setting and studied in a controlled manner. The experiments performed will, when carefully conducted, promote a better understanding of the phenomenon of interest than will simple observation of events and reflection about them. This book is largely about the proper conduct of such experimental studies—how to develop hypotheses, arrange experimental conditions to test the hypotheses, collect observations (data) within an experiment, and then analyze and interpret the data collected. In short, in this book we try to cover the fundamentals of scientific inquiry as applied to psychology.

Before examining the specifics of research, we discuss some general issues in the remainder of this chapter. The research on social loafing is used to illustrate several aspects of psychological science—its purposes, its sources, and its nature.

Curiosity: The Wellspring of Science

A scientist wants to discover how and why things work. In this desire, he or she is not different from a child or anyone else who is curious about the world we inhabit. The casual observer may not feel terribly frustrated if some observation (e.g., that water always goes down a sink drain counterclockwise or that individual effort in a group is low) cannot be explained. However, the professional scientist has a strong desire to pursue an observation until an explanation is at hand or a problem is solved. It is not so much that scientists are more curious than other people as it is that they are willing to go to much greater lengths to satisfy their curiosity than are nonscientists. This unwillingness to tolerate unanswered questions and unsolved problems has led science to develop several techniques for obtaining relief from curiosity. It is the careful application of these techniques that distinguishes scientific curiosity from everyday curiosity.

The common denominator for many of these scientific techniques is skepticism. Skepticism is the philosophical belief that the truth of all knowledge is questionable. Therefore, all inquiry must be accompanied by reasonable doubt. No scientific fact can be known with 100 percent certainty. For example, bridge engineering is a practical discipline derived from a scientific foundation in such fields as physics and metallurgy. Most people, when they drive a car across a bridge, do not actively consider that the bridge might collapse. It is a known fact that well-maintained bridges are safe. Yet in the summer of 2007, a bridge in Minneapolis–St. Paul, Minnesota, collapsed. This event has led to further research, to result in safer bridges being built. Many of the tools, such as statistics, discussed in this text allow the skeptical scientist to measure reasonable doubt.

Of what use is scientific curiosity? What purpose does it serve? We have stated that psychologists try to determine why people think and act as they do. Let us explore what this means in more detail.

SOURCES OF KNOWLEDGE

Fixation of Belief

The scientific method is a valid way to acquire knowledge about the world around us. What characteristics of the scientific approach make it a desirable way to learn about and arrive at beliefs about the nature of things? Perhaps the best way to answer this question is to contrast science with other modes of fixing belief, since science is only one way in which beliefs are formed.

More than 100 years ago, the American philosopher Charles Sanders Peirce (1877) compared the scientific way of knowing with three other methods

of developing beliefs. He called these the **authority**, **tenacity**, and **a priori methods**. According to Peirce, the simplest way of fixing belief is to take someone else's word on faith. A trusted authority tells you what is true and what is false. Young children believe what their parents tell them simply because mommy and daddy are always right. As children get older, they may discover, unhappily, that mom and dad are not always correct when it comes to astrophysics, macroeconomics, computer technology, and other specialized fields of knowledge. Although this may cause children to doubt some of their parents' earlier proclamations, it may not result in utter rejection of this method of fixing belief. Instead, some other authority may be sought.

Religious beliefs are formed by the **method of authority**. Long after Catholic children have rejected their parents as the source of all knowledge, particularly about religious doctrine, they may still believe that the pope is infallible. Believing the news you see on television means that you accept CNN or some other news network as an authority. You may believe your professors because they are authorities. Since people lack the resources to investigate everything they learn, much knowledge and many beliefs are fixed by the method of authority. Provided nothing happens to raise doubts about the competence of the authority setting the beliefs, this method offers the great advantages of minimum effort and substantial security. It is most pleasant in a troubled world to have complete faith in beliefs handed down to you.

Another method of fixing belief is one in which a person steadfastly refuses to alter acquired knowledge, regardless of evidence to the contrary. The **method of tenacity**, as it was termed by Peirce, is commonly seen in racial bigots who rigidly cling to a stereotype even in the presence of a good counterexample. Although this method of maintaining a belief may not be entirely rational, we cannot say it is completely without value. The method of tenacity allows people to maintain a uniform and constant outlook on things, so it may relieve them from a certain amount of stress and psychological discomfort.

The third nonscientific method discussed by Peirce fixes belief a priori. In this context, the term *a priori* refers to something that is believed without prior study or examination. Propositions that seem reasonable are believed. This is an extension of the method of authority. However, there is no one particular authority being followed blindly in this method. The general cultural outlook is what seems to fix belief a priori. People once believed the world was flat, and it did seem reasonable to suppose that the sun revolved around the earth as does the moon. Indeed, the world does look flat if you are not in a spacecraft.

The tenacity and a priori methods are similar in that they minimize the possibility of being influenced by conflicting opinion. In the method of tenacity, other points of view, although noticed, are completely discounted. Thus, a racial stereotype is preserved despite other evidence, such as the good qualities of a person of a different race who lives next door. In the a priori method, other points of view go unnoticed. For example, the sight of a ship disappearing from bottom to top, instead of all at once, as it leaves port may seem irrelevant if you already know the world is flat.

The last of Peirce's methods, the **scientific method**, fixes belief on the basis of experience. Science is based on the assumption that events have causes and that we can discover those causes through controlled observation. This belief, that observable causes determine events, is known as **determinism**. If we define scientific psychology (as well as science in general) as a repeatable, self-correcting undertaking that seeks to understand phenomena on the basis of empirical observation, then we can see several advantages to the scientific method over the methods just outlined. Let us see what we mean by **empirical** and **self-correcting** and examine the advantages associated with those aspects of science.

The first advantage of the scientific method is its emphasis on observation. None of those other methods relies on data (observations of the world) obtained by systematic observation. In other words, there is no empirical basis for fixing belief. The word *empirical* is derived from an old Greek word meaning "experience." Having an empirical basis for beliefs means that experience, rather than faith, is the source of knowledge. Having one's beliefs fixed by authority carries no guarantee that the authority obtained data before forming an opinion. By definition, the method of tenacity refuses to consider data, as does the a priori method. Facts that are considered in these other modes of fixing belief are not ordinarily obtained by systematic procedures. For example, casual observation was the "method" that led to the ideas that the world was flat and that frogs spontaneously generated from the mud each spring, as Aristotle believed.

The second advantage of science is that it offers procedures for establishing the superiority of one belief over another. Persons holding different beliefs will find it difficult to reconcile their opinions. Science overcomes this problem. In principle, anyone can make an empirical observation, which means that scientific data can be public and can be repeatedly obtained. Through public observations, new beliefs are compared with old beliefs, and old beliefs are discarded if they do not fit the empirical facts. This does not imply that each and every scientist instantaneously drops outmoded beliefs in favor of new opinions. Changing scientific beliefs is usually a slow process, but eventually incorrect ideas are weeded out. Empirical, public observations are the cornerstone of the scientific method, because they make science a *self-correcting* endeavor.

THE NATURE OF THE SCIENTIFIC EXPLANATION

What Is a Theory?

A theory can be crudely defined as a set of related statements that explains a variety of occurrences. The more the occurrences and the fewer the statements, the better the theory. The law of gravity explains falling apples, the behavior of roller coasters, and the position of bodies within the solar system. With a small number of statements about the mutual attraction of bodies, it explains a large number of events. It is therefore a powerful theory. (This does not necessarily mean it is a correct theory, since there are some events it cannot explain.)

Theory in psychology performs two major functions. First, it provides a framework for the systematic and orderly display of data—that is, it serves as a convenient way for the scientist to *organize* data. Even the most dedicated inductive scientist will eventually have difficulty remembering the outcomes of dozens of experiments. Theory can be used as a kind of filing system to help experimenters organize results. Second, it allows the scientist to generate *predictions* for situations in which no data have been obtained. The greater the degree of precision of these predictions, the better the theory. With the best of intentions, scientists who claim to be testing the same theory often derive from the theory different predictions about the same situation. This unfortunate circumstance is relatively more common in psychology, where many theories are stated in a loose verbal fashion, than in physics, where theories are more formal and better quantified through the use of mathematics. Although psychologists are rapidly becoming equipped to state their theories more precisely through such formal mechanisms as mathematics and computer simulations, the typical psychological theory is still not as precise as theories in more established, older sciences.

Let us see how the theory devised by Latané to account for social loafing stacks up with regard to organization and prediction. The theory of diffusion of responsibility organizes a substantial amount of data about social loafing. More important, the theory seems to account for a remarkable variety of other observations. For example, Latané (1981) notes that the size of a tip left at a restaurant table is inversely related to the number of people in the dinner party. Likewise, proportionately more people committed themselves to Christ at smaller Billy Graham crusades than at larger ones. Finally, work by Latané and Darley (1970), which is discussed in detail later in this book, shows that the willingness of people to help in a crisis is inversely related to the number of other bystanders present. The entire pattern of results can be subsumed under the notion of diffusion of responsibility, which asserts that people feel less responsibility for their own actions when they are in a group than when they are alone—so they are less likely to help in an emergency, they are less likely to leave a large tip, and so on. Latané's theory also makes rather precise predictions about the impact of the presence of other people on a person's actions. In fact, one version of the theory (Latané, 1981) presents its major assumptions in terms of mathematical equations.

Theories are devised to organize concepts and facts into a coherent pattern and to predict additional observations. Sometimes the two functions of theory—organization and prediction—are called **description** and **explanation**, respectively. Unfortunately, formulating the roles of theory in this manner often leads to an argument about the relative superiority of deductive or inductive approaches to science—a discussion the following section concludes is fruitless. According to the deductive scientist, the inductive scientist is concerned only with description. The inductive scientist defends against this charge by retorting that description is explanation—if a psychologist could correctly predict and control all behavior by referring to properly organized sets of results, then that psychologist would also be explaining behavior.