

**Module 2, Part 2: The Scientific Method:
Marrying Logic and Empiricism**

Elementary Statistical Concepts and
the Logic of the Scientific Method
Module 2, Part 2
The Scientific Method:
Marrying Logic and Empiricism

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Elementary Statistical Concepts and
the Logic of the Scientific Method
On-line Modules

- Module 1: Knowledge Generation
- **Module 2: The Scientific Method**
Part 1: Logic and Reasoning
**Part 2: The Scientific Method;
Marrying logic and empiricism**
- Module 3: Elementary Statistics &
Research Design
- Module 4: Describing Your Data
- Module 5: Inferential Statistics & Research Design
- Module 6: Selecting Statistics by Design
- Module 7: Research Design and Statistics:
Examples and Practice

Just a suggestion....

- Please open and/or print the handout
associated with this presentation
- Following along with the handout allows you
to add notes as the presentation
goes along
- You can always pause the presentation, too...

Overview of Module 2:

- Building Natural Systems of Knowledge
Requires use of the Scientific Method
- The Scientific Method Marries the Essential
Elements of Logic and Empiricism
- We Need to Know a Bit About Logic

Module 2...

Previously...

- Part 1: Introduction to the Essentials of Logic
(see the Part 1 presentation; on the web site)

In This Module - Module 2, Part 2:

- **Building Knowledge of Natural Systems:
Theory and Hypothesis Testing**
- **The Scientific Method and the
Elements of a Research Article**

Creating a Body of Knowledge:
The Scientific Method

Why Scientific Method?

Powerful means to reduce error involved in the
process of building knowledge about the world -
particularly understanding “**natural systems.**”.

Allows us to **explain, predict, and control** how the
world operates. Much better than religion, political
authority, or your mom (sorry, mom)...

If you recall from Part 1...

The Scientific Method as an Instance of Deductive Reasoning

Theory

Premise

Deduction

Inference

Hypothesis

Conclusion

- We deduce hypotheses from theory. If the theoretical statements are true, and the inference is valid, the hypothesis (containing concrete concepts) must be true.
- Theory is related to hypothesis via deductive logic

Focus is on How to Build Our Understanding of Natural Systems:

- Discovery
- Using Common and Agreed Upon Methods to Define What We Know
- Replicable and Defensible – Based on Sound Reasoning
- Tentative and Open to Revision and Enhancement

Natural Knowledge Systems

- Composed of concepts and rules/processes (e.g., relationships among concepts)
- We theorize (create theory) and, then, we look to confirm theories via hypothesis testing
- We need to define: Concepts (and rules/processes), Theory, Hypotheses

Natural Systems:

Concepts, Theory, and Hypotheses

Abstract Concepts are NOT constrained by specific time or place.

Concrete Concepts ARE constrained to a specific time or place.

Natural Systems:

Concepts, Theory, and Hypotheses

Abstract:

- Temperature
- Three days
- Attitude
- Social System
- Identity status

Concrete:

- Temp. of the lake on June 1, 2010
- Dec. 4-6, 1967
- What Harry thinks of the president
- General Motors
- A score on an “identity status” scale

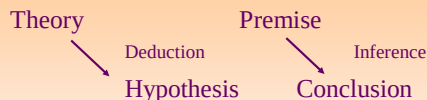
Natural Systems:

Concepts, **Theory**, and **Hypothesis**

- **Theory:** A set of *theoretical statements* about the world
- **Theoretical statement:** A set of abstract (versus concrete) concepts used to describe the relationship between two or more variables.
- **Hypothesis:** An assertion, using concrete concepts, subject to verification, and based on theory.

**Module 2, Part 2: The Scientific Method:
Marrying Logic and Empiricism**

The Scientific Method as an Instance of Deductive Reasoning



- We deduce hypotheses from theory. If the theoretical statements are true, and the inference is valid, the hypothesis (containing concrete concepts) must be true.
- Theory is related to hypothesis via deductive logic

The Scientific Method as an Instance of Logical Reasoning

- **Hypothesis:** An assertion of an expected relationship between two or more variables (concrete concepts), subject to verification, and based on theory.
- When testing a hypothesis, if the “null hypothesis” is rejected, then, these results serve as a “confirmatory instance” of theoretical rational used to deduce the hypothesis; **giving ONLY inductive support for the theory. NOT proving the theory.**

The Scientific Method:

Operational Definitions of Concepts

- **Goal: Measuring abstract concepts**
Making an abstract concept into a concrete concept (for the purpose of hypothesis testing) is to “**operationalize**” the concept.
- To operationalize a concept is to make it available to “sense data” (i.e., something we can see, hear, touch, smell, or taste; something empirical). Valid and reliable instruments are invented to measure concrete concepts.

Making the Abstract, Concrete...

- **Ego Identity**
(see a sample article on this topic, posted in the “Activities and Resources” area for this module)
- **Temperature**
(<http://www.uh.edu/engines/epi45.htm>)
- **Enzyme**
(see - <http://en.wikipedia.org/wiki/Enzyme>)
- **Apoptosis**
(see the seminal article on this topic, posted in the “Activities and Resources” area for this module)

The Scientific Method:

Operational Definitions of Concepts

Four measurement options
for concrete concepts:

- Nominal
- Ordinal **NOIR**
- Interval
- Ratio

Abstract to Concrete Revisited:

Operationalizing Concepts/Variables

Qualitative Data:

- **Nominal:** Types of cars, gender, race, hair color
- **Ordinal:** Most popular car in America, finishing rank in a race

Quantitative (i.e., continuous) Data:

- **Interval:** Time, Likert-items
- **Ratio:** Temperature,

Food for Thought:
What Level of Measurement
is a Likert Scale?

Examples:

Disagree	Neutral	Agree
1	2	3

Very Satisfied	Satisfied	Dissatisfied	Very Dissatisfied
1	2	3	4

Abstract to Concrete Revisited:
Operationalizing Concepts/Variables

Why does it matter?

- Ability to “see” the concept and manipulate the data from what we see (describe, summarize, divide, multiply, etc.) appropriately is dependent on the level of measurement
- Selecting appropriate test statistic (in the “Results” section) is dependent on:
 - Research design
 - Level of measurement of all measured variables

Quick Review

- The scientific method is, thus, the marriage of logic and “empiricism” = logical empiricism
- We theorize about concepts and rules/processes that may explain the world around us, then, we deduce hypotheses to test our theories
- If our theories are correct, by deduction, our hypotheses must be correct or..... (but that is for future modules)...
- Next: Here is what research looks like and how it conforms to the scientific method...

Overview:
Stages in the Scientific Method

- 1) Recognize a problem
- 2) Define the problem in clear specific language
- 3) Develop hypotheses
- 4) Develop techniques or instruments to obtain information related to the problem and hypotheses
- 5) Collect data or information
- 6) Analyze the data or information
- 7) Generate conclusions based upon data related to the hypotheses

Standard Components of a Research Article and the 7 Components of the Scientific Method

Introduction:

- 1) Recognize a problem
- 2) Define the problem in clear specific language
- 3) Develop hypotheses

Standard Components of a Research Article and the 7 Components of the Scientific Method

Methods:

- 4) Develop techniques or instruments to obtain information related to the problem and hypotheses
- 5) Collect data or information

**Module 2, Part 2: The Scientific Method:
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Standard Components of a Research
Article and the 7 Components of the
Scientific Method

Results:

- 6) Analyze the data or information

Discussion:

- 7) Generate conclusions based upon data
related to the hypotheses

Standard Components of a
Research Article: The Details....

Introduction:

- What are the abstract concepts (variables) we believe are operating in the world and what are the effects of these on other concepts (variables) and with what population(s)?
- In a concrete setting, what do we expect to see if the above situation is true? What are the questions and the hypotheses?
- It's necessary to operationalize concepts and produce hypotheses about what we expect to actually see/find in the world.

Standard Components of a
Research Article

Methods:

- Who are the subjects ("Subjects" section)?
- How did we operationalize the concepts / variables ("Instrumentation")? What is the level of measurement of each variable measured?
- How are we testing the hypotheses ("Procedure" section)?

Standard Components of a
Research Article

Results:

- Does the data indicate "real" differences or is error / chance a possible explanation of our data?
- Does our obtained data occur infrequently enough or is it rare enough that it is likely from a different population (i.e., we reject the null hypothesis)?

Standard Components of a
Research Article

Discussion:

- What does our data mean? What does it imply regarding our theories about the world?
(Refers back to the problems defined in the "Introduction".)

Next Up... Module 3:

Elementary Statistics & Research Design

- More About NOIR
- Independent, Dependent, and Control Variables
- Causation and Correlation
- Arguing causation but..
 - Threats to Internal Validity
 - Threats to External Validity
- Deconstructing and Constructing Research Articles and Presentations