Unit 1: Introduction to Data

3. More Exploratory Data Analysis

(Chapter 1.6)

2/10/2020

Central tendency

What's the difference between .mp3 and .FLAC?
.jpeg and .png?

.mp3 and .jpeg are **lossy compression** -- they make data smaller by throwing some of it away.

Central tendency is a kind of lossy compression: **What one number is the most representative of my data**?

Key ideas

1. Good visualizations help you understand your data
2. Descriptive statistics compress data so you can communicate about it
3. The “right” statistics depend on the shape of the data

Center and Variability

A common measure of central tendency is the mean, denoted as $\bar{x}$

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

A common measure of central tendency is the standard deviation, denoted as s

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

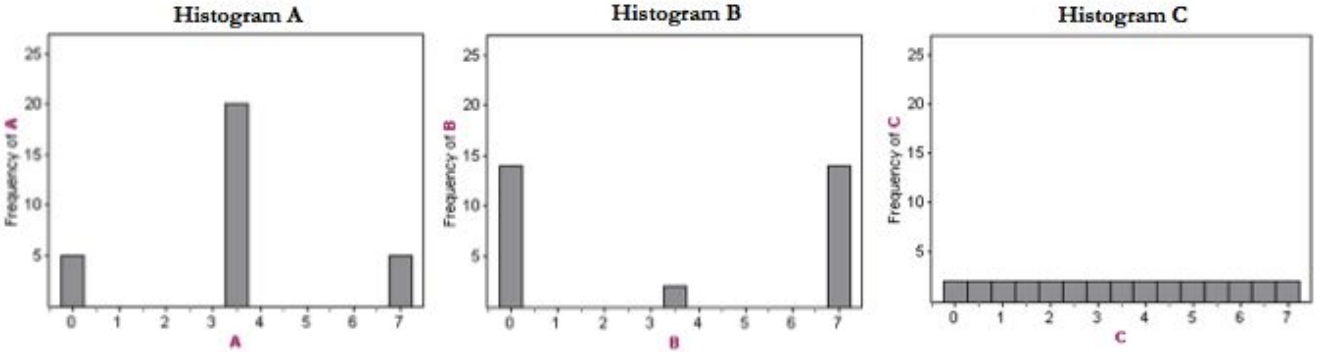
Why do we care about both center and spread?

Spread tells you how well your central tendency represents your data

	# people at Sally's book club	# people at Maria's book club
Week 1	8	1
Week 2	10	18
Week 3	11	10
Week 4	9	2
Week 5	12	19
Mean	$= \frac{8+10+11+9+12}{5} = 10$	$= \frac{1+18+10+2+19}{5} = 10$
Standard Deviation	$= \sqrt{\frac{(8-10)^2+(10-10)^2+(11-10)^2+(9-10)^2+(12-10)^2}{4}} \approx 1.6$	$= \sqrt{\frac{(1-10)^2+(18-10)^2+(10-10)^2+(2-10)^2+(19-10)^2}{4}} \approx 8.5$

Practice Question 1

Which of these is most variable?



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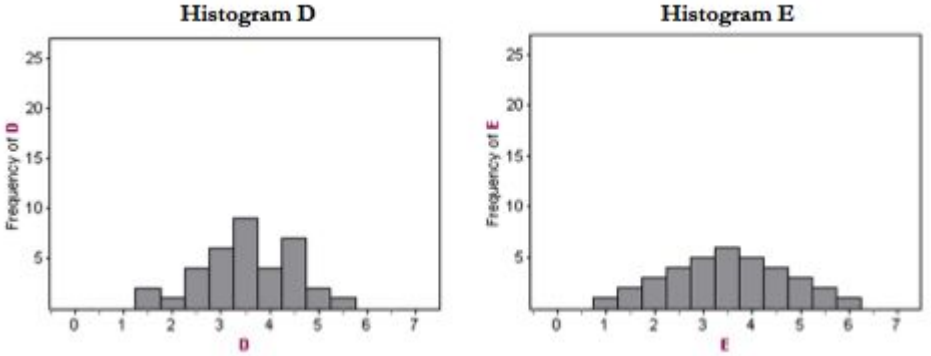

Should you always use the mean to measure central tendency?

Can you think of something where almost everyone in the population is above the mean?

When distributions are not symmetric, the mean can sometimes be misleading.

Median

The median is the value that splits the data in half when ordered in ascending order.

$$0, 1, 2, 3, 4$$

If there are an even number of observations, then the median is the average of the two values in the middle.

$$0, 1, \underline{2, 3}, 4, 5 \rightarrow \frac{2+3}{2} = 2.5$$

Since the median is the midpoint of the data, 50% of the values are below it. Hence, it is also the 50th percentile.

Practice Question 2

How do the mean and median of the following two datasets compare?

Dataset 1: 30, 50, 70, 90
Dataset 2: 30, 50, 70, 1000

(a) $\bar{x}_1 = \bar{x}_2$, $\text{median}_1 = \text{median}_2$

(b) $\bar{x}_1 < \bar{x}_2$, $\text{median}_1 = \text{median}_2$

(c) $\bar{x}_1 < \bar{x}_2$, $\text{median}_1 < \text{median}_2$

(d) $\bar{x}_1 > \bar{x}_2$, $\text{median}_1 < \text{median}_2$

(e) $\bar{x}_1 > \bar{x}_2$, $\text{median}_1 = \text{median}_2$

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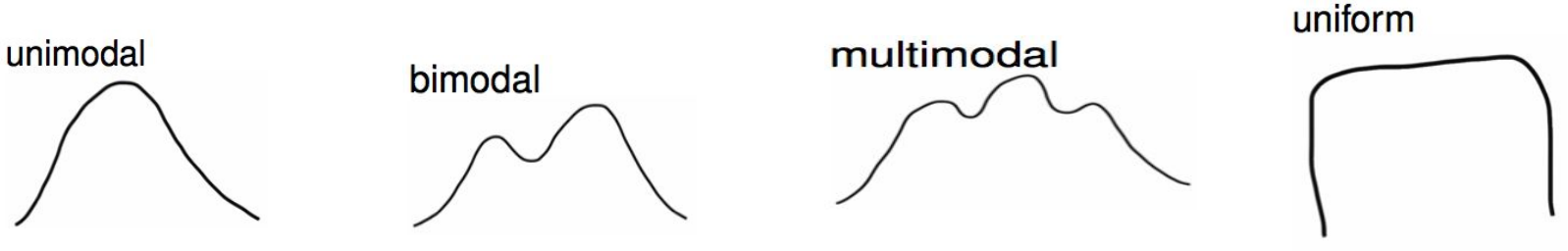
Let’s look at our class data

Can both the mean and median be misleading?



Interquartile range to measure spread

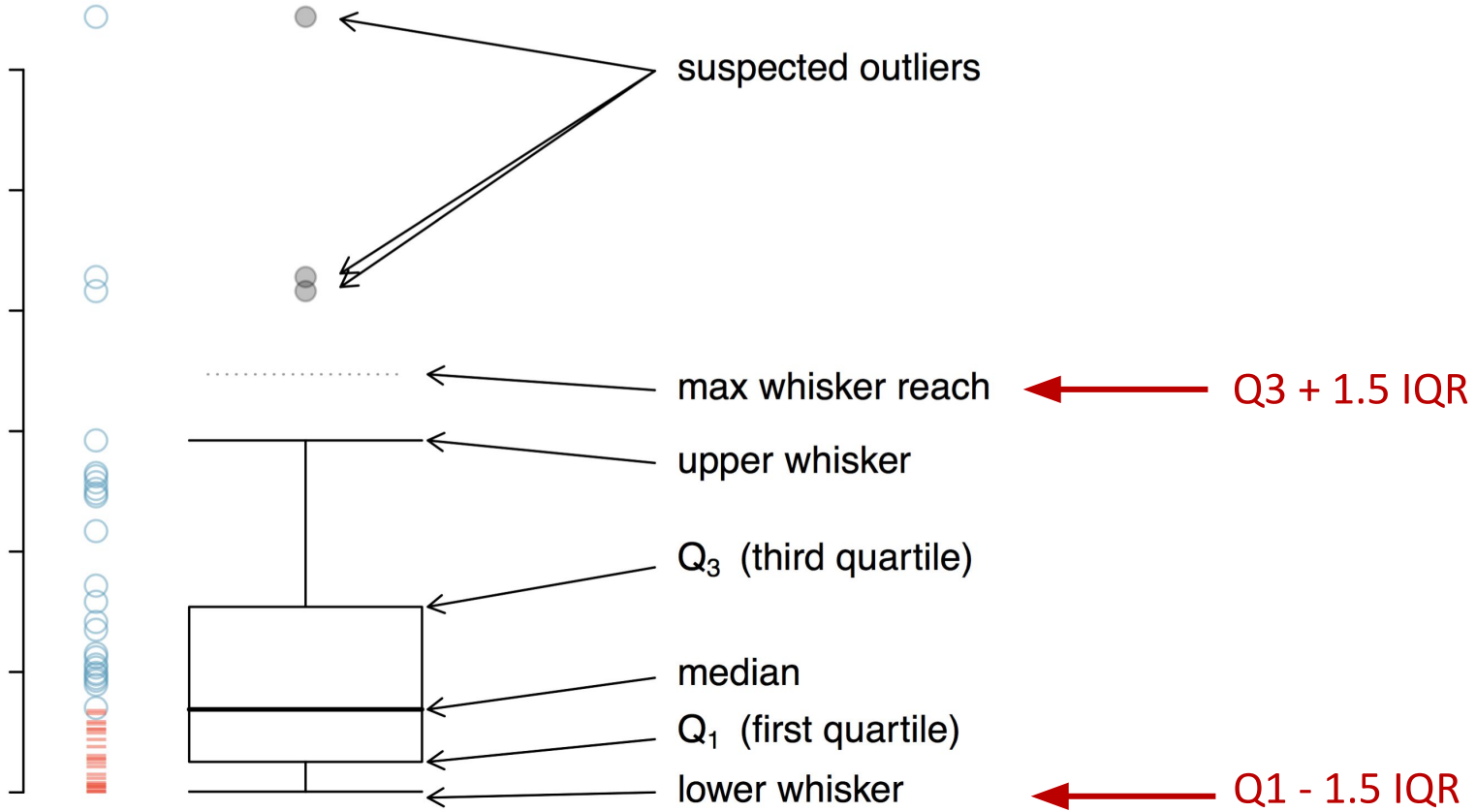
The 25th percentile is called the first quartile (Q1)

The 50th percentile is called the median

The 75th percentile is called the third quartile (Q3)

Between the first and third quartile are 50% of the data. The range between Q1 and Q3 is called Interquartile Range or IQR

Boxplots are visualizations that use percentiles to compress data



Outliers

A potential outlier is defined as an observation beyond the maximum reach of the whiskers.

It appears extreme relative to the rest of the data.

Why is it important to look for outliers?

- Identify extreme skew in the distribution.
- Identify data collection and entry errors.
- Provide insight into interesting features of the data.

Robust statistics

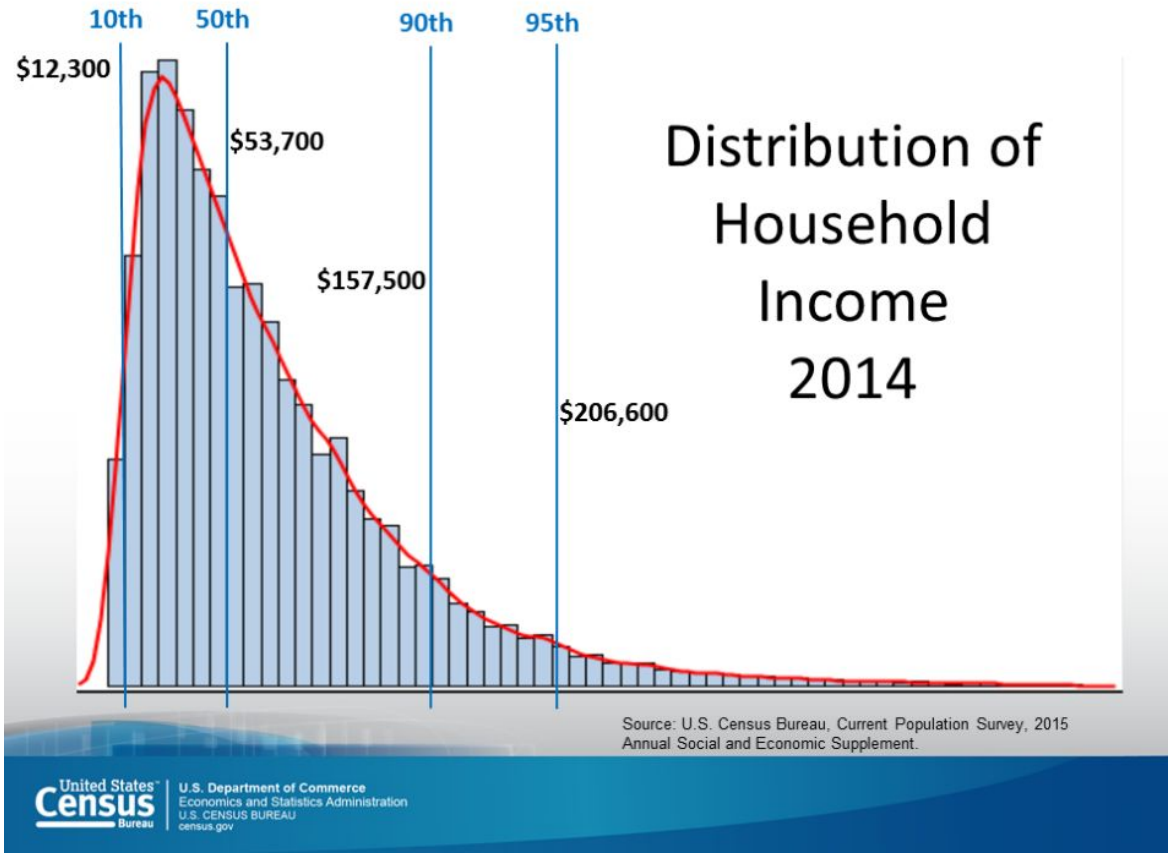
Median and IQR are more robust to skewness and outliers than mean and SD.

- for skewed distributions it is often more helpful to use median and IQR to describe the center and spread
- for symmetric distributions it is often more helpful to use the mean and SD to describe the center and spread

If you would like to estimate the typical household income in the US, would you be more interested in mean or median income?

Median

US Household Income



Median: $53,700

Mean: $75,738

What makes a good visualization?

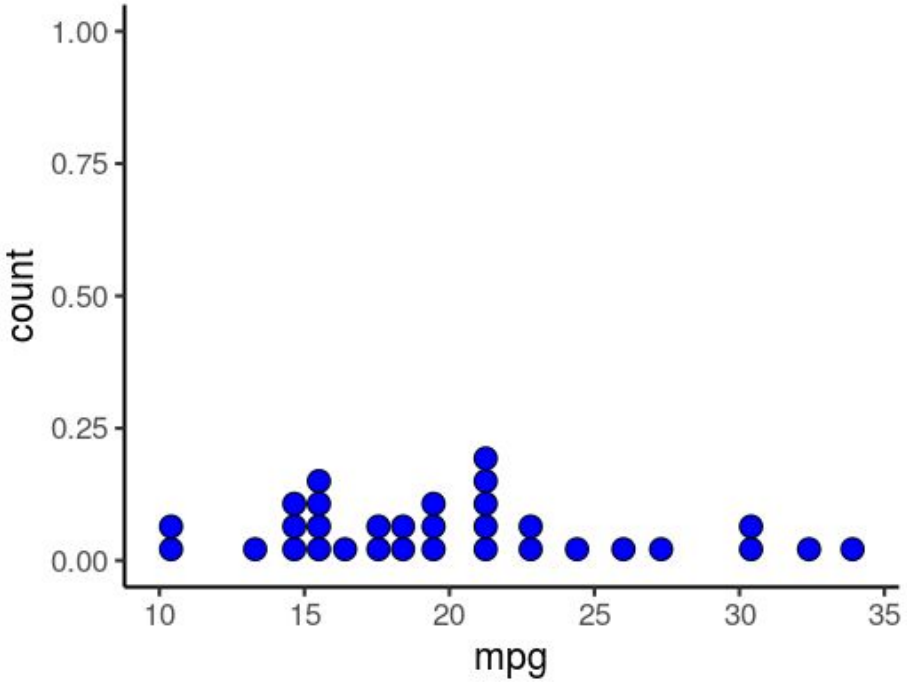
```
> mtcars
                   mpg cyl  disp  hp drat    wt  qsec vs am gear carb
Mazda RX4         21.0   6 160.0 110 3.90 2.620 16.46  0  1    4    4
Mazda RX4 Wag     21.0   6 160.0 110 3.90 2.875 17.02  0  1    4    4
Datsun 710        22.8   4 108.0  93 3.85 2.320 18.61  1  1    4    1
Hornet 4 Drive    21.4   6 258.0 110 3.08 3.215 19.44  1  0    3    1
Hornet Sportabout 18.7   8 360.0 175 3.15 3.440 17.02  0  0    3    2
Valiant           18.1   6 225.0 105 2.76 3.460 20.22  1  0    3    1
Duster 360        14.3   8 360.0 245 3.21 3.570 15.84  0  0    3    4
Merc 240D         24.4   4 146.7  62 3.69 3.190 20.00  1  0    4    2
Merc 230          22.8   4 140.8  95 3.92 3.150 22.90  1  0    4    2
Merc 280          19.2   6 167.6 123 3.92 3.440 18.30  1  0    4    4
Merc 280C         17.8   6 167.6 123 3.92 3.440 18.90  1  0    4    4
Merc 450SE        16.4   8 275.8 180 3.07 4.070 17.40  0  0    3    3
Merc 450SL        17.3   8 275.8 180 3.07 3.730 17.60  0  0    3    3
Merc 450SLC       15.2   8 275.8 180 3.07 3.780 18.00  0  0    3    3
Cadillac Fleetwood  10.4   8 472.0 205 2.93 5.250 17.98  0  0    3    4
Lincoln Continental 10.4   8 460.0 215 3.00 5.424 17.82  0  0    3    4
Chrysler Imperial   14.7   8 440.0 230 3.23 5.345 17.42  0  0    3    4
Fiat 128          32.4   4  78.7  66 4.08 2.200 19.47  1  1    4    1
Honda Civic       30.4   4  75.7  52 4.93 1.615 18.52  1  1    4    2
Toyota Corolla    33.9   4  71.1  65 4.22 1.835 19.90  1  1    4    1
Toyota Corona     21.5   4 120.1  97 3.70 2.465 20.01  1  0    3    1
Dodge Challenger  15.5   8 318.0 150 2.76 3.520 16.87  0  0    3    2
AMC Javelin       15.2   8 304.0 150 3.15 3.435 17.30  0  0    3    2
Camaro Z28        13.3   8 350.0 245 3.73 3.840 15.41  0  0    3    4
Pontiac Firebird  19.2   8 400.0 175 3.08 3.845 17.05  0  0    3    2
Fiat X1-9         27.3   4  79.0  66 4.08 1.935 18.90  1  1    4    1
Porsche 914-2     26.0   4 120.3  91 4.43 2.140 16.70  0  1    5    2
Lotus Europa      30.4   4  95.1 113 3.77 1.513 16.90  1  1    5    2
Ford Pantera L    15.8   8 351.0 264 4.22 3.170 14.50  0  1    5    4
Ferrari Dino      19.7   6 145.0 175 3.62 2.770 15.50  0  1    5    6
Maserati Bora     15.0   8 301.0 335 3.54 3.570 14.60  0  1    5    8
Volvo 142E        21.4   4 121.0 109 4.11 2.780 18.60  1  1    4    2
```

Let’s look at the miles per gallon of these cars

Good visualizations

A good visualization makes your intuitions when seeing the data match the results of your statistical analyses

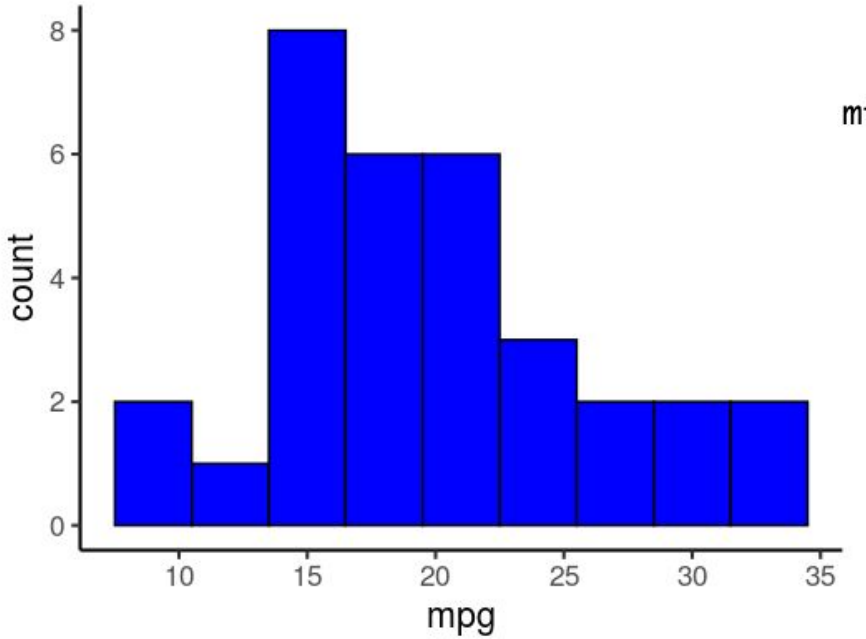
Dot plots make it easy to see where most of the data is.




```
mtcars %>%
  ggplot(aes(x = mpg)) +
  geom_dotplot(fill = "blue", color = "black")
```

Good visualizations

Histograms make it easy to see where most of the data is.

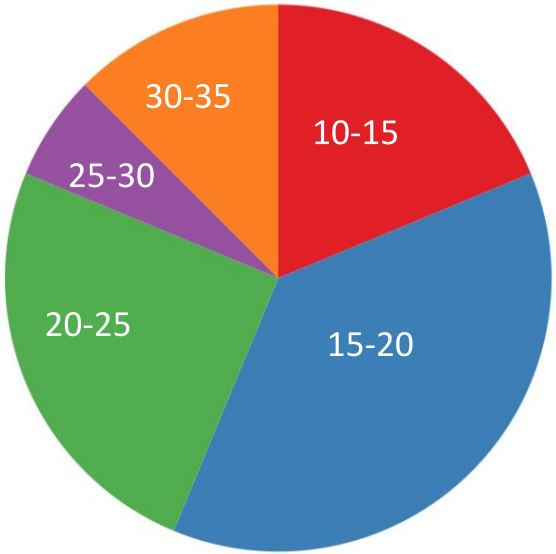



```
mtcars %>%
  ggplot(aes(x = mpg)) +
  geom_histogram(fill = "blue", color = "black",
                 binwidth = 3)
```

Can they be bad sometimes?

Bad visualizations

Pie charts make it difficult to see where most of the data is



Why?

We are not good at integrating dimensions

Children under ~7 will fail at this conservation task

But so will you if I don’t pour the water in front of you!

Piaget (1965)

Key ideas

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