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Writing Hypotheses

Introduction

Now that you have done some preliminary background research on (a) your entity, (b) the independent variable, (c) the dependent variable, and (d) previous research completed on similar topics, you should have a better idea of what sort of experiment will help you address the questions you have about your topic.

As first noted in Chapter 2, the two purposes of the hypothesis are to formulate what you want to test and to define the limit of your experiment. You construct a hypothesis (in writing) *after* you do your preliminary background research but *before* the experiment begins.

Learning Objectives

During the course of the chapter you will

- write hypotheses that are testable by experimentation and
- write drafts of a hypothesis for your own experimental project.

By the end of the chapter, you should be able to

1. identify at what point—during the process of designing an experiment—the researcher should write the hypothesis and
2. explain the importance of a prediction in a hypothesis.

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Key Term

Hypothesis: A tentative (i.e., not final and definite) and testable statement that proposes an explanation for an observable phenomenon.

Although "an educated guess" is a definition commonly given in response to the question, "What is a hypothesis?" this definition is not only inadequate but also misleading. The word *guess* suggests that a hypothesis is not based on any real background information but is just someone's hunch. In fact, hypotheses are written only after extensive background research has been done—often after scientists have made numerous, careful observations about a specific phenomenon. A better definition of *hypothesis* would be the following:

> *A hypothesis is a tentative (i.e., not final and definite) and testable statement that proposes an explanation of an observable phenomenon. A hypothesis can predict a possible connection between two variables within a phenomenon or event or it can predict a difference between two groups.*

A hypothesis is "tentative" because it is a temporary statement that a researcher makes to test an idea. The researcher expects the statement to be either supported or rejected by the experiment. And even after a hypothesis is supported by one experiment, it does not make the connections between the variables "certain." Researchers recognize that there are variables in an experiment that they were not aware of and could not account for. Therefore, a researcher never says that a hypothesis has been *proven*; instead, it is *supported*. This is how the scientific process works.

A hypothesis can propose a possible connection between two variables within a phenomenon or event or it can predict a difference between two groups. This book focuses on the first type, which proposes a connection between two variables. If you are interested in a study that *compares differences* between two groups, such as comparing the effects of watershed disturbance on the plant diversity in two different areas, then you will need to learn more about research design that uses hypothesis-testing statistics. There are various online statistic tutorials, such as Stat Trek (*http://stattrek.com/Lesson5/HypothesisTesting.aspx*), that will explain how to write hypotheses for research studies that compare groups.

Writing Drafts of the Hypothesis

You have already chosen (in Chapter 2) the independent and dependent variables that you want to include in your hypothesis. Now you need to make a prediction of what type of relationship—either positive or negative—may

exist between these two variables. For example, if you were looking to make a connection between number of hours studied and exam scores, you might propose a positive relationship:

As the number of study hours increases, test scores will also increase.

or a negative relationship:

As the number of study hours increases, test scores will decrease.

When writing a draft of your hypothesis, you might start by using any of the following sentence formats as a guide:

- If __(IV)___ is related to ___(DV)____, then (predict the effect) .
- If the _(IV)_ is (describe the changes), then the _(DV)_ will (predict the effect).
- _(DV)_ will (predict the effect) when_(IV)_ (describe the changes).

Once you have a draft of a hypothesis, you can move parts of the sentence around so that it flows well. What is important is that your hypothesis includes three elements:

1. Independent variable
2. Dependent variable
3. A prediction of what kind of effect the independent variable will have on the dependent variable. Predictions usually include phrases that propose differences, such as *increased/decreased, higher/lower, more/less*, or *faster/slower.*

Sample Hypotheses

For an experiment testing the effects of water temperature on planaria reproduction, a hypothesis could be written several ways. (In the sample hypotheses below, the independent variable is underlined once and the dependent variable is underlined twice.)

1. If the speed of planaria reproduction is related to temperature, then planaria in lower temperatures will reproduce more slowly than those in higher temperatures.

2. If the temperature of a planaria's environment is lowered, then the speed of planaria reproduction will decrease.

3. A decreased temperature of a planaria's environment will decrease the speed of planaria reproduction.

What is important is that these predictions are based on background research that confirmed that a relationship between the two variables is already known, allowing the researcher to write a hypothesis that includes a prediction. In an experiment predicting the effects of tennis court surfaces on a tennis ball's rebound height, a hypothesis could be written in several ways.

1. *If a tennis court's texture is related to a tennis ball's rebound height, then rough-textured surfaces will decrease a ball's rebound height.*
2. *The coarser the texture of a tennis court, the lower rebound height a tennis ball will have.*
3. *Tennis court texture will decrease the rebound height of a tennis ball when bounced on rough court surfaces compared to smooth court surfaces.*

Note that all three versions of the tennis court hypothesis include a description of a relationship between the texture of a tennis court and rebound height of a tennis ball, as well as a prediction of the effect.

It takes a lot of work to write a really good hypothesis, even if the hypothesis doesn't contain many words. In addition to introducing the two variables, a hypothesis also must state what kind of data will be collected. In the tennis ball examples above, "rebound height" is the data being collected.

The major difference between the original basic research question you started with in Chapter 2 and the hypothesis you are now writing is that the hypothesis statement must be testable. *Testable* means that the wording of the hypothesis makes it clear how a test will be performed to connect the two variables. This following statement is *untestable:* "Tennis court texture affects tennis ball rebound height." This hypothesis statement is not testable because it does not indicate how you plan on supporting that claim. Your hypothesis should predict a specific relationship between the independent variable and the dependent variable. The data you collect will either support or reject the predicted relationship. Anyone who reads the hypothesis should have an idea as to what the experiment will measure, although they will not know how the data will be collected.

Read the following hypothesis. What scientific facts did the researcher have to know before he or she could write this hypothesis? (*See the answer at the bottom of the page *after* you have answered this question.)

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* The researcher had to know the following before he or she could write this hypothesis:
- The rate of transpiration can be measured by its condensation levels.
- The size of the wavelengths of light is determined by the color of the light.
- Changing the color of light is a way to control the wavelength each plant receives.

*If the rate of transpiration is related to wavelengths of light, then exposing a plant (*Philodendron scandens*) to shorter wavelengths of light will produce less condensation.*

Writing a testable hypothesis takes time. In fact, a hypothesis may change quite a bit from when you first start working on it until you have a finished, testable hypothesis. Table 4.1 shows a specific example of how a hypothesis may progress over the course of its development.

Table 4.1

Progressive Drafts of a Hypothesis

Four Drafts of a Hypothesis	Comments on the Hypothesis
First draft: Plants and gravitropism (movement of plant stem and roots due to gravity)	Basic topic. Only the entity and a possible independent variable are given.
Second draft: The amount of root cap on a root affects plant gravitropism.	Describes the connection and is more specific than the hypothesis above but still not testable.
Third draft: Roots of plants that have root caps removed will differ in root gravitropism from plants that do not.	Proposes a connection between the IV and DV. This is not appropriate for an experiment because this relationship is commonly known.
Fourth and final draft: If root gravitropism is related to the amount of root cap removed, the more root cap cells are removed, the more the root will show change in angle growth.	Complete hypothesis. Proposes a connection between the IV and DV and tells what the experiment is testing and what will be measured. From this hypothesis, it is clear that the angle of bending roots will be measured.

As you take additional background research notes, get your proposal approved, begin to collect data, and then statistically analyze what happened, remember to frequently refer back to your all-important hypothesis. At the end of your experiment, you will be expected (by your teacher, mentor, or other people who are reviewing your experiment) to explain in your final research paper whether your hypothesis was supported or rejected and then explain why. More specifically, you will be expected to explain whether the relationship and prediction you made regarding the two variables was indeed supported by your data. Complete Student Handout #4, Practicing Writing Hypotheses, pages 63–65.

Chapter Questions

1. At what point during the process of designing an experiment should you write the hypothesis?
2. What is the importance of a prediction in a hypothesis?

Chapter Applications

Using Student Handout #4 compare the hypotheses written by other students in your class. How are they similar to each other? How are they different? Be ready to discuss which hypotheses are more easily testable and measureable.

Work with your teacher to write a testable hypothesis for your own research project. Have several versions of a hypothesis ready to share with your teacher and listen to his or her feedback. Because you have already begun background research, you should have a good sense of a prediction you can make in your hypothesis. Keep in mind that although hypotheses are not long in word count, they take careful thinking to write well. Share your several versions with your classmates and listen to their feedback. Continue working with your teacher until your hypothesis is accepted. In the next chapter, you will learn guidelines for writing your research proposal and enter into the current debate about the "voice" and grammar appropriate for a scientific paper.

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