Introduction

Grinnell College

January 21, 2026

R stuff before we begin

Do three things in this order

1. Download and install R (link)

2. Download and install RStudio (link)

3. Open the lab file on the course website, copy and paste and run the code in your R console

My Background

In full: Reid Vincent Eli Paris, Ph.D.

- Melrose, IA, pop. 110
- University of Maine (BS)
- Iowa State University (MS, PhD)
- Three summers at ORNL
- Taught (and TA'd) for intro stat courses
- Stat consulting at ISU for the last 5 years (140 projects)

My Research

Experimental Design

- How to get the biggest bang for your buck
- Dissertation on bias in experiments
  - Overly simple model due to resource limitations
  - Unrealistic experimental conditions
  - Hyundai and Nissian fined $230 million
- Order-of-Addition Experiments is my current interest
  - Deglaze your pan with....
    - ★ soy sauce then chocken stock *or*
    - ★ chicken stock and then soy sauce?
  - Ordering of medication matters

and random papers for consulting projects (concrete shrinkage, photoluminescence crystals, UV air filtration, etc...)

My Quirks

- Avid chess player despite not being great
  - 64^{th} percentile
  - Alekhine defence, always
- 21 National Parks and counting
  - Shout out to national forests and state parks though
  - Valley of Fire State Park all-time favorite
  - Summer desert camping
- DnD nerd
- Violin and mandolin
- Occasionally non sequitur statements but I dovetail back to a point
- Multiple audial sources (especially voices) is very distracting for me, please limit talking in lectures

Things We Will Study

A brief sketch of topics in the class

1. Describe data and variable relationships
   - graphical displays
   - designing studies
2. Estimation
   - Populations vs Samples
   - Confidence intervals
3. Hypothesis Testing
   - z-test
   - t-test
   - Chi-square tests
4. Statistical Models
   - Regression

What are you learning today?

What is *statistics*, and why do we need it?

How would you describe the statistical framework to a relative?

What is an observation and how do we describe its characteristics?

What types of variables are there, and when is each appropriate?

What is Statistics?

Statistics (the field) is the study of variability

- Deterministic systems are what the mathematicians study
- How much difference (variability) is there between groups of things?

Eg Are girls the same height as guys?

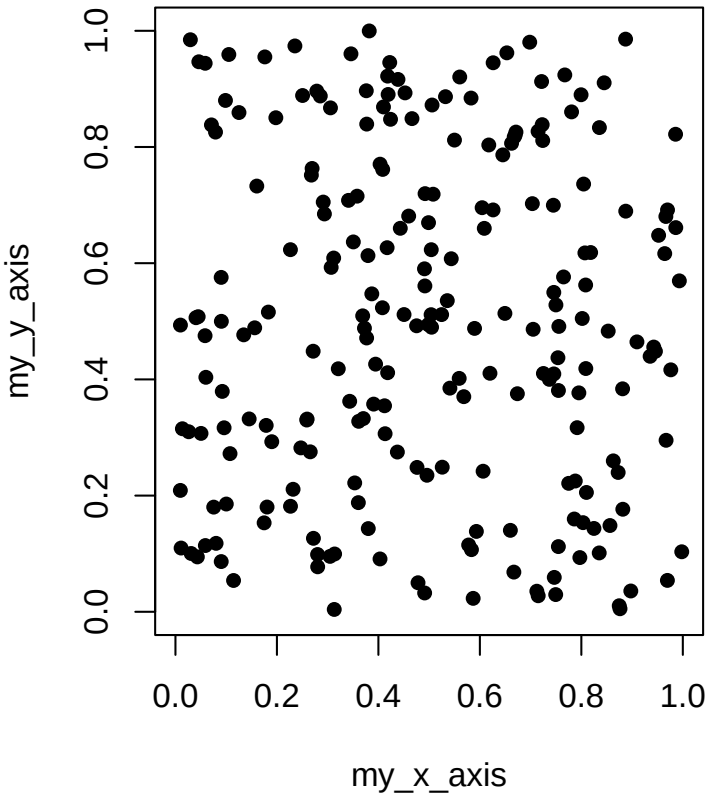
- Variability due to age
- Variability due to environmental + genetic factors
- Variability due to biology
  - want to estimate this
- Variability due to random noise

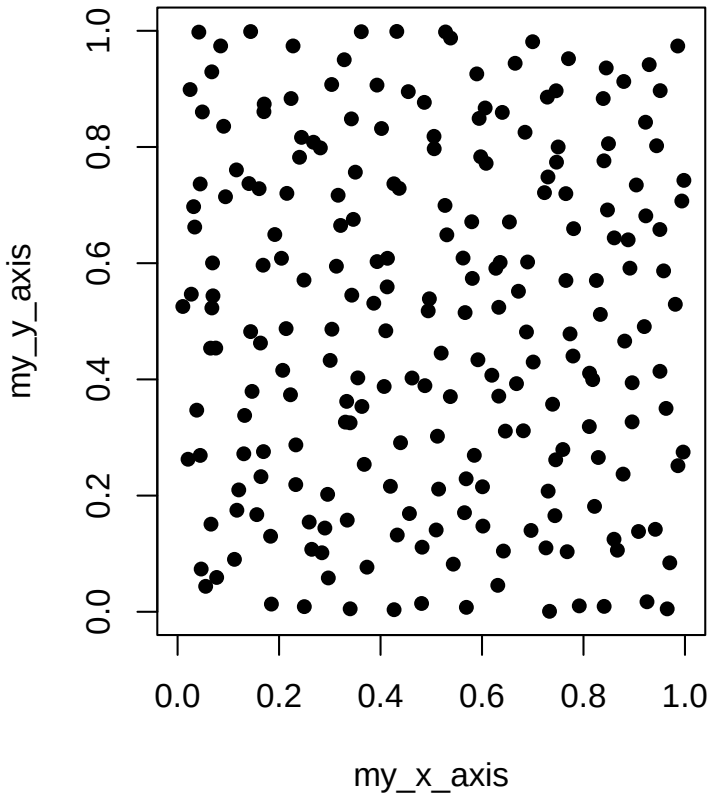
Old Statistician Trick

Pick a number between 1 and 4

Dots

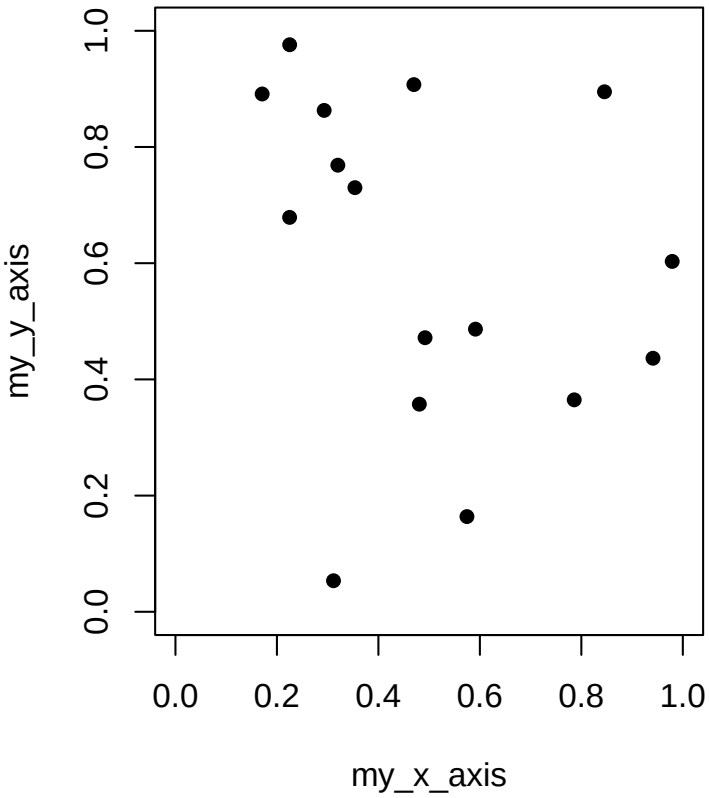
Which of these graphs look random?

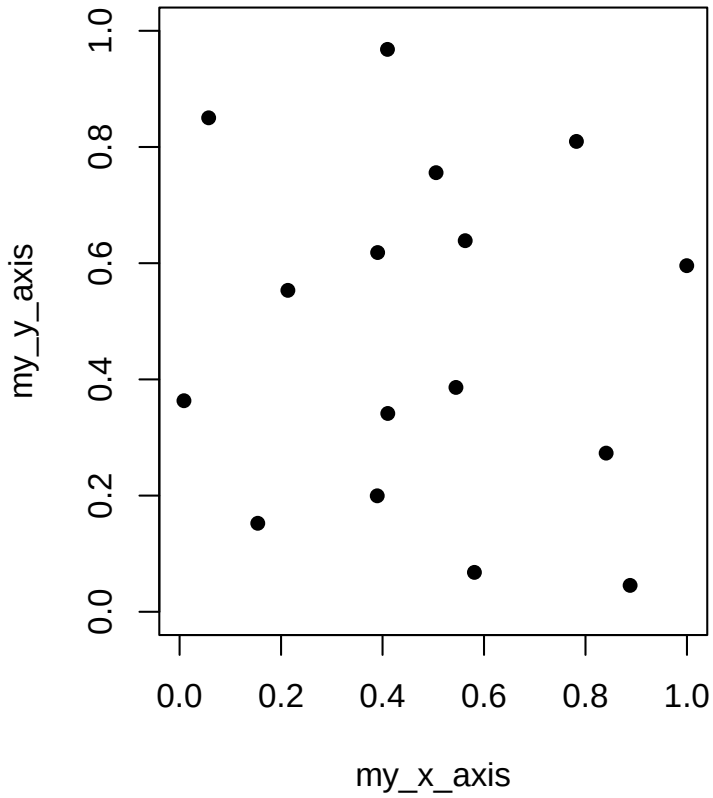




Dots 2

Sometimes it's easier if we simplify...





Why do we need statistics?

Human beings are great at identifying patterns

- Cognitive biases
- Poor intuition of uncertainty and randomness

Statistics gives us a framework for answering questions about the world using data (scientific method)

1. Clearly define your research question
2. Construct a hypothesis
3. Collect data
4. Consider evidence
5. Draw conclusions

Populations and Parameters

A **population** is a constrained group of subjects/events/things about which we wish to ask a scientific question

A **parameter** is a *quantifiable* attribute of a population. It is often assumed to be a fixed value within the bounds of the population

A **census** is a complete collection of data for a population. This lets us exactly determine the value of a parameter within the population

Samples and Statistics

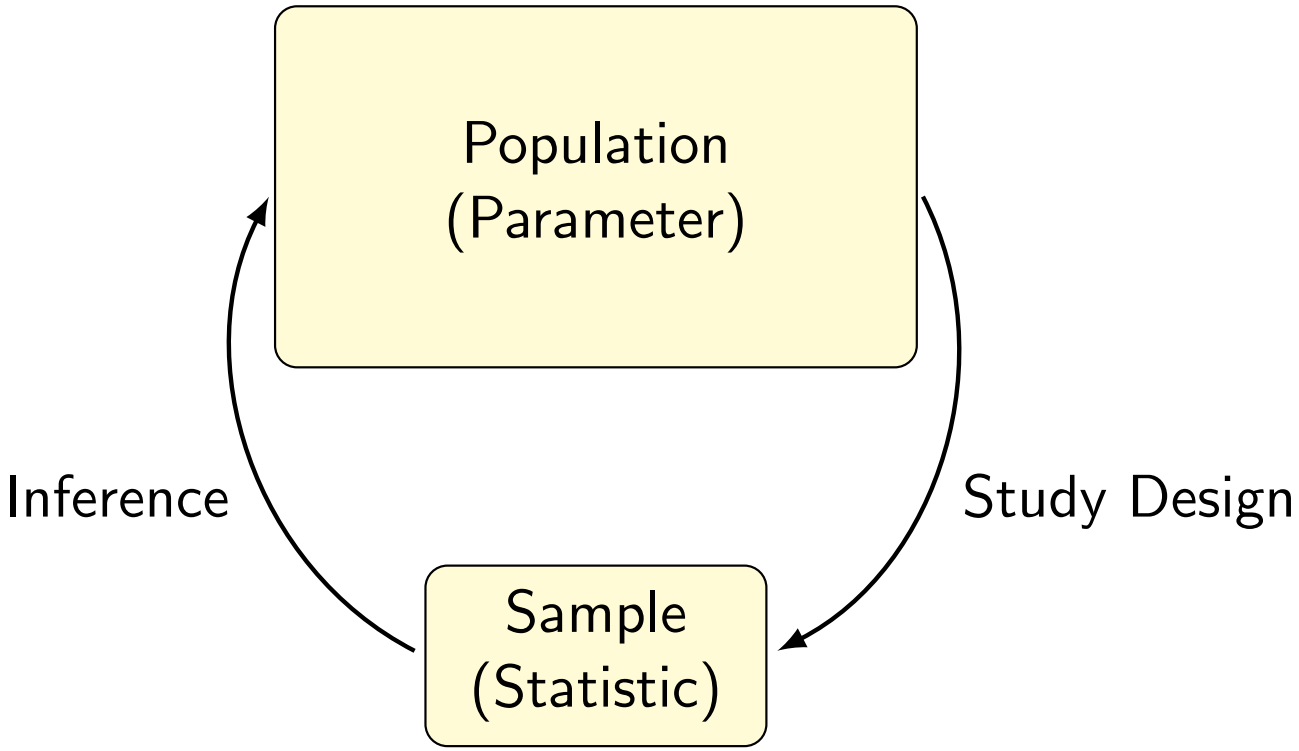
A **sample** is (often) a much smaller, (generally) *randomly collected* subgroup of a larger population

A **statistic** is an *estimate* of a parameter that we get using data collected from the sample

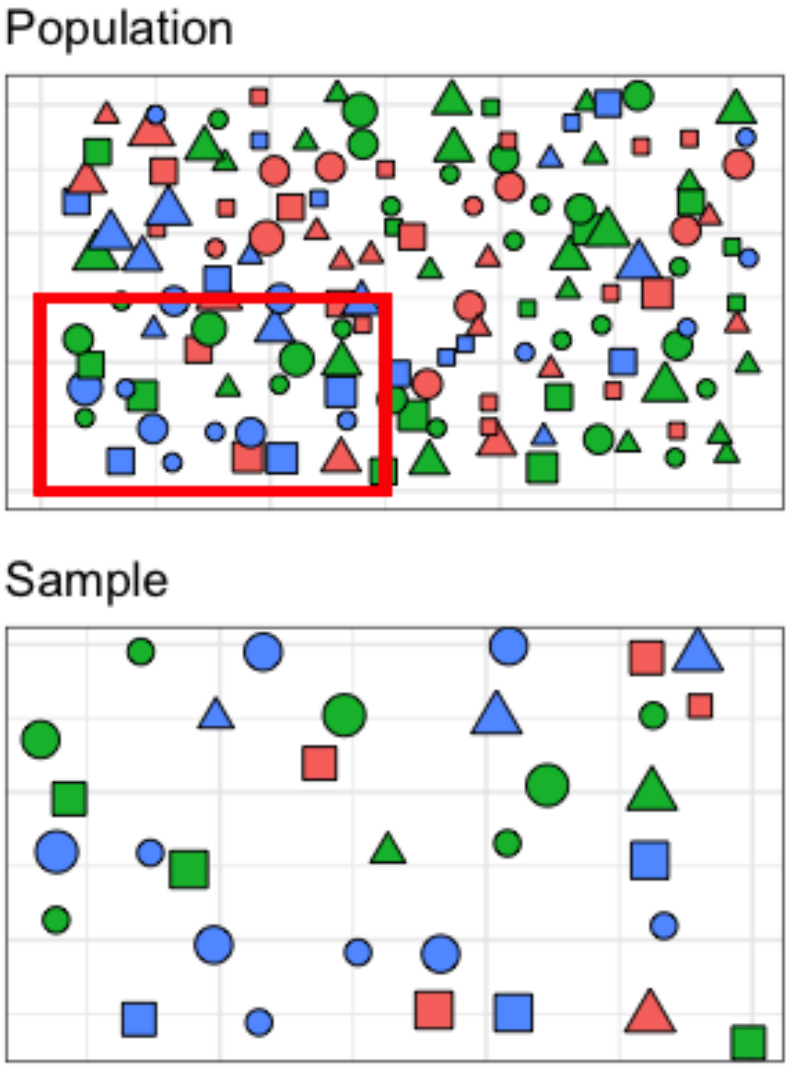
Group	**Population**	**Sample**
Method of collecting data	Census	Sampling
Numeric Summary	Parameter	Statistic
Uncertainity	No	Yes

We use statistics to say something about the parameters

The Statistical Framework



Population and Samples



An example

Suppose we are interested in determining the average height of students currently enrolled at Grinnell College

Does it matter *which* students we sample?

Does it matter *how many* students we sample?

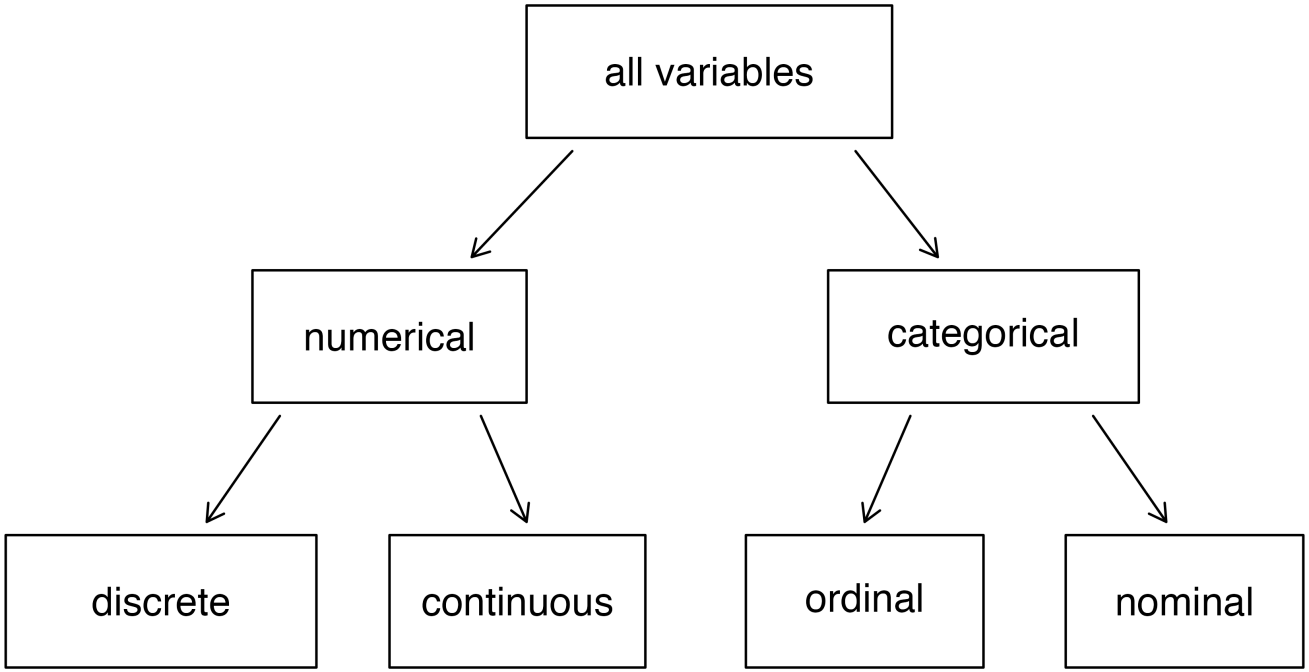
Some definitions

An **observation** (sometimes called an observational unit or case) is the literal thing we are collecting data from and are recording

The information we write down is known as **variables**. Variables typically come in one of two types:

1. **Quantitative Variable:** Typically data that is stored in the form of *numbers*, and is numerical in nature
   - Continuous data i.e., height and weight
   - Discrete data (only specific values allowed) i.e., points scored in a game
2. **Categorical Variable:** variables that are naturally divided into *groups*
   - Nominal (no ordering) ex: eye color
   - Ordinal (ordering makes sense) ex: year in college (F/J/So/Se)

Variables


all variables
numerical
categorical
discrete
continuous
ordinal
nominal

Example: Herbicide

A new computer system attempts to spray only weeds (see-and-spray) and not blanket the who field (full coverage)

Field ID	Spray Type	Wind Speed (mph)	Weed Count	Weeds covered (%)
A	see-and-spray	12	18	72
B	see-and-spray	15	29	55
C	full coverage	8	34	98
D	full coverage	11	18	97
E	see-and-spray	12	24	66
F	full coverage	14	56	95

What is the observational units? What are the variables?

Example: Herbicide

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The different fields (rows) are the obs. units while the variables are the columns (Field ID, Spray Type, Wind Speed, etc...)

Gray areas

The type of variable dictates how we analyze it:

- Numeric data often uses means (averages)
- Categorical data often uses proportions (or percentages)
- Sometimes there are situations in which a variable is technically one type, but it may be more useful to analyze it as another.
  - Total sales for a grocery store will be recorded in cents but often just say continuous for simplicity
- Sometimes the type of variable can be different depending on how we record or organize our data.
  - Age: recorded in years is numeric but young/middle-aged/elderly is categorical

Gray areas

Thoughts on if these might be used as quantitative or categorical variables?

1. Grades for a statistics class
2. A Likert Scale with five levels, measuring pain from "None at all" to "Extreme"
3. The year of birth for people enrolled in STA-209

"An approximate answer to the right problem is worth a good deal more than an exact answer to an approximate problem."
John Tukey, Statistician

Key Takeaways

- Populations are the things we want to study (students)
  - A parameter is a measurable summary of the population (mean height of students)
- A sample is a subset of the population (my students)
  - A statistic is a measurable summary of the sample (mean height my students)
- We use the sample to say something about the population
- An observation is the smallest unit of study within a population (Jack's height)

Key Takeways 2

Variables primarily come in two types:

- Quantitative
  - Continuous (height)
  - Discrete (number of people)
- Categorical
  - Nominal (favorite color)
  - Ordinal (educational attainment)

Closing

To Do Attempt to download R (first) and RStudio (second)

Suggested Readings Sections 1.2.1, 1.2.2, and 1.2.3 from IMS

Next Time: Introduction to R

Sources

IMS textbook

Prof.s Miller, Nolte and Friedrichsen's course notes

Dr. Ziegler's (ISU) course notes