

Step 6: Writing Your Hypotheses

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Introduction

To determine if a theory has the ability to explain, predict, or describe, you conduct experimentation and observation to test inferences derived from the theory. For example, a general inference based on experience and research may be that “extroverted students are more successful in the traditional learning environment than the distance education learning environment” or “community increases learning in a distance education classroom.” In order to test one of these inferences, you need to express it in operational terms, that is formulate a hypothesis, e.g. Students’ high scores on the community scale will be highly related to good grades in the distance education course.

A hypothesis is an educated guess, and it can be supported or refuted through experimentation or observation. If the hypothesis is supported, evidence exists that supports the theory. If the hypothesis is refuted, the theory is not supported. As findings support hypotheses related to a theory, the theory gains trustworthiness. For example, Knowles adult learning theory has been tested and the inference, “adult learners are independent and self-directed”, has been supported through multiple observations. As such, adult educators trust this theory and apply it. Some adult educators will ask students to formulate their own learning objectives during the first week of the course to encourage independent and adult students’ control of their learning.

We are going to discuss developing research hypotheses that are well written and acceptable for research. That is, a hypothesis states the expected relationship between variables, is testable, is stated simply and concisely as possible, and is founded in the problem statement and supported by the literature, and aligns with your research question (Bartos, 1992).

Topical Discussion: Writing a Hypothesis

Hypothesis Defined

A hypothesis is an educated guess. It is a statement about what you, as the researcher, expect to occur in your experiment or observation. And, a hypothesis written for the purpose of research or hypothesis testing, is a statement about what will occur with a specified population using the data obtained from a sample (terms we will discuss in another lesson).

The Purpose of Hypotheses

In writing a hypothesis(es), it is important to remember the purpose and role of the hypothesis in research.

- ▶ A well stated hypothesis demonstrates to others that you as the research have a good understanding of the literature.
- ▶ A hypothesis provides a framework and direction for collecting, analyzing, and interpreting and reporting data.
- ▶ The primary focus of research is to test the hypothesis(es) stated. Once data is collected statistical analysis is used to reject or fail to reject the null hypothesis(es) to support or

refute a theoretical inference; thus, supporting or refuting a theory. Note that hypotheses are only tested using inferential statistics, not descriptive.

Types of Hypotheses

After writing a well formulated research question, the next step is to write the null hypothesis (H_0) and the alternative hypothesis (H_1 or H_A). These hypotheses are derived from the research question and can be written with words or symbols. For most social science research words are expected.

The **research or alternative hypothesis** (e.g. $H_1: \mu_1 \neq \mu_2$) is a statement about what is expected. Derived from the questions posed about the Parent-to-Parent program example in the previous lesson, you, as a researcher, could write the following alternative hypotheses:

- The Math 2.0 program will have a significant effect on second grade students' attitudes toward math as measured by the Attitudes Toward Mathematics Inventory.
- There will be a statistically significant difference the second grade students' attitudes toward math as measured by the Attitudes Toward Mathematics Inventory who participate in the Math 2.0 program as opposed to second grade students who participate in a traditional math class.

The research hypothesis can be written in a directional or non-directional manner.

- **Directional (one tailed)** – specifies the direction of the expected relationship (e.g., $H_0: \mu_1 \leq \mu_2$, $H_A: \mu_1 > \mu_2$). When you test the null hypothesis, you are testing to see if the mean of the sample is only less than or only greater than the mean of the control group.
- **Non-directional (two tailed)**– does not specify the direction of the expected relationship (e.g., $H_1: \mu_1 \neq \mu_2$, $H_0: \mu_1 = \mu_2$). When you test the null hypothesis, you are testing to see if the mean of the sample is either less than or greater than the mean of the control group.

The above posed hypotheses are both non-directional. An example of a directional hypothesis is:

- Second grade students who participate in the Math 2.0 program will have significantly higher mean scores on the Attitudes Toward Mathematics Inventory as opposed to second grade students who participate in a traditional math class.

Just as with the directional research question, you as the researcher use words such as “increase”, “decrease”, “positive relationship,” and “negative relationship” to denote direction. The proposed research question and hypothesis should be congruent. For example, if you pose a directional question, consistently propose a directional hypothesis. This is similar to subject verb agreement in English grammar. If a writer uses the term “they” then the verb must be “are” rather than “is.” Just as subjects and verbs need to agree in number, research questions and hypotheses need to agree in direction.

Directional hypotheses should only be posed if strong empirical support exists. For, if a wrong direction is predicted, significant findings can be missed as a directional hypothesis is tested with one tailed analysis.

The **null hypothesis** (e.g. $H_0: \mu_1 = \mu_2$ or $H_0: \mu_1 - \mu_2 = 0$) states that there is no statistically significant difference or relationship between variables. Terms such as “no statistically significant effect,” “no statistically significant difference,” or “no statistically significant relationship” are used. Some researchers hold that it is sufficient to simply state the null hypothesis. Caveat: remember that no statistically significant difference does not mean no actual difference, there may be an actual difference, however the actual difference is not large enough to be statistically significant.

Characteristics of Acceptable Hypotheses

In writing a hypothesis, you usually start with a general inference, and then develop it into a researchable hypothesis. According to Bartos (1992), a well-stated researchable hypothesis has 5 primary characteristics:

- states the expected relationship between variables,
- is testable,
- is stated as simply and concisely as possible.
- is derived from the problem statement and supported by the literature
- and aligns with the research question(s)

Let’s take a look at an example: The statement, “The parenting class will be effective in helping parents deal with their difficult children” is not very clear and focused; thus, not testable. As discussed in the research question lesson, operationally defining terms and clearly identifying all variables will assist you in formulating a well-stated researchable hypothesis(es). The non-directional hypotheses stated above are much clearer and researchable than the one stated here.

As with the research question, it is also important to use precise terminology as the hypothesis should inform both your research design and analysis choices.

If the research question asks about the mean difference between groups, then the alternative hypothesis should state there is a or “a statistically significant difference” between or among the group means ($H_1: \mu_1 \neq \mu_2$). Remember, when using inferential statistics there may be an actual difference, but if it is not statistically significant the researcher will still fail to reject the null hypothesis. The null hypothesis should state there is “no difference” or “no statistically significant difference” between or among the group means ($H_0: \mu_1 = \mu_2$; Note Use: $H_0: \mu = k$, where k is a constant and a criterion is being used). If the research question asks about the relationship between variables, then the alternative hypothesis (also known as “the researcher’s hypothesis”) should state there is “a relationship” or “a statistically significant difference” between or among the variables ($H_1: \rho \neq 0$; ρ is rho and represents the strength of relationship). The null hypothesis should state there is “no relationship” or “no statistically significant relationship” between or among variables ($H_0: \rho = 0$).

Note: The terminology “no difference” is the same as “no statistically significant difference” when writing a hypothesis. However, when testing the hypothesis, you are examining whether

there was not only a difference, but a statistically significant one. You are observing whether the difference was due to chance or the intervention. If the first is true, then you cannot reject the null hypothesis. A difference or increase is not enough; the variance must be at a statistically significant level.

The Number of Hypotheses

Every research question should have at least one corresponding hypothesis; however, sometimes more than one hypothesis is needed. The number of hypotheses needed is based upon the number of variables under investigation.

Let's consider the question,

- Is the difference in the second grade students' attitudes toward math as measured by the *Attitudes Toward Mathematics Inventory* who participate in the Math 2.0 program as opposed to second grade students who participate in a traditional math class?

There is one independent variable (IV) and one dependent variable (DV). The IV is type of math program (the Math 2.0 program and traditional math class); the DV is attitudes toward mathematics. So, only a single null hypothesis needs to be tested.

- H_{01} : There is no statistically significant difference in the second grade students' attitudes toward math as measured by the Attitudes Toward Mathematics Inventory who participate in the Math 2.0 program as opposed to second grade students who participate in a traditional math class.

If additional variables were considered then additional hypotheses would need to be proposed.

Let's consider the question,

- What is the effect of the Math 2.0 program and gender on second grade students' attitudes toward math as measured by the Attitudes Toward Mathematics Inventory.

Here there is still one dependent variable, but there are two independent variables, type of math program and gender. This research question requires three hypotheses, two main effect and one interaction effect:

- H_{01} : There is no difference in students' attitudes toward math as measured by the Attitudes Toward Mathematics Inventory based on type of math program the second grade student participated in. (*This hypothesis attends to the first main effect.*)
- H_{02} : There is no difference in students' attitudes toward math as measured by the Attitudes Toward Mathematics Inventory based the second grade students' gender. (*This hypothesis attends to the second main effect.*)
- H_{03} : There is no difference in students' attitudes toward math as measured by the Attitudes Toward Mathematics Inventory based on type of math program the second grade student participated in and their gender (*This hypothesis attends to the interaction effect.*) Rejection of this null hypothesis, would lead you as a research to conclude that the dependent variable by type of program depends on the gender. For example, males

have better attitudes toward math after participating in the Math 2.00 program while females have better attitudes toward math after participating in a traditional math class.

So, as just stated, if you are conducting research examining the differences between groups and have one independent variable and one dependent variable, you test one null hypothesis - a main effect hypothesis. If you have two independent variables and one dependent variable, you test three null hypotheses- two main effect null hypotheses and one interaction hypothesis.

Each time you add an independent variable to your question, your number of hypotheses increase. If you have three independent variables and one dependent variable, you test seven null hypotheses- three main effect null hypotheses, three first order interaction hypotheses, and one second order interaction hypothesis. The first order interactions address interactions between all possible pairs of independent variables. The second order interaction involves all three independent variables.

If you plan to examine two or more correlated dependent variables, then you need to pose a hypothesis for the linear combination of variables as well as each variable separately. Note that I said correlated here. If dependent variables are significantly correlated, they need to be analyzed together in order to control for possible Type II error. They should be considered separately if they are not correlated.

Let's consider the question,

- What is the effect of participation in the Math 2.0 program on second grade students' math motivation scale scores?

Here the math motivation scale instrument consists of three correlated subscales (e.g. external, introjected, and identified regulation). Thus, there is one independent variable but three dependent variables. This research question requires four hypotheses, one that considers the linear combination of variables as well as each variable separately:

- ▶ H_{01} : There is no statistically significant difference in second grade students' mean scores on the math motivation scale based on type of math program participated in.
- ▶ H_{02} : There is no statistically significant difference in second grade students' introjected mean scores on the math motivation scale based on type of math program participated in.
- ▶ H_{03} : There is no statistically significant difference in second grade students' identified regulation mean scores on the math motivation scale based on type of math program participated in.
- ▶ H_{04} : There is no statistically significant difference in second grade students' external mean scores on the math motivation scale based on type of math program participated in.

Here independent and dependent variables are discussed; however, the rules hold true when examining variables of interest in a correlational study. The number of hypotheses needed is based upon the number of variables under study.

It is also important to note that control variables need to be reflected in the hypotheses. Don't remember what a control variable is, see the next lesson.

The Case of Charlie

Charlie proposed the following research questions:

- Is there a difference in the anxiety levels (as measured by the Beck Anxiety Inventory® (BAI®); Beck & Steer, 1990) of college freshman diagnosed with generalized anxiety disorder when participating in a traditional freshman orientation as compared with the EI CBT freshman orientation while controlling for anxiety scores?
- What is the effect of participation in a traditional freshman orientation as compared with the EI CBT freshman orientation on college freshman's academic achievement as measured by first semester GPA while controlling for previous achievement (i.e. High school GPA)?
- What is the effect of participation in a traditional freshman orientation as compared with the EI CBT freshman orientation on college freshman's interpersonal skills as measured by the Positive Relations With Others scale (Ryff,1989; Ryff & Keyes, 1995) while controlling for previous interpersonal skills?

Here Charlie has 3 dependent variables; however, there is not strong evidence that they are correlated. The inventories that Charlie choose do not have subscales; thus, he proposed three separate null hypotheses, one for each question:

- H_{01} : There is no statistically significant difference in the anxiety levels (as measured by the Beck Anxiety Inventory® (BAI®); Beck & Steer, 1990) of college freshman diagnosed with generalized anxiety disorder when participating in a traditional freshman orientation as compared with the EI CBT freshman orientation while controlling for anxiety scores.
- H_{02} : There is no statistically significant effect of participation in a traditional freshman orientation as compared with the EI CBT freshman orientation on college freshman's academic achievement as measured by first semester GPA while controlling for previous achievement (i.e. High school GPA).
- H_{03} : There is no statistically significant effect of participation in a traditional freshman orientation as compared with the EI CBT freshman orientation on college freshman's interpersonal relationship skills as measured by the Positive Relations With Others scale (Ryff,1989; Ryff & Keyes, 1995) while controlling for previous interpersonal skills.

Application: Developing My Research Plan

Now it is your turn. Write each research question. What are your corresponding hypothesis or hypotheses for each question? Write them out in alternative and null form.

Based on the terminology used, is my hypothesis(es), directional or non-directional? Directional/
Non-directional

Does the literature support my directional or non-directional hypothesis(es)? Does the posed type
of direction align with my research question(s)? Explain.

Do I want to keep my hypothesis(es), as they are or change it/ them to be directional or non
directional?

How many independent variables are proposed for each hypothesis? ____
How many correlated dependent variables are proposed for each hypothesis? ____
How many variables of interest are proposed for each hypothesis? ____

Do the number of proposed hypotheses reflect the number of variables I am proposing to study?

Here are the hypothesis(es) and corresponding questions, I plan to use for my research plan.

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