



---

# **Module 1 Lecture - Review of Scale of Measurement, Research Design, and Descriptive Statistics**

## Analysis of Variance

---

Quinton Quagliano, M.S., C.S.P

Department of Educational Psychology

## Table of Contents

<b>1</b>	<b>Overview and Introduction</b>	<b>3</b>
1.1	Instructor Learning Objectives . . . . .	3
1.2	Introduction and Overview . . . . .	3
<b>2</b>	<b>Sampling, Statistics, and Parameters</b>	<b>3</b>
2.1	Concept of Sampling . . . . .	3
2.2	Statistics and Parameters . . . . .	4
<b>3</b>	<b>Scales of Measurement and Describing Variables</b>	<b>5</b>
3.1	Introduction . . . . .	5
3.2	Quantitative vs Qualitative . . . . .	6
3.3	Nominal, Ordinal, Interval, Ratio . . . . .	7
3.4	Recap of Scale of Measurement . . . . .	8
<b>4</b>	<b>Descriptive Statistics and Plots</b>	<b>8</b>
4.1	Introduction . . . . .	8
4.2	Measures of Central Tendency . . . . .	9
4.3	Measures of Dispersion . . . . .	10
4.4	Percentiles and Quartiles . . . . .	12
4.5	Descriptions of Distributions . . . . .	13
4.5.1	Skewness . . . . .	13
4.5.2	Kurtosis . . . . .	14
4.5.3	Modality . . . . .	14
4.5.4	The Normal Distribution . . . . .	15
4.6	Descriptive Plots . . . . .	16
4.6.1	Bar Graphs . . . . .	16
4.6.2	Frequency Histograms . . . . .	18
4.6.3	Boxplots . . . . .	18
4.7	Practicing Choosing Descriptives and Plots . . . . .	19
4.8	Descriptive Tables and Frequencies . . . . .	20
<b>5</b>	<b>Hypothesis Testing</b>	<b>22</b>
5.1	Introduction . . . . .	22
5.2	Hypotheses Pairs . . . . .	22
5.2.1	Null Hypotheses . . . . .	23
5.2.2	Alternative Hypotheses . . . . .	24
5.3	Testing . . . . .	25
5.3.1	Using the Sample to Test the Null Hypothesis . . . . .	25
5.3.2	Decision and Conclusion . . . . .	26
5.4	Tails of a Test . . . . .	26
<b>6</b>	<b>Conclusion</b>	<b>27</b>

6.1 Recap . . . . .	27
---------------------	----

<b>Key Terms</b>	<b>27</b>
------------------	-----------

# 1 Overview and Introduction

## 1.1 Instructor Learning Objectives

- This material is to help refresh your knowledge of foundational statistics concepts, ideas, and descriptives, prior to more advanced topics to be covered in this course; this will be especially useful if you have not recently taken a statistics class
- Students will be able:
  - Appreciate the relationship between samples and populations
  - Correctly identify scales of measurement for variable
  - Appropriately use and calculate common descriptive statistics and plots
  - Understand the structure of hypothesis testing with statistics

## 1.2 Introduction and Overview

- Analysis of variance, or \_\_\_\_\_ for short, is the core focus of this class, but is a complex technique that benefits from a good understanding of foundational statistics
- Prior to us learning about ANOVA, we'll briefly recap the things you've likely already learned in a previous stats class, i.e., EDPS-641
- Though this is likely review, I still encourage you still engage and refresh yourself on these ideas now, so you don't get lost later on!
  - This is going to crunch the content of an intro to stats class into a single lecture

# 2 Sampling, Statistics, and Parameters

## 2.1 Concept of Sampling

- When we do research, the group we desire to \_\_\_\_\_ and understand is our **population of interest**
  - E.g., All high school students, all teachers
  - The population is usually a group we can't practically, \_\_\_\_\_ study (as they are usually too large or dispersed!)
  - In the case that we did somehow gather data about \_\_\_\_\_ members of a population, we would call this a **census**

Discuss: Given this definition of a census, I just provided, explain why would we call the periodic counting of all individuals in the US a 'census'

- Instead of gather data on the population as a whole, we take a \_\_\_\_\_ subset of individuals that are meant to represent the population, which we would call a **sample**
  - We get our sample via some method of **sampling**, which is exactly how we get our subset - it can be done in a "good" or "bad" way, resulting in a representative or non-representative sample, respectively

## 2.2 Statistics and Parameters

- The numeric values that we use to calculate and describe on our \_\_\_\_\_ is called a **statistic**, which, in turn, is meant to represent the **parameter** of the population
  - Another way to say this is that the sample statistic is an \_\_\_\_\_ of the population parameter
  - A mnemonic to remember this:
    - \* Poulation → Parameter
    - \* Sample → Statistic

Discuss: I am interested in the average numeric exam score of PSY-101 students, and I take 10 individuals out of the 300 total to represent all the PSY-101 students - what is the sample and what is the population in this example? I take the mean average of the 10 individuals - is this mean a statistics or a parameter, and why?

- But, remember our goal is often to study the \_\_\_\_\_, not just the subset we gather data for!

- Thus, we want to have great \_\_\_\_\_ that whatever statistics we have, \_\_\_\_\_ represent their respective parameters
- One part of ensuring this accuracy is to use a sampling method that results in a **representative sample**

**!** Important

Don't lose sight of this - our sample is just a practical way for us to try and say something about our population, which is what we are really after.

### 3 Scales of Measurement and Describing Variables

#### 3.1 Introduction

- The data we use for analysis will be organized into \_\_\_\_\_ and \_\_\_\_\_, with values for each individual in our sample
  - It's critical we can accurately describe variables, especially when it comes to applying \_\_\_\_\_ statistics and plots
- **Variables** are some defined measure/observation with variance in the data
  - I.e., there needs to be \_\_\_\_\_ numbers in the data, the characteristic can take different values - otherwise it is a **statistical constant**
  - \_\_\_\_\_ can also be either **numeric** or **categorical**, that is, they produce data of a specified type
  - E.g., Age in years → \_\_\_\_\_
  - E.g., Job title → \_\_\_\_\_

**?** I gather information about all the individuals enrolled at a local college, and all live in the state of Indiana. Is state of residence a constant or variable, and is it categorical or numeric?

- A) Categorical Constant
- B) Categorical Variable
- C) Numeric Constant
- D) Numeric Variable

Explanation:

- Variables have some distribution

- A description of how values of a variable are spread out and distributed across the range of possible values
- We'll cover ways to represent these distributions well in the section: Descriptive Statistics and Plots

## 3.2 Quantitative vs Qualitative

- Let's dive more into the different \_\_\_\_\_ of data
  - These are closely related to the above "categorical" and "numeric" terms
- qualitative data come from a more descriptive (via words or \_\_\_\_\_)
  - E.g., Eye/hair color, more complicated: description of internal feelings
  - Because of its nature, it is almost always \_\_\_\_\_ in nature
  - Qualitative data is often times represented in \_\_\_\_\_ of occurrences of a certain description, for the purpose of analysis - e.g., I have 10 people in my sample with brown eyes, and 5 with blue eyes
- quantitative data is something represent by an \_\_\_\_\_ or numeric measurement
  - However, within quantitative data, it can be discrete or continuous
  - Discrete data is that which is \_\_\_\_\_, or has no intervals between the integers, e.g., number of phone calls had → I can't have half a phone call
  - Continuous data does indeed have \_\_\_\_\_ between integers, e.g., Age → I can be half a year of age.
  - For better or for worse, these two types are often treated \_\_\_\_\_, even when that may not be accurate

? Consider this variable: Numbers of children a parent has. What could this be classified as?

- A) Qualitative
- B) Discrete Quantitative
- C) Continuous Quantitative
- D) None of the above

Explanation:

### 3.3 Nominal, Ordinal, Interval, Ratio

- **Nominal scale** variables are qualitative and categorical, with classifying and no defined “order”.
  - E.g., state/country of residence, hair/eye/skin color
- **Ordinal scale** variables are those that have an order, but there is not a clear between each interval or place in the order
  - Thus, it sort of blurs the line between categorical and
  - E.g., place in a foot race, class rank
- **Interval scale** variables do have a clear, consistent interval in-between each integer, but no absolute zero point
  - E.g., temperature, IQ scores, ranges, etc.
- **Ratio scale** is the same as interval scale, but does have a clear zero point as well.
  - E.g., score on an exam
- Generally, the different levels/scales of measurement are different levels of for analysis, in this order: Nominal (most restrictive) to Ratio (least restrictive).
  - Of course, having mostly nominal scale data does not always spell doom, but it can involve more tricky
  - We'll discuss in this class how to account for more tricky data types, e.g., in ANOVA analyses, during this class

**► Discuss:** I put all the students in my class from shortest to tallest and assign them the number they are from being the shortest in the class, what scale of measurement would this data be and why?

### 3.4 Recap of Scale of Measurement

- The nature and scale of \_\_\_\_\_ of variable is limiting to what descriptive statistics, plots, and inferential statistics we can apply
  - There is significant overlap between these descriptors - usually Nominal, Ordinal, Interval, Ratio are sufficient ways to describe a variable for determining what analyses can be done
  - However, you'll see the other descriptors come up, so you should be aware

 Discuss: Think of a person's annual salary in dollar; look back at all the vocabulary in this last section and list all the different ways you can describe this data

## 4 Descriptive Statistics and Plots

### 4.1 Introduction

- Data, in it's raw form, is very \_\_\_\_\_
  - Especially large data sets are likely to be borderline \_\_\_\_\_

 Discuss: With the following table, try to say something meaningful about this data/explain it

Student	Q1	Q2	Q3	Q4	Q5
Student 1	1	0	1	1	0
Student 2	0	1	0	1	1
Student 3	1	1	1	0	0
Student 4	0	0	1	0	1
Student 5	1	1	0	1	1

- Realistically, we need a way to \_\_\_\_\_ our datasets in a way that capture the overarching trends in the values
  - This can be done both \_\_\_\_\_ and via \_\_\_\_\_ statistics, and often times, both!

! Important

There is usually not only one 'right' way to graph or represent data - it may be advantageous to try multiple methods and see how they compare

## 4.2 Measures of Central Tendency

- **Measures of central tendency** of a \_\_\_\_\_ of scores are statistics that \_\_\_\_\_ scores that are typical, central or average in the distribution.
  - The most \_\_\_\_\_ measures of central tendency in the social sciences are the mode, the median and the mean.
- The **mode** is the most commonly \_\_\_\_\_ value in a variable/-dataset
  - Mode is often just spelled out, and not given a special notation
  - There is not a very useful formula for finding the mode, but realistically all you need to do is a bar plot and find the \_\_\_\_\_ bar (for the highest frequency)
- The **median** is the value at the 50th percentile, second quartile ( $Q_2$ ), or, put simply, the value that \_\_\_\_\_ the data into two equal halves when ordered from smallest to largest
  - In the case that there is no actual exact middle value when ordered smallest to largest, we'd \_\_\_\_\_ the two middle-most values
  - Sample median \_\_\_\_\_ notation:  $X_m$
  - Population median \_\_\_\_\_ notation:  $M$
  - The best strategy for finding median is to order the values and then cross values off from both ends until you end up with one uncrossed value
  - To find the *location* of the median, one can do:  $\frac{n+1}{2}$

- The **mean** is the arithmetic average of the data
  - Sample mean \_\_\_\_\_ notation:  $\bar{x}$  (x-bar)
  - Population mean \_\_\_\_\_ notation:  $\mu$  (mu)
  - The sample mean is calculated with:

$$\bar{x} = \frac{x_1 + x_2 + x_3 + \dots + x_n}{n}$$

**!** Important

Something worth noting is that the median is less prone to be affected by outliers than the mean, making it useful in certain circumstances.

? I have data 1,2,2,2,3,4,5. Datapoint 2 is the most commonly occurring value, thus it is the [BLANK]

- A) Mode
- B) Median
- C) Mean
- D) None of the above

Explanation:

### 4.3 Measures of Dispersion

- Measures of dispersion** are statistics that summarize how data is \_\_\_\_\_ out across a distribution
  - The most \_\_\_\_\_ measures of dispersion we should be concerned with are standard deviation, variance, range, and interquartile range.
- Each number in a dataset has a **deviation**, or how \_\_\_\_\_ away it is from the mean
  - This is calculated simply as the \_\_\_\_\_ between the value and the sample mean of the data
  - $x - \bar{x}$  or
  - $x_i - \bar{x}$

- To calculate the standard deviation, we first will calculate the **variance**, which is just the \_\_\_\_\_ standard deviation
  - Sample variation statistic:  $s^2$
  - Population variation parameter:  $\sigma^2$
  - The variation sample statistic and population parameter formulas are, respectively:

$$s^2 = \frac{\sum (x - \bar{x})^2}{n - 1}$$

$$\sigma^2 = \frac{\sum (x - \mu)^2}{n}$$

**!** Important

The reason we must use variance to calculate standard deviation relates to the need to square in order to avoid getting 0 from summing the deviations

- By far, the most important and most used way to describe the \_\_\_\_\_ of all the data is the **standard deviation**
  - A measure of the average \_\_\_\_\_ away from the mean that a point is in a distribution
  - It is used instead of variance because it removes the “square” from interpretation
  - Sample standard deviation statistic:  $s$
  - Population standard deviation parameter:  $\sigma$  (sigma)
  - The standard deviation sample statistic and population parameter formulas are, respectively:

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

$$\sigma = \sqrt{\frac{\sum (x - \mu)^2}{n}}$$

**!** Important

Realistically, we tend to only directly use the sample statistics calculations

Discuss: Look back at the previous equations; which of the measures of central tendency sees the greatest use in these formulas?

- The **range** is the \_\_\_\_\_ between the largest and smallest values in the data
- The **interquartile range (IQR)** is the 75th percentile (upper quartile,  $Q_3$ ) minus the 25th percentile (lower quartile,  $Q_1$ ). It is the width of the interval that contains the \_\_\_\_\_ 50% of the data.
  - In formula it could be represented as:  $Q_3 - Q_1 = IQR$

#### 4.4 Percentiles and Quartiles

- Quartiles** are used to cut numerical data into 4 equal-sized \_\_\_\_\_ when the data is ordered smallest to largest
  - $Q_1$  (first quartile) is above 1/4 or 25% of the data
  - $Q_2$  (second quartile) is above 1/2 or 50% of the data
  - $Q_3$  (third quartile) is above 3/4 or 75% of the data
- Percentiles** function the same as quartiles, but \_\_\_\_\_ the data into 100 equal-sized sections
  - For example, at the 90th percentile, 90% of scores are lower
  - Percentiles are especially commonly used to describe roughly where data points fall - this comes up often in standard-ized testing
  - The 25th percentile is equivalent to  $Q_1$ , 50th percentile is equivalent to  $Q_2$ , and the 75th percentile is equivalent to  $Q_3$

## 4.5 Descriptions of Distributions

Discuss: Quickly list as much as you can remember about the characteristics of a 'normal distribution'

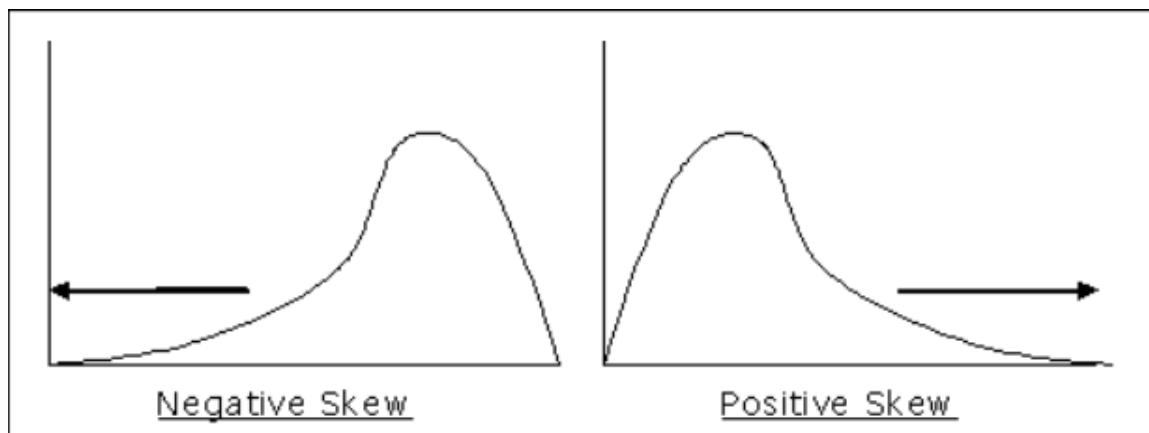
- There are several \_\_\_\_\_ that are not well described as either **Measures of Dispersion** or **Measures of Central Tendency**, but still helpful in understanding the layout of a continuous distribution
- Usually, we use **The Normal Distribution** as an "ideal", and describe variables' distribution in how it \_\_\_\_\_ to the normal distribution
  - This is how we will describe **Skewness**, **Kurtosis**, and **Modality**

### 4.5.1 Skewness

- **Skewness** is a description of how a distribution departs from \_\_\_\_\_ or has a 'tail'
  - A **positive/right skew**: when a distribution has most values clustered towards the \_\_\_\_\_ end, and a tail out to the right side of the frequency histogram
  - A **negative/left skew**: when a distribution has most values clustered towards the \_\_\_\_\_ end, and a tail out to the left side of the frequency histogram

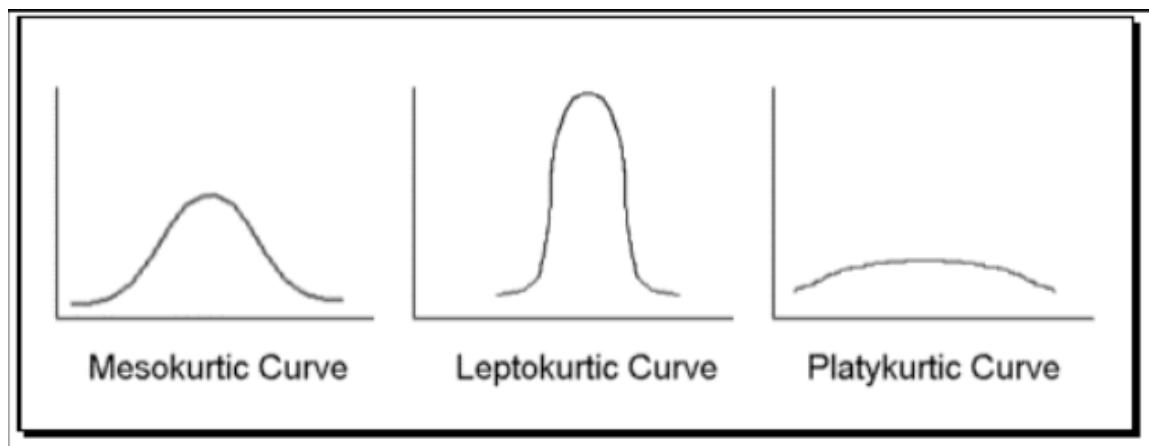
#### ! Important

As a helpful mnemonic, the direction of the skew is the direction of the 'tail', not the 'hump'



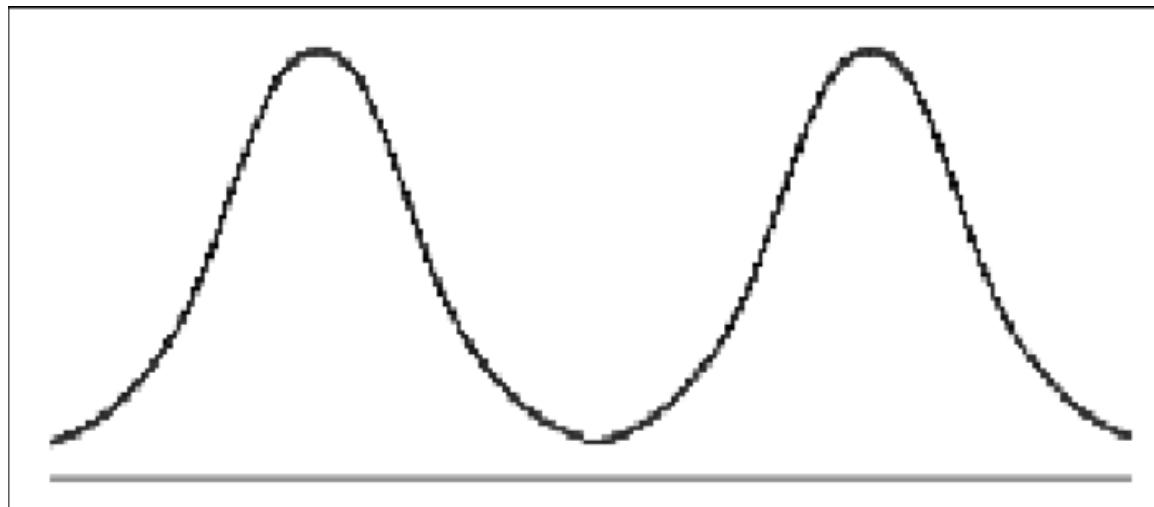
#### 4.5.2 Kurtosis

- **Kurtosis** is a description of how 'peaked' a distribution is
  - A **leptokurtic** distribution has too many scores concentrated in the center and not \_\_\_\_\_ in the tails. (peaked)
  - A **platykurtic** distribution has too few scores in the center and too many in the \_\_\_\_\_. (flat)
  - **The Normal Distribution** is said to be \_\_\_\_\_



#### 4.5.3 Modality

- **Modality** a description of how many \_\_\_\_\_ a distribution has
  - A distribution is **unimodal** when it has only one peak, and **bimodal** when it has two peaks

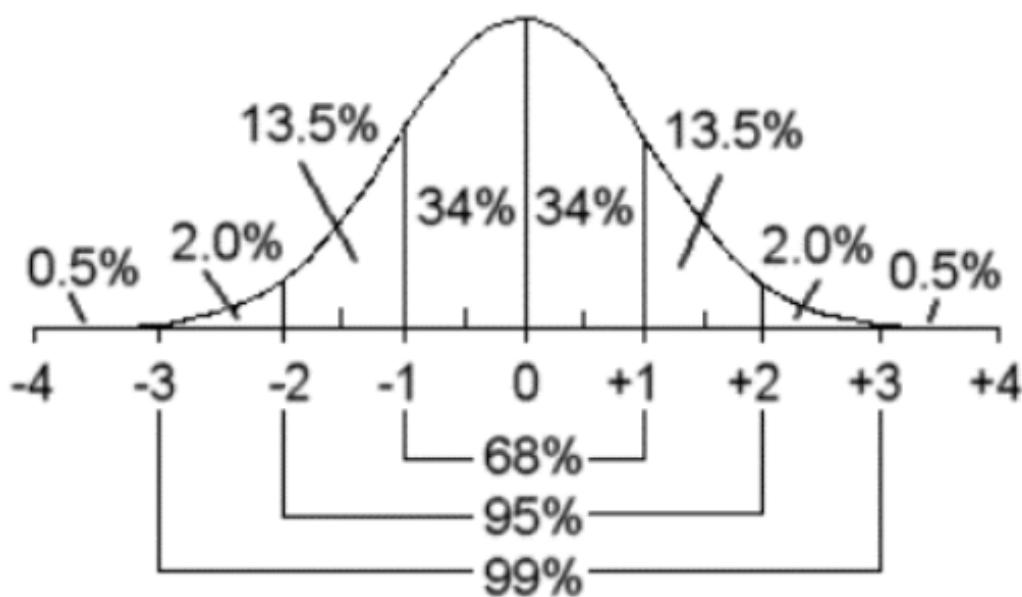


Discuss: Take a guess at what a distribution with three peaks would be called

#### 4.5.4 The Normal Distribution

##### Important

The normal distribution, is an 'ideal' and used theoretically. In practice, collected raw data will never be perfectly normal. There are also other ideal distributions such as the exponential and uniform distributions, that are also useful in certain circumstances.



- The **normal distribution** is a distribution of a \_\_\_\_\_ variable that is unimodal, symmetrical, mesokurtic, bell-shaped, and the mean, median, and mode are equal
  - Follows the **empirical rule**

**Discuss:** Reading the distribution chart above, at what number of standard deviations are 84 percent of values beneath it?

## 4.6 Descriptive Plots

- There are *many* ways to \_\_\_\_\_ represent data in a coherent way - we'll cover just a few: **Frequency Histograms, Bar Graphs, and Boxplots**

### 4.6.1 Bar Graphs

- Bar graphs** help show \_\_\_\_\_ of values of categorical/nominal variables

*"I don't mind not knowing. It doesn't scare me." — Richard P. Feynman*

Figure 1: Frequency of Students by Class

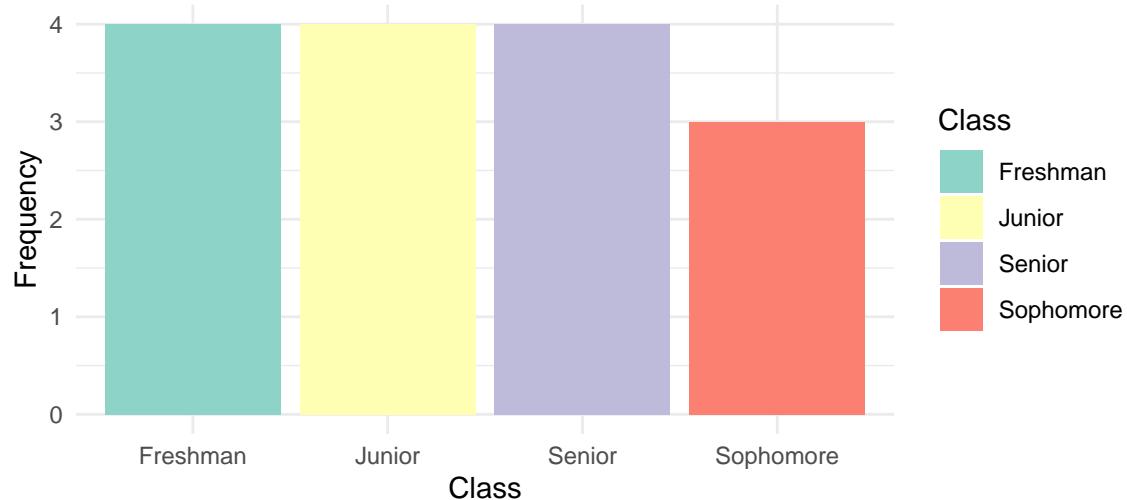
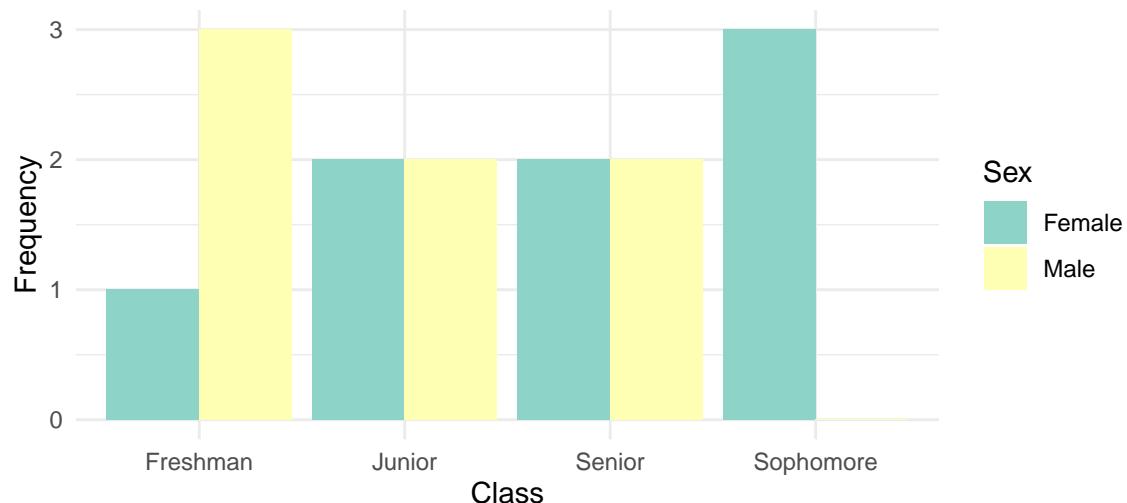


Figure 2: Frequency of Students by Class and Sex



Discuss: Come up with 2 additional examples of variable that could be well-represented with a bar chart

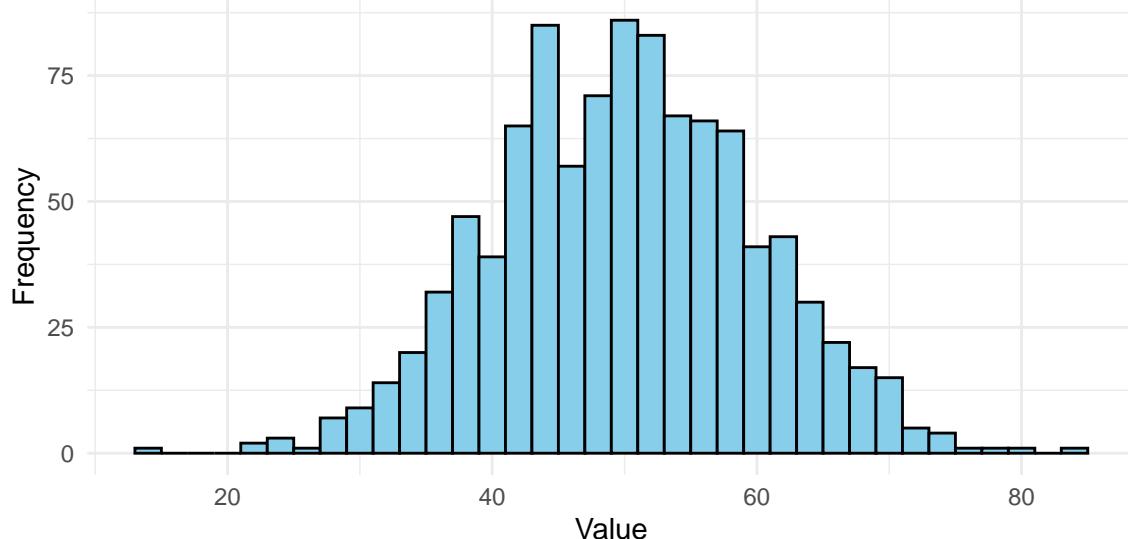
#### 4.6.2 Frequency Histograms

- A frequency histogram, at first glance, looks much like a \_\_\_\_\_ plot, as described prior.
- However, rather than use individual discrete points or labels, histograms will \_\_\_\_\_ values by a defined bin width, and count the frequencies of values within that bin
  - All the intervals will be the same \_\_\_\_\_, and we choose that width somewhat arbitrarily
  - But, it's worth noting that the bin interval can have a \_\_\_\_\_ impact on the overarching interpretation

##### ! Important

Smaller bin size is not always better! Especially in data that is more spread out.

Figure 3: Example of a Histogram (Bin width = 2)

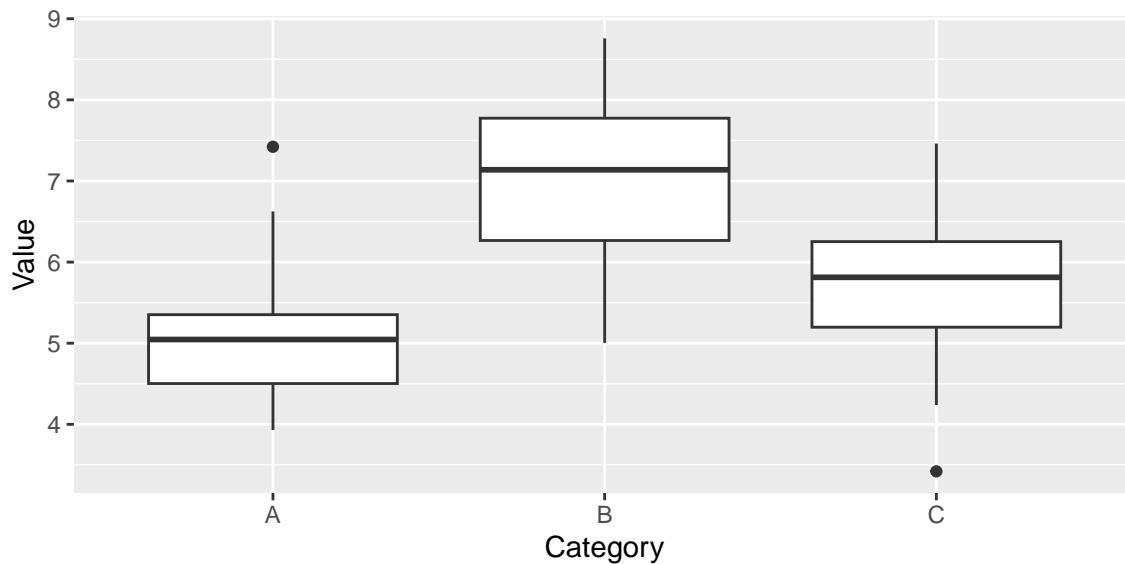


#### 4.6.3 Boxplots

- Boxplots are useful for representing information about the quartiles, percentiles, and \_\_\_\_\_ all in a single plot
  - Also called box-and-whisker plots (may be the preferred name for the cat-lovers like myself)

- The \_\_\_\_\_ of a box plot represents a median, edges of the box represent  $Q_1$  and  $Q_3$  (i.e., the box is the IQR), the whiskers usually extend to the farthest values

Figure 4: Boxplot example



## 4.7 Practicing Choosing Descriptives and Plots

- Not all plots and descriptive statistics provide the \_\_\_\_\_ information - try the following questions for practice

? I want to graphically examine the median and IQR of SAT scores in a local school district, how could I do this?

- A) Boxplot
- B) Frequency histogram
- C) Kurtosis
- D) Arithmetic Mean

Explanation:

? I want to know the numeric value most commonly appearing in a dataset, how could I find this?

- A) Mean
- B) Median
- C) Boxplot
- D) Mode

Explanation:

? I want visually compare my variable of student wellbeing ratings (continuous) against a normal distribution, how could I best examine this?

- A) Boxplot
- B) Bar plot
- C) Histogram
- D) Mean

Explanation:

## 4.8 Descriptive Tables and Frequencies

- **Simple frequency** is a count of the \_\_\_\_\_ of cases – or frequency - that fall in the different \_\_\_\_\_ or that obtain certain scores.
  - E.g., - the number of girls and boys in a sample the number of students who identify themselves as African-American, Asian- American, Hispanic, or White on a questionnaire; the number of people who obtain different scores on a test
- **Relative frequency** is the \_\_\_\_\_ or percentage of cases for each score in the distribution
- **Cumulative frequency** is a count of the number of cases that fall \_\_\_\_\_

a certain score. A cumulative frequency is provided for all scores in the distribution

- Cumulative relative frequency is the \_\_\_\_\_ or percentage of cases that fall below a certain score.

Score	Frequency	Cumulative Frequency	Percent	Valid Percent	Cumulative Percent
0	1	1	2.2	2.2	2.2
2	1	2	2.2	2.2	4.3
3	3	5	6.5	6.5	10.9
4	2	7	4.3	4.3	15.2
5	4	11	8.7	8.7	23.9
6	4	15	8.7	8.7	32.6
7	6	21	13.0	13.0	45.7
8	3	24	6.5	6.5	52.2
9	7	31	15.2	15.2	67.4
10	7	38	15.2	15.2	82.6
11	3	41	6.5	6.5	89.1
12	2	43	4.3	4.3	93.5
13	2	45	4.3	4.3	97.8
15	1	46	2.2	2.2	100.0
Total	46		100.0	100.0	

► Discuss: Based on your reading of the above table, what is the cumulative frequency at score '11'?

## 5 Hypothesis Testing

### 5.1 Introduction

- In statistics, hypothesis testing is the process by which we \_\_\_\_\_ whether data supports making a certain conclusion beyond a \_\_\_\_\_ doubt
- We have certain \_\_\_\_\_ to work through a hypothesis test:
  - Set up the \_\_\_\_\_ null and alternative hypotheses
  - Collect data in a \_\_\_\_\_
  - Determine an appropriate \_\_\_\_\_ test and distribution to represent our \_\_\_\_\_
  - Conclude whether we can \_\_\_\_\_ the null hypothesis or if we cannot

#### ! Important

I think it's important to emphasize that it is not our 'goal' to reject the null hypothesis - as empiricists, our orientation should be towards truth, not a certain outcome

### 5.2 Hypotheses Pairs

- A hypothesis is just a prediction or a statement of a possible \_\_\_\_\_
  - E.g., I hypothesize (or predict) that college students who are Gen Z have significantly worse attention than Millennial college students
  - Most scientific \_\_\_\_\_ begin with some hypothesis of what outcomes will look like

► Discuss: Consider that you are a middle-school teacher being asked by administration to implement an especially permissive attendance structure, write a hypothesis of what this will do to student math scores

- When we make \_\_\_\_\_ in statistics, we do so in a \_\_\_\_\_ pair by making a null hypothesis and an alternative hypothesis
  - In \_\_\_\_\_ statistical testing, we frame our inferential tests as helping us determine whether to reject the [Null Hypothesis] - there is a whole other field of statistics called \_\_\_\_\_ statistics that has a somewhat different focus

❗ Important

It's important to understand that, as part of the statistical testing process, we should always consider what our null and alternative hypothesis is!

### 5.2.1 Null Hypotheses

- A **null hypothesis** is a prediction or statement of \_\_\_\_\_ difference or relationship between two or more things
  - It is usually written as  $H_0$
  - \_\_\_\_\_ of alternative hypothesis
- A null hypothesis is often written to include an \_\_\_\_\_ sign such as with:
  - =
  - But also,  $\geq$  &  $\leq$
- Example: There is *no* difference in average attention between Gen Z and Millennial college students
  - Represented in notation  $H_0 : \mu_{Attn-Z} = \mu_{Attn-Millennial}$

🔊 Discuss: Write the null hypothesis for comparing mental health between women and men in the legal field, where they have equal levels of depression

### 5.2.2 Alternative Hypotheses

- Our **alternative hypothesis** suggests a difference between two or more things
  - It is most often represented as  $H_A$  or  $H_1$
  - Opposite of Null Hypothesis
  - This is usually close to how we would phrase a \_\_\_\_\_ hypothesis
- The \_\_\_\_\_ hypothesis does *not* contain equal signs
  - This would include  $\neq$ ,  $>$ , and  $<$
- Example: There *is* a difference between Gen Z and Millennial college students in average attention
  - Represented in notation  $H_A : \mu_{Attn-Z} \neq \mu_{Attn-Millennial}$

🔊 Discuss: Write the alternative hypothesis for comparing mental health between women and men in the legal field, where women have higher levels of depression

🔊 Discuss: Look back at the example null and alternative hypotheses - am I using notation for population parameters or sample statistics? Why do I do it this way?

## 5.3 Testing

- While accounting for the \_\_\_\_\_, statistics, parameters, and sampling distribution we have do help us make good choices about hypothesis testing - they don't tell us everything
  - We always have to remember that things in statistics are \_\_\_\_\_!
  - With our sampling and data gathering we may run into a **rare event**
- To account for the \_\_\_\_\_ of a rare event, we test the null hypothesis somehow

🔊 Discuss: Try re-explaining, in your own words, what 'probabilistic' means and why it's readily applicable to the practice of statistics

### 5.3.1 Using the Sample to Test the Null Hypothesis

- This is where we introduce the **p-value**, which is the \_\_\_\_\_ that, under the null hypothesis being \_\_\_\_\_, our results will be as extreme as they are
  - Example: a test result returns a p-value of 0.07. Assuming the null hypothesis is true, this result only had a 7% chance of occurring.
- Effectively, when we \_\_\_\_\_ against the null hypothesis and determine a p-value, we are trying to gauge how likely our results were to

occur if the null hypothesis was true

- If our results are especially \_\_\_\_\_ under the null hypothesis (i.e., a low p-value), then we may be inclined to believe that our case is somehow truly different, and thus the null hypothesis is incorrect and can be \_\_\_\_\_

### ! Important

There are many misunderstandings people have about statistics, but failing to understand the meaning of p-values is probably the single most common and pervasive errors people make in interpreting statistics.

### 5.3.2 Decision and Conclusion

- How do we determine if the p-value is, “rare enough”?
  - Ideally, we test it against a preset/preconceived **significance level**, also given as  $\alpha$ .
  - We \_\_\_\_\_ whether our p-value is  $\geq$  or  $<$  our  $\alpha$
- If you don’t see further information, the most \_\_\_\_\_ significance level is  $\alpha = 0.05$ 
  - However, this isn’t a hard set rule.
- If our p is  $< \alpha$  then we say we have **statistical significance**
  - In the context of an inferential test, like a t-test, we are looking for our test statistics to be more extreme than the **critical value**

### 5.4 Tails of a Test

- A test may be described as two-tailed, left-tailed, or right-tailed, dependent on the \_\_\_\_\_ used in the alternative hypothesis
  - $H_a : P > 0.5 \rightarrow$  right-tailed (one-tailed)
  - $H_a : P < 0.5 \rightarrow$  left-tailed (one-tailed)
  - $H_a : P \neq 0.5 \rightarrow$  two-tailed
- This needs to be set as part of the study set up, not during analysis!

🔊 Discuss: Consider the following example: Johnny predicts that Samantha has more money than Becky right now. Is this a one-tailed or two-tailed test and why?

## 6 Conclusion

### 6.1 Recap

- This was a (not so) quick recap of basics ideas in describing and examining data, and the nature of variables, samples, populations, and distributions
- We saw examples of how to appropriately apply certain descriptive procedures, and also discussed some of the limitations
- We also began talking about the framework of hypothesis testing and how that provides a way for us to determine if results are significant or not

## Key Terms

### A

**alternative hypothesis** A statement of non-equivalence between two or more things; opposite of the null hypothesis [24](#)

### B

**Bar graphs** Show frequencies of values of categorical/nominal variables [16](#)

**bimodal** When a distribution has two peaks [14](#)

**bin width** The range of each 'bar' in a frequency histogram [18](#)

**Boxplots** A graphical representation of a continuous variable that shows the median, 25th percentile, and 75th percentile [18](#)

### C

**categorical** A description of data in that it can be represented with qualitative labels and represents some type of group membership 5

**census** A scenario in which we gather data on all members of a population of interest

3

**continuous** A description of numeric data that implies intervals in-between each integer 6

**critical value** The point at which our test statistic is extreme enough to result in a p-value that is less than a set alpha 26

**Cumulative frequency** A count of the number of cases that fall below a certain score 20

**Cumulative relative frequency** The percentage of scores that fall below a certain score 21

## D

**deviation** How far away a point is away from the mean of the data 10

**discrete** A description of numeric data that implies 'counts', i.e., data that can not have parts in-between 6

**distribution** A description of how values of a variable are spread out and distributed across the range of possible values 6

## E

**empirical rule** A way to understand the percent of values at a certain number of standard deviation in a normal distribution 16

## F

**frequency histogram** A graphical representation of a continuous variable using bin width ranges to count frequencies falling within certain ranges 18

## H

**hypothesis** An empirical prediction that should be falsifiable. In statistics, it is a statement of comparison between two or more values 22

**hypothesis testing** A process for quantitatively testing predictions using inferential statistics, with the goal of inspecting whether we have sufficient evidence to reject the null hypothesis 22

## I

**interquartile range (IQR)** is the 75th percentile (upper quartile) minus the 25th percentile (lower quartile). It is a measure of spread. It is the width of the interval that contains the middle 50 percent of the data. 12

**Interval scale** Scale of measurement that has clear distance between each point, but no clear zero point 7

## K

**Kurtosis** A description of how 'peaked' a distribution is **14**

## L

**leptokurtic** When a distribution has scores clustered towards the center **14**

## M

**mean** The arithmetic average of the data **10**

**Measures of central tendency** statistics that summarize the typical, central, or average scores in a distribution **9**

**Measures of dispersion** statistics that summarize how data is spread out across a distribution **10**

**median** The value in the data in which half of values in the data fall below it, when ordered from smallest to largest **9**

**Modality** A description of how many 'peaks' a distribution has **14**

**mode** The most commonly occurring value in a variable **9**

## N

**negative/left skew** When a distribution has most values clustered towards the high end, and a tail out to the left side of the frequency histogram **13**

**Nominal scale** Scale of measurement that has no order and no distance between categories **7**

**normal distribution** A distribution of a continuous variable that is unimodal, symmetrical, bell-shaped, and the mean, median, and mode are equal **16**

**null hypothesis** A prediction or statement of no difference between two or more things, or non-relation; opposite of alternative hypothesis **23**

**numeric** A description of data in that it can be represented with numbers **5**

## O

**Ordinal scale** Scale of measurement that has inconsistent or unclear distance between each point, but does have order **7**

## P

**p-value** The probability, under the null hypothesis, that results will be as or more extreme than a given sample **25**

**parameter** A number or value in the population, estimated via the sample statistic **4**

**Percentiles** Points in the data that divide the data into 100 equal-sized amounts **12**

**platykurtic** When a distribution has scores clustered in the tails **14**

**population of interest** A group of individual with specified characteristics, that we are interested in studying and producing results that are generalizable to the broader group **3**

**positive/right skew** When a distribution has most values clustered towards the low end, and a tail out to the right side of the frequency histogram **13**

## Q

**qualitative data** Data/variables that describe a characteristic in words **6**

**quantitative data** Data/variables that describe a characteristic in numbers **6**

**Quartiles** Points in the data that divide the data into 4 equal-sized amounts **12**

## R

**range** The difference between the largest and smallest values in the data **12**

**rare event** An occurrence of a unlikely outcome that appears to contradict our assumption or pre-existing belief (the null hypothesis) **25**

**Ratio scale** Scale of measurement that has clear distance between each point AND a clear zero point **7**

**Relative frequency** The percent of total cases that fall in a certain category or at a certain point **20**

**representative sample** A sample which is genuinely representative of the population of interest it is pulled from; usually taken by some form of random sampling **5**

## S

**sample** A subset of individual taken from the population of interest, but are meant to be representative of the broader population. Those who data is actually gathered from. **4**

**sampling** The process by which we select individuals from the population to be included in our sample **4**

**significance level** The preset alpha level we arbitrarily choose to test our hypotheses and p-values against **26**

**Simple frequency** A count of the number of cases that fall in a certain category or at a certain point **20**

**Skewness** A description of how a distribution departs from symmetry or has a 'tail' **13**

**standard deviation** A measure of the average distance away from the mean that a point is in a distribution **11**

**statistic** A calculated number or value taken from our sample, meant as an estimate of the population parameter **4**

**statistical constant** Some characteristic or measurement that only has one constant value; opposite of variable **5**

**statistical significance** When our p-value is less than the set alpha value **26**

## U

**unimodal** When a distribution only has one peak **14**

## V

**Variables** Measurements or characteristics that change or can take different values **5**

**variance** The average squared deviation scores from the mean **11**

*The instructor-provided glossary may not include all terms worth memorizing, make sure you consider using the vocabulary list in your book and your own judgment to make sure you have all relevant terms*