Visualizing Data and Summary Statistics

Introduction to Evolution and Scientific Inquiry

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Quantitative vs. Categorical variables

- Quantitative variables are described by data as *numbers*
  - Height of a plant
  - Number of legs on an octopus
  - Length of gestation time

- Categorical variables are described by data as *categories*
  - Colors
  - Species names
  - iPhone models

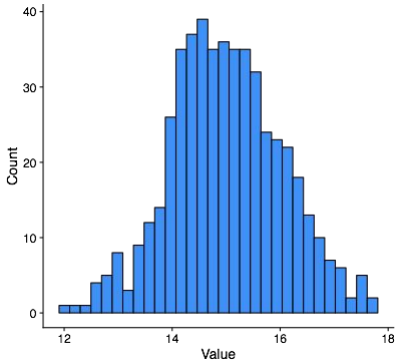
There are two types of quantitative data

- Continuous
  - Any real-number value within some range
  - Example: height, weight,
  - If it can be a decimal, it is continuous

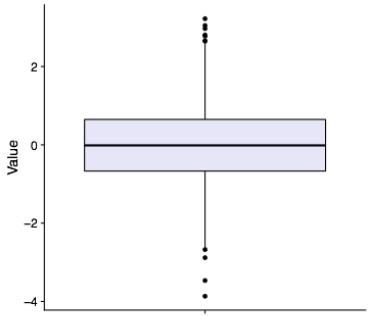
- Discrete (also known as discontinuous in book)
  - Values are in indivisible units, i.e. whole or counting numbers
  - "Count data"
  - If it can NOT have a decimal (i.e. there are not 2.5 people), it is discrete
- Note: discreet is different.

How we represent data depends on what kind it is

Visualize quantitative data

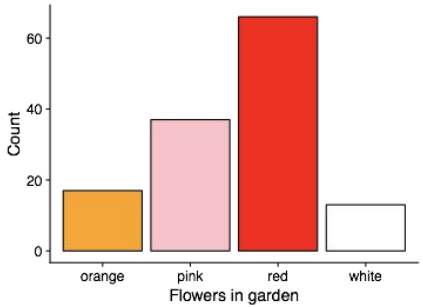


Histogram



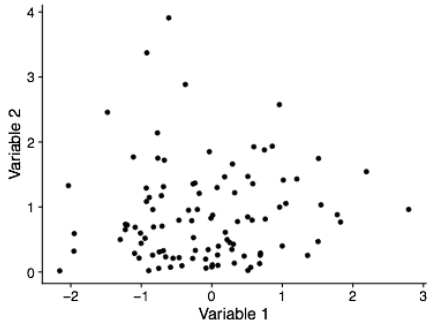
Boxplot

Visualize categorical data*



Bar plot

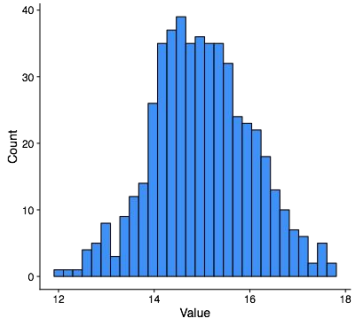
Visualize how **two quantitative** variables relate

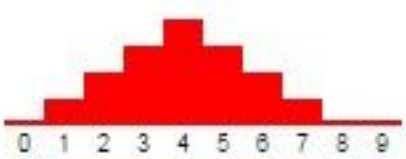


Scatterplot

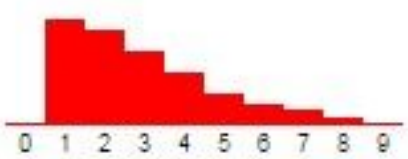
*Commonly used for quantitative data as well, but it “shouldn’t be”

Histograms

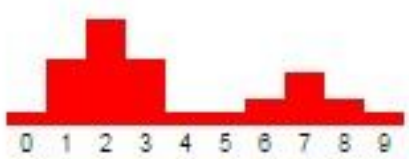




Symmetric, unimodal, bell-shaped

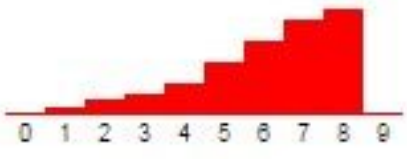


Skewed right

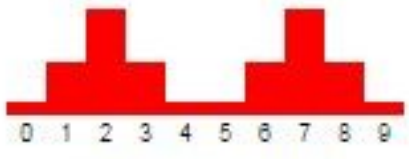


Non-symmetric, bimodal

Uniform

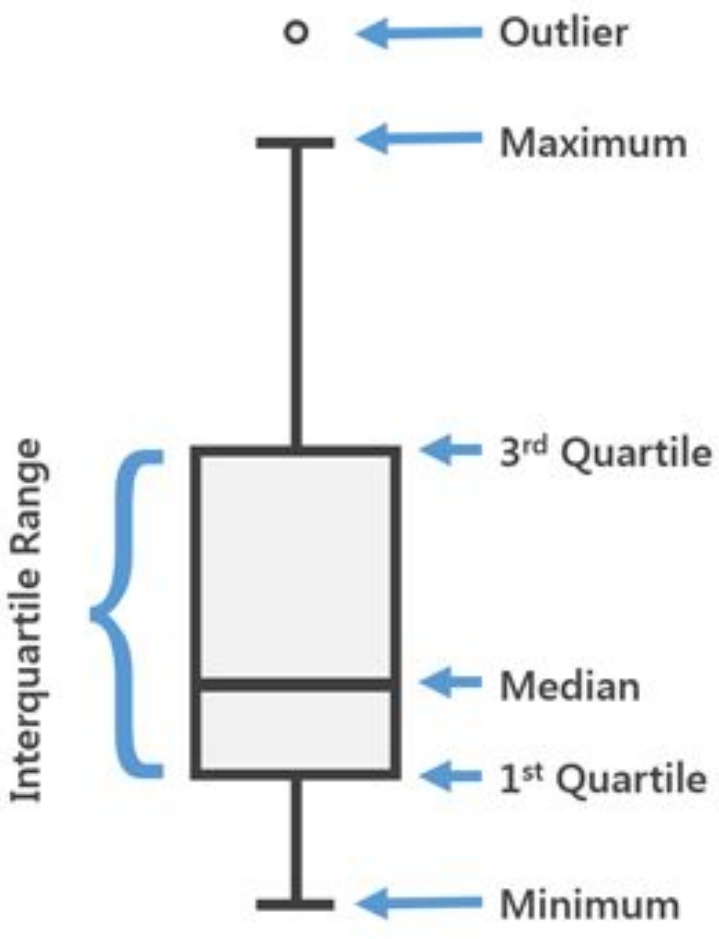


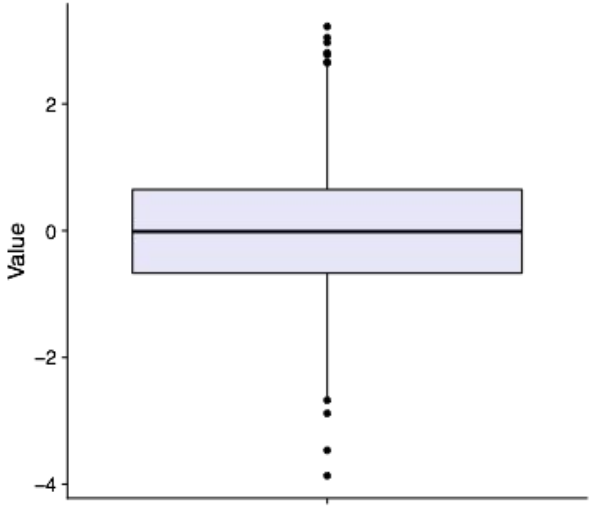
Skewed left



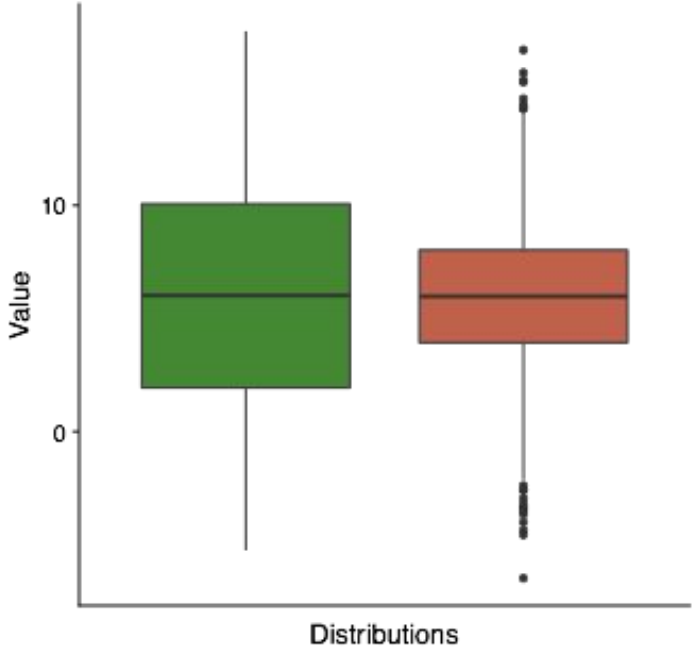
Symmetric, bimodal

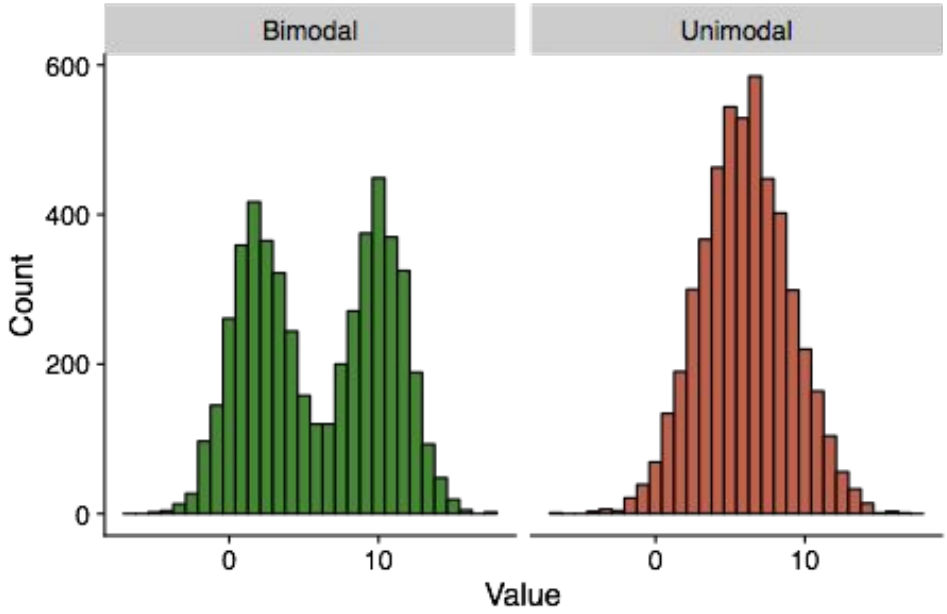
Boxplots


Outlier
Maximum
3rd Quartile
Median
1st Quartile
Minimum
Interquartile Range


Value
2
0
−2
−4

Boxplots vs. histograms

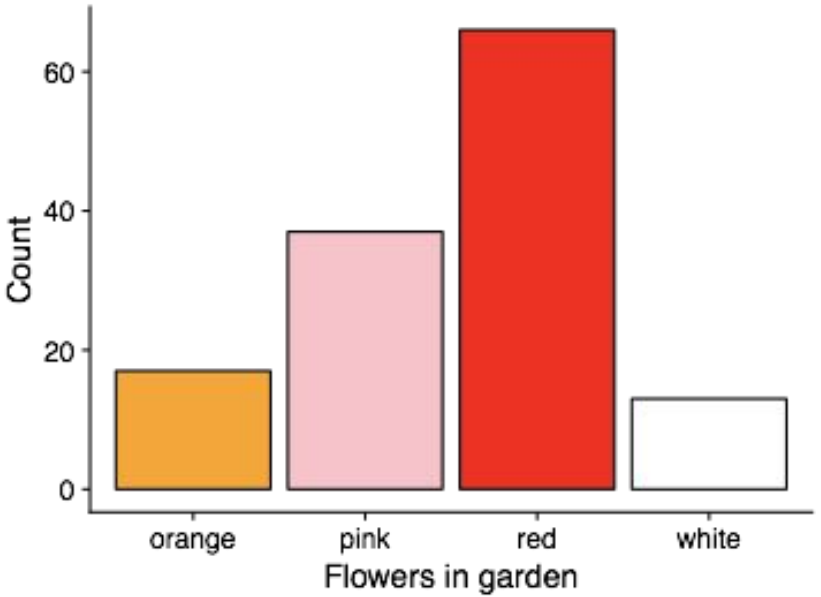




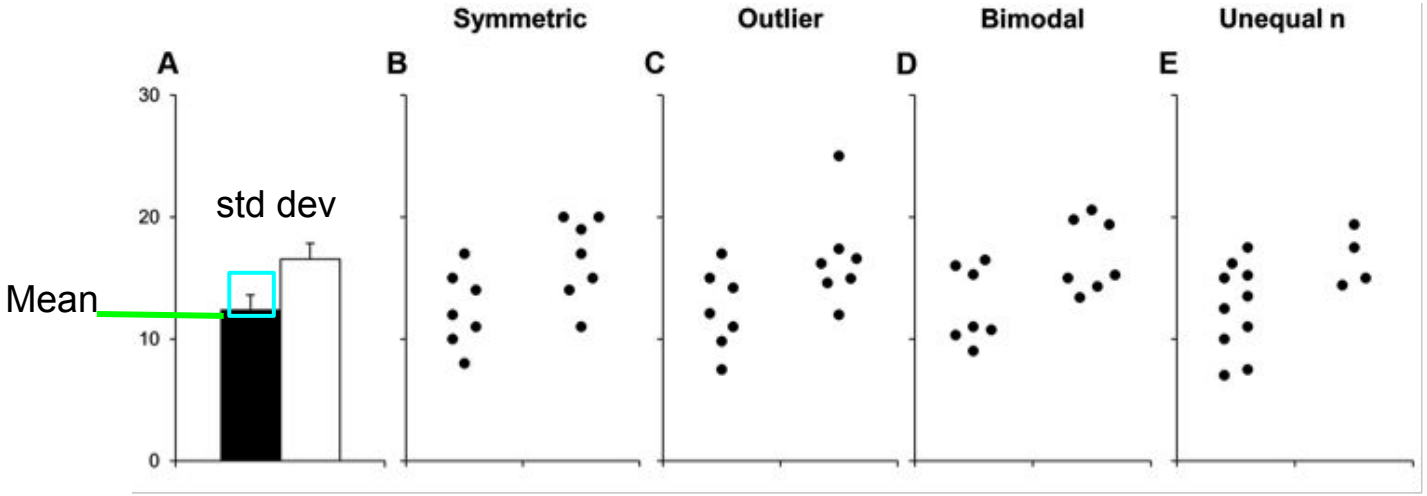
Barplots

In my garden, there are...

- 18 orange flowers
- 37 pink flowers
- 62 red flowers
- 15 white flowers



Barplots can also show mean and standard deviation

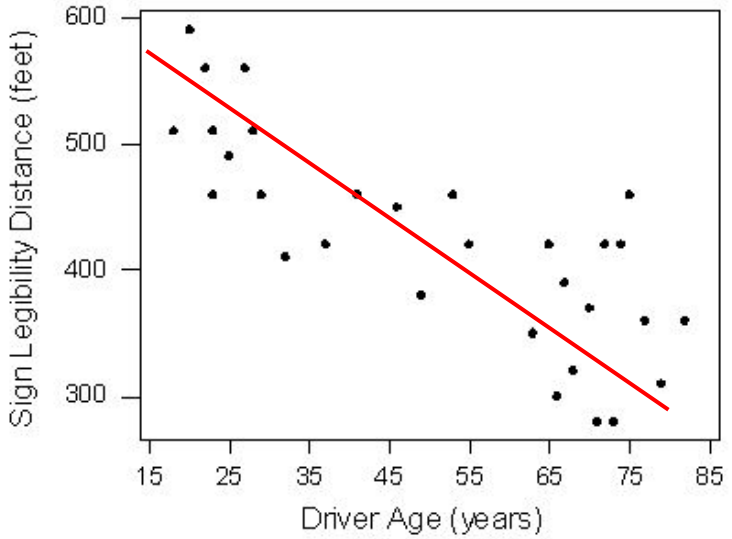


http://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.1002128

Scatterplots

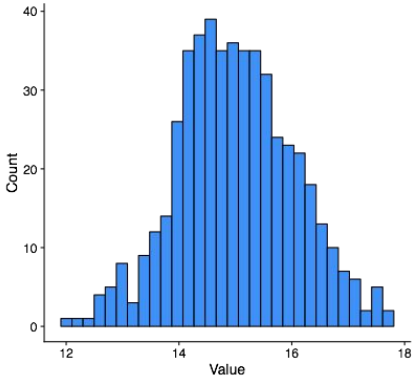
- X-axis shows **independent variable**

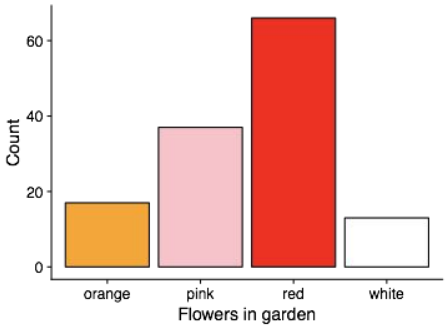
- Y-axis shows **dependent (response) variable**

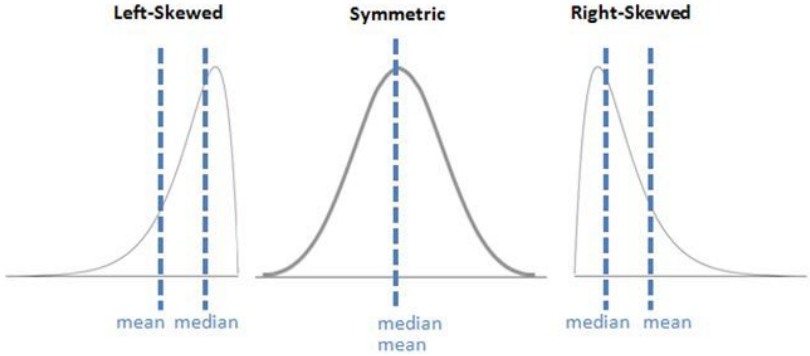


Describing the location of a distribution

- Location is a fancy word for “center”
  - Mean and median for quantitative data
  - Mode for categorical data







Describing the spread of a distribution

- Range
  - 1, 2, 3, 7, 9 → **8**
  - 1, 2, 3, 7, 9, 500 → **499**
- Standard deviation
  - Variance = s^2

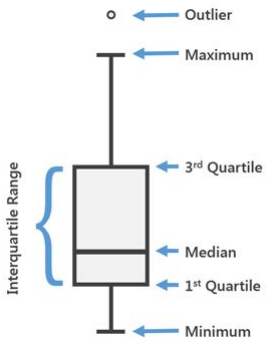
$$s_x = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}}$$

n = The number of data points

$\bar{x}$ = The mean of the x_i

x_i = Each of the values of the data

- Interquartile Range (IQR)
  - Middle 50% of the numbers (goes with median)

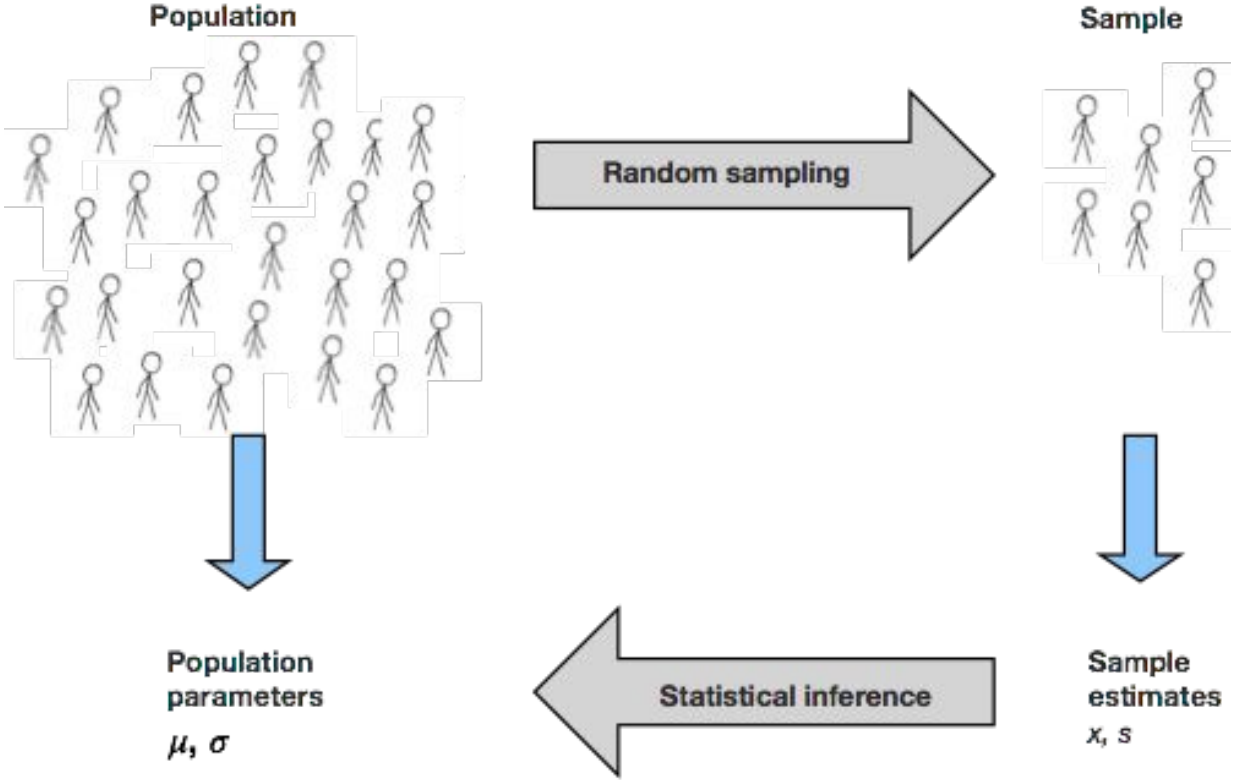


A note on the word population

- In **biology**, a population is group of organisms of a single species who live around the same area

- In **statistics**, a population is total set of observations, data points, etc. that can be made
  - Except in a few cases, we generally never know the population

Statistical Inference: Does my sample represent the true population?



How well does my sample represent the population?

- Standard Error: The distance between my measured statistic and the true population parameter

- **SEM = Standard Error of the Mean**

$$SE_{\bar{x}} = \frac{s}{\sqrt{n}}$$

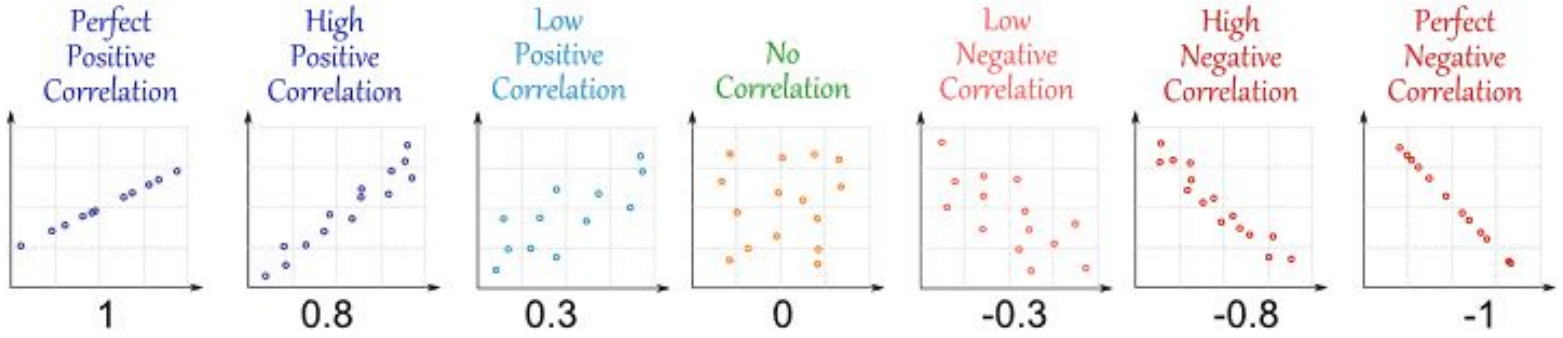
Standard deviation vs standard error

- Standard Deviation: how does the sample vary around the *sample* mean?
  - Low SD = very narrow
  - High SD = lots of spread

- Standard error of the mean: how does the sample mean compare to the *population* mean?
  - Low SEM: sample mean is very close to “true” mean
  - High SEM: sample mean is very far from “true” mean
  - Generally larger sample size yields lower SEM

Describing relationships between quantitative variables

- One common measure is *correlation*
- The Pearson Correlation Coefficient: **-1 <= r <= 1**



Major Correlation Caveats

- *Linear relationship only!* (for now)
  - Curves use different types of *correlation coefficients*

- **CORRELATION 👏 IS 👏 NOT 👏 CAUSATION 👏**
  - http://www.tylervigen.com/spurious-correlations

Explore quantitative data visualization

https://sjspielman.shinyapps.io/plot-iris/

http://guessthecorrelation.com/