

Data Visualization

Cohen Chapter 2

EDUC/PSY 6600

Always plot your data first!

"Always." - Severus Snape

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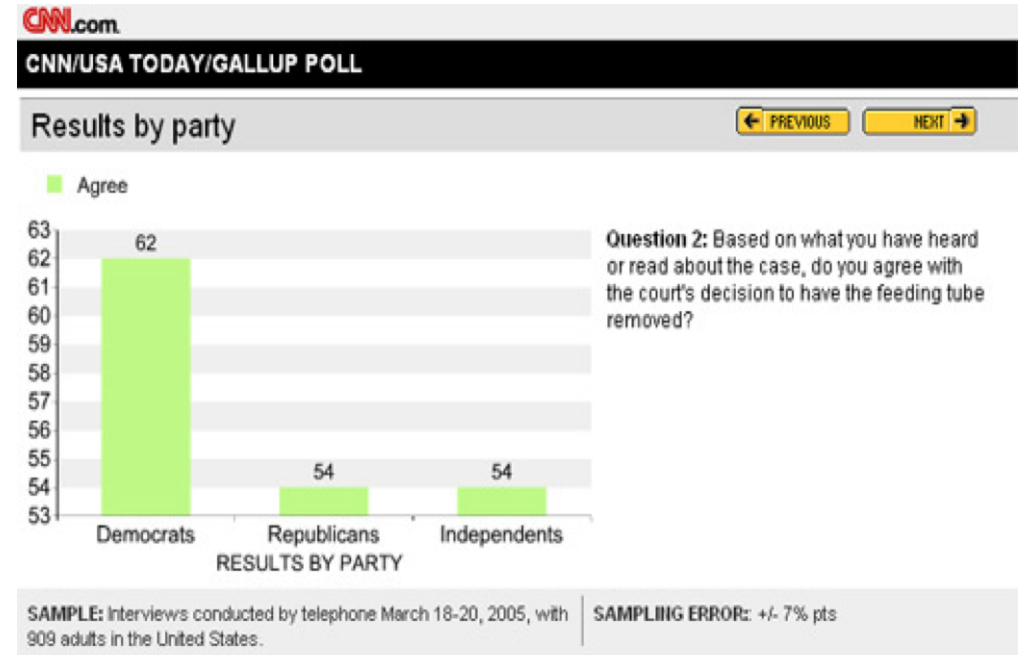
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Why?

- **Outliers** and impossible values
- Determine correct **statistical approach**
- **Assumptions** and diagnostics
- Discover new **relationships**

The Visualization Paradox

- Often the **most informative** aspect of analysis
- **Communicates** the "data story" the best
- Most abused area of quantitative science
- Figures can be *very* **misleading**

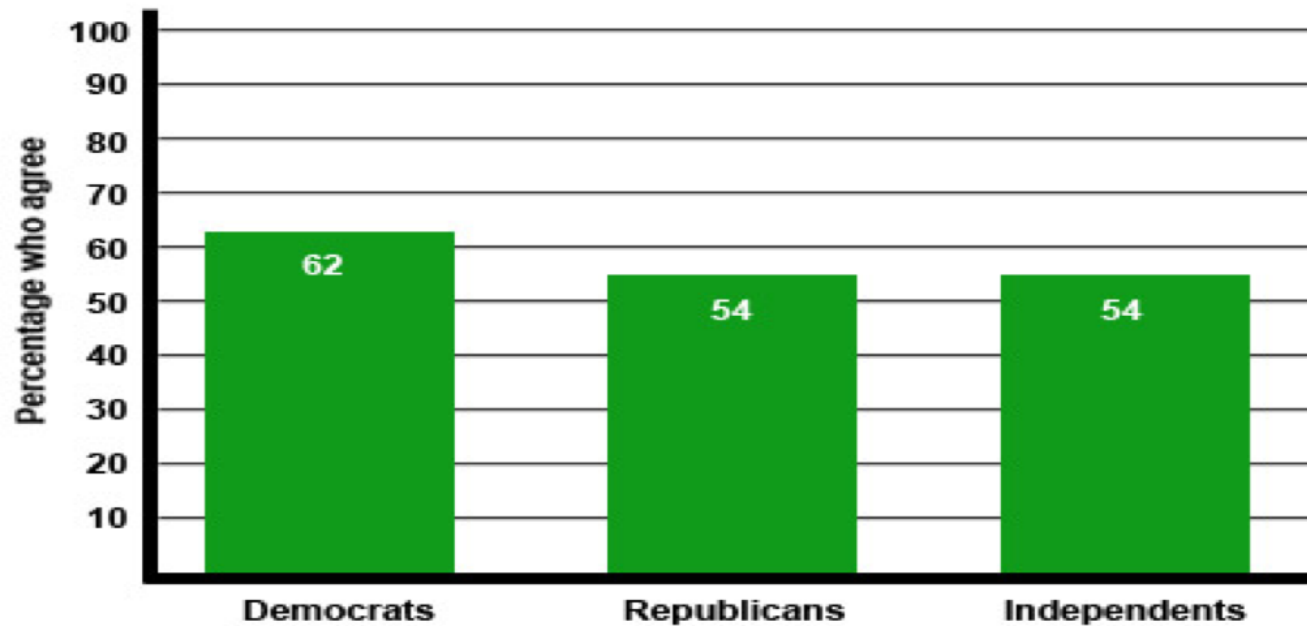


Misleading Graphs

Much better

RESULTS BY PARTY: CNN/USA Today/Gallup Poll
Margin of error: +/- 7%

Question 2: Based on what you have heard or read about the case, do you agree with the court's decision to have the feeding tube removed?



Keys to Good Viz's

- Graphical method should match level of measurement
- Label all axes and include figure caption
- Simplicity and clarity
- Avoid of 'chartjunk'

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- Graphical method should match level of measurement
- Label all axes and include figure caption
- Simplicity and clarity
- Avoid of 'chartjunk'
- Unless there are 3 or more variables, avoid 3D figures (and even then, avoid it)
- Black & white, grayscale/pattern fine for most simple figures

Data Visualizations

Takes practice -- try a bunch of stuff

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Resources

- Edward Tufte's books
- "R for Data Science" by Grolemund and Wickham
- "Data Visualization for Social Science" by Healy

Frequency Distributions

Counting the number of occurrences of unique events

- Categorical or continuous
- just like with `tableF()` and `table1()`

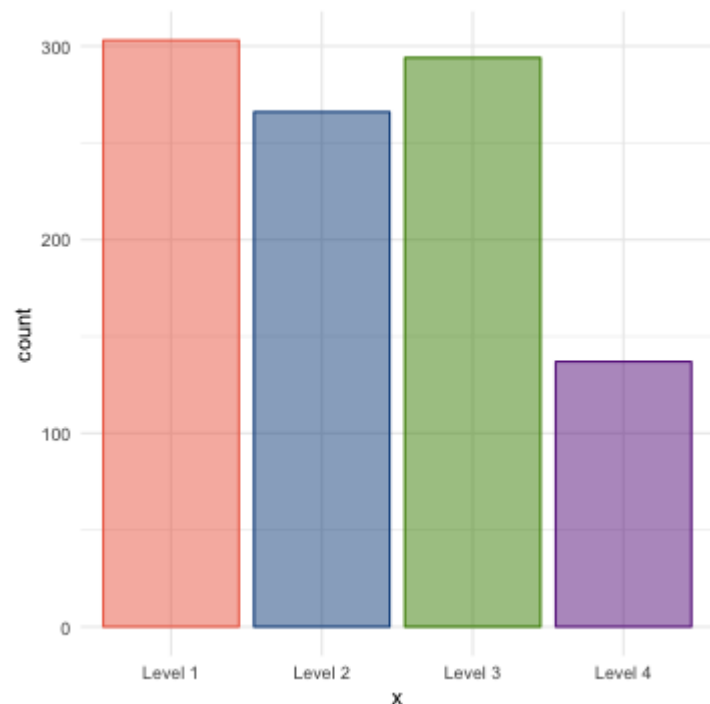
Can see **central tendency** (continuous data) or **most common value** (categorical data)

Can see **range and extremes**

| x | Freq | CumFreq | Percent | CumPerc | Valid | CumValid |
|---------|------|---------|---------|---------|--------|----------|
| 1 | 216 | 216 | 21.60% | 21.60% | 22.13% | 22.13% |
| 2 | 260 | 476 | 26.00% | 47.60% | 26.64% | 48.77% |
| 3 | 253 | 729 | 25.30% | 72.90% | 25.92% | 74.69% |
| 4 | 247 | 976 | 24.70% | 97.60% | 25.31% | 100.00% |
| Missing | 24 | 1000 | 2.40% | 100.00% | | |

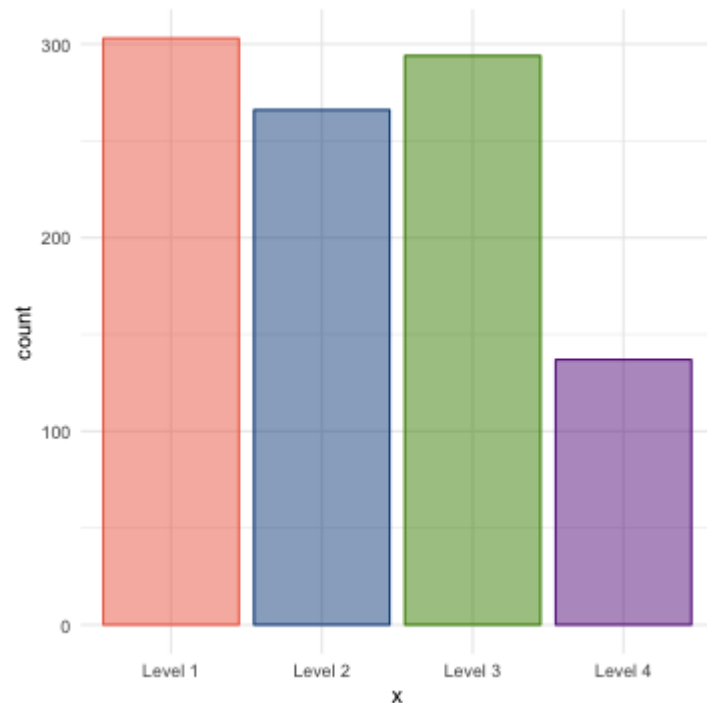
Frequencies and Viz's Together ❤️

Bar Graph

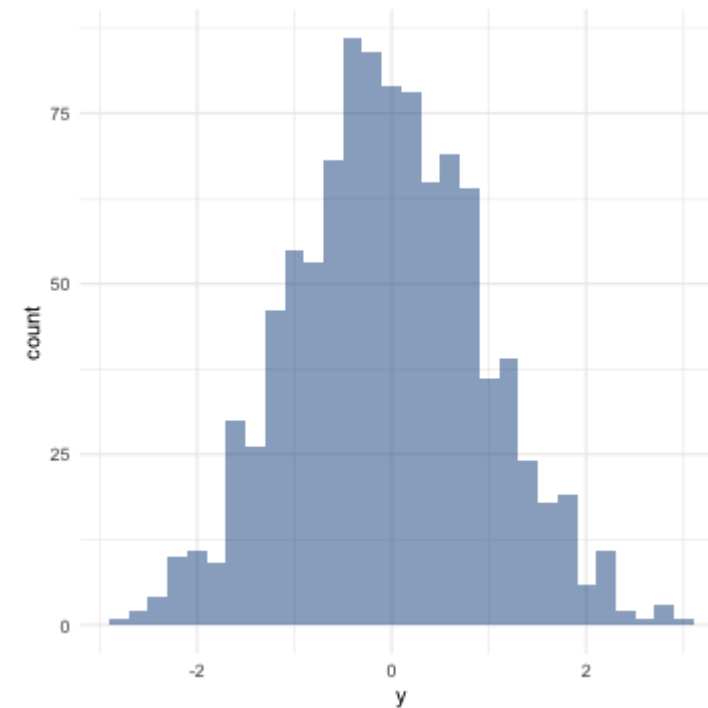


Frequencies and Viz's Together ❤️

Bar Graph



Histogram



What does DISTRIBUTION mean?

The way that the data points are scattered

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For Continuous

- General shape
- Exceptions (outliers)
- Modes (peaks)
- Center & spread (chap 3)
- Histogram

For Categorical

- Counts of each
- Percent or Rate (adjusts for an 'out of' to compare)
- Bar chart
- Pie chart - avoid!

Let's Apply This To the Inho Dataset

Reminder

Key

Sub_num: arbitrary ID number for each participant.

Gender: 1 = Female; 2 = Male.

Major: 1 = Psychology; 2 = Premed; 3 = Biology; 4 = Sociology; 5 = Economics.

Reason: 1 = Program requirement; 2 = Personal interest; 3 = Advisor recommendation.

Exp_cond: 1 = Easy; 2 = Moderate; 3 = Difficult; 4 = Impossible.

Coffee: 0 = not a regular coffee drinker; 1 = regularly drinks coffee.

Num_cups = number of cups of coffee drunk prior to the experiment on the same day.

Phobia: 0 = No phobia to 10 = Extreme phobia.

Prevmath = Number of math courses taken prior to statistics course.

Mathquiz = Score on Math Background Quiz (a blank for this value indicates that a student did not take the quiz).

Statquiz = Score on 10-question stats quiz given one week before the experiment.

Exp_sqz = Score on stats quiz given as part of the experiment (number correct, including the 11th question).

HR_base = Baseline heart rate (in beats per minute).

HR_pre = Prequiz heart rate.

HR_post = Postquiz heart rate.

Anx_base = Baseline anxiety score.

Anx_pre = Prequiz anxiety score.

Anx_post = Postquiz anxiety score.

Read in the Data

```
library(tidyverse)  # the easy button
library(rio)        # read in Excel files
library(furniture)  # nice tables

data_raw <- rio::import("Ihno_dataset.xls") %>%
  dplyr::rename_all(tolower)           # converts all variable names to lower case
```

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```
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data_raw <- rio::import("Ihno_dataset.xls") %>%
  dplyr::rename_all(tolower)           # converts all variable names to lower case
```

And Clean It

```
data_clean <- data_raw %>%
  dplyr::mutate(majorF = factor(major,
                                levels= c(1, 2, 3, 4, 5),
                                labels = c("Psychology", "Premed",
                                             "Biology", "Sociology",
                                             "Economics")))) %>%
  dplyr::mutate(coffeeF = factor(coffee,
                                  levels = c(0, 1),
                                  labels = c("Not a regular coffee drinker",
                                              "Regularly drinks coffee"))))
```

Frequency Distributions

```
data_clean %>%  
  furniture::tableF(major)
```

```
##  
##  
## major Freq CumFreq Percent CumPerc  
## 1 29 29 29.00% 29.00%  
## 2 25 54 25.00% 54.00%  
## 3 21 75 21.00% 75.00%  
## 4 15 90 15.00% 90.00%  
## 5 10 100 10.00% 100.00%  
##
```

```
data_clean %>%  
  furniture::tableF(phobia)
```

```
##  
##  
## phobia Freq CumFreq Percent CumPerc  
## 0 12 12 12.00% 12.00%  
## 1 15 27 15.00% 27.00%  
## 2 12 39 12.00% 39.00%  
## 3 16 55 16.00% 55.00%  
## 4 21 76 21.00% 76.00%  
## 5 11 87 11.00% 87.00%  
## 6 1 88 1.00% 88.00%  
## 7 4 92 4.00% 92.00%  
## 8 4 96 4.00% 96.00%  
## 9 1 97 1.00% 97.00%  
## 10 3 100 3.00% 100.00%  
##
```

Frequency Viz's

For viz's, we will use `ggplot2`

This provides the most powerful, beautiful framework for data visualizations

Frequency Viz's

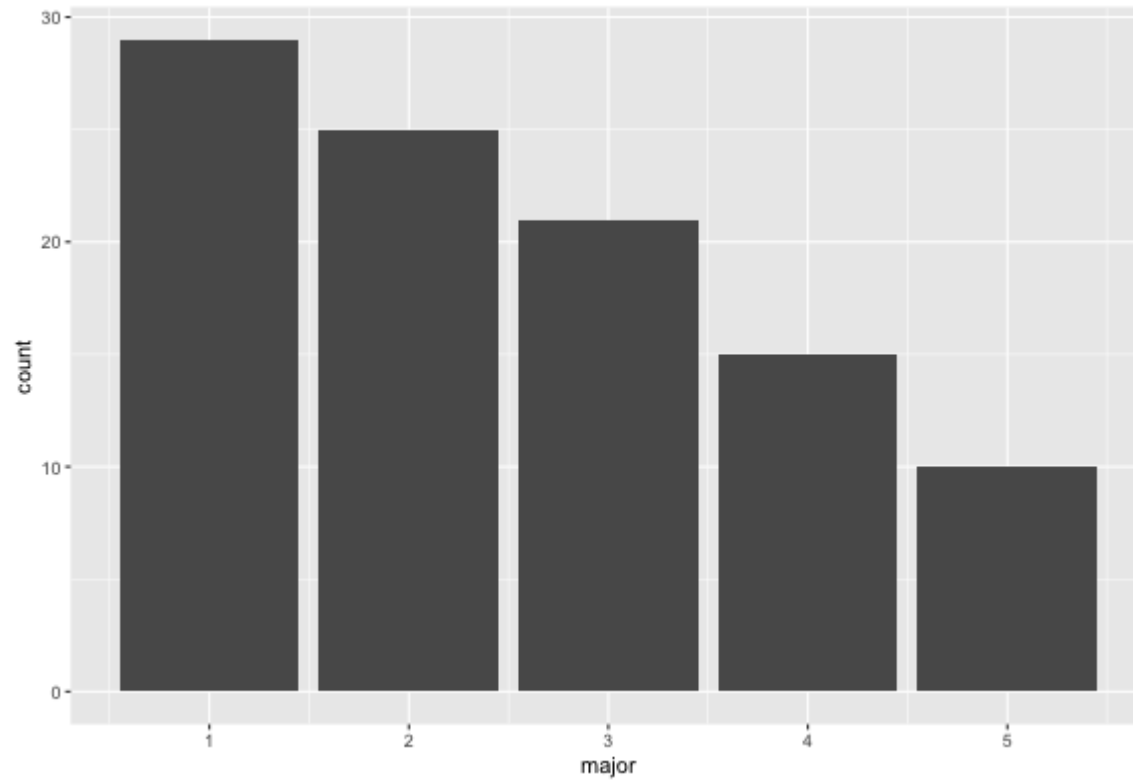
For viz's, we will use `ggplot2`

This provides the most powerful, beautiful framework for data visualizations

- It is built on making **layers**
- Each plot has a **"geom"** function
 - e.g. `geom_bar()` for bar charts, `geom_histogram()` for histograms, etc.

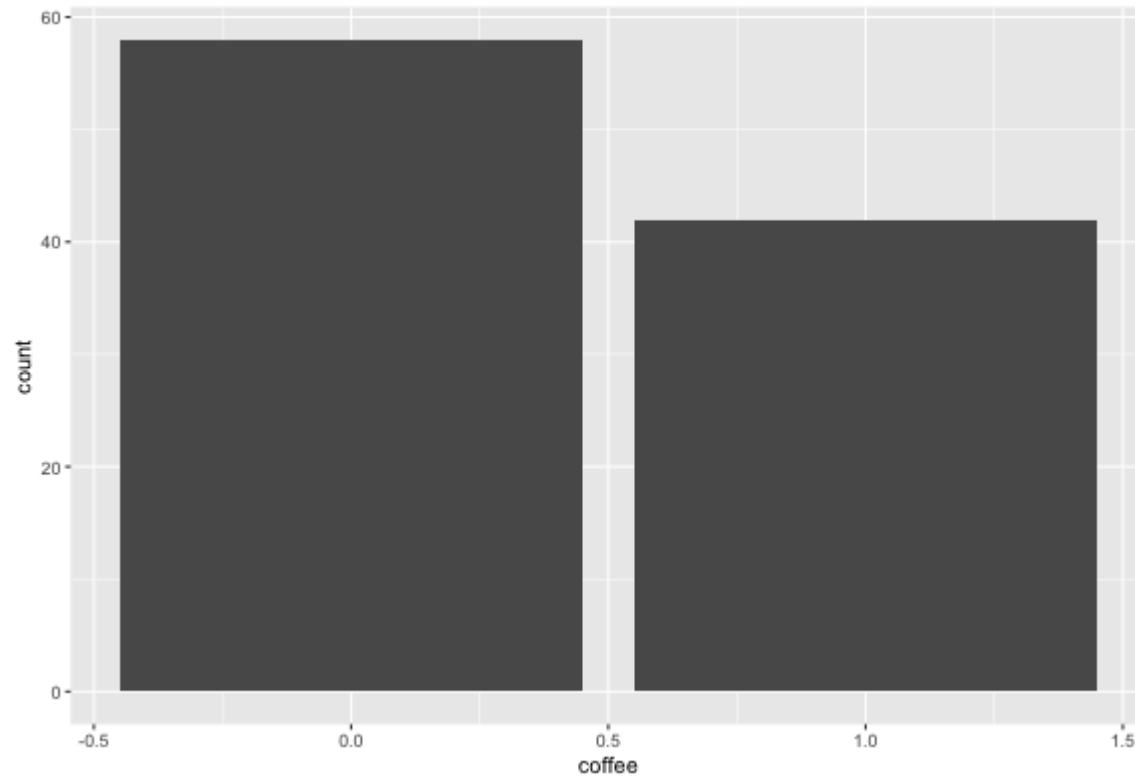
Bar Charts

```
data_clean %>%  
  ggplot(aes(major)) +  
  geom_bar()
```



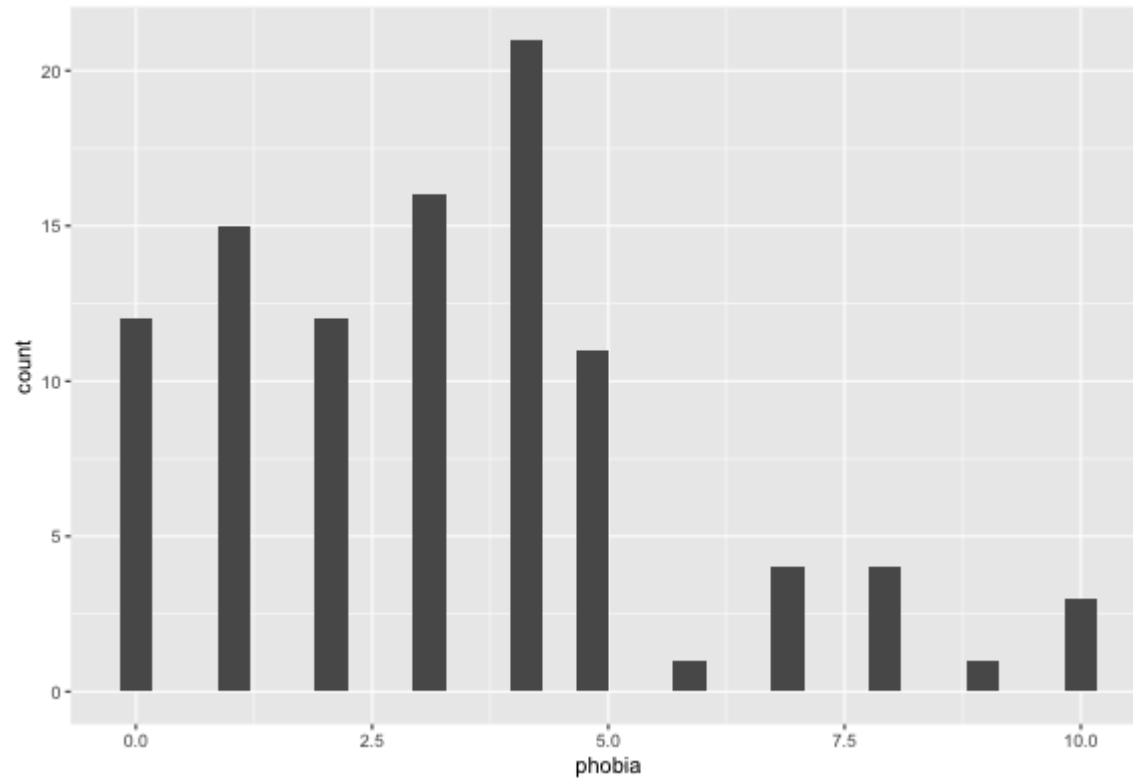
Bar Charts

```
data_clean %>%  
  ggplot(aes(coffee)) +  
  geom_bar()
```



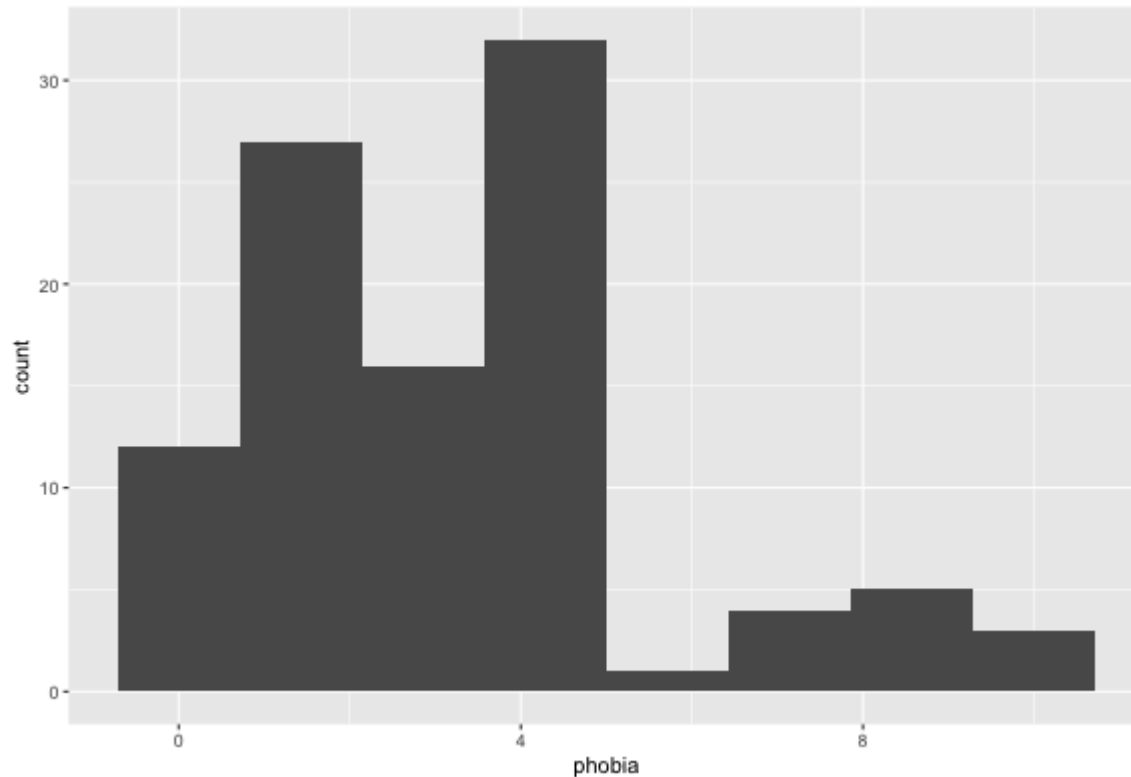
Histograms

```
data_clean %>%  
  ggplot(aes(phobia)) +  
  geom_histogram()
```



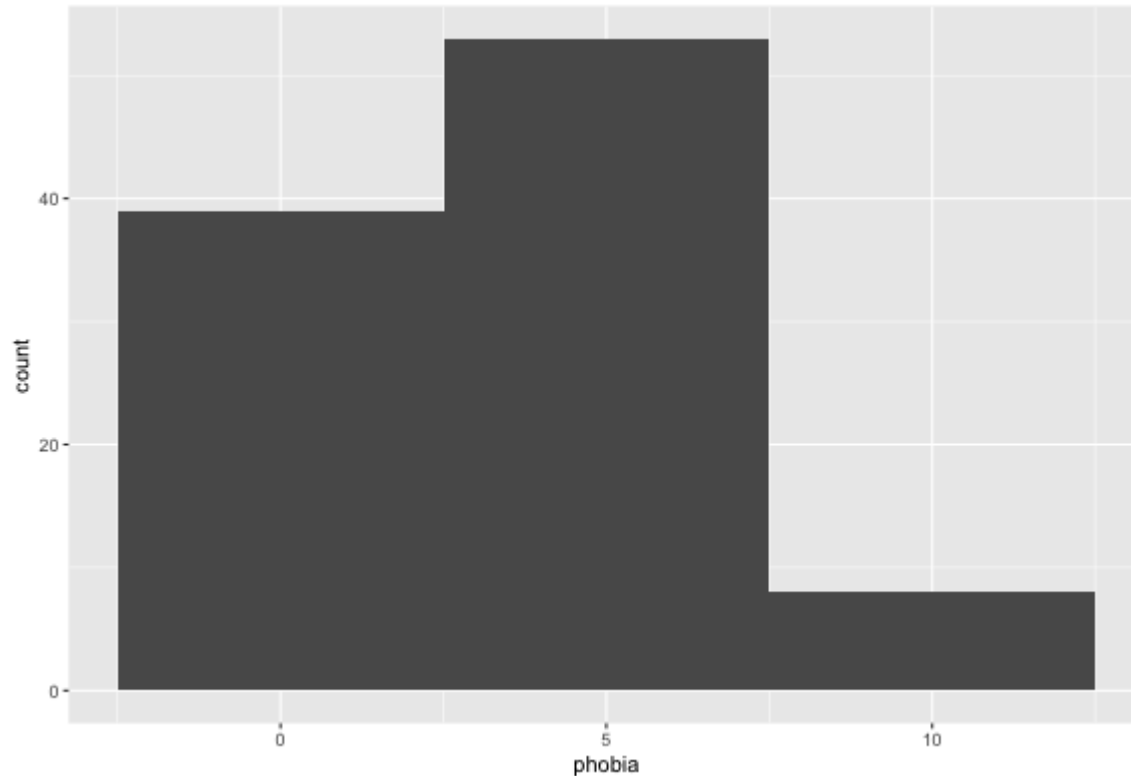
Histograms (change number of bins)

```
data_clean %>%  
  ggplot(aes(phobia)) +  
  geom_histogram(bins = 8)
```



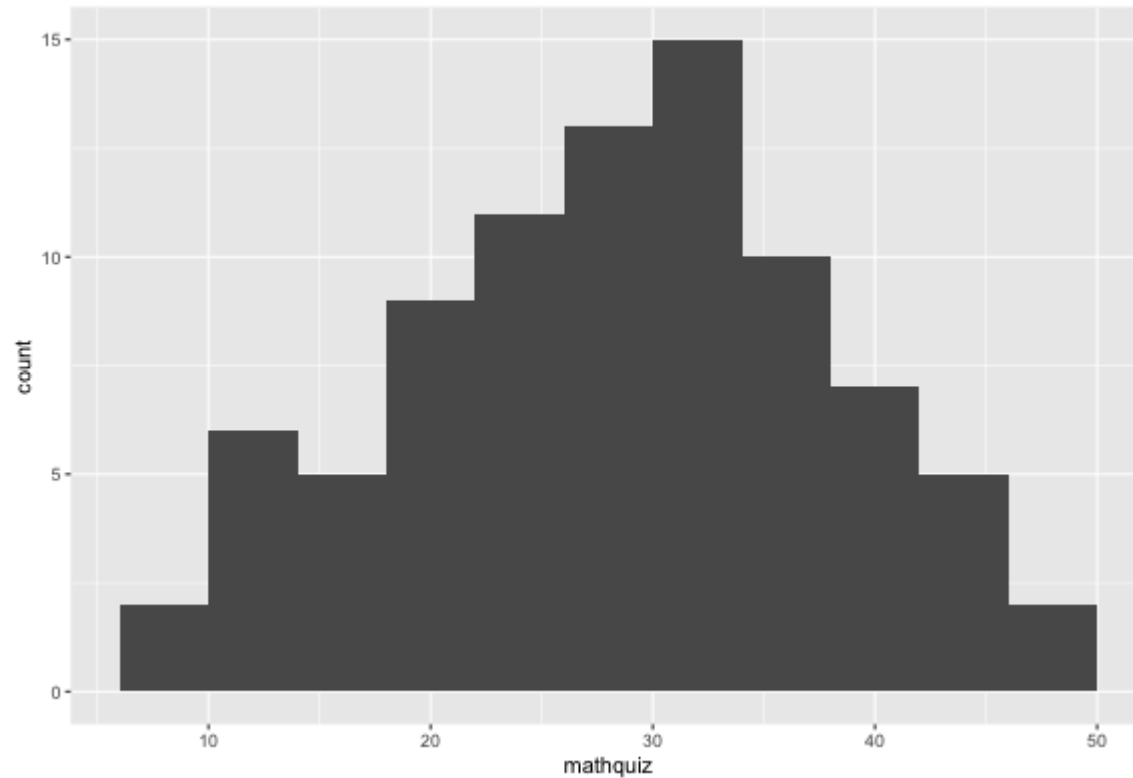
Histograms (change bins to size 5)

```
data_clean %>%  
  ggplot(aes(phobia)) +  
  geom_histogram(binwidth = 5)
```



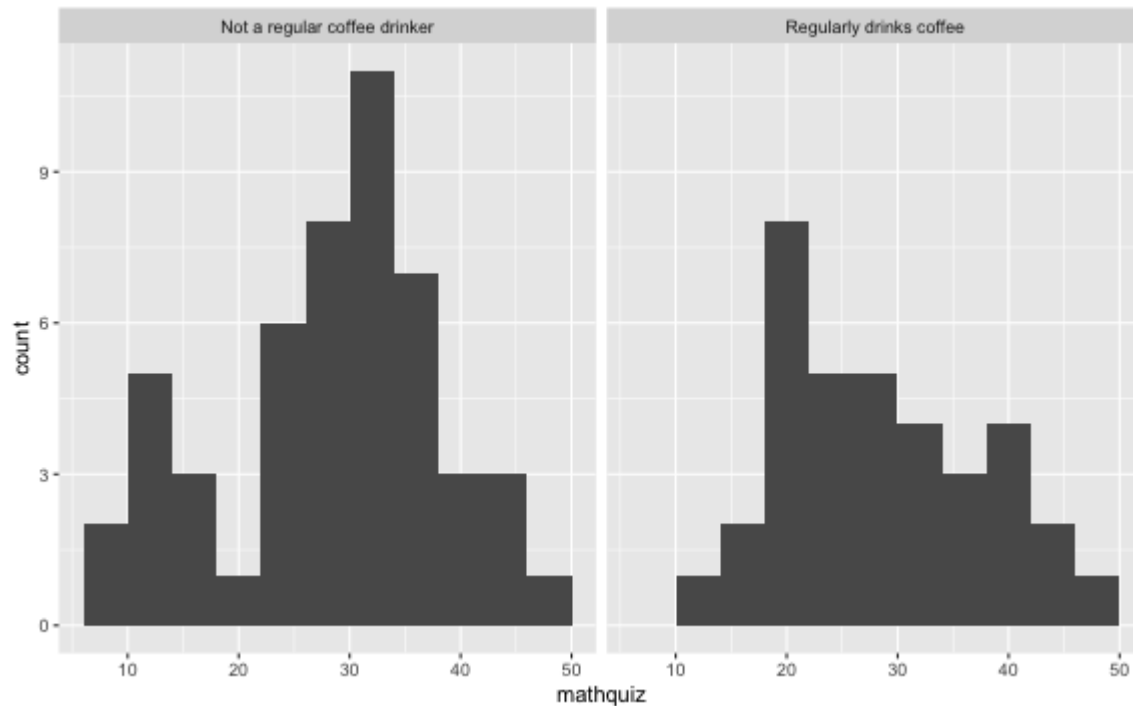
Histograms

```
data_clean %>%  
  ggplot(aes(mathquiz)) +  
  geom_histogram(binwidth = 4)
```



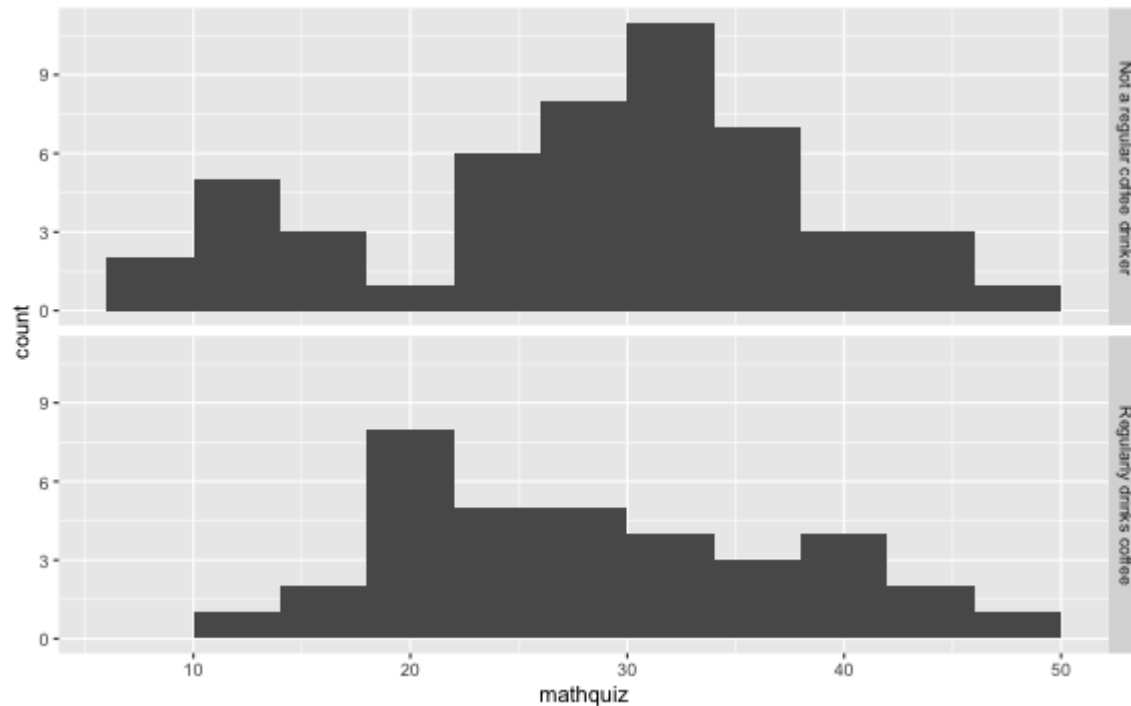
Histograms -by- a Factor (columns)

```
data_clean %>%  
  ggplot(aes(mathquiz)) +  
  geom_histogram(binwidth = 4) +  
  facet_grid(. ~ coffeeF)
```



Histograms -by- a Factor (rows)

```
data_clean %>%  
  ggplot(aes(mathquiz)) +  
  geom_histogram(binwidth = 4) +  
  facet_grid(coffeeF ~ .)
```



Deciles (break into 10% chunks)

```
data_clean %>%  
  dplyr::pull(statquiz) %>%  
  quantile(probs = c(.10, .20, .30, .40, .50, .60, .70, .80, .90))
```

```
## 10% 20% 30% 40% 50% 60% 70% 80% 90%  
## 4.0 6.0 6.0 7.0 7.0 8.0 8.0 8.0 8.1
```

Deciles - with missing values

```
data_clean %>%  
  dplyr::pull(mathquiz) %>%  
  quantile(probs = c(.10, .20, .30, .40, .50, .60, .70, .80, .90))
```

```
Error in quantile.default(., probs = c(0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, : missing  
values and NaN's not allowed if 'na.rm' is FALSE
```

Deciles - `na.rm = TRUE`

```
data_clean %>%  
  dplyr::pull(mathquiz) %>%  
  quantile(probs = c(.10, .20, .30, .40, .50, .60, .70, .80, .90),  
            na.rm = TRUE)
```

```
## 10% 20% 30% 40% 50% 60% 70% 80% 90%  
## 15.0 21.0 25.2 28.0 30.0 32.0 33.8 37.2 41.0
```


Quartiles (break into 4 chunks)

```
data_clean %>%  
  dplyr::pull(statquiz) %>%  
  quantile(probs = c(0, .25, .50, .75, 1))
```

```
##      0%    25%    50%    75%   100%  
##       1      6      7      8     10
```

Percentiles

```
data_clean %>%  
  dplyr::pull(statquiz) %>%  
  quantile(probs = c(.01, .05, .173, .90))
```

```
##      1%      5% 17.3%   90%  
##  2.98  3.00  5.00  8.10
```

Questions?

Next Topic

Center and Spread