# Describing Categorical Variables

**Stat 120**

September 18 2023

## Descriptive Statistics

- *In order to make sense of data, we need ways to summarize and visualize it*
- *Summarizing and visualizing variables and relationships between two variables is often known as descriptive statistics, also known as exploratory data analysis (EDA)*
- *The type of summary statistics and visualization methods depend on the type of variable(s) being analyzed (categorical or quantitative)*

# One Categorical Variable

**A random sample of US adults in 2012 were surveyed regarding the type of cell phone owned**


Android? iPhone? Blackberry? Non-smartphone? No cell phone?

# Frequency Table

**A frequency table shows the number of cases or counts that fall in each category:**

| Subset of Raw Data | |
|---|---|
| Case 1 | Android |
| Case 2 | none |
| Case 3 | none |
| Case 4 | iPhone |
| Case 5 | Non Smartphone |
| Case 6 | iPhone |
| Case 7 | Blackberry |
| Case 8 | Non Smartphone |
| Case 9 | Android |
| Case 10 | Android |
| ... | (for 2253 cases ...) |

| Cell Phone Type | Frequency |
|---|---|
| Android | 458 |
| iPhone | 437 |
| Blackberry | 141 |
| Non Smartphone | 924 |
| No Cell Phone | 293 |
| Total | 2253 |

## Proportion

**The proportion in a category is found by**

$$\text{proportion} = \frac{\text{number in category}}{\text{total sample size}}$$

***Percentages/proportions (relative frequencies)***

- $p$ ***= proportion for a population (parameter)***
- $\hat{p}$ ***= proportion for a sample (statistic) ("p-hat")***

## What proportion of adults sampled do not own a cell phone?

| Cell Phone Type | Frequency | Proportion |
|---|---|---|
| Android | 458 | 0.203 |
| iPhone | 437 | 0.194 |
| Blackberry | 141 | 0.063 |
| Non Smartphone | 924 | 0.41 |
| No Cell Phone | 293 | 0.13 |
| Total | 2253 | 1.000 |

Proportions and percentages can be used interchangeably

## Distribution of a variable

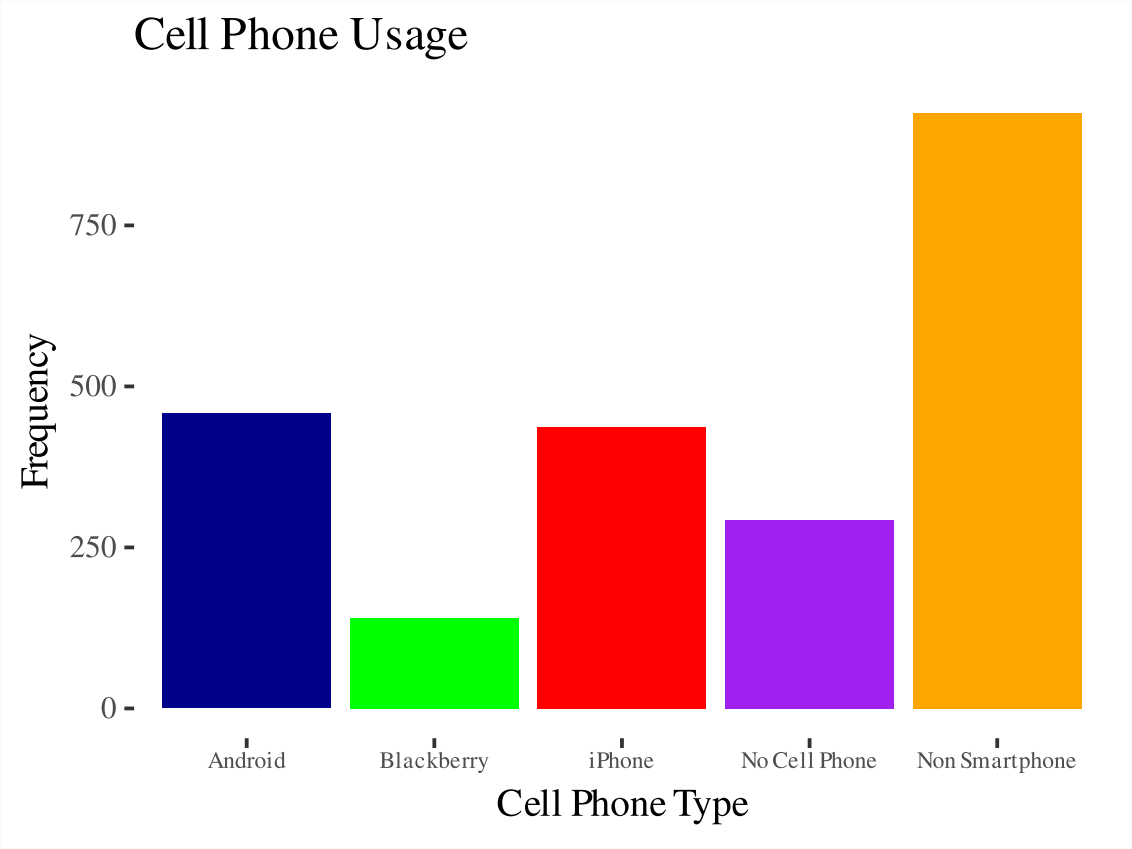
**The "distribution of variable Y"**

- **describes the count or percent of observations that fall into each category of "variable Y"**

- E.g. In the 2020 election, 51.3% of voters voted for Biden, 46.8% for Trump and 1.8% for third-party candidates

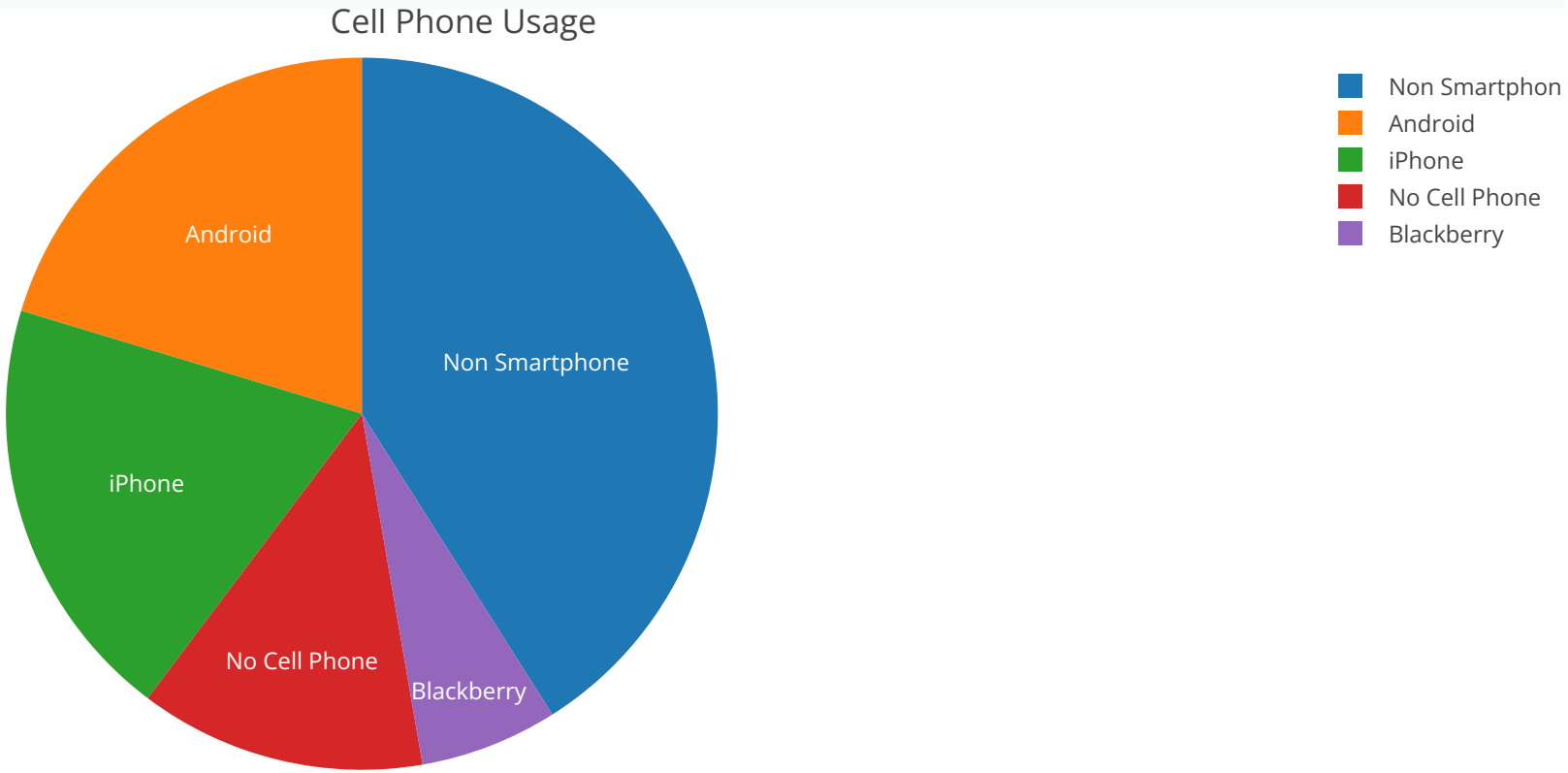
# Bar Chart/Plot/Graph

**In a barplot, the height of the bar corresponds to the number of cases falling in each category**



# Pie Chart

**In a pie chart, the relative area of each slice of the pie corresponds to the proportion in each category**



# Two Categorical Variables

**Look at the relationship between two categorical variables**

- **Relationship status**
- **Gender**

| | Female | Male | Total |
|---|---|---|---|
| In a Relationship | 32 | 10 | 42 |
| It's Complicated | 12 | 7 | 19 |
| Single | 63 | 45 | 108 |
| Total | 107 | 62 | 169 |

We add a second dimension to a frequency table to account for the second categorical variable

## Relationship status and Gender

Proportion of students that are in a relationship?

```
ans <- 42/169
round(ans,2)
[1] 0.25
```

Proportion of students in a relationship that are female?

```
ans <- 32/42
round(ans,2)
[1] 0.76
```

Proportion of students in a relationship that are male?

```
ans <- 10/42
round(ans,2)
[1] 0.24
```

## Relationship status and Gender

Proportion of males that are in a relationship?

```
ans <- 10/62
round(ans,2)
[1] 0.16
```

Proportion of females that are in a relationship?

```
ans <- 32/107
round(ans,2)
[1] 0.3
```

## Difference in proportions

**A difference in proportions is a difference in proportions for one categorical variable calculated for different levels of the other categorical variable**

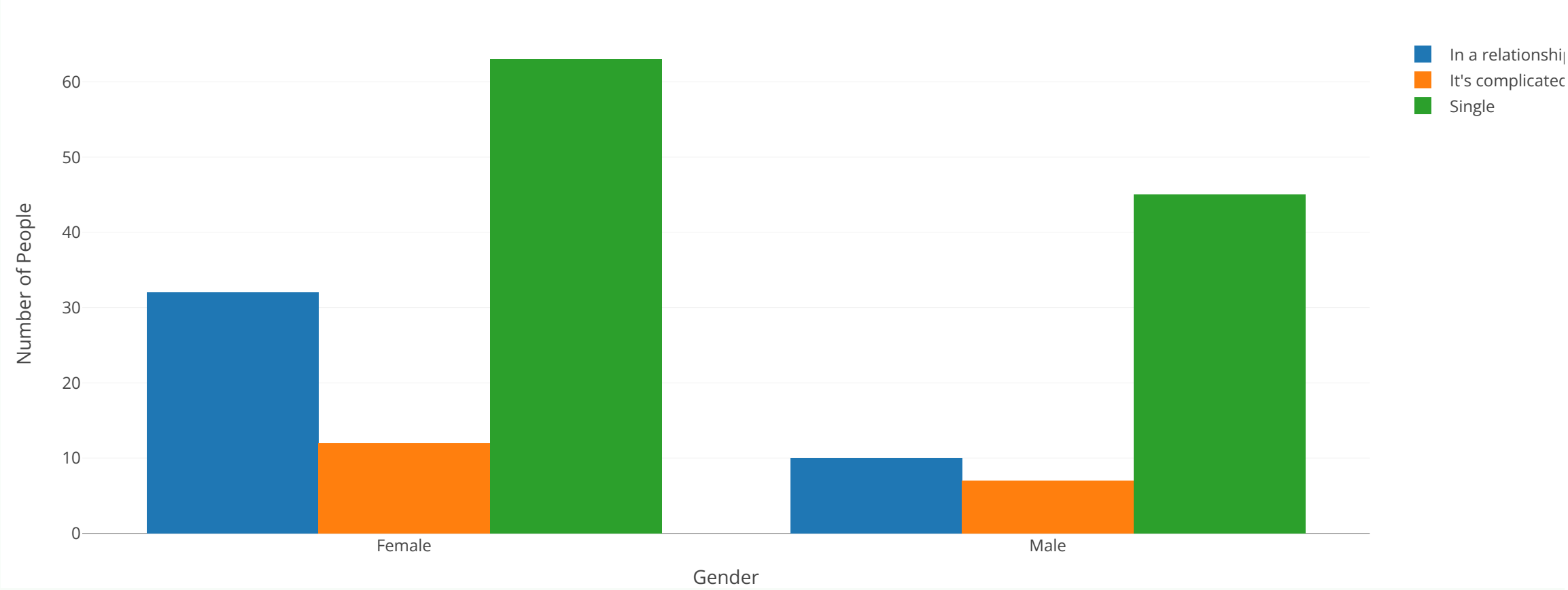
- Example: Difference in proportions of male and female that are in a relationship:

$$\text{proportion}_{\text{Females}} - \text{proportion}_{\text{Males}} = \hat{p}_F - \hat{p}_M = \frac{32}{107} - \frac{10}{62} = 0.14$$

```
# R-code
prop.female <- 32/107
prop.male <- 10/62
prop.diff <- prop.female - prop.male
round(prop.diff,2) # round the final answer to 2 significant digits
[1] 0.14
```

# Side-by-Side bar Chart

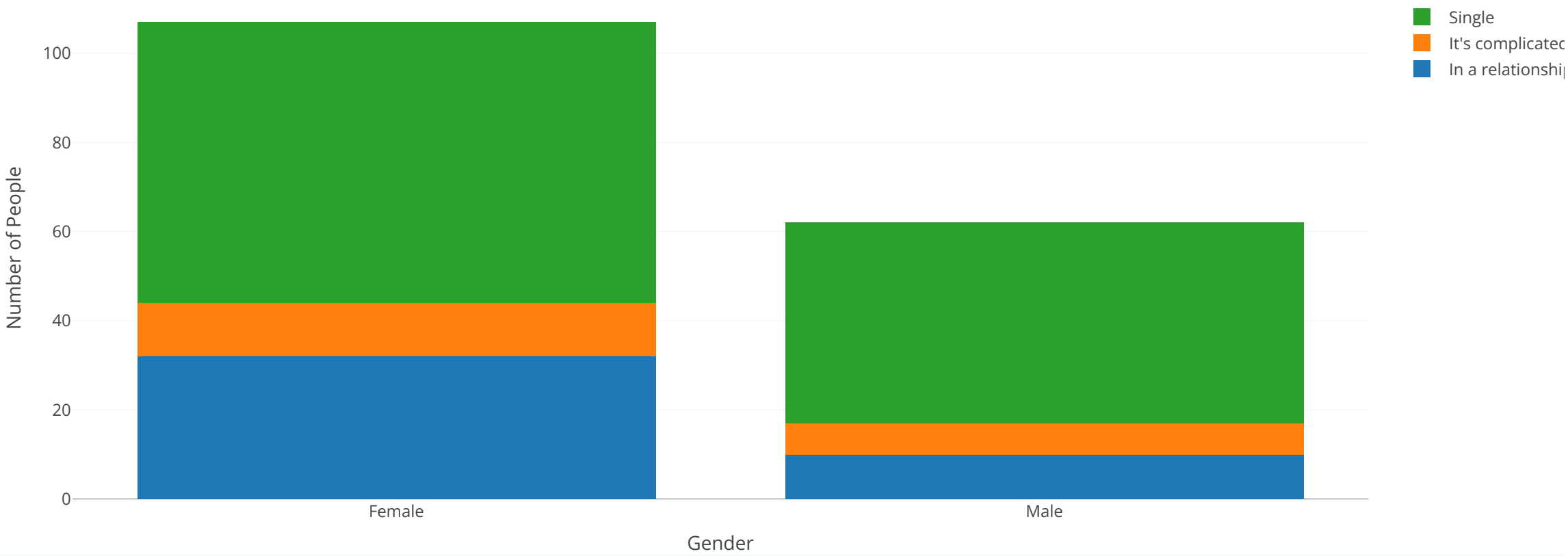
**The height of each bar is the number of the corresponding cell in the two-way table**




Source: https://www.lockfstat.com/StatKey/index.html

# Segmented Bar Chart

**A segmented bar chart is like a side-by-side bar chart, but the bars are stacked instead of side-by-side**



# Case Study: Flowers v. Mississippi

***2019 Supreme Court case:***

- ***Has Mississippi prosecutor Doug Evans deliberately use "peremptory challenges" to strike black jurors from jury pools?***

American Public Media journalist collected trial data from this district from 1992 to 2017 (Link)

***The data set APM_DougEvansCases.csv contains data on 1517 jurors for cases which listed Doug Evans as the first prosecutor.***

- ***Only looking at jurors with race listed as Black or White.***
- ***These jurors are eligible for Evans to strike.***

Source: Click here

## Look at the data

```
jurors <- read.csv("https://raw.githubusercontent.com/deepbas/statdatasets/main/APM_DougEvansCases.csv"
```

```
dim(jurors) # dimension of dataset
[1] 1517    6
```

Look at the first **three rows** of the data set

```
jurors[c(1,2,3), ]  #[rows, columns]
  trial__id  race        struck_state defendant_race      same_race
1         4 Black Not struck by State          White different race
2         4 Black     Struck by State          White different race
3         4 White Not struck by State          White      same race
                      struck_by
1 Juror chosen to serve on jury
2           Struck by the state
3 Juror chosen to serve on jury
```

# Look at the data

```
jurors$struck_state[1:10] # first 10 entries in the `struck_state` variable
 [1] "Not struck by State" "Struck by State"     "Not struck by State"
 [4] "Not struck by State" "Struck by State"     "Not struck by State"
 [7] "Struck by State"     "Not struck by State" "Not struck by State"
[10] "Not struck by State"
```

## Numeric summaries: counts and proportions

`table` gives counts of whether the state struck a juror:

```
counts <- table(jurors$struck_state)
counts
```

```
Not struck by State     Struck by State
               1084                 433
```

`prop.table` turns these counts into proportions:

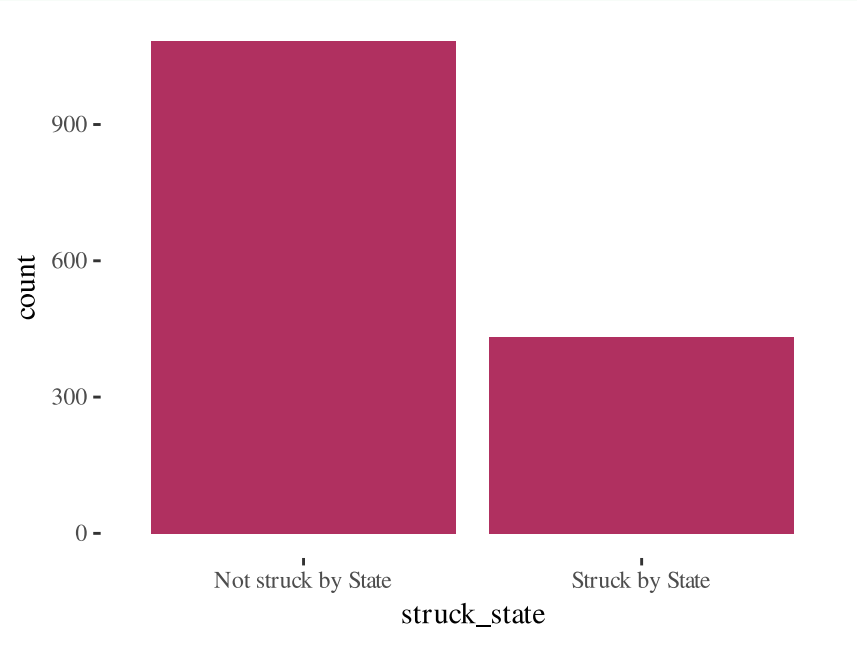
```
prop.table(counts)
```

```
Not struck by State     Struck by State
          0.7145682           0.2854318
```

What proportion of eligible jurors were struck by the state from the jury pool?

# Graphical summary: bar plot using ggplot2

```
library(ggplot2)  # load the library
ggplot(jurors, aes(x=struck_state)) +
  geom_bar(fill="maroon")
```



## Associations between two categorical variables

How does state struck status vary by juror race? (How are race and state strikes associated?)

***Numerically:***

- ***summarize counts in a contingency/two-way table***
- ***conditional proportions: "The conditional distribution of Y given variable X" describes how Y is distributed within each category of X (group by X).***

***Graphically:***

- ***stacked bar graph of conditional proportions***

# Two-way (contingency) table

First 10 entries of race and struck_state variable is

```
jurors[(1:10), (2:3)]
    race        struck_state
1  Black Not struck by State
2  Black     Struck by State
3  White Not struck by State
4  White Not struck by State
5  Black     Struck by State
6  White Not struck by State
7  Black     Struck by State
8  White Not struck by State
9  White Not struck by State
10 White Not struck by State
```

table gives two-way tables when two variables are included.

```
mytable <- table(jurors$race, jurors$struck_state)
mytable

        Not struck by State Struck by State
  Black                 225              310
  White                 859              123
```

## Conditional proportions

`prop.table` gives conditional proportions grouped by the `row` variable when `margin=1`

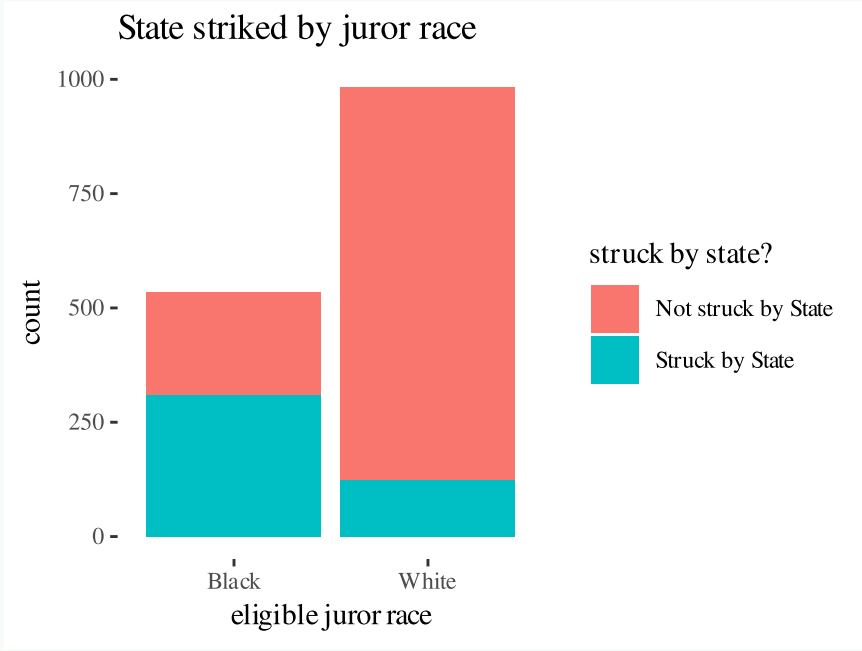
```
prop.table(mytable, margin = 1)

        Not struck by State Struck by State
  Black           0.4205607       0.5794393
  White           0.8747454       0.1252546
```

- **Of all eligible black jurors, about 57.9% were struck by the state.**
- **What proportion of eligible white jurors were struck by the state?**

Is there evidence of an association between juror race and state strikes?

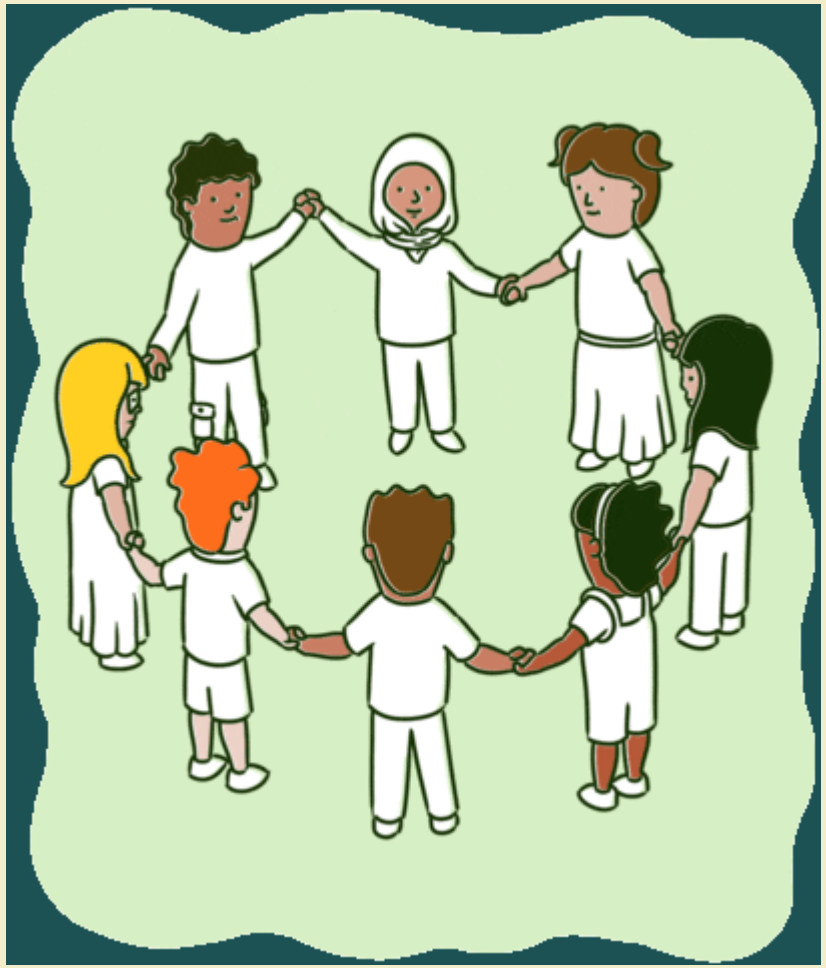
# Stacked bar graph (counts)

```
ggplot(jurors, aes(x = race, fill = struck_state)) +
  geom_bar(stat="count") +
  labs(title = "State striked by juror race",
       y = "count",
       x = "eligible juror race",
       fill = "struck by state?")
```



# GROUP WORK 2

20:00



- Let's go over some more examples at the course helper page
- We will then do a class activity together