CHAPTER 5

The Hypothesis in Quantitative Research

A hypothesis transforms a general idea into a plan for what to look for.

INSTRUCTIONAL OBJECTIVES

After studying this chapter, the student will be able to:

1. Define *hypothesis*.
2. Describe the purposes of the hypothesis(es) in quantitative and qualitative research.
3. List the criteria of a theory useful for a research study.
4. Distinguish between an inductive and a deductive hypothesis.
5. State the criteria used to evaluate hypotheses for research.
6. Define *operational definition* and give an example.
7. Identify a testable hypothesis from given examples.
8. Define *null hypothesis* and explain its purpose in a research study.
9. Write a research hypothesis and a null hypothesis for a research study.
10. Distinguish between a directional and a nondirectional hypothesis.
11. Describe the steps in testing a hypothesis.
12. State the purpose of the research plan and list the elements to be included.
13. State the purpose of a pilot study.

After stating the research question and examining the literature, the quantitative researcher is ready to state a **hypothesis** based on the question.* This should be done before beginning the research project. Recall that the quantitative problem asks about the relationship between two (or more) variables. The hypothesis presents the researcher's expectations about the relationship between variables within the question. Hence, it is put forth as a suggested answer to the question, with the understanding that the ensuing investigation may lead to either support for the hypothesis or lack of support for it. Note that we use the word *support*, not *prove*. Research may find support for a hypothesis, but it does not prove a hypothesis.

*The role of the hypothesis in qualitative research is discussed in Chapter 15.

A researcher might ask the question, "What is the effect of preschool training on the first-grade achievement of culturally disadvantaged children?" The hypothesis would read "Culturally disadvantaged children who have had preschool training achieve at a higher level in first grade than culturally disadvantaged children who have not had preschool training." You can see that the hypothesis related the variables of preschool training and first-grade achievement. The following are additional examples of hypotheses in educational research:

1. Boys in elementary school achieve at a higher level in single-sex classes than in mixed classes.
2. Students who complete a unit on problem-solving strategies will score higher on a standardized mathematics test than those who have completed a control unit.
3. Middle school students who have previously taken music lessons will have higher math aptitude scores.
4. Middle school students who have siblings will be more popular among their peers than students who do not have siblings.
5. Students who do warm-up exercises before an examination will score higher on that examination than those who do not.
6. Elementary school children who do not get adequate sleep will perform at a lower level academically than will their peers who have adequate sleep.

Although hypotheses serve several important purposes, some research studies may proceed without them. Hypotheses are tools in the research process, not ends in themselves. Studies are often undertaken in areas in which there is little accumulated background information. A researcher may not know what outcome to predict. For example, surveys that seek to describe the characteristics of particular phenomena, or to ascertain the attitudes and opinions of groups, often proceed without hypotheses.

Two reasons for stating a hypothesis before the data-gathering phase of a quantitative study are (1) a well-grounded hypothesis indicates that the researcher has sufficient knowledge in the area to undertake the investigation, and (2) the hypothesis gives direction to the collection and interpretation of the data; it tells the researcher what procedure to follow and what type of data to gather and thus may prevent a great deal of wasted time and effort on the part of the researcher.

PURPOSES OF THE HYPOTHESIS IN QUANTITATIVE RESEARCH

Principal purposes served by the hypothesis include the following:

1. *The hypothesis brings together information to enable the researcher to make a tentative statement about how the variables in the study may be related*. By integrating information based on experience, related research, and theory, the researcher states the hypothesis that provides the most satisfactory prediction or the best solution to a problem.

2. *Because hypotheses propose tentative explanations for phenomena, they stimulate a research endeavor that results in the accumulation of new knowledge*. Hypothesis testing research permits investigators to validate or fail to validate theory through an accumulation of data from many studies. In this way, knowledge is extended.
3. *The hypothesis provides the investigator with a relational statement that is directly testable in a research study*. That is, it is possible to collect and analyze data that will confirm or fail to confirm the hypothesis. Questions cannot be tested directly. An investigation begins with a question, but only the proposed relationship between the variables can be tested. For instance, you do not test the question, "Do teachers' written comments on students' papers result in an improvement in student performance?" Instead, you test the hypothesis that the question implies: "Teachers' written comments on students' papers result in a meaningful improvement in student performance" or, specifically, "The performance scores of students who have had written teacher comments on previous papers will exceed those of students who have not had written teacher comments on previous papers." You then proceed to gather data about the relationship between the two variables (teachers' written comments and student performance).
4. *The hypothesis provides direction to the research*. The hypothesis posits a specific relationship between variables and thus determines the nature of the data needed to test the proposition. Very simply, the hypothesis tells the researcher what to do. Facts must be selected and observations made because they have relevance to a particular question, and the hypothesis determines the relevance of these facts. The hypothesis provides a basis for selecting the sampling, measurement, and research procedures to use, as well as the appropriate statistical analysis. Furthermore, the hypothesis helps keep the study restricted in scope, preventing it from becoming too broad or unwieldy.

   For example, consider again the hypothesis concerning preschool experience of culturally disadvantaged children and their achievement in first grade. This hypothesis indicates the research method required and the sample, and it even directs the researcher to the statistical test that would be necessary for analyzing the data. It is clear from the statement of the hypothesis that the researcher will conduct an ex post facto study that compares the first-grade achievement of a sample of culturally disadvantaged children who went through a preschool program and a similar group of disadvantaged children who did not have preschool experience. Any difference in the mean achievement of the two groups could be analyzed for statistical significance by the t test or analysis of variance technique. (We discuss these procedures in Chapter 7.)
5. *The hypothesis provides a framework for reporting the findings and conclusions of the study*. The researcher will find it very convenient to take each hypothesis separately and state the conclusions that are relevant to it; that is, the researcher can organize this section of the written report around the provision of answers to the original hypotheses, thereby making a more meaningful and readable presentation.

SUGGESTIONS FOR DERIVING HYPOTHESES

As explained in Chapter 3, a study might originate in a practical problem, in some observed behavioral situation in need of explanation, in previous research, or even more profitably in some educational, psychological, or sociological theory. Thus, researchers derive hypotheses inductively from observations of behavior or deductively from theory or from the findings of previous research. Induction and deduction are complementary processes. In induction, one starts with specific observations and reaches general conclusions; in deduction, one begins with generalizations and makes specific predictions.

DERIVING HYPOTHESES INDUCTIVELY

In the inductive procedure, the researcher formulates an **inductive hypothesis** as a generalization from apparent observed relationships; that is, the researcher observes behavior, notices trends or probable relationships, and then hypothesizes an explanation for this observed behavior. This reasoning process should be accompanied by an examination of previous research to determine what findings other investigators have reported on the question.

The inductive procedure is a particularly fruitful source of hypotheses for classroom teachers. Teachers observe learning and other student behavior every day and try to relate it to their own behavior, to the behavior of other students, to the teaching methods used, to changes in the school environment, and so on. Teachers might observe, for example, that when they present particularly challenging activities in the classroom, some students get motivated and really blossom, whereas others withdraw from the challenge. Some students learn complex concepts best from primarily verbal presentations (lectures), whereas others learn best from discussions and hands-on activities. After reflecting on such experiences, teachers may inductively formulate generalizations that seek to explain the observed relationship between their methods and materials and students' learning. These tentative explanations of why things happen as they do can become the hypotheses in empirical investigations.

Perhaps a teacher has observed that classroom tests arouse a high degree of anxiety and believes this adversely affects student performance. Furthermore, the teacher has noted that when students have an opportunity to write comments about objective questions, their test performance seems to improve. The teacher reasons that this freedom to make comments must somehow reduce anxiety and, as a result, the students score better. This observation suggests a hypothesis: Students who are encouraged to write comments about test items on their answer sheets will achieve higher test scores than students who have no opportunity to make comments.

The teacher could then design an experiment to test this hypothesis. Note that the hypothesis expresses the teacher's belief concerning the relationship between the two variables (writing or not writing comments about test items and performance on the test). Note also that the variable *anxiety* that was part of the reasoning chain leading to the hypothesis is not part of the final hypothesis. Therefore, the results of the investigation would provide information concerning only the relation between writing comments and test performance. The relationships between anxiety and comments, and anxiety and test performance, could

be subjects for subsequent hypotheses to investigate. Frequently, an original idea involves a series of relationships that you cannot directly observe. You then reformulate the question to focus on relationships that are amenable to direct observation and measurement.

The following are additional examples of hypotheses that might be arrived at inductively from a teacher's observations:

- Students' learning of computer programming in the middle grades increases their development of logical thinking skills.
- Using advance organizers increases high school students' learning from computer-assisted instruction in chemistry.
- Students trained to write summaries of a lecture will perform better on an immediate posttest on lecture comprehension than will students who simply take notes.
- Children score higher on final measures of first-grade reading achievement when they are taught in small groups rather than large groups.
- The cognitive and affective development of first-grade children is influenced by the amount of prior preschool experience.
- After-school tutoring programs increase the achievement of at-risk students.

In the inductive process, the researcher makes observations, thinks about the problem, turns to the literature for clues, makes additional observations, and then formulates a hypothesis that seeks to account for the observed behavior. The researcher (or teacher) then tests the hypothesis under controlled conditions to examine scientifically the assumption concerning the relationship between the specified variables.

DERIVING HYPOTHESES DEDUCTIVELY

In contrast to hypotheses formulated as generalizations from observed relationships, some others are derived by deduction from **theory.** These hypotheses have the advantage of leading to a more general system of knowledge because the framework for incorporating them meaningfully into the body of knowledge already exists within the theory. A science cannot develop efficiently if each study results in an isolated bit of knowledge. It becomes cumulative by building on the existing body of facts and theories. A hypothesis derived from a theory is known as a **deductive hypothesis.**

After choosing a theory of interest, you use deductive reasoning to arrive at the logical consequences of the theory. If A is true, then we would expect B to follow. These deductions then become the hypotheses in the research study. For example, social comparison theory suggests that students form academic self-concepts by comparing their self-perceived academic accomplishments to some standard or frame of reference. The frame of reference for most students would be the perceived academic abilities of their classmates. If this is true, then one might hypothesize that gifted students would have lower academic self-concepts if they were placed in selective homogeneous groups than if they were in heterogeneous or mixed-ability groups in which they compare themselves to less able students.

One could investigate this hypothesis by examining the change over time in the academic self-concept of gifted students in homogeneous classes compared to that of matched gifted students placed in regular, heterogeneous classes. The evidence gathered will support, contradict, or possibly lead to a revision of social comparison theory.

Another useful theory from which an educational researcher might make deductions is Piaget's classic theory on the development of logical thinking in children. Piaget (1968) suggested that children pass through various stages in their mental development, including the stage of concrete operations, which begins at age 7 or 8 years and marks the transition from dependence on perception to an ability to use some logical operations. These operations are on a concrete level but do involve symbolic reasoning. Using this theory as a starting point, you might therefore hypothesize that the proportion of 9-year-old children who will be able to answer correctly the transitive inference problem, "Frank is taller than George; George is taller than Robert; who is the tallest?" will be greater than the proportion of 6-year-olds who are able to answer it correctly. Such research has implications for the importance of determining students' cognitive capabilities and structuring educational tasks that are compatible with their developmental level.

Piaget's cognitive theory also emphasizes that learning is a highly active process in which learners must construct knowledge. This tenet that knowledge must be constructed by learners rather than simply being ingested from teachers is the basis for much of the research on discovery-oriented and cooperative learning.

In a study designed to test a deduction from a theory, it is extremely important to check for any logical gaps between theory and hypothesis. The researcher must ask, "Does the hypothesis logically follow from the theory?" If the hypothesis does not really follow from the theory, then the researcher cannot reach valid conclusions about the adequacy of the theory. If the hypothesis is supported but was not rigorously deduced from the theory, the researcher cannot say that the findings furnish credibility to the theory. Table 5.1 shows propositions from some well-known theories and a hypothesis based on each theory.

CHARACTERISTICS OF A USABLE HYPOTHESIS

After tentatively formulating the hypothesis, but before attempting any actual empirical testing, you must evaluate the hypothesis. The final worth of a hypothesis cannot be judged prior to empirical testing, but there are certain useful criteria for evaluating hypotheses.

A HYPOTHESIS STATES THE EXPECTED RELATIONSHIP BETWEEN VARIABLES

A hypothesis should conjecture the relationship between two or more variables. For example, suppose you attempt to start your car and nothing happens. It would be unprofitable to state, "The car will not start and it has a wiring system," because no relationship between variables is specified, and so there is

Table 5.1 Well-Known Theories and a Hypothesis Based on Each Theory

Theory	Hypothesis
Achievement motivation (McClelland, 1953) People have a tendency to strive for success and to choose goal-oriented, success/failure activities.	There is a positive relationship between achievement motivation and success in school.
Attribution theory (Weiner, 1994) People attempt to maintain a positive self-image; people explain their success or failure in a way that preserves their self-image.	If students are given a task and told that they failed or succeeded (even though all actually succeed), those who are told they failed say it is due to bad luck; those who are told they are successful will attribute it to skill and intelligence.
Theory of multiple intelligences (Gardner, 1993) People have a number of separate intelligences that may vary in strength.	Teaching science concepts using a variety of approaches will result in greater achievement than when using only linguistic and mathematical approaches.
Cognitive dissonance theory (Festinger, 1957) People experience discomfort when a new behavior clashes with a long-held belief or with their self-image. To resolve the discomfort, they may change their beliefs or behavior.	Requiring middle school students who smoke to write an essay on why young people should not smoke will change their attitudes about smoking.
Vygotsky's theory of learning (1978) Cognitive development is strongly linked to input from other people.	Tutoring by more able peers will have a positive effect on the learning of at-risk students.
Maslow's human needs theory (1954). In a hierarchy of needs, people must satisfy their lower level needs (hunger or safety) before they are motivated to satisfy higher level needs (self-esteem or need to know).	Children from economically disadvantaged homes who are given breakfast at school will show higher achievement than similar students not given breakfast.
Behaviorism (Skinner, 1953) Behavior that is positively reinforced will increase in strength.	On-task behavior will increase when teachers positively reinforce it.

no proposed relationship to test. A fruitful hypothesis would be "The car will not start because of a fault in the wiring system." This criterion may seem patently obvious, but consider the following statement: "If children differ from one another in self-concept, they will differ from one another in social studies achievement." The statement appears to be a hypothesis until you note that there is no statement of an expected relationship. An expected relationship could be described as "Higher self-concept is a likely antecedent to higher social studies achievement." This hypothesis would then be stated as "There will be a positive relationship between self-concept and social studies achievement." If the opposite is predicted—that is, higher self-concept leads to lower social studies achievement—then the hypothesis would be "There will be a negative relationship between self-concept and social studies achievement." Either statement would meet this first criterion.

A HYPOTHESIS MUST BE TESTABLE

The most important characteristic of a "good" hypothesis is testability. A **testable hypothesis** is verifiable; that is, deductions, conclusions, or inferences can be drawn from the hypothesis in such a way that empirical observations either support or do not support the hypothesis. If the hypothesis is on target, then

certain predictable results should be manifest. A testable hypothesis enables the researcher to determine by observation and data collection whether consequences that are deductively implied actually occur. Otherwise, it would be impossible either to confirm or not to confirm the hypothesis. In the preceding example, the hypothesis "The car's failure to start is a punishment for my sins" is obviously untestable in this world.

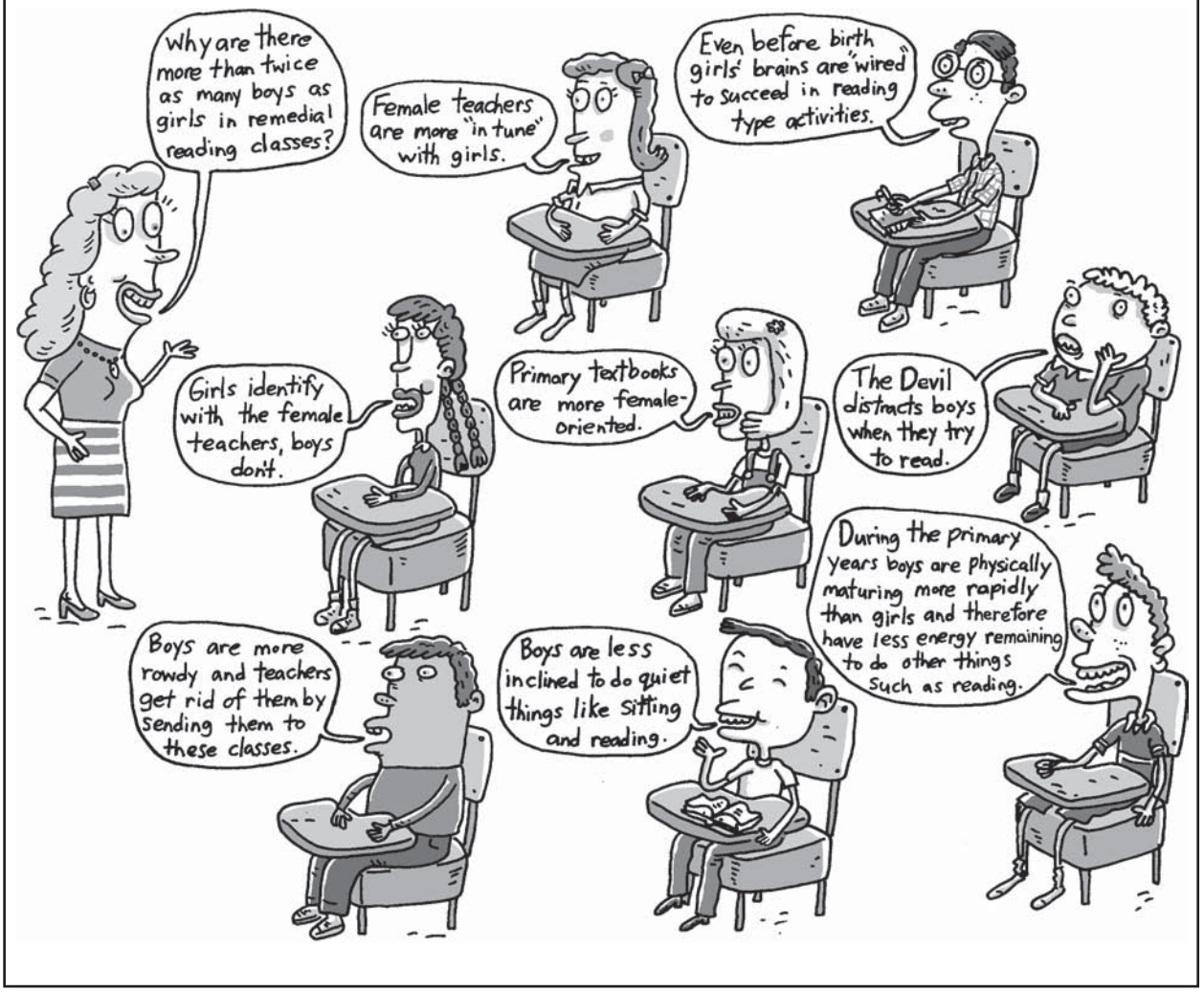
Many hypotheses—or propositions, as they may initially be stated—are essentially untestable. For instance, the hypothesis "Preschool experience promotes the all-around adjustment of the preschool child" would be difficult to test because of the difficulty of operationalizing and measuring "all-around adjustment." To be testable, a hypothesis must relate variables that can be measured. If no means are available for measuring the variables, then no one could gather the data necessary to test the validity of the hypothesis. We cannot emphasize this point too strongly. Unless you can specifically define the indicators of each variable and subsequently can measure these variables, you cannot test the hypothesis.

The indicators of the variables are referred to as **operational definitions.** Recall from Chapter 2 that variables are operationally defined by specifying the steps the investigator takes to measure the variable. Consider the hypothesis "High-stressed nursing students will perform less well on a nursing test than will low-stressed students." The operational definition of stress is as follows: One group of students is told that their performance on the nursing test will be a major determinant of whether they will remain in the nursing program (high stress), and the other group is told that they need to do as well as they can but that their scores will not be reported to the faculty or have any influence on their grades (low stress). The operational definition of test performance would be scores from a rating scale that assessed how well the students did on the various tasks making up the test. Or consider the following hypothesis: "There is a positive relationship between a child's self-esteem and his or her reading achievement in first grade." For this hypothesis to be testable, you must define the variables operationally. You might define *self-esteem* as the scores obtained on the Self-Image Profile for Children (Butler, 2001) and reading achievement as scores on the California Reading Test, or as first-grade teachers' ratings of reading achievement.

Make sure the variables can be given operational definitions. Avoid the use of constructs for which it would be difficult or impossible to find adequate measures. Constructs such as *creativity*, *authoritarianism*, and *democracy* have acquired such diverse meanings that reaching agreement on operational definitions of such concepts would be difficult, if not impossible. Remember that the variables must be defined in terms of identifiable and observable behavior.

It is important to avoid value statements in hypotheses. The statement "A counseling program in the elementary school is desirable" cannot be investigated in an empirical study because "desirable" is too vague to be measured. However, you could test the hypothesis "Elementary pupils who have had counseling will have higher scores on a measure of expressed satisfaction with school than will those who have not had counseling." You can measure verbal expressions of satisfaction, but whether they are desirable is a value judgment.

PICTURE THIS



Joe Rocco

Think About It 5.1

Which of the explanations in the cartoon are not testable hypotheses about why there are more boys than girls in remedial reading classes?

Answer

The one about the "wiring" in the brain and the one about the devil's activities are not testable.

A HYPOTHESIS SHOULD BE CONSISTENT WITH THE EXISTING BODY OF KNOWLEDGE

Hypotheses should not contradict previously well-established knowledge. The hypothesis "My car will not start because the fluid in the battery has changed to gold" satisfies the first two criteria but is so contrary to what is known about the

nature of matter that you would not pursue it. The hypothesis "The car will not start because the fluid in the battery has evaporated to a low level" is consistent with previous knowledge and therefore is worth pursuing. It would probably be unprofitable to hypothesize an *absence* of relationship between the self-concept of adolescent boys and girls and their rate of physical growth because the preponderance of evidence supports the *presence* of such a relationship. Historians of science find that people such as Einstein, Newton, Darwin, and Copernicus developed truly revolutionary hypotheses that conflicted with what was accepted knowledge in their time. However, remember that the work of such pioneers was not really so much a denial of previous knowledge as a reorganization of existing knowledge into more satisfactory theory. In most cases, and especially for the beginning researcher, it is safe to suggest that the hypothesis should agree with knowledge already well established in the field. Again, this highlights the necessity for a thorough review of the literature so that hypotheses are formulated on the basis of previously reported research in the area.

A HYPOTHESIS SHOULD BE STATED AS SIMPLY AND CONCISELY AS POSSIBLE

A hypothesis should be presented in the form of a concise declarative statement. A complete and concisely stated hypothesis makes clear what the researcher needs to do to test it. It also provides the framework for presenting the findings of the study. If a researcher is exploring more than one relationship, he or she will need to state more than one hypothesis. The general rule is to state only one relationship in any one hypothesis. For example, if you were investigating the effect of a new teaching method on student achievement and student satisfaction, you would state two hypotheses—one for effect on achievement and one for effect on satisfaction. You need not worry about the verbal redundancy inevitable in stating multiple hypotheses. Remember that the goals of testability and clarity will be served better by more specific hypotheses.

Think About It 5.2

Which of the explanations used to explain the greater number of boys in remedial reading in the previous cartoon is not consistent with the existing body of knowledge?

Answer

The one that posits that in the primary grades boys mature more rapidly than girls. There is overwhelming evidence that at that stage girls mature more rapidly than boys. Boys finally catch up at approximately age 17 years.

The terms used in the hypothesis should be the simplest acceptable for conveying the intended meaning; avoid ambiguous or vague constructs. Use terms in the way that is generally accepted for referring to the phenomenon. When two hypotheses are of equal explanatory power, prefer the simpler one because it will provide the necessary explanation with fewer assumptions and variables to be defined. Remember that this principle of parsimony is important in evaluating hypotheses.

TYPES OF HYPOTHESES

There are three categories of hypotheses: research, null, and alternate.

THE RESEARCH HYPOTHESIS

The hypotheses we have discussed thus far are called **research hypotheses.** They are the hypotheses developed from observation, the related literature, and/or the theory described in the study. A research hypothesis states the relationship one expects to find as a result of the research. It may be a statement about the expected relationship or the expected *difference* between the variables in the study. A hypothesis about children's IQs and anxiety in the classroom could be stated "There is a positive relationship between IQ and anxiety in elementary schoolchildren" or "Children classified as having high IQs will exhibit more anxiety in the classroom than children classified as having low IQs." Research hypotheses may be stated in a **directional** or **nondirectional** form. A directional hypothesis states the direction of the predicted relationship or difference between the variables. The preceding two hypotheses about IQ and anxiety are directional. A directional hypothesis is stated when one has some basis for predicting a change in the stated direction. A nondirectional hypothesis, in contrast, states that a relationship or difference exists but without specifying the direction or nature of the expected finding—for example, "There is a relationship between IQ and anxiety in children." The literature review generally provides the basis for stating a research hypothesis as directional or nondirectional.

THE NULL HYPOTHESIS

It is impossible to test research hypotheses directly. You must first state a **null hypothesis** (symbolized H_0) and assess the probability that this null hypothesis is true. The null hypothesis is a statistical hypothesis. It is called the null hypothesis because it states that there is no relationship between the variables in the population. A null hypothesis states a negation (not the reverse) of what the experimenter expects or predicts. A researcher may hope to show that after an experimental treatment, two populations will have different means, but the null hypothesis would state that after the treatment the populations' means will *not* be different.

What is the point of the null hypothesis? A null hypothesis lets researchers assess whether apparent relationships are genuine or are likely to be a function of chance alone. It states, "The results of this study could easily have happened by chance." Statistical tests are used to determine the probability that the null hypothesis is true. If the tests indicate that observed relationships had only a slight probability of occurring by chance, the null hypothesis becomes an unlikely explanation and the researcher rejects it. Researchers aim to reject the null hypothesis as they try to show there *is* a relationship between the variables of the study. Testing a null hypothesis is analogous to the prosecutor's work in a criminal trial. To establish guilt, the prosecutor (in the U.S. legal system) must provide sufficient evidence to enable a jury to reject the presumption of innocence beyond reasonable doubt. It is not possible for a prosecutor to prove guilt conclusively, nor can a researcher obtain unequivocal support for a research hypothesis. The defendant is presumed innocent until sufficient evidence indicates that he or she is not, and the null hypothesis is presumed true until sufficient evidence indicates otherwise.

For example, you might start with the expectation that children will exhibit greater mastery of mathematical concepts through individual instruction than through group instruction. In other words, you are positing a relationship between the independent variable (method of instruction) and the dependent variable (mastery of mathematical concepts). The research hypothesis is "Students taught through individual instruction will exhibit greater mastery of mathematical concepts than students taught through group instruction." The null hypothesis, the statement of no relationship between variables, will read "The mean mastery scores (population mean μ_i) of all students taught by individual instruction will equal the mean mastery scores (population mean μ_g) of all those taught by group instruction." H_0: $\mu_i = \mu_g$.*

THE ALTERNATIVE HYPOTHESIS

Note that the hypothesis "Children taught by individual instruction will exhibit less mastery of mathematical concepts than those taught by group instruction" posits a relationship between variables and therefore is *not* a null hypothesis. It is an example of an **alternative hypothesis.**

In the example, if the sample mean of the measure of mastery of mathematical concepts is higher for the individual instruction students than for the group instruction students, and inferential statistics indicate that the null hypothesis is unlikely to be true, you reject the null hypothesis and tentatively conclude that individual instruction results in greater mastery of mathematical concepts than does group instruction. If, in contrast, the mean for the group instruction students is higher than the mean for the individual instruction students, and inferential statistics indicate that this difference is not likely to be a function of chance, then you tentatively conclude that group instruction is superior.

If inferential statistics indicate that observed differences between the means of the two instructional groups could easily be a function of chance, the null hypothesis is retained, and you decide that insufficient evidence exists for concluding there is a relationship between the dependent and independent variables. The retention of a null hypothesis is *not* positive evidence that the null hypothesis is true. It indicates that the evidence is insufficient and that the null hypothesis, the research hypothesis, and the alternative hypothesis are all possible.

TESTING THE HYPOTHESIS

A quantitative study begins with a research hypothesis, which should be a simple, clear statement of the expected relationship between the variables. Previously, we explained that hypotheses must be testable—that is, amenable to empirical verification. When researchers speak of testing a hypothesis, however, they are referring to the null hypothesis. Only the null hypothesis can be directly tested by statistical procedures. **Hypothesis testing** involves the following steps:

1. State, in operational terms, the relationships that should be observed if the research hypothesis is true.
2. State the null hypothesis.

*The Greek letter mu, μ, is used to symbolize population mean.

3. Select a research method that will enable the hypothesized relationship to be observed if it is there.
4. Gather the empirical data and select and calculate appropriate descriptive statistics for these data (see Chapter 6).
5. Calculate inferential statistics to determine the probability that your obtained results could have occurred by chance when the null hypothesis is true (see Chapter 7).
6. If the probability of the observed findings being due to chance is very small (e.g., only 1 in 100 chances), one would have sufficient evidence to reject the null hypothesis.

Many hypotheses that are formulated are rejected after empirical testing. Their predictions are not supported by the data. Many beginning researchers believe that if the data they collect do not support their hypothesis, then their study is a failure. This is not the case. In the history of scientific research, hypotheses that failed to be supported have greatly outnumbered those that have been supported. Experienced researchers realize that unconfirmed hypotheses are an expected and useful part of the scientific experience. They can lead to reconsideration or revision of theory and the generation of new hypotheses, which often brings science closer to a correct explanation of the state of affairs. Darwin (1887/2007) wrote,

> I have steadily endeavored to keep my mind free so as to give up any hypothesis, however much beloved (and I cannot resist forming one on every subject), as soon as facts are shown to be opposed to it. Indeed, I have had no choice but to act in this manner, for with the exception of the Coral Reefs, I cannot remember a single first-formed hypothesis which had not after a time to be given up or greatly modified. (p. 293)

Although you may find support for a hypothesis, the hypothesis is not *proved* to be true. A hypothesis is never proved or disproved; it is only supported or not supported. Hypotheses are essentially probabilistic in nature; empirical evidence can lead you to conclude that the explanation is probably true or that it is reasonable to accept the hypothesis, but it never proves the hypothesis.

CLASSROOM EXAMPLE OF TESTING A HYPOTHESIS

A teacher is interested in investigating reinforcement theory in the classroom. From her understanding of reinforcement theory, this teacher hypothesizes that teachers' positive comments on students' papers will lead to greater achievement.

Step 1. The deduced implication is stated as follows: "Teachers' positive comments on students' papers during a specified unit will result in higher scores on the end-of-unit test for those students, compared with students who received no comments." It is the relationship between the two variables—teachers' positive comments and pupil performance on the end-of-unit test—that will be investigated.

Step 2. For statistical testing, the research hypothesis must be transformed into a null hypothesis: "The population mean achievement score for students receiving positive comments (experimental group) will be the same as the population mean achievement score for students receiving no comments (control group)."

Step 3. After getting permission from parents or guardians for the children to participate, the teacher would select students to be randomly assigned to the experimental and control groups. For those students in the experimental group, she would write positive comments on their papers, whereas the students assigned to the control group would receive no comments. The comments to the experimental group should simply be words of encouragement, such as "Excellent," "Keep up the good work," or "You're doing better." These comments should have nothing to do with content or the correction of particular errors; otherwise, any improvement could be attributed to the instructional usefulness of such comments.

Step 4. After completing the specified unit, the teacher would administer a common end-of-unit test to both groups and derive average (mean) achievement scores on the test for each group.

Step 5. Inferential statistics can then be used to indicate whether any difference in mean achievement scores is real or is likely to be merely a function of chance. If the difference is not likely to be a function of chance, the researcher tentatively concludes that it results from the different treatments given to the two groups.

THE QUANTITATIVE RESEARCH PLAN

After identifying a worthwhile problem and stating the expected outcome in the form of a research hypothesis, you are ready to develop a tentative **research plan.** The research plan at this stage is only a preliminary proposal; many changes will probably be needed before the final, formal proposal is written. Developing this tentative research plan is essential because it forces you to set down ideas in a concrete form. Many initial ideas seem promising until you must spell them out in black and white; then the difficulties or the inadequacies become obvious.

Another advantage of a written plan is that you can give it to others for their comments and criticism. In a research methods class, for example, the professor would certainly need to see what research students are planning. The director of a thesis or dissertation would want to see a written plan rather early in the process. It is much easier for another person to detect flaws and problems in a proposal that is written out than in one communicated orally. Another point to keep in mind is that the more complete and detailed the initial proposal, the more useful it will be to the researcher and the more time may be saved later.

A research plan should include the following elements: the problem, the hypothesis, the research methodology, and proposed data analysis. The following list briefly describes each component:

1. *Problem*. The plan begins with a clear statement of the research problem. A quantitative problem asks about the relationship between specified variables. Include the rationale for the study and a brief description of the background of the problem in theory and/or related research.
2. *Hypothesis*. A quantitative question is followed by a concise statement of the research hypothesis. Provide operational definitions of the variables.

3. *Methodology*. This section explains how you will conduct the study. Include the proposed research design, the population of concern, the sampling procedure, the measuring instruments, and any other information relevant to the conduct of the study.
4. *Data analysis*. Indicate how you will analyze the data to test the hypothesis and/or answer the research question. Beginning quantitative researchers may find it difficult to write this section because they are not yet familiar with statistics. You might look at the related literature to determine what type of statistical analysis other researchers used, or you might consult with your professor or an expert in statistics.

Think About It 5.3

State a hypothesis to test the notion that teachers assign rowdy students to remedial reading classes to get rid of them. State the null hypothesis and list the steps for testing it.

Answer

1. Research hypothesis: Students assessed as rowdy on a behavioral assessment scale are more often assigned to remedial reading classes than are nonrowdy students with equivalent reading skills as measured on the California Achievement Test.
2. Null hypothesis: Rowdy and nonrowdy students with the same reading skills are equally likely to be assigned to remedial reading classes.
3. Administer the Reading subtest of the California Achievement Test to all students. Match students in remedial reading classes with students with the same reading skills who are in regular classes. Use a behavioral assessment scale to identify which students are rowdy and which are not.
4. Calculate the proportion of rowdy and nonrowdy students in remedial reading classes and the proportion of rowdy and nonrowdy students in regular classes.
5. Test the null hypothesis by using a statistical test to determine if the difference in the proportions could easily be a function of chance alone.

THE PILOT STUDY

After the tentative research plan is approved, it may be helpful to try out the proposed procedures on a few participants. This trial run, or **pilot study,** will help the researcher to decide whether the study is feasible and whether it is worthwhile to continue. At this point, one can ask a colleague to check one's procedures for any obvious flaws. The pilot study provides the opportunity to assess the appropriateness of the data-collection methods and other procedures and to make changes if necessary. It also permits a preliminary testing of the hypothesis, which may give some indication of its tenability and suggest whether further refinement is needed.

Unanticipated problems that appear can be solved at this stage, thereby saving time and effort later. A pilot study is well worth the time required and is especially recommended for the beginning researcher.

SUMMARY

To proceed with the confirmatory phase of a quantitative research study, it is important to have one or more clearly stated hypotheses. The hypothesis is a powerful tool in scientific inquiry. It enables researchers to relate theory to observation and observation to theory. Hypotheses enable researchers, in the search for knowledge, to employ both the ideas of the inductive philosophers, with their emphasis on observation, and the logic of the deductive philosophers, with their emphasis on reason.

The hypothesis is the researcher's prediction about the outcome of the study. Hypotheses are derived inductively from observation or deductively from a known theory. Experience and knowledge in an area and familiarity with previous research are important factors in formulating a satisfactory hypothesis.

The hypothesis serves multiple functions in research. It provides direction to the researcher's efforts because it determines the research method and the type of data relevant to the solution of the problem. It also provides a framework for interpreting the results and for stating the conclusions of the study.

A good hypothesis must satisfy certain criteria. It must be testable, which means that it is possible to gather evidence that will either support or fail to support the hypothesis. It must agree with the preponderance of existing data. It must be stated as clearly and concisely as possible. Also, it must state the expected relationship between variables that can be measured.

Once formulated and evaluated in terms of these criteria, the research hypothesis is ready to be subjected to an empirical test. The researcher also states a null hypothesis—the negation of what the researcher expects—which is important in the statistical analysis of the findings. It is important to remember that a research hypothesis cannot be proved or disproved, only supported or not supported. Even if it is not supported, a hypothesis may still serve a useful purpose because it can lead the researcher to reevaluate rationale and procedures and to consider other approaches to the problem.

KEY CONCEPTS

alternative hypothesis
deductive hypothesis
directional hypothesis
hypothesis
hypothesis testing
inductive hypothesis
nondirectional hypothesis
null hypothesis
operational definition
pilot study
purposes of hypotheses
research hypothesis
research plan
testable hypotheses
theory

EXERCISES

1. What are the purposes of the hypothesis in research?
2. What is the difference between an inductive and a deductive hypothesis?
3. State a hypothesis based on each of the following research questions:
   - **a.** What would be the effect of using the Cuisenaire method in teaching elementary arithmetic?
   - **b.** Is there a relationship between the gender of the tutor and the gains made in reading achievement by black male elementary students?
   - **c.** Does living in interracial housing affect attitudes toward members of another race?
   - **d.** Is there any relationship between the type of reinforcement (tangible or intangible) and the amount of learning achieved by socioeconomically disadvantaged children?
   - **e.** Does preschool experience reduce the educational gap separating advantaged and disadvantaged children before they enter first grade?
   - **f.** Do teacher expectations of children's intellectual performance have any effect on the children's actual performance?
4. Rewrite the following hypothesis in null form: "Children who read below grade level

will express less satisfaction with school than those who read at or above grade level."

5. Evaluate the adequacy of each of the following hypotheses. If a hypothesis is inadequate, state the reason for the inadequacy and write an adequate hypothesis.
   - **a.** "Teachers deserve higher pay than administrators."
   - **b.** "Students who take a middle school government course will be capable of more enlightened judgments concerning local political affairs than will those who do not take the course."
   - **c.** "Computer-based drill and practice is a better way to teach slow learners multiplication combinations than is flash cards."
   - **d.** "If students differ in their socioeconomic status, they will differ in their English proficiency scores."
   - **e.** "Children who show high achievement motivation will show high anxiety as measured by the Children's Manifest Anxiety Scale."
   - **f.** "Positive verbal reinforcement of student responses by the teacher will lessen the probability of future responses."
6. Write a directional and a nondirectional hypothesis based on the research question "What is the relationship between the rate of maturation of adolescent boys and their self-concepts?"
7. Why should a hypothesis be clearly stated before a quantitative research study is initiated?
8. Label the following hypotheses as research hypotheses or null hypotheses:
   - **a.** "Students will receive lower scores on achievement tests that measure the higher levels of Bloom's taxonomy than on tests measuring lower levels of Bloom's taxonomy.
   - **b.** "There is no difference in the performance of students taught mathematics by method A and those taught mathematics by method B."
   - **c.** "The mean retention scores of children receiving experimental drug X will not differ from the scores of children who do not receive drug X."
   - **d.** "Students taught by laissez-faire teachers will show higher problem-solving skills than students taught by highly structured teachers."
9. Locate a research study stating a hypothesis and try to identify the theory from which the hypothesis originated.
10. Evaluate the following statements as possible research hypotheses:
    - **a.** "Asian high school students are better in mathematics than American high school students."
    - **b.** "Do SAT prep courses improve students' scores on the SAT?"
    - **c.** "Students who participate in the high school volunteerism program become better adult citizens than students who do not."
11. A researcher has a theory about children's ordinal position in the family and their achievement motivation. Write a research hypothesis and a hypothesis in null form.
12. Formulate a tentative research plan for your class project.
    - **a.** What is the general research problem under consideration for investigation?
    - **b.** State the preceding general research problem as a research question.
    - **c.** Explain the rationale for such a study. What are its theoretical or practical applications?
    - **d.** State the hypothesis (or hypotheses) for this study.
    - **e.** Was this hypothesis derived deductively from theory or inductively from experience and observation? Explain.
    - **f.** Identify the variables in the study and operationally define each.
    - **g.** What kind of research methodology will be required for this study?
    - **h.** What subjects (sample) will you select for the study?
    - **i.** Have you located any published research related to your problem? If so, briefly summarize the findings.
13. Which of the following evidence contributes to the development of a theory?
    - **a.** Evidence that supports a hypothesis
    - **b.** Evidence that contradicts a hypothesis
    - **c.** Both of the above
14. Select a theory that you find interesting and derive a research hypothesis from this theory. You might choose a learning theory, motivational theory, theory of cognitive dissonance, or any other educational or psychological theory.

ANSWERS

1. The purposes of hypotheses are to provide a tentative proposition suggested as a solution to a problem or as an explanation of some phenomenon, stimulate research, provide a relational statement that is directly testable, and provide direction for research.
2. With an inductive hypothesis, the researcher makes observations of relationships and then hypothesizes an explanation for the observed behavior. With a deductive hypothesis, the researcher formulates a hypothesis based on known theory, accompanied by a rationale for the particular proposition.
3. **a.** "Elementary students taught by the Cuisenaire method will score higher on an arithmetic test than students taught by an alternative method."
   b. "Black male elementary students tutored by another male will achieve higher reading scores than will black male elementary students tutored by a female."
   c. "People living in interracial housing will express more favorable attitudes toward those of another race than will people living in segregated housing."
   d. "Socioeconomically disadvantaged children reinforced with tangible rewards will exhibit greater learning achievement than will children reinforced with intangible rewards."
   e. "Advantaged and disadvantaged children of preschool age receiving preschool training will be separated by a smaller educational gap than will advantaged and disadvantaged children of preschool age not receiving preschool training." (*Note*: The terms advantaged and disadvantaged children, preschool training, and educational gap would need to be defined.)
   f. "Children whose teachers have high expectations of their intellectual performance will perform at a higher level than will children whose teachers have low expectations of their intellectual performance."
4. There is no difference in the satisfaction with school expressed by children who read below grade level and children who read at or above grade level.
5. **a.** The hypothesis is inadequate because it is a value statement and cannot be investigated in a research study. A legitimate hypothesis would be "Teachers who receive higher pay than their administrators will express greater job satisfaction than will teachers who do not receive higher pay than their administrators."
   b. The hypothesis is inadequate because enlightened judgments is a value term. An acceptable hypothesis would be "Students who take a middle school government course will evidence more knowledge concerning local political affairs, and will more often arrive at inferences based on this knowledge, than will students who do not take a middle school government course."
   c. The hypothesis is inadequate because *better* is a value term and because it lacks clear and concise operational definitions. A testable hypothesis would be "Those students performing below grade level in math who practice multiplication combinations through computer drill and practice will, on average, score a higher proportion of correct answers on a criterion test than will students performing below grade level who spend the same amount of time practicing multiplication combinations with flash cards."
   d. The hypothesis is inadequate because there is no statement of an expected relationship between variables. An acceptable hypothesis would be "Students classified as having high socioeconomic status will have higher scores on an English proficiency test than will students classified as having low socioeconomic status."
   e. The hypothesis is inadequate because there are no independent or dependent variables. An acceptable hypothesis would be "Children who show high achievement motivation will have higher scores on the Children's Manifest Anxiety Scale than children with low achievement motivation."
   f. The hypothesis is inadequate because it is inconsistent with the existing knowledge of positive reinforcement and its effect on student responses.

6. *Directional hypothesis*: "Early maturing boys will exhibit more positive self-concepts than late-maturing boys." *Nondirectional hypothesis*: "There is a difference in the self-concepts of early and late-maturing adolescent boys."
7. The hypothesis gives direction to the collection and interpretation of data. Clearly stating the hypothesis reveals flaws that were not apparent while developing the vague idea of the study in mind.
8. **a.** Research
   b. Null
   c. Null
   d. Research
9. Answers will vary.
10. **a.** "Better in math" needs to be operationally defined.
    b. A hypothesis should not be stated in question form.
    c. It is not testable as stated. How would you define and measure "better adult citizens"?
11. *Research hypothesis*: "Achievement motivation and ordinal birth position in the family are positively related; or first-born children have greater achievement motivation than their siblings." *Null hypothesis*: "There is no relationship between children's birth position in the family and their achievement motivation."
12. Answers will vary.
13. c
14. Answers will vary.

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