Introduction to Statistics

Grinnell College

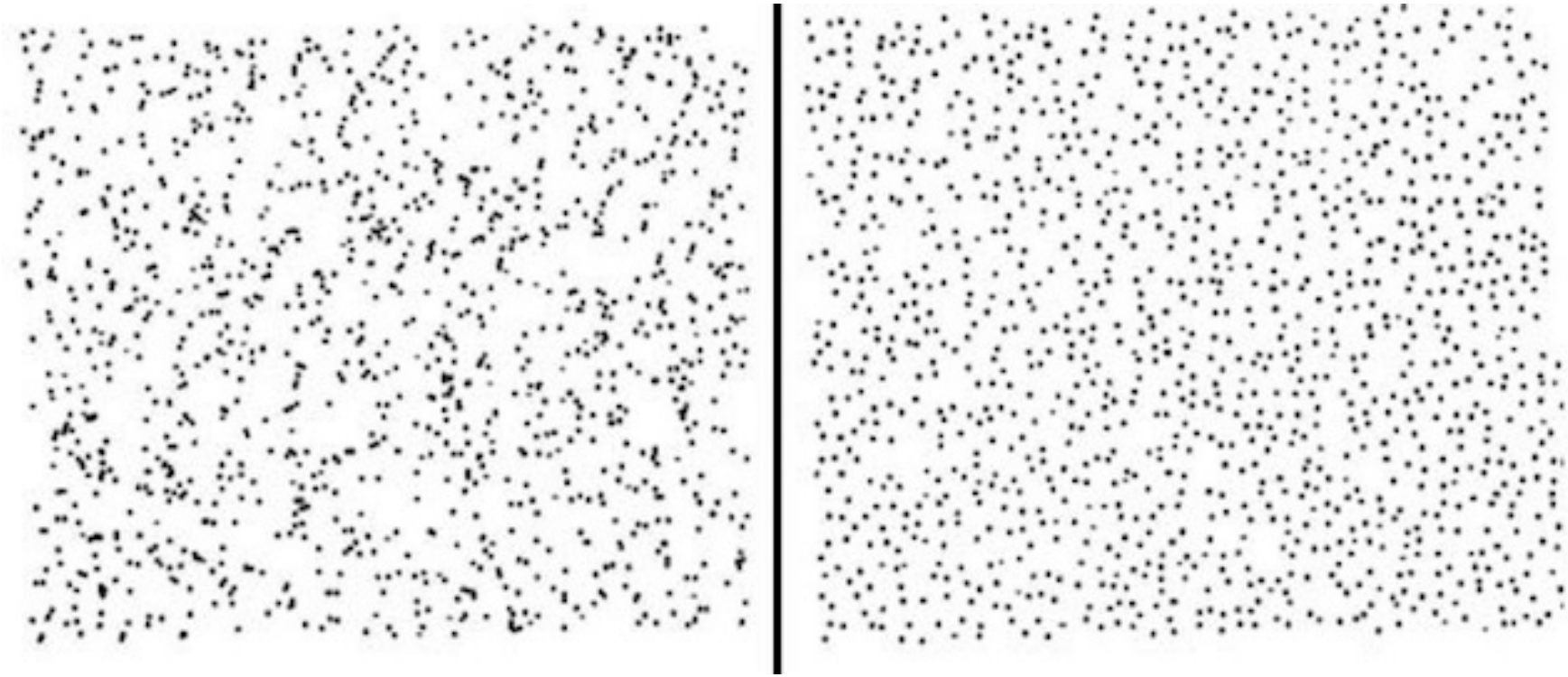
January 22, 2025

A brief outline of the class

1. Part 1 – Data Summaries
   - Visualizations
   - Numerical Summaries
   - Tables
2. Part 2 – Basics of Hypothesis Testing
   - Study design
   - Samples and distributions
   - Hypothesis testing
3. Part 3 – Statistical Tools and Applications
   - Multivariate tests
   - Statistical modeling

Dots

What differentiates these two distributions of dots? Which of these do you think reflects true randomness, and which of these seems artifically contrived?



Why do we need statistics?

Human beings are great at identifying patterns

- Cognitive biases
- Poor understanding of uncertainty

Statistics as a discipline is about the *quantification of uncertainty*.

1. Construct a hypothesis
2. Collect data
3. Consider evidence
4. Draw conclusions

Populations and Parameters

A **population** is a constrained set of events or subjects 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 or immutable quality within the bounds set by the population

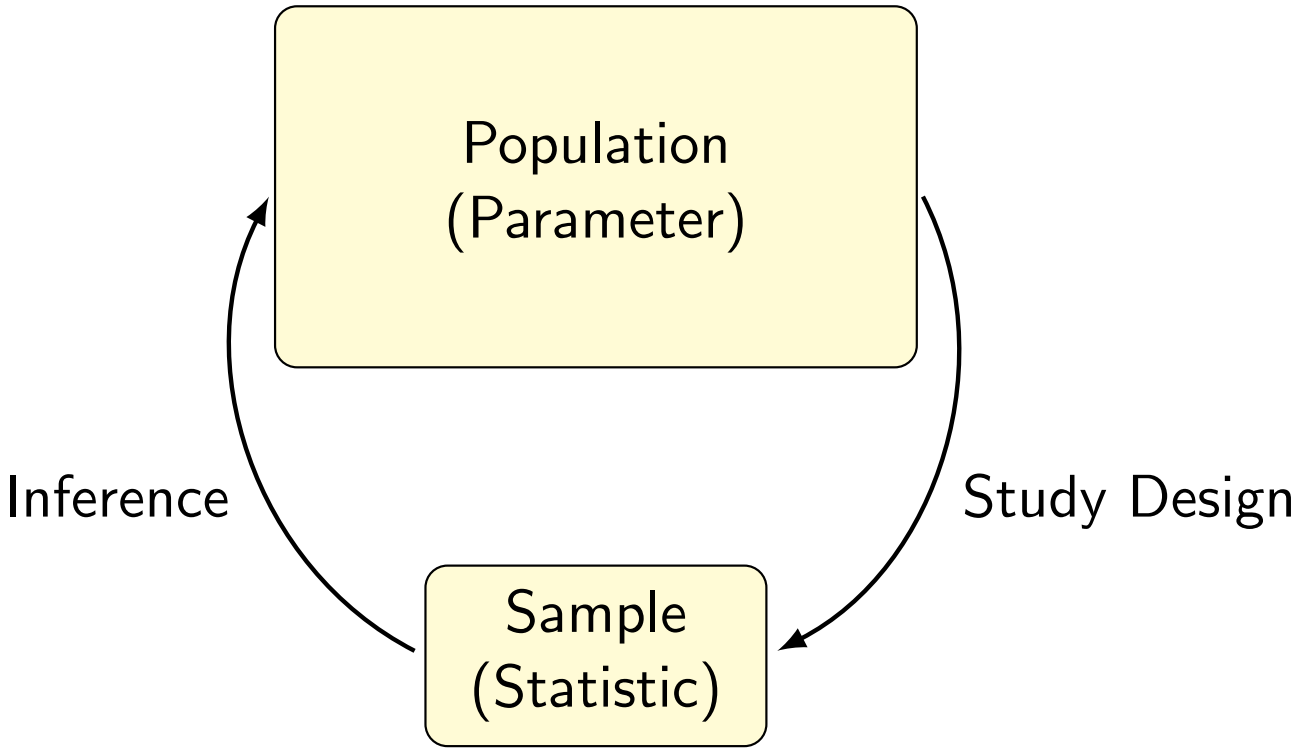
To determine the value of a parameter within a population with certainty is to conduct a **census**

Samples and Statistics

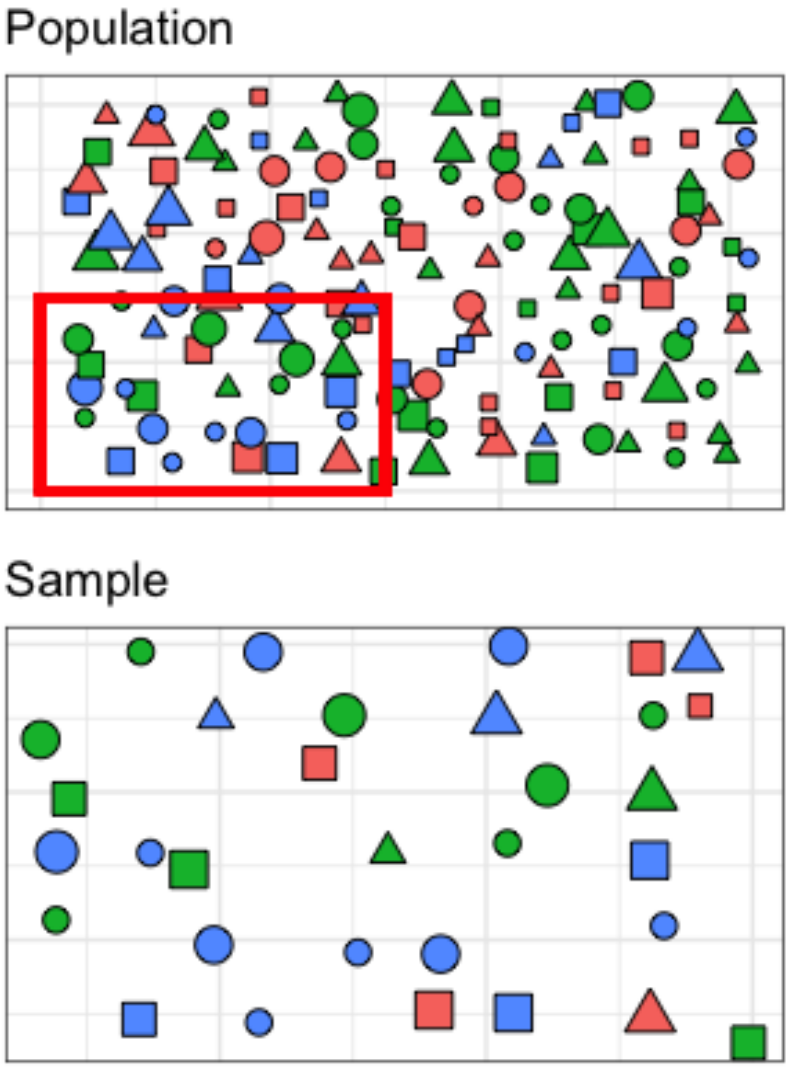
A **sample** is (often) a much smaller, (generally) *randomly collected* subset of a larger population

A **statistic** is an *estimate* of a parameter derived from data collected within the sample

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?

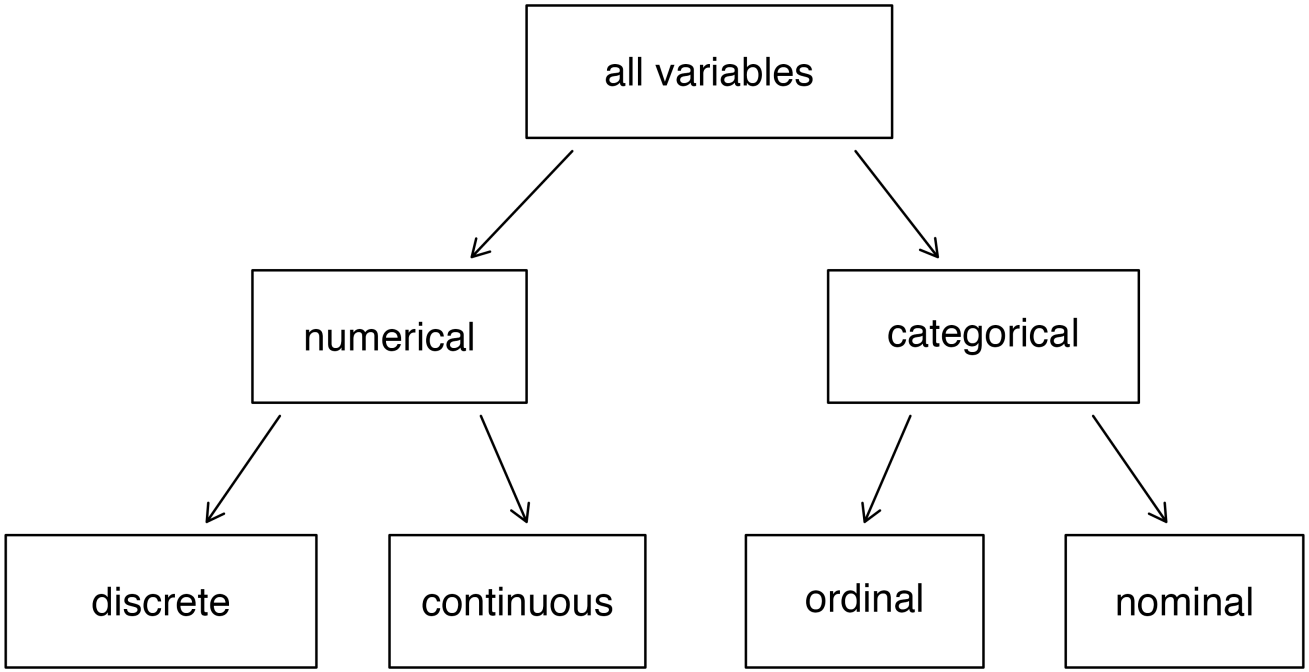
How much confidence do we have that our estimate of the average height is close to correct?

Some definitions

In this course we will primarily be working with data derived from *observations*, our most basic unit of study. Characteristics of an observation are known as **variables**. Variables typically come in one of two types:

1. **Quantitative Variable:** Data that is typically stored in the form of *numbers* and is numerical in nature
    - Continuous data i.e., height and weight
    - Discrete data i.e., points scored in a game
2. **Categorical Variable:** Variables that are naturally divided into *groups*
    - Binary
    - Nominal
    - Ordinal

Variables


all variables
numerical
categorical
discrete
continuous
ordinal
nominal

Gray areas

The type of variable dictates how we analyze it:

- We often use the **mean** or **average** to analyze quantitative variables
- We often use **proportions** or **percentages** to analyze categorical variables

Sometimes there are situations in which a variable is technically one type, but it may be more useful to analyze it as another

Key Takeaways

- Statistics is a domain agnostic tool that allows us to make quantitative statements about a population based on the properties of a sample
- Parameters are attributes of populations that we are interested in study. A sample is a subset of a population, and a statistic is a derived estimate of a parameter
- An observation is the smallest unit of study within a population. It's charactersistics are called variables

Key Takeaways

- Variables primarily come in two types:
  - Quantitative
    - ★ Continuous (height)
    - ★ Discrete (number of people)
  - Categorical
    - ★ Binary (disease status)
    - ★ Nominal (favorite color)
    - ★ Ordinal (educational attainment)