PICTURE THIS

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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