

Quantitative Research: Working with Hypotheses and Variables

Dr. Paul L. Hewett, Jr. & Dr. Beth L. Hewett, Defend & Publish, LLC



Hypotheses

Hypotheses Defined

- Hypotheses are:
 - Testable statements
 - Predictions about relationships of independence and dependence
 - Educated guesses
- Hypotheses predict relationships between variables.



About Hypothesizing

- Hypotheses should reflect the general problem statement or question that was the motivation for undertaking the research study.
- Hypotheses should be based on your research question: What are you trying to understand?
- Hypotheses help you travel from a problem statement to testing.



Criteria for Hypotheses

- Hypotheses are written/stated in declarative (sentence) form .
- Hypotheses are not stated as a question—therefore, a research question IS NOT an hypothesis.
- Hypotheses pose an expected relationship between and/or among variables.
 - Avoid the "fishing trip"
 - Reflect theory and literature on which they are based
- Hypotheses are brief and to the point.
- Hypotheses are testable (usually using a statistical technique).



The Null Hypothesis

- Predicts no statistically significant relationship between or among variables.
- A statement of equality: "There will be no significant difference between test scores of students taking Introductory Statistics in the first and fifteenth weeks..."
 - The assumption is that if there is a difference, it is due to chance.
 - The job of the researcher "is to eliminate chance as a factor and to evaluate other factors that might contribute to differences."
- It is your starting point and your benchmark—to see whether research outcomes are caused by chance or some other factor.



Research Hypotheses

- Are also called "alternative hypotheses"
- Are statements of inequality
- Pose a relationship between or among variables
 - Directional research hypotheses
 - "More than" or "less than" or "greater than"
 - Specifies the direction of the difference
 - Points out which group is greater/lesser
 - Example: Fire chiefs from east coast departments will score higher on the Creativity and Risk Taking Index than fire chiefs from west coast departments.
 - Nondirectional research hypotheses
 - "Is different from"
 - Doesn't point out which group is greater/lesser
 - Example: There is a difference in political status between fire chiefs from the east coast and fire chiefs from the west coast.



Comparing Null and Research Hypotheses

TABLE 6.1 Null Hypothesis and Corresponding Research Hypotheses			
Null Hypothesis	Nondirectional Research Hypothesis	Directional Research Hypothesis	
There will be no difference in the average score of 9th graders and the average score of 12th graders on the ABC memory test.	Twelfth graders and 9th graders will differ on the ABC memory test.	Twelfth graders will have a higher average score on the ABC memory test than will 9th graders.	
There is no difference between the effectiveness of community-based, long-term care for older adults and the effectiveness of in-home, long-term care on the Margo- lis Scale of Social Activities in older adults.	The effectiveness of commu- nity-based, long-term care for older adults is <i>different</i> from the effectiveness of in-home, long-term care on the social activities of older adults when measured using the Margolis Scale of Social Activities.	Older adults exposed to com- munity-based, long-term care score higher on the Margolis Scale of Social Activities than do older adults receiving in- home, long-term care.	
There is no relationship between reaction time and problem-solving ability.	There is a relationship between reaction time and problem- solving ability.	There is a positive relationship between reaction time and problem-solving ability.	
There is no difference between white and black families in the amount of assistance offered to their children.	The amount of assistance offered by white families to their children is different from the amount of support offered by black families to their children.	The amount of assistance offered by white families to their children is more than the amount of support offered by black families to their children.	



Comparing Null and Research Hypotheses

- Null: no relationship between variables (an equality)
- Research: there is a relationship (an inequality)
- Null: always refer to the population
- Research: always refer to the sample
- Null: indirectly test and infer from testing the research hypothesis
- Research: directly tested
- Null: an implied hypothesis
- Research: an explicit hypothesis



Accepting/Rejecting the Null

- Future statistics will lead us to:
 - "Accept" the null hypothesis $\ensuremath{\mathfrak{S}}$
 - Accept there is no difference
 - "Reject" the null hypothesis 🙂
 - There is a difference
 - You will use "cut-off" points with statistics to decide whether you can reject the null hypothesis.





Variables

About variables

- They have to "vary."
- They have to fluctuate.
- They have to change.

Get the idea?



Examples of variables

- Age
- Gender
- Political efficacy
- Wind speed
- Voter turnout
- Number of residents in Red Cross shelter
- Years of education
- Number of college degrees
- Social class



A little more about variables

- Research relies on the study of variables and how they are (or are not) related.
- Variables form a cornerstone for the development of theory.
- Variables help us to be more precise in our understanding of relationships.



About attributes

- Variables are "logical groupings of attributes."
- Attributes are characteristics or qualities.
- Attributes describe objects.
 - Example attributes: female, Asian, alienated, conservative, intelligent, prepared.
- Think of specific variables and their attributes:
 - Age: young, middle-aged, old
 - Gender: female, male
 - Occupation: politician, pollster, emergency manager
 - Race/ethnicity: African American, Latina, European
 - Social class: upper, middle, lower



More variables and attributes

- Prejudice (variable) can be described through its attributes "prejudiced" and "unprejudiced."
- Education (variable) can be described through its attributes "uneducated" and "educated."
- Is there a relationship or association between or among these variables?
 - Can you describe a potential relationship between or among these variables using the attributes?



There is more than one kind of variable

- Independent variables (IV)
 - Presumed to cause a change in the dependent variable
 - Represents the "treatment" variable, the one that will be manipulated in an experiment
 - Other names: treatment variable, factor, predictor variable
- Dependent variables (DV)
 - Rely on the independent variable
 - Presumed to be changed by the independent variables
 - Are the measure that reflects the outcomes of a research study
 - Other names: outcome variable, results variable, criterion variable





Problem Statements, Hypotheses, and Variables: The Sequel

Some additional thoughts on the Statement of the Problem, Variables, and Hypotheses and how they fit into a research proposal

"One can't be absolutely positive about anything."

This is why we ask research questions and do research!



Where does the Statement of the Problem come from?

- Pick a topic of great interest to you that comes from a felt need, prior research and theory, or an important concept.
 - The problem is how to be impartial if your interest and sense of need is high (passion leads to bias).
 - Concepts are names for things, are tentative, and capture some significant and definable item in reality.
 - Theory tries to explain "observed fact" in the most probable or efficient way.
- When you define needs, concepts, and theory as variables, they can grow up to become hypotheses.



Characteristics of the Statement of the Problem

- Problem statements are Succinct Specific Precise
- Problem statements lead to the subsequent steps of operationalizing the study and developing hypotheses.





Descriptive Questions

- These are not questions that you might ask in a survey or interview.
- They are questions that you ask yourself about the problem that you want to study so that you can identify variables and how to measure them.
- The first step in operationalizing the problem is to critically think about the problem. This step requires time.
- Descriptive questions help you determine variable attributes:
 - What does X look like?
 - How does Y behave?
 - What possible variations of Z exist?
 - How do I measure X, Y, or Z ?



More on Variables

- Variables <u>MUST</u> vary.
- Variables may be an attribute or condition, but they cannot be the subject of the study.
- An independent variable causes the effect on the dependent variable (what the independent variable changes).
- Forms that variables take:
 - <u>Categorical</u>: An attribute that you can group, such as age, gender, rank, etc.
 - <u>Continuous</u>: An infinite number of values in a range, such as years of service.
 - <u>Dichotomy</u>: Only two possibilities, such as male/female or on/off.



More on the Null Hypothesis

- One must have a null hypothesis for a quantitative or experimental study. The statistics resulting from such studies are meaningless without one because the statistics test for differences.
- Null hypotheses start with the assumption that there is no difference, relationship, or causal connection due to changes greater than what would be caused by chance.
- This is why the correct practice is to say: "There will be no statistically significant difference (relationship, causal connection) . . . "

There will be no statistically significant relationship between critical thinking skills and student grades in ICS 410 classes taught at the National Fire Academy.



More on Null Hypotheses (continued)

- They are not simple statements of "nothingness," of something not existing (e.g., no behaviors or attitudes).
- They are operationalized summaries of the problem that indicate that there is no difference, relationship, or causal connection between the variables <u>due to chance</u>.
- They are statements that express what the statistics are testing. In contrast, the research hypothesis is a statement about what we think the result might be.
- They are logical extensions of the statement of the problem, the literature review, and study significance.
- They are reasonable and rather narrow—any generalization is what is tested by the study.



An example (using an experimental design)

There are 9000 extraterrestrials (ETs) in the United States. I want to teach them English. The ETs are willing to do whatever I want as part of the study. The ETs exist in three distinct and equal groups defined by head shape (round, square, elliptical). Each group also has three equal divisions of gender (male, female, hermaphrodite). I will use two different teaching methods: Extra Sensory Perception (ESP) and "The Gauntlet." I will measure the ETs' understanding of English by their laugh levels at limericks.





An example (continued)

- <u>Statement of the problem</u>: To understand the ETs' ability to learn English, I will examine the relationship among ET head shape, ET gender, and English teaching method.
- My variables:

Variable Type	Variable Name	Measured By
IV #1	Teaching Method	ESP or "The Gauntlet" (Dichotomy)
IV #2	Gender	Male, Female, Hermaphrodite (Categorical)
IV #3	Head Shape	Round, Square, Elliptical (Categorical)
DV	Laugh Level	Loudness of laughter, measured by a decibel meter (Continuous)

My DV is what I will measure that changes because of the IV. Laugh level is the indicator for understanding English.



An example (continued)

- I would actually have to have 18 sample groups of aliens to account for all of the IVs.
- I would typically write 9 null hypotheses to account for the possible combinations of ET head shapes and gender.
- An example null hypotheses would be:
 - There will be no statistically significant relationship among ET gender, heads shape, and teaching method and their understanding of English as measured by laugh level at limericks.
- An example of a research hypothesis would be:
 - Male ETs with round heads who were taught English by ESP will show a higher understanding of English than male ETs with round heads taught English by "The Gauntlet" method.



Questions



