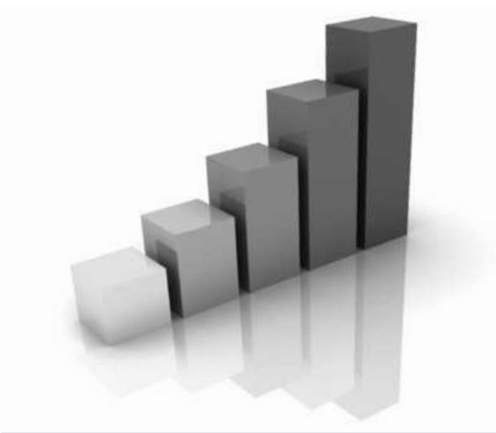
Third Edition

Statistics

PLAIN AND SIMPLE

Sherri L. Jackson



STATISTICS
Plain and Simple

THIRD EDITION

Sherri L. Jackson
Jacksonville University

WADSWORTH
CENGAGE Learning

Australia • Brazil • Japan • Korea • Mexico • Singapore • Spain • United Kingdom • United States

WADSWORTH
CENGAGE Learning®

***Statistics Plain and Simple*, Third Edition**
Sherri L. Jackson

Publisher: Jon-David Hague

Acquisitions Editor: Tim Matray

Assistant Editor: Jessica Alderman

Editorial Assistant: Nicole Richards

Media Editor: Mary Noel

Brand Manager: Liz Rhoden

Market Development Manager: Chris Sosa

Art and Cover Direction, Production Management, and Composition: PreMediaGlobal

Manufacturing Planner: Karen Hunt

Rights Acquisitions Specialist: Roberta Broyer

Cover Image: Zketch/Shutterstock

Library of Congress Control Number: 2012940372

ISBN-13: 978-1-133-31253-6

ISBN-10: 1-133-31253-5

Wadsworth
20 Davis Drive
Belmont, CA 94002-3098
USA

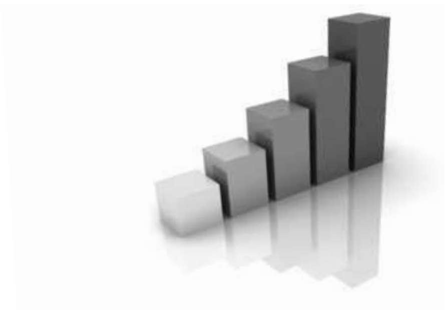
Cengage Learning is a leading provider of customized learning solutions with office locations around the globe, including Singapore, the United Kingdom, Australia, Mexico, Brazil, and Japan. Locate your local office at **www.cengage.com/global.**

Cengage Learning products are represented in Canada by Nelson Education, Ltd.

To learn more about Wadsworth, visit **www.cengage.com/wadsworth**

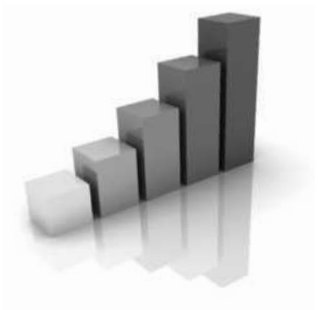
Purchase any of our products at your local college store or at our preferred online store **www.cengagebrain.com.**

Printed in the United States of America
1 2 3 4 5 6 7 16 15 14 13 12

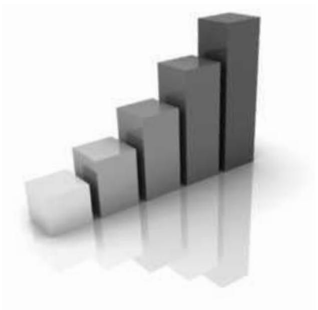


About the Author

Sherri L. Jackson is Professor of Psychology at Jacksonville University, where she has taught since 1988. At JU, she has won Excellence in Teaching, Scholarship, and University Service awards, the university-wide Professor of the Year Award in 2004, the Woman of the Year Award in 2005, and the Institutional Excellence Award in 2007. She received her M.S. and Ph.D. in cognitive/experimental psychology from the University of Florida. Her research interests include human reasoning and the teaching of psychology. She has published numerous articles in both areas. In 1997, she received a research grant from the Office of Teaching Resources in Psychology (APA Division 2) to develop *A Compendium of Introductory Psychology Textbooks 1997–2000*. She is also the author of *Research Methods and Statistics: A Critical Thinking Approach*, 4th ed. (Belmont, CA: Wadsworth, 2012), *Research Methods: A Modular Approach*, 2nd ed. (Belmont, CA: Wadsworth, 2011), and *A Concise Guide to Statistical Analyses Using Excel, SPSS, and the TI-84 Calculator*, (Belmont, CA: Wadsworth, 2013).



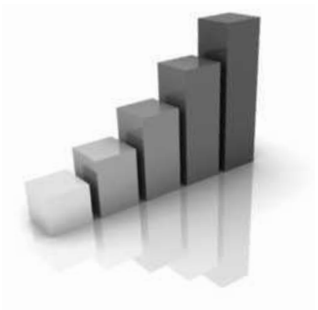
Brief Contents



Contents

CHAPTER 8

Repeated Measures and Two-Factor ANOVAs 251



Preface

Statistics Plain and Simple, 3rd edition, was written to provide students and instructors with a simple, straightforward approach to learning and teaching statistics. The text is designed to be used in a variety of classroom situations—as a statistics text in an undergraduate course, as a supplement to a combined statistics and methodology course, or as a quick review at the graduate level. Most of the statistical concepts typically covered in briefer statistics texts are covered here along with some additional statistical concepts not typically found in such texts (for example, effect size, confidence intervals, repeated measures ANOVAs, and Wilcoxon tests).

One of my goals in writing this text was to be *concise yet comprehensive.* The text is organized into ten chapters, each divided into brief modules. This modular format allows students to digest smaller chunks and teachers to have greater flexibility in reading assignments and the amount of material covered in each class. Most modules are brief, just 6 to15 pages in length. However, despite the brevity of the modules, most statistics covered in the typical undergraduate course are covered here. Moreover, the coverage of each statistical test is divided into four clear subsections. The first describes the statistical test and what it does for a researcher. The second subsection provides the formulas for the test and an example of how to apply the formulas. In the third subsection I demonstrate how to interpret the results from the test and how to report these results in APA publication format. In the final subsection, I discuss the assumptions that underlie the test. Using the same format for the discussion of each test means that students become familiar with what to expect with each new statistical test. Moreover, these subsections also serve to break the material down into chunks that are easier to understand and digest.

In addition, I have made every attempt to use a straightforward, easy-to-understand *writing style.* I present the information in a simple, direct, clear fashion. Because statistics is one of the more difficult courses for many students, I also try to write in an engaging, conversational style, much as if the reader were a student seated in front of me in my classroom. I hope, through this writing style, to help students better understand some of the more troublesome concepts without losing their interest.

Pedagogical Aids

The text uses several pedagogical aids. Each chapter begins with a *chapter outline* followed by *learning objectives* at the beginning of each module. A *running glossary* appears in the margins of each module and is alphabetized at the end of the book. *In Review* summary matrices occur at the end of major subsections in each module, providing a tabular review of the major concepts within that subsection. The summary matrices are immediately followed by *Critical Thinking Checks,* which vary in length and format but typically involve a series of application questions concerning the information in the preceding subsection. The questions are designed to foster analytical and critical thinking skills in students in addition to reviewing the module subsection information. Thus, students can study the *In Review* summary after reading a module subsection and then respond to the *Critical Thinking Check* on that information. At the end of each module, the *Module Exercises* allow students to further review and apply the knowledge gained in the module. At the end of each chapter, a *Chapter Summary and Review* provides a built-in study guide consisting of a chapter summary, Fill-in Self-Test Questions, Multiple-Choice Self-Test Questions, and Self-Test Problems. Answers to the Critical Thinking Checks are provided at the end of each module. Answers to the odd-numbered Module Exercises and all Chapter Summary and Review Exercises are included in Appendix B.

New to This Edition

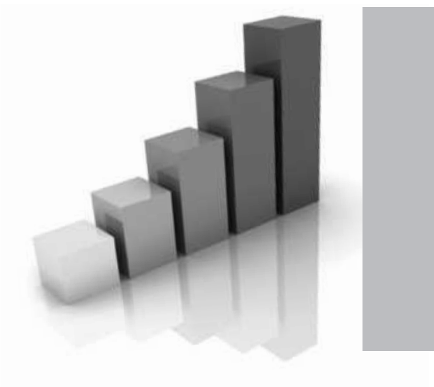
The major change to the third edition of *Statistics Plain and Simple* is that the Excel, SPSS, and TI-84 material that previously appeared in Appendix C has now been integrated into the book and appears as a Statistical Software Resources section at the end of relevant chapters. In addition the coverage of various procedures in Excel and SPSS has increased. Lastly, two new nonparametric statistics have been added to Module 22—the Kruskal-Wallis test and the Friedman test. The SPSS procedures for each of these is also covered.

Acknowledgments

I must acknowledge several people for their help with this project. I thank my husband, Richard Griggs, for his careful proofreading and insightful comments, and Percy for the encouragement of her ever-wagging tail. In addition, I would like to thank those who reviewed the text in its various stages. The reviewers include Patricia L. Tomich, Kent State University; Christine Ferri, Richard Stockton College of New Jersey; Brendan Morse, Bridgewater State College; and Tina Jameson, Bridgewater State College.

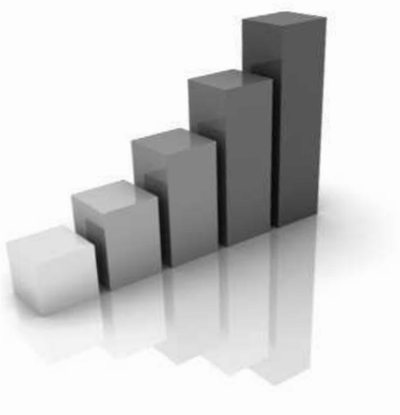
Special thanks to Timothy Matray, Acquiring Sponsoring Editor, for his support and guidance, and Jon-David Hague, Publisher; Nicole Richards, Editorial Assistant; Janay Pryor, Associate Marketing Program Manager; Talia Wise, Marketing Programs Director; Brenda Carmichael, Art Director; Karen Hunt, Manufacturing Planner; and Roberta Broyer, Rights Acquisition Specialist, all of Wadsworth/Cengage Learning. Finally, thanks to Dewanshu Ranjan and PreMediaGlobal for their production expertise and to Pamela Rockwell for her excellent copyediting skills.

Sherri L. Jackson



CHAPTER 1

Getting Started



MODULE 1
Science and Statistics

Learning Objectives

- Explain the goals of science.
- Identify and compare descriptive methods.
- Identify and compare predictive (relational) methods.
- Describe the explanatory method. Your description should include independent variable, dependent variable, control group, and experimental group.
- Explain how we "do" science and how proof and disproof relate to doing science.

You may be wondering why you are enrolled in a statistics class. Most students take statistics because it is a requirement in their major field, and often students do not understand *why* it is a requirement. Scientists and researchers use statistics to describe data and draw inferences. Thus, no matter whether your major is in the behavioral sciences, the natural sciences, or in more applied areas such as business or education, statistics are necessary to your discipline. Why? Statistics are necessary because scientists and researchers collect data and test hypotheses with these data using statistics. A **hypothesis** is a prediction regarding the outcome of a study. This prediction concerns the potential relationship between at least two variables (a **variable** is an event or behavior that has at least two values). Hypotheses are stated in such a way that they are testable. When we test our hypotheses, statistics may lead us to conclude that our hypothesis is or is not supported by our observations.

hypothesis A prediction regarding the outcome of a study involving the potential relationship between at least two variables.

variable An event or behavior that has at least two values.

theory An organized system of assumptions and principles that attempts to explain certain phenomena and how they are related.

In science, the goal of testing hypotheses is to arrive at or test a **theory**—an organized system of assumptions and principles that attempts to explain certain phenomena and how they are related. Theories help us to organize and explain the data gathered in research studies. In other words, theories allow us to develop a framework regarding the facts in a certain area. For example, Darwin's theory organizes and explains facts related to evolution. In addition to helping us organize and explain facts, theories also help in producing new knowledge by steering researchers toward specific observations of the world.

Students are sometimes confused about the differences between a hypothesis and a theory. A *hypothesis* is a prediction regarding the outcome of a single study. Many hypotheses may be tested and several research studies conducted before a comprehensive theory on a topic is put forth. Once a *theory* is developed, it may aid in generating future hypotheses. In other words, researchers may have additional questions regarding the theory that help them to generate new hypotheses to test. If the results from these additional studies further support the theory, we are likely to have greater confidence in the theory. However, every time we test a hypothesis, statistics are necessary.

Goals of Science

Scientific research has three basic goals: (1) to describe, (2) to predict, and (3) to explain. All of these goals lead to a better understanding of behavior and mental processes.

Description **Description** begins with careful observation. Behavioral scientists might describe patterns of behavior, thought, or emotions in humans. They might also describe the behavior(s) of other animals. For example, researchers might observe and describe the type of play behavior exhibited by children or the mating behavior of chimpanzees. Description allows us to learn about behavior and when it occurs. Let's say, for example, that you were interested in the channel-surfing behavior of males and females. Careful observation and description would be needed in order to determine whether or not there were any gender differences in channel-surfing. Description allows us to observe that two events are systematically related to one another. Without description as a first step, predictions cannot be made.

description Carefully observing behavior in order to describe it.

Prediction **Prediction** allows us to identify the factors that indicate when an event or events will occur. In other words, knowing the level of one variable allows us to predict the approximate level of the other variable. We know that if one variable is present at a certain level, then there is a greater likelihood that the other variable will be present at a certain level. For example, if we observed that males channel-surf with greater frequency than females, we could then make predictions about how often males and females might change channels when given the chance.

prediction Identifying the factors that indicate when an event or events will occur.

Explanation Finally, **explanation** allows us to identify the causes that determine when and why a behavior occurs. In order to explain a behavior, we need to demonstrate that we can manipulate the factors needed to produce or eliminate the behavior. For example, in our channel-surfing example, if gender predicts channel-surfing, what might cause it? It could be genetic or environmental. Maybe males have less tolerance for commercials and thus channel-surf at a greater rate. Maybe females are more interested

explanation Identifying the causes that determine when and why a behavior occurs.

in the content of commercials and are thus less likely to change channels. Maybe the attention span of females is greater. Maybe something associated with having a Y chromosome increases channel-surfing, or something associated with having two X chromosomes leads to less channel-surfing. Obviously the possible explanations are numerous and varied. As scientists, we test these possibilities to identify the best explanation of why a behavior occurs. When we try to identify the best explanation for a behavior, we must systematically eliminate any alternative explanations. To eliminate alternative explanations, we must impose control over the research situation. We will discuss the concepts of control and alternative explanations shortly.

An Introduction to Research Methods in Science

The goals of science map very closely onto the research methods that scientists use. In other words, there are methods that are descriptive in nature, predictive in nature, and explanatory in nature. I will briefly introduce these methods here.

Descriptive Methods

observational method Making observations of human or other animal behavior.

Behavioral scientists use three types of descriptive methods. First is the **observational method**—simply making observations of human or other animal behavior. Scientists approach observation in two ways. *Naturalistic observation* involves observing humans or other animals behave in their natural habitat. Observing the mating behavior of chimpanzees in their natural setting would be an example of this approach. *Laboratory observation* involves observing behavior in a more contrived and controlled situation, usually the laboratory. Bringing children to a laboratory playroom to observe play behavior would be an example of this approach. Observation involves description at its most basic level. One advantage of the observational method, as well as other descriptive methods, is the flexibility to change what one is studying. A disadvantage of descriptive methods is that the researcher has little control. As we use more powerful methods, we gain control but lose flexibility.

case study method An in-depth study of one or more individuals.

A second descriptive method is the **case study method**. A case study is an in-depth study of one or more individuals. Freud used case studies to develop his theory of personality development. Similarly, Jean Piaget used case studies to develop his theory of cognitive development in children. This method is descriptive in nature, as it involves simply describing the individual(s) being studied.

survey method Questioning individuals on a topic or topics and then describing their responses.

The third method that relies on description is the **survey method**—questioning individuals on a topic or topics and describing their responses. Surveys can be administered by mail, over the phone, on the Internet, or as a personal interview. One advantage of the survey method over the other descriptive methods is that it allows researchers to study larger groups of individuals more easily. This method has disadvantages, however. One concern has to do with the wording of questions. Are they easy to understand? Are they written in such a manner that they bias the respondents' answers? Such concerns relate to the validity of the data collected. Another concern relevant to the survey method (and most other research methods) is whether the group of people who participate in the study (the **sample**) is representative of all the people about whom the study is meant to generalize (the **population**). This concern can usually be overcome through random sampling. A *random sample* is achieved when, through random selection, each member of the population is equally likely to be chosen as part of the sample.

sample The group of people who participate in a study.

population All of the people about whom a study is meant to generalize.

Predictive (Relational) Methods

Two methods allow researchers to not only describe behaviors but also predict from one variable to another. The first, the **correlational method,** assesses the degree of relationship between two measured variables. If two variables are correlated with each other, we can predict from one variable to the other with a certain degree of accuracy. For example, height and weight are correlated. The relationship is such that an increase in one variable (height) is generally accompanied by an increase in the other variable (weight). Knowing this, we can predict an individual's approximate weight, with a certain degree of accuracy, given the person's height.

correlational method A method that assesses the degree of relationship between two variables.

One problem with correlational research is that it is often misinterpreted. Frequently, people assume that because two variables are correlated, there must be some sort of causal relationship between the variables. This is not so. *Correlation does not imply causation.* Remember that a correlation simply means that the two variables are related in some way. For example, being a certain height does not cause you to also be a certain weight. It would be nice if it did, because then we would not have to worry about being either under- or overweight. What if I told you that watching violent TV and displaying aggressive behavior were correlated? What could you conclude based on this correlation? Many people might conclude that watching violent TV causes one to act more aggressively. Based on the evidence given (a correlational study), however, we cannot draw this conclusion. All we can conclude is that those who watch more violent television programs also tend to act more aggressively. It is possible that the violent TV causes aggression, but we cannot draw this conclusion based only on correlational data. It is also possible that those who are aggressive by nature are attracted to more violent television programs, or that some other variable is causing both aggressive behavior and violent TV watching. The point is that observing a correlation between two variables simply means that they are related to each other.

The correlation between height and weight, or violent TV and aggressive behavior, is a **positive relationship**: As one variable (height) increases, we observe an increase in the second variable (weight). Some correlations indicate a **negative relationship:** As one variable increases, the other variable systematically decreases. Can you think of an example of a negative

positive relationship A relationship between two variables in which an increase in one variable is accompanied by an increase in the other variable.

negative relationship A relationship between two variables in which an increase in one variable is accompanied by a decrease in the other variable.

relationship between two variables? Consider this: As mountain elevation increases, temperature decreases. Negative correlations also allow us to predict from one variable to another. If I know the mountain elevation, it will help me predict the approximate temperature.

quasi-experimental method Research that compares naturally occurring groups of individuals; the variable of interest cannot be manipulated.

Besides the correlational method, a second method that allows us to describe and predict is the **quasi-experimental method.** Quasi-experimental research allows us to compare naturally occurring groups of individuals. For example, we could examine whether alcohol consumption by students in a fraternity or sorority differs from that of students not in such organizations. You will see in a moment that this method differs from the experimental method, described below, in that the groups studied occur naturally. In other words, we do not assign people to join a Greek organization or not. They have chosen their groups on their own, and we are simply looking for differences (in this case, in the amount of alcohol typically consumed) between these naturally occurring groups. This is often referred to as a *subject* or *participant variable*—a characteristic inherent in the participants that cannot be changed. Because we are using groups that occur naturally, any differences that we find may be due to the variable of being a Greek member or not, or the differences may be due to other factors that we were unable to control in this study. For example, maybe those who like to drink more are also more likely to join a Greek organization. Once again, if we find a difference between these groups in amount of alcohol consumed, we can use this finding to predict what type of student (Greek or non-Greek) is likely to drink more. However, we cannot conclude that belonging to a Greek organization *causes* one to drink more because the participants came to us after choosing to belong to these organizations. In other words, what is missing when we use predictive methods such as the correlational and quasi-experimental methods is control.

When using predictive methods, we do not systematically manipulate the variables of interest; we only measure them. This means that, although we may observe a relationship between variables (such as that described between drinking and Greek membership), we cannot conclude that it is a causal relationship. Why? Because there could be other, *alternative explanations* for this relationship. An **alternative explanation** is the idea that it is possible that some other, uncontrolled, extraneous variable may be responsible for the observed relationship. For example, maybe those who choose to join Greek organizations come from higher-income families and have more money to spend on such things as alcohol. Or maybe those who choose to join Greek organizations are more interested in socialization and drinking alcohol before they even join the organization. Thus, because these methods leave the possibility for alternative explanations, we cannot use them to establish cause-and-effect relationships.

alternative explanation The idea that it is possible that some other, uncontrolled, extraneous variable may be responsible for the observed relationship.

Explanatory Method

experimental method A research method that allows a researcher to establish a cause-and-effect relationship through manipulation of a variable and control of the situation.

When using the experimental method, researchers pay a great deal of attention to eliminating alternative explanations by using the proper controls. Because of this, the **experimental method** allows researchers not only to describe and predict but also to determine whether there is a cause-and-effect relationship between the variables of interest. In other words, this method enables researchers to know when and why a behavior occurs. Many preconditions must be met in order for a study to be experimental in nature. Here, we will simply consider the basics—the minimum requirements needed for an experiment.

The basic premise of experimentation is that the researcher controls as much as possible in order to determine whether there is a cause-and-effect relationship between the variables being studied. Let's say, for example, that a researcher is interested in whether taking vitamin C supplements leads to fewer colds. The idea behind experimentation is that the researcher manipulates at least one variable (known as the **independent variable**) and measures at least one variable (known as the **dependent variable**). In our study, what should the researcher manipulate? If you identified amount of vitamin C, then you are correct. If amount of vitamin C is the independent variable, then number of colds is the dependent variable. For comparative purposes, the independent variable has to have at least two groups or conditions. We typically refer to these two groups or conditions as the control group and the experimental group. The **control group** is the group that serves as the baseline or "standard" condition. In our vitamin C study, the control group is the group that does not take vitamin C supplements. The **experimental group** is the group that receives the treatment—in this case, those who take vitamin C supplements. Thus, in an experiment, one thing that we control is the level of the independent variable that participants receive.

independent variable The variable in a study that is manipulated by the researcher.

dependent variable The variable in a study that is measured by the researcher.

control group The group of participants that does not receive any level of the independent variable and serves as the baseline in a study.

experimental group The group of participants that receives some level of the independent variable.

What else should we control to help eliminate alternative explanations? Well, we need to control the type of participants in each of the treatment conditions. We should begin by drawing a random sample of participants from the population. Once we have our sample of participants, we have to decide who will serve in the control group versus the experimental group. In order to gain as much control as possible, and eliminate as many alternative explanations as possible, we should use **random assignment**—assigning participants to conditions in such a way that every participant has an equal probability of being placed in any condition. How does random assignment help us to gain control and eliminate alternative explanations? By using random assignment we should minimize or eliminate differences between the groups. In other words, we want the two groups of participants to be as alike as possible. The only difference we want between the groups is that of the independent variable we are manipulating—amount of vitamin C. Once participants are assigned to conditions, we keep track of the number of colds they have over a specified time period (the dependent variable).

random assignment Assigning participants to conditions in such a way that every participant has an equal probability of being placed in any condition.

Let's review some of the controls we have used in the present study. We have controlled who is in the study (we want a sample representative of the population about whom we are trying to generalize), who participates in each group (we should randomly assign participants to the two conditions), and the treatment each group receives as part of the study (some take vitamin C supplements and some do not). Can you identify other variables that we might need to consider controlling in the present study? How about amount of sleep received each day, type of diet, and amount of exercise (all variables that might contribute to general health and well-being)? There are undoubtedly other variables we would need to control if we were to complete this study. The basic idea is that when using the experimental method, we try to **control** as much as possible by manipulating the independent variable and controlling any other extraneous variables that could affect the results of the study. Randomly assigning participants also helps to control for participant differences between the groups. What does all of this control gain us? If, after completing this study with the proper controls, we found that those in the experimental group (those who took vitamin C supplements) did in fact have fewer colds than those in the control group, we would have evidence supporting a cause-and-effect relationship between these variables. In other words, we could conclude that taking vitamin C supplements reduces the frequency of colds.

control Manipulating the independent variable in an experiment or any other extraneous variables that could affect the results of a study.

IN REVIEW

AN INTRODUCTION TO RESEARCH METHODS

Goal Met	Research Methods	Advantages/Disadvantages
Description	Observational method	Descriptive methods allow description of behavior(s)
	Case study method	Descriptive methods do not support reliable predictions
	Survey method	Descriptive methods do not support cause-and-effect explanations
Prediction	Correlational method	Predictive methods allow description of behavior(s)
	Quasi-experimental method	Predictive methods support reliable predictions from one variable to another
		Predictive methods do not support cause-and-effect explanations
Explanation	Experimental method	Allows description of behavior(s)
		Supports reliable predictions from one variable to another
		Supports cause-and-effect explanations

CRITICAL THINKING CHECK 1.1

1. In a recent study, researchers found a negative correlation between income level and incidence of psychological disorders. Jim thinks this means that being poor leads to psychological disorders. Is he correct in his conclusion? Why or why not?
2. In a study designed to assess the effects of exercise on life satisfaction, participants were assigned to groups based on whether they reported exercising or not. All participants then completed a life satisfaction inventory.
   a. What is the independent variable?
   b. What is the dependent variable?
   c. Is the independent variable a participant variable or a true manipulated variable?

3. What type of method would you recommend researchers use to answer the following questions?
   a. What percentage of cars runs red lights?
   b. Do student athletes spend as much time studying as student nonathletes?
   c. Is there a relationship between type of punishment used by parents and aggressiveness in children?
   d. Do athletes who are randomly assigned to a group using imagery techniques perform better than those who are randomly assigned to a group not using such techniques?

Doing Science

Although the experimental method can establish a cause-and-effect relationship, most researchers would not wholeheartedly accept a conclusion from only one study. Why is that? Any one of a number of problems can occur in a study. For example, there may be control problems. Researchers may believe they have controlled for everything but miss something, and the uncontrolled factor may affect the results. In other words, a researcher may believe that the manipulated independent variable caused the results when, in reality, it was something else.

Another reason for caution in interpreting experimental results is that a study may be limited by the technical equipment available at the time. For example, in the early part of the 19th century, many scientists believed that studying the bumps on a person's head allowed them to know something about the internal mind of the individual being studied. This movement, known as phrenology, was popularized through the writings of physician Joseph Gall (1758–1828). At the time that it was popular, phrenology appeared very "scientific" and "technical." With hindsight and with the technological advances that we have today, the idea of phrenology seems laughable to us now.

Finally, we cannot completely rely on the findings of one study because a single study cannot tell us everything about a theory. The idea of science is that it is not static; the theories generated through science change. For example, we often hear about new findings in the medical field, such as "Eggs are so high in cholesterol that you should eat no more than two a week." Then, a couple of years later, we might read "Eggs are not as bad for you as originally thought. New research shows that it is acceptable to eat them every day." You may have heard people confronted with such contradictory findings complain, "Those doctors, they don't know what they're talking about. You can't believe any of them. First they say one thing, and then they say completely the opposite. It's best to just ignore all of them." The point is that when testing a theory scientifically, we may obtain contradictory results. These contradictions may lead to new, very valuable information that subsequently leads to a theoretical