

Scientific method

Lab 1

Objectives

- ▶ At the end of this series of lectures you should be able to:
  - ▶ Define terms.
  - ▶ Describe the basic structure of the scientific method.
  - ▶ Explain what makes a good scientific question.
  - ▶ Define hypothesis, falsifiable, and null hypothesis.
  - ▶ Identify the different types of variables.
  - ▶ Identify the different scales of variables.

Scientific method

- ▶ Observation
- ▶ Question
  - ▶ Definable
  - ▶ Measurable
  - ▶ Controllable
- ▶ Hypothesis
  - ▶ Falsifiable
  - ▶ Null Hypothesis

Scientific method

- ▶ Experiment
  - ▶ Define variables (Types of variables)
    - ▶ Dependent variable
    - ▶ Independent variable
    - ▶ Controlled variable

Scientific method

- ▶ Experiment
  - ▶ Procedure
    - ▶ Manipulation
    - ▶ Level of treatment
    - ▶ Measurement
    - ▶ Sample size/replication
    - ▶ Control treatment
    - ▶ Predict the outcome
    - ▶ Execute the experiment

Scientific method

- ▶ Conclusions
- ▶ Communication

### Different models of the scientific method

- ▶ Observational vs. experimental science.
- ▶ Differences between a hypothesis, a theory, and a scientific law.

### Definitions

- ▶ **Statistics**
  - ▶ Descriptive Statistics
  - ▶ Inferential Statistics

### Definitions

- ▶ **Variable** – The property being measured or of interest
  - ▶ Character – Typically discrete
  - ▶ Needs to vary
  - ▶ A variable and a variate are different.
    - ▶ Multivariable ≠ Multivariate
- ▶ **Datum** – An individual observation of a variable
- ▶ **Data** – A collection of observations of the same variable.

### Definitions

- ▶ **Measurement** – The process of systematically assigning numbers (or other descriptors) to objects or their properties.
- ▶ **Operationalization** – The process of specifying how a concept will be defined and measured.
  - ▶ Proxy variable – A variable used to represent another variable that might be difficult/expensive to measure.
    - ▶ Blood alcohol content – police stop

### Types of Variables vs. Scales of Variables

Types of Variables	Scales of Variables
▶ Dependent	▶ Nominal
▶ Independent	▶ Ordinal
▶ Controlled	▶ Interval
	▶ Ratio
▶ (Proxy)	
▶ (Factor)	
▶ (Predictor)	
▶ (Covariate)	

### Variable Scales

- ▶ **Nominal scale**
  - ▶ Names
  - ▶ Colors, sex, species
- ▶ **Ordinal scale**
  - ▶ Ranks
  - ▶ Tallest, heaviest, most colorful
- ▶ **Interval scale**
  - ▶ Consistent scale of measure, negative values possible (meaningless 0).
  - ▶ °F, °C, I.Q.
- ▶ **Ratio scale**
  - ▶ Consistent scale of measure, negative values not possible (meaningful 0) – ratios are informative.
  - ▶ °K, lengths, mass, number of chromosomes

### Definitions

- ▶ Accuracy – How close to the true value your measurements or estimates are.
- ▶ Precision – How repeatable your measurements or estimates are.
- ▶ Which is more important in science?

### Definitions

- ▶ Population – All of the possible observations for the variable of interest.
  - ▶ Can be defined by space and time.
  - ▶ Your conclusions will be limited to this group.
  - ▶ Not the same as an ecological or demographic population.
    - ▶ It is the value of the variables not the individuals that the values represent.
  - ▶ Can be quite large
    - ▶ Do not have to be large
- ▶ Parameter – the true value of some aspect of a variable for a population.
  - ▶ Noted by Greek letters

### Definitions

- ▶ Sample – A subset of the population used to represent the population.
  - ▶ If the population is large or difficult to access, then using a sample is practical.
  - ▶ Typically we will be using/referring to samples.
  - ▶ Statistic – an estimate of a parameter derived from a sample.
  - ▶ Noted by Latin letters.

### Definitions

- ▶ Random – Every measurement in the population has an equal chance of being in the sample.
  - ▶ Deviations from random

### Definitions

- ▶ Statistical Bias – A statistic that consistently overestimates or underestimates a parameter.
- ▶ Measurement Bias – A sample that does not accurately represent the population.
  - ▶ Selection Bias
    - ▶ Volunteer Bias
    - ▶ Sampling Bias
  - ▶ Retention Bias
  - ▶ Information Bias
    - ▶ Interviewer Bias
    - ▶ Recall Bias
    - ▶ Detection Bias
    - ▶ Social Bias

### Definitions

- ▶ Parsimony – The simplest explanation (hypothesis) consistent with the data.
  - ▶ Occam's Razor
    - ▶ When you have two competing theories that make exactly the same predictions, the simpler one is the better