Descriptive Stats and Data Exploration

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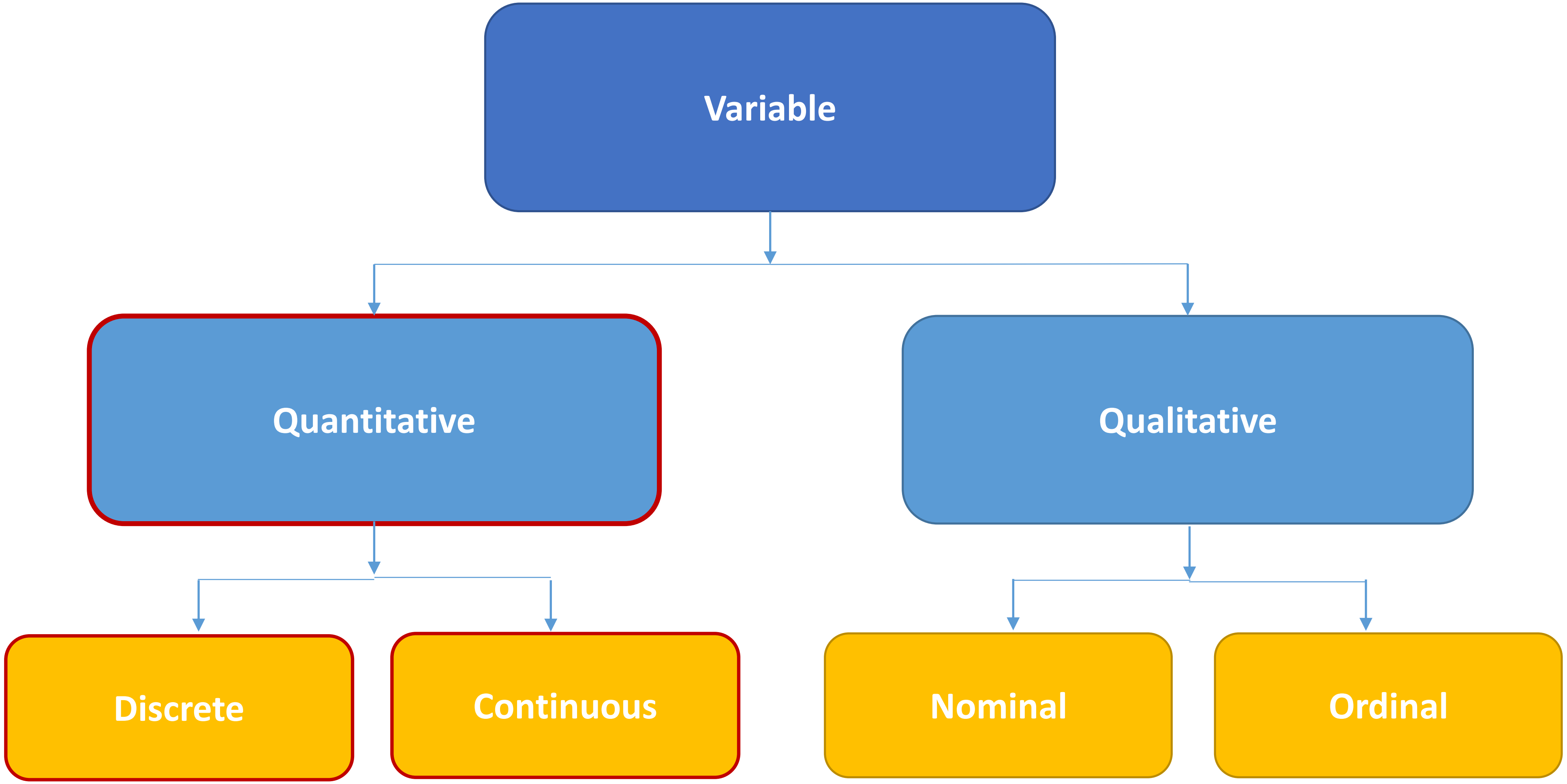
v2020-05


Variable
Quantitative
Qualitative
Discrete
Continuous
Nominal
Ordinal

Quantitative data

- They take numerical values (units of measurement)

- Discrete: obtained by counting
  - Example: number of students in a class
  - values vary by finite specific steps
- or continuous: obtained by measuring
  - Example: height of students in a class
  - any values

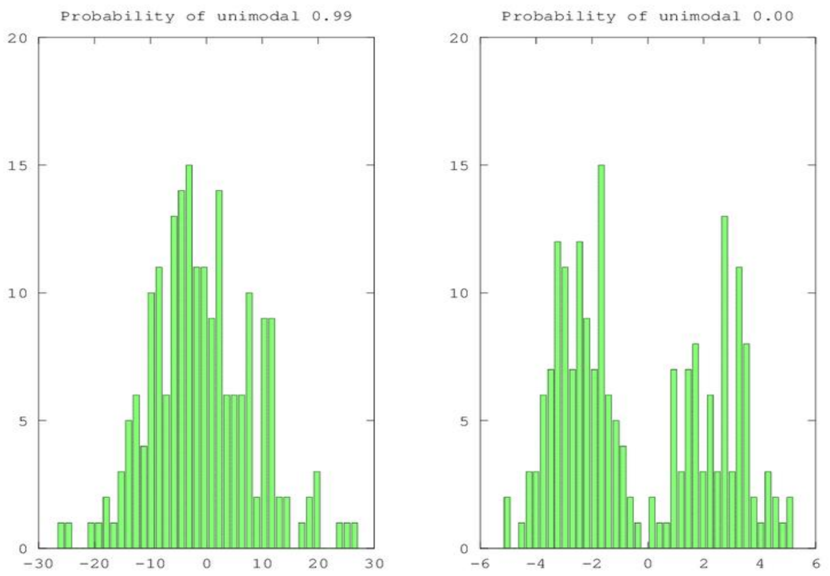
https://github.com/allisonhorst/stats-illustrations#other-stats-artwork

- They can be described by a series of parameters:
  - Mean, variance, standard deviation, standard error and confidence interval

Measures of central tendency

Mode and Median

- **Mode:** most commonly occurring value in a distribution

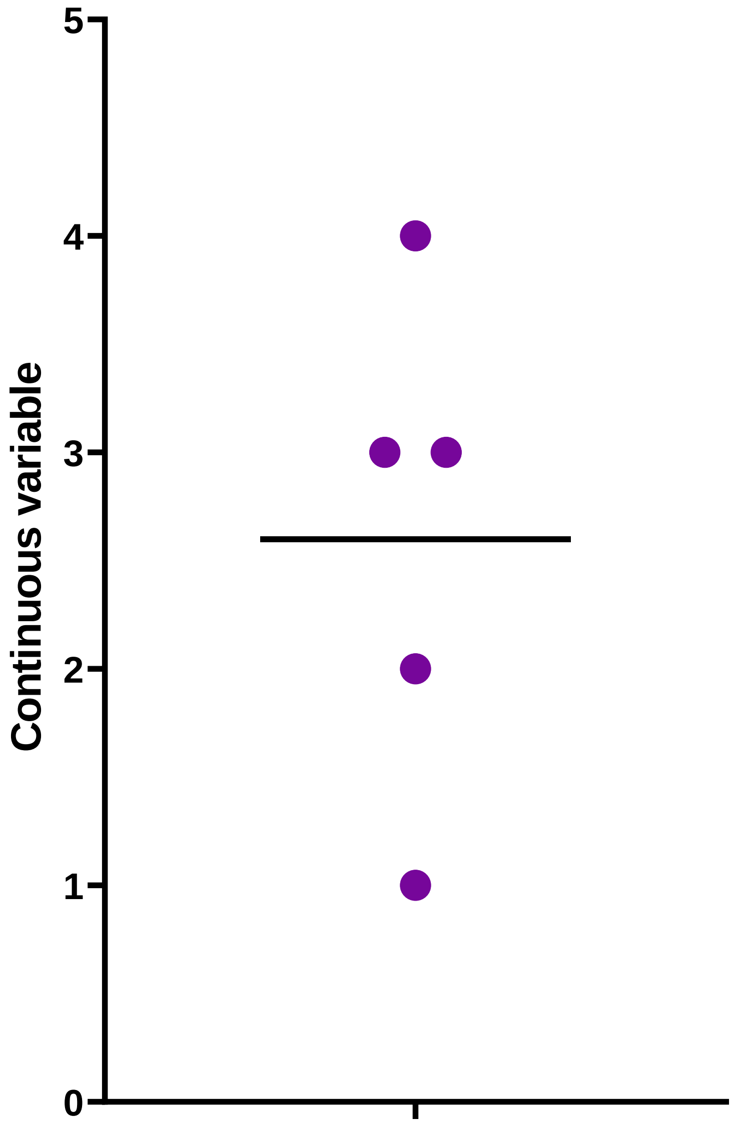


- **Median:** value exactly in the middle of an ordered set of numbers

Example 1: 18 27 34 52 54 59 61 68 78 82 85 87 91 93 100, Median = 68
Example 2: 18 27 27 34 52 52 59 61 68 68 85 85 85 90, Median = 60

Measures of central tendency
Mean

- Definition: average of all values in a column.
- Example: mean of: 1, 2, 3, 3 and 4
  - (1+2+3+3+4)/5 = 2.6
- The mean is a model because it summaries the data.
- How do we know that it is an accurate model?
  - Difference between the real data and the model created



Measures of dispersion

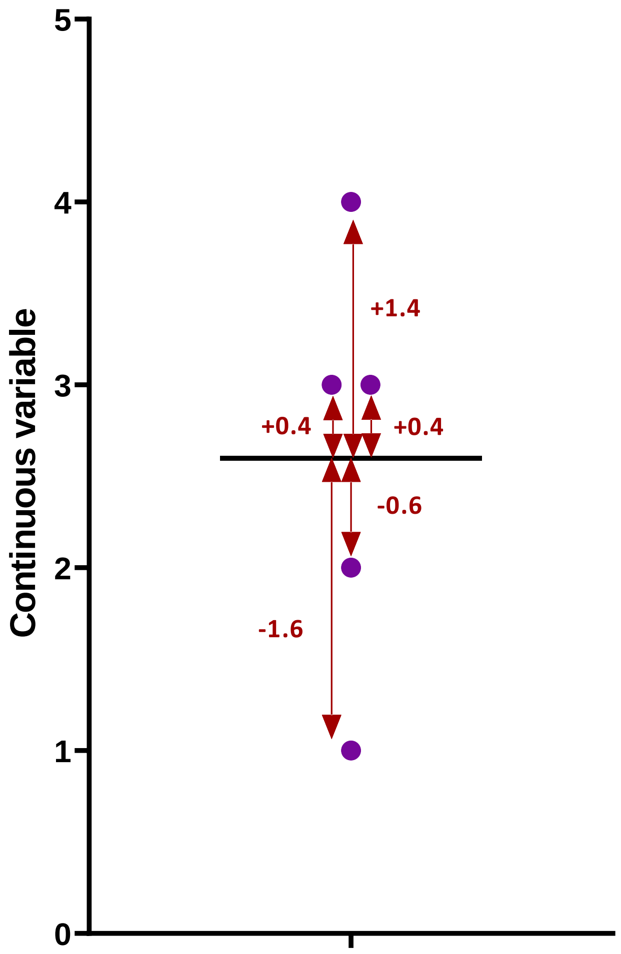
- Calculate the magnitude of the differences between each data and the mean

- Total error = sum of differences

$$= \Sigma(x_i - \overline{x}) = -1.6 - 0.6 + 0.4 + 0.4 + 1.4 = 0$$

No errors !

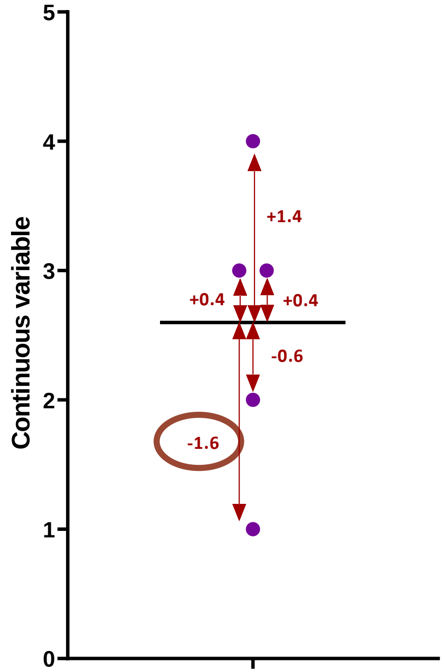
  - Positive and negative: they cancel each other out.



Sum of Squared errors (SS)

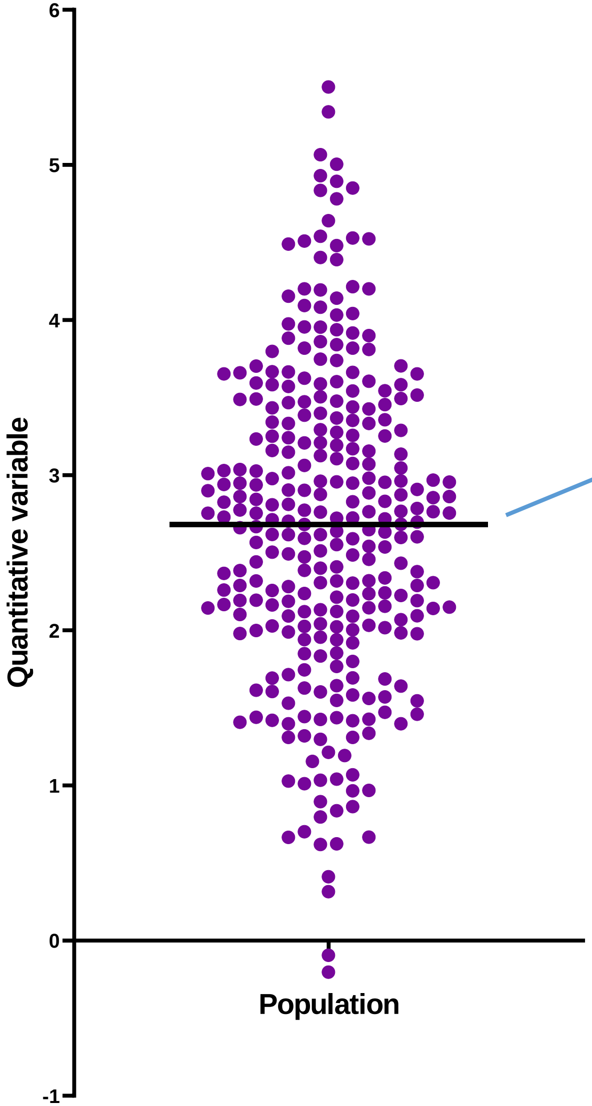
- To solve that problem: we square errors
  - Instead of sum of errors: sum of squared errors (SS):

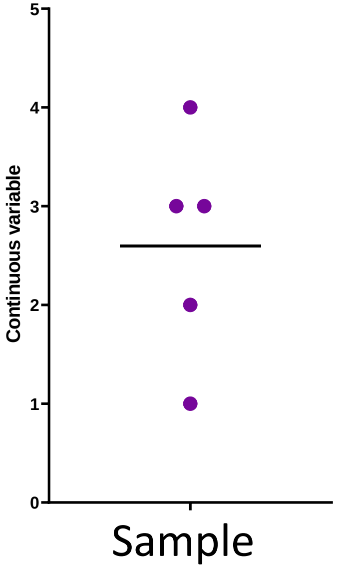
$$(SS) = \Sigma(x_i - \overline{x})(x_i - \overline{x})$$
$$= (-1.6)^2 + (-0.6)^2 + (0.4)^2 + (0.4)^2 + (1.4)^2$$
$$= 2.56 + 0.36 + 0.16 + 0.16 + 1.96$$
$$= 5.20$$



- SS gives a good measure of the accuracy of the model
  - But: dependent upon the amount of data: the more data, the higher the SS.
  - Solution: to divide the SS by the number of observations (N)
    - As we are interested in measuring the error in the sample to estimate the one in the population, we divide the SS by N-1 instead of N and we get the **variance** (S^2) = SS/N-1

Degrees of freedom





Mean Population (μ) = Mean Sample ($\bar{x}$) = 2.6

$\bar{x}$= 2.6 = (1+2+3+3 **+4)/5 = 2.6**

First (n-1) values: whatever

n^{th} value: fixed

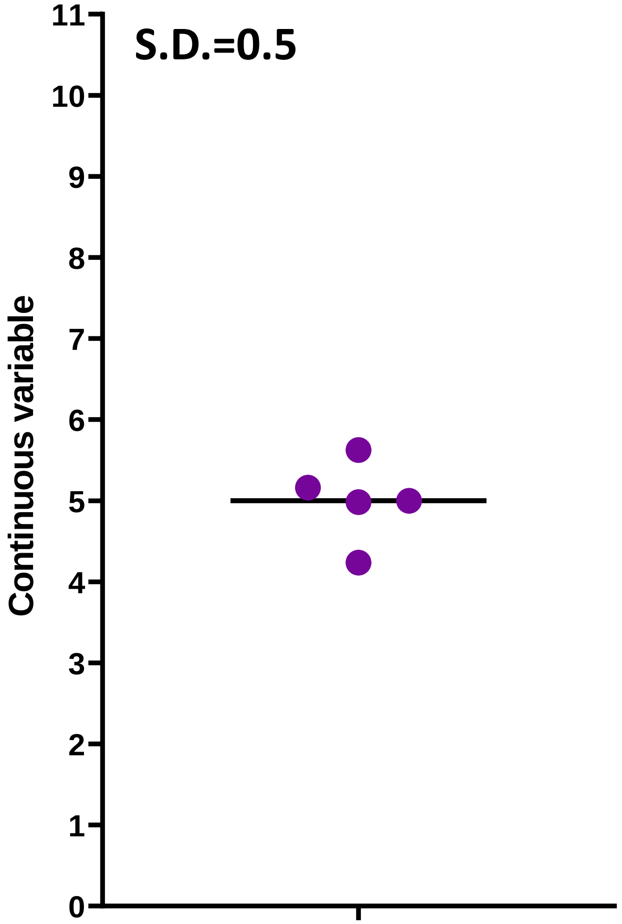
n – 1 degrees of freedom

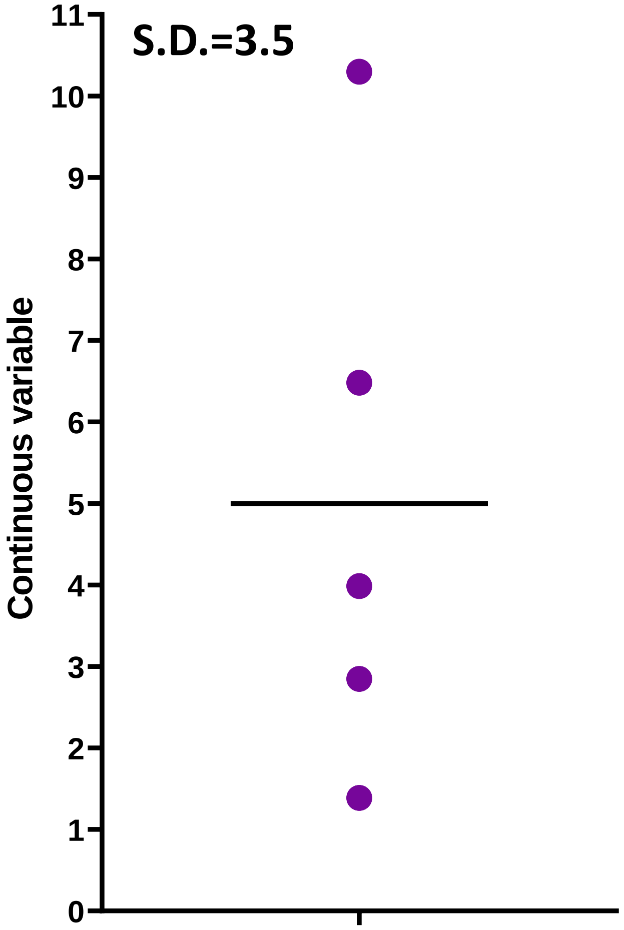
Variance and standard deviation

- $variance\ (s^2) = \frac{SS}{N-1} = \frac{\Sigma\,(x_i - \overline{x})^2}{N-1} = \frac{5.20}{4} = 1.3$

- Problem with variance: measure in squared units
  - The square root of the variance is taken to obtain a measure in the same unit as the original measure:
    - the **standard deviation**
      - S.D. = √(SS/N-1) = √(s^2) = s = $\sqrt{1.3} = 1.14$
    - The **standard deviation** is a measure of how well the mean represents the data.

Standard deviation

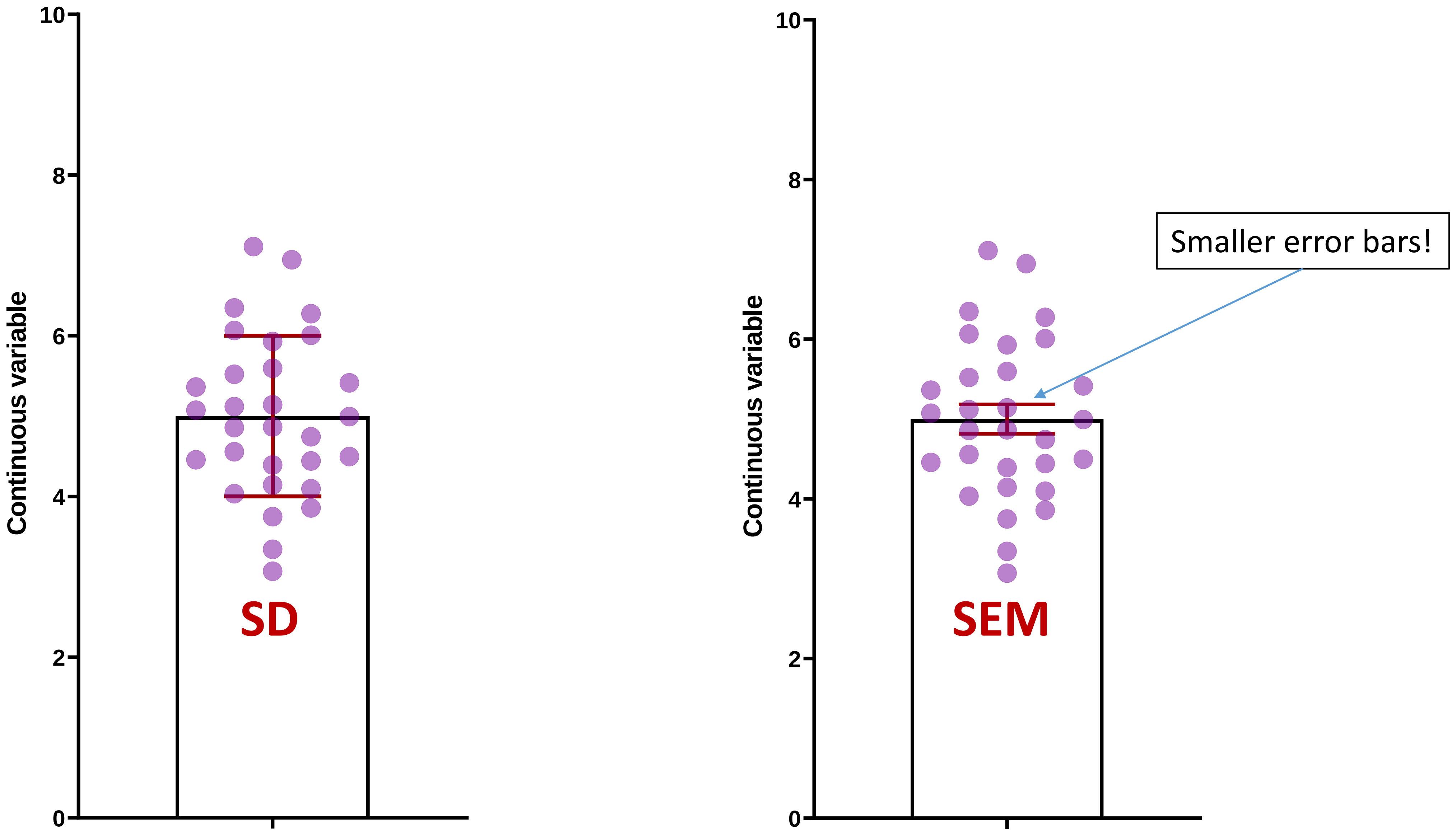




Small S.D.:
data close to the mean:
mean is a good fit of the data

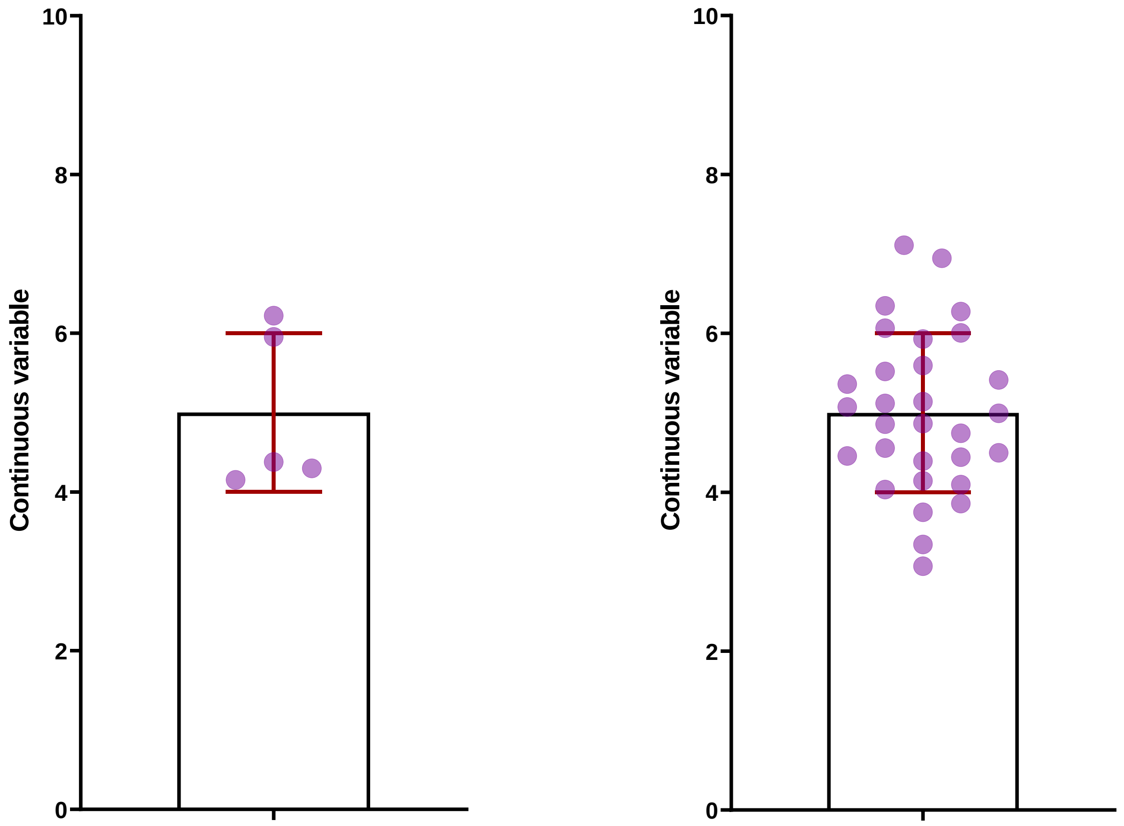
Large S.D.:
data distant from the mean:
mean is not an accurate representation

Standard Deviation (SD) or Standard Error Mean (SEM)?



Standard Deviation

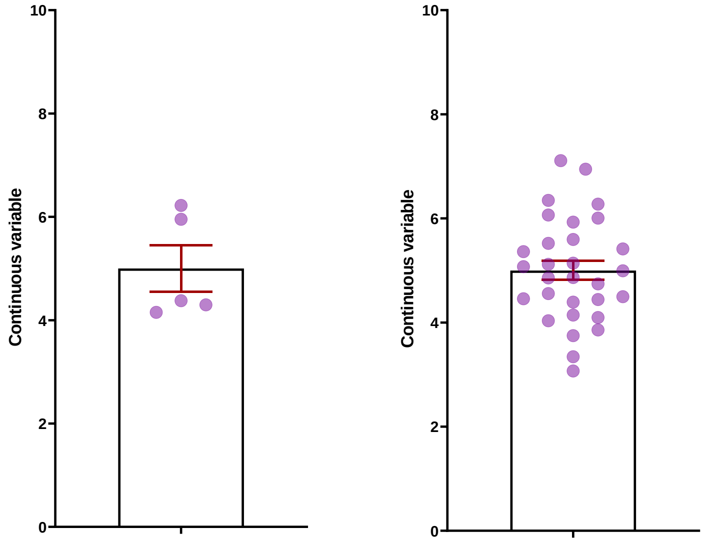
- The **SD** quantifies **how much the values vary** from one another
  - **scatter or spread**
  - The **SD** does not change predictably as you acquire more data.



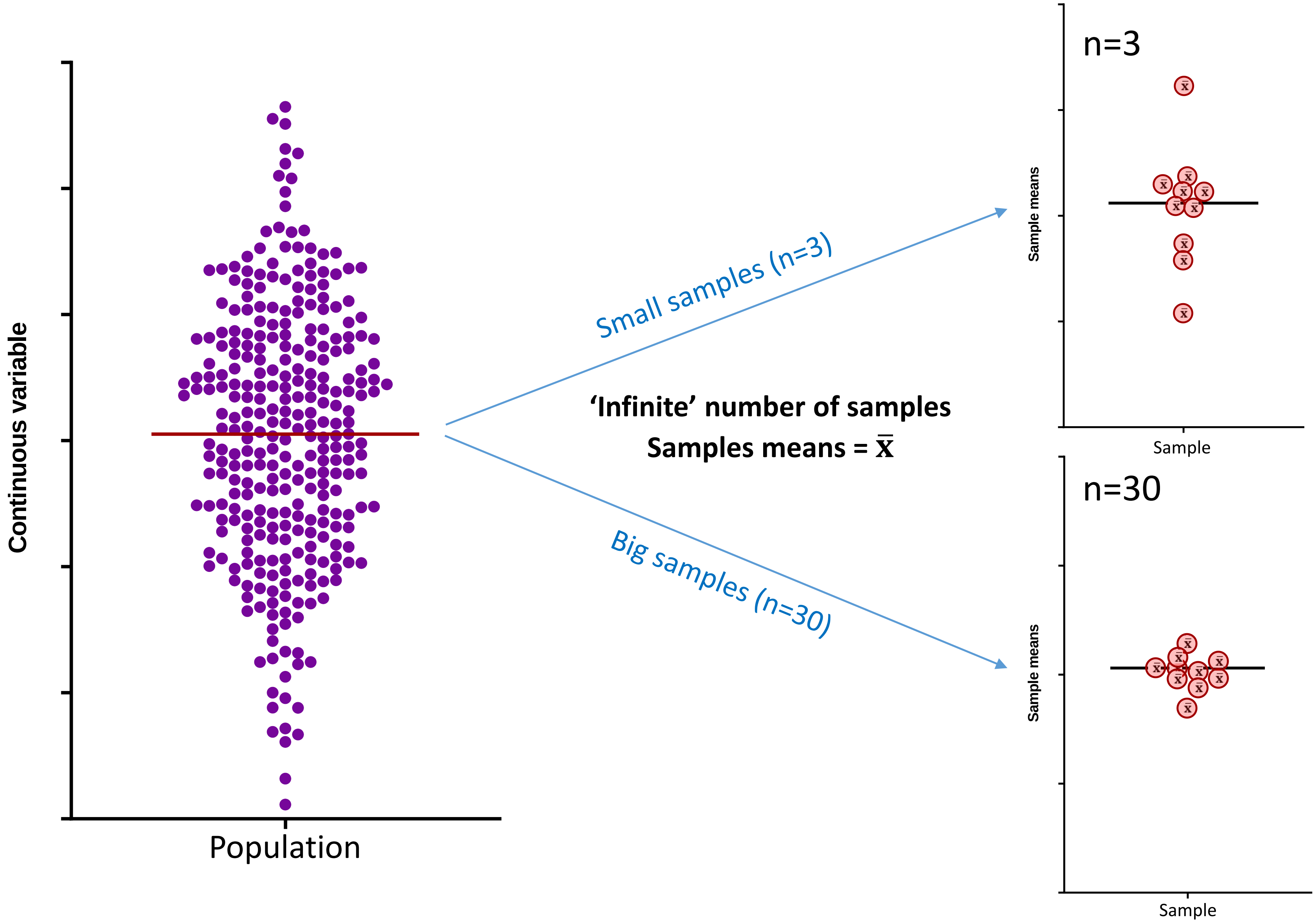
Standard Error Mean

$$\mathbf{SEM} = \frac{\mathbf{SD}}{\sqrt{N}}$$

- The **SEM** quantifies **how accurately** we know the **true mean** of the population.
  - Why? Because it takes into account: **SD + sample size**
- The SEM gets smaller as your sample gets larger
  - Why? Because the mean of a large sample is likely to be closer to the true mean than is the mean of a small sample.



The SEM and the sample size



SD or SEM ?

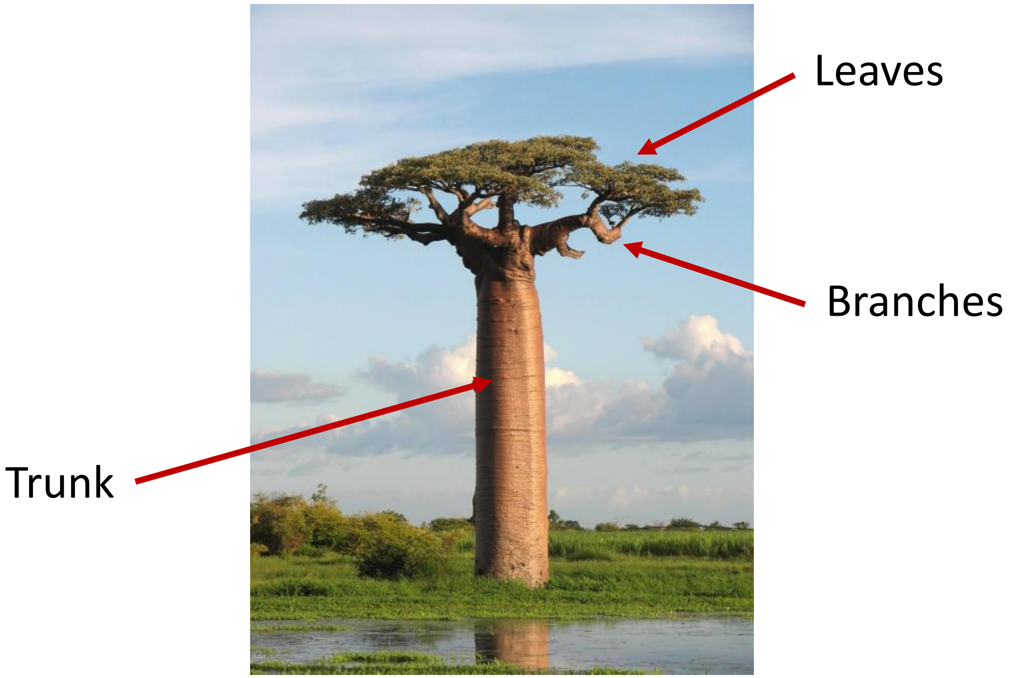
- If the scatter is caused by biological variability, it is important to show the variation.
  - Report the SD rather than the SEM.
    - Better even: show a graph of all data points.

- If you are using an in vitro system with no biological variability, the scatter is about experimental imprecision (no biological meaning).
  - Report the SEM to show how well you have determined the mean.

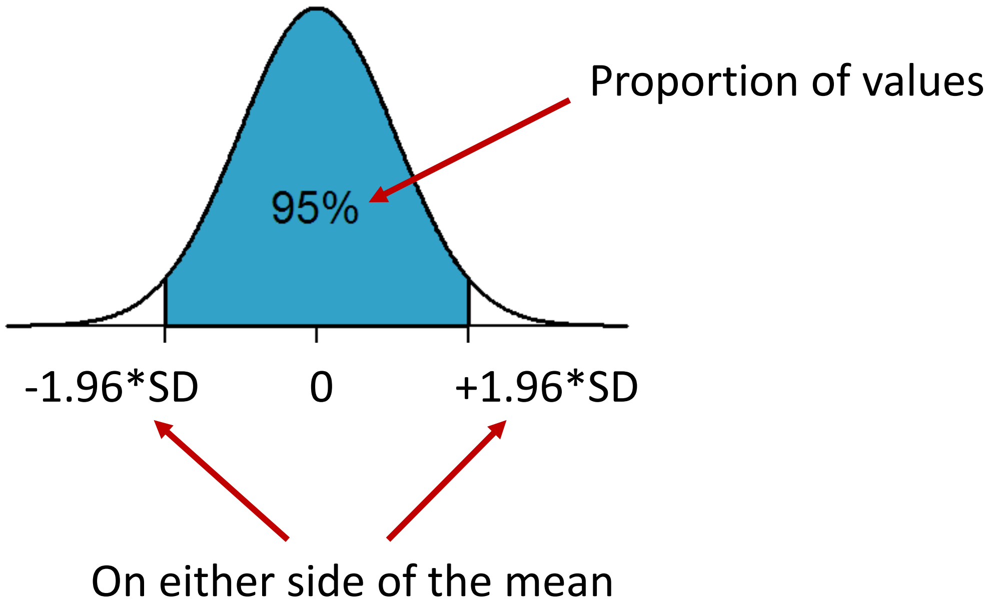
Confidence interval

- Range of values that we can be 95% confident contains the true mean of the population.
  - Limits of 95% CI: **[Mean - 1.96 SEM; Mean + 1.96 SEM]** (SEM = SD/√N)

A distribution is not something made, it is something observed.



This is a tree

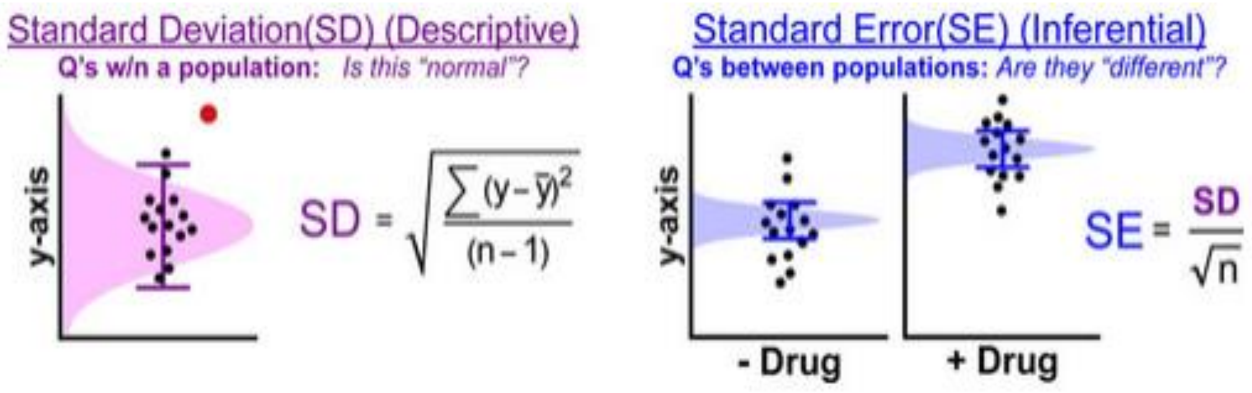


This is a normal distribution

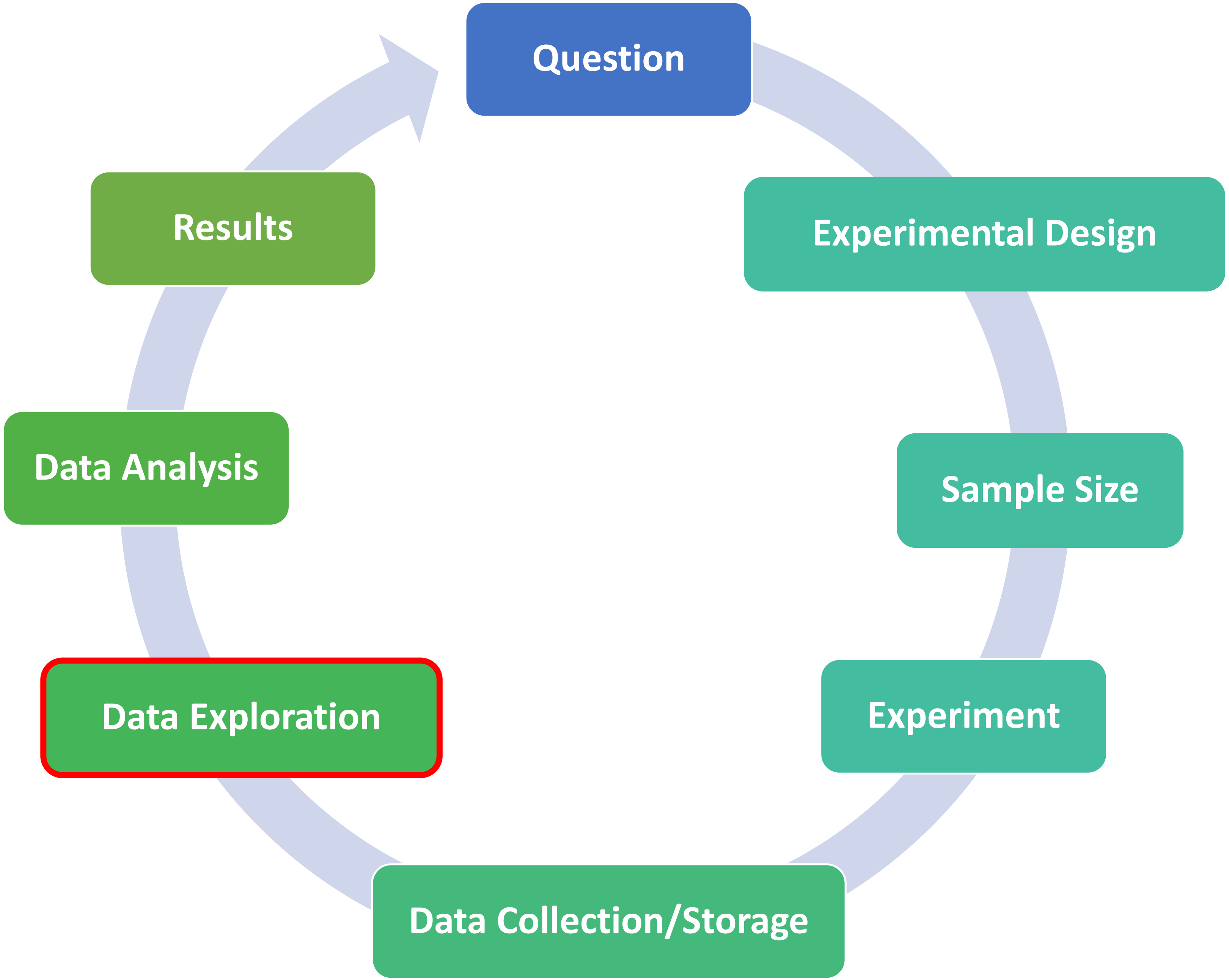
To recapitulate

- The Standard Deviation is **descriptive**
  - Just about the sample.

- The Standard Error and the Confidence Interval are **inferential**
  - Sample → General Population

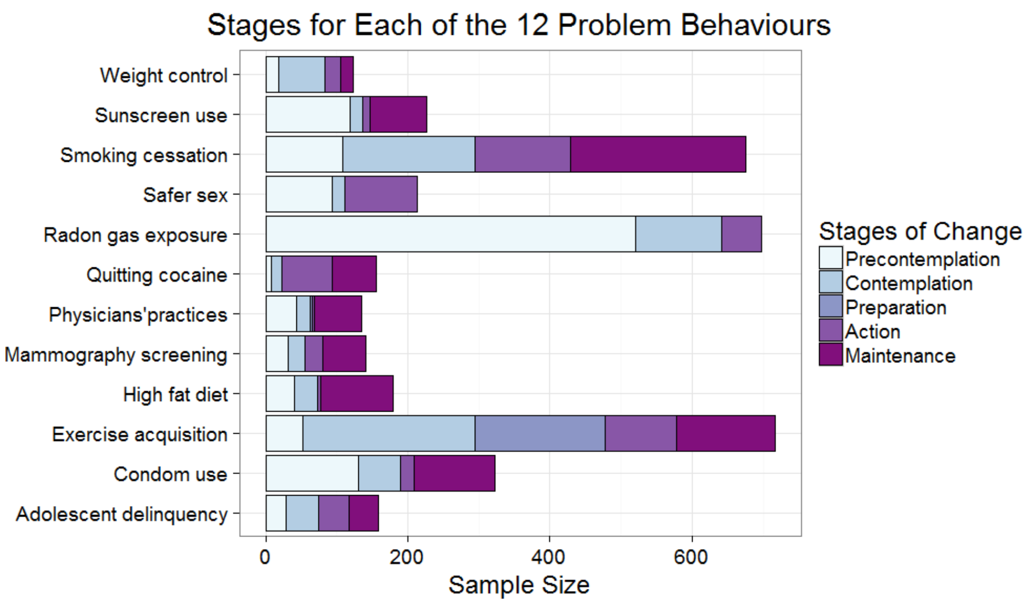


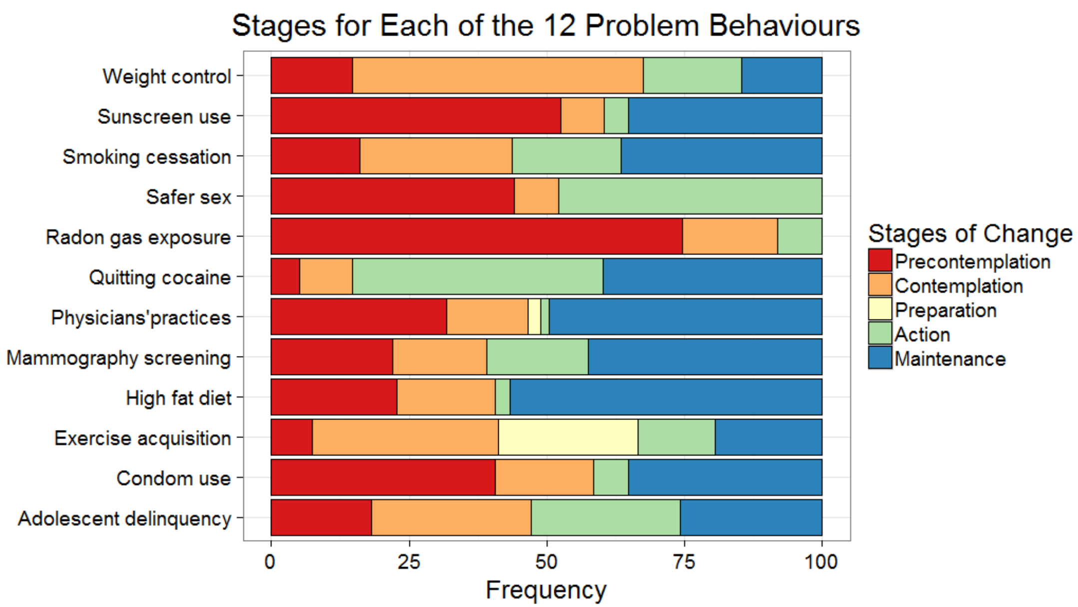
Graphical exploration of data

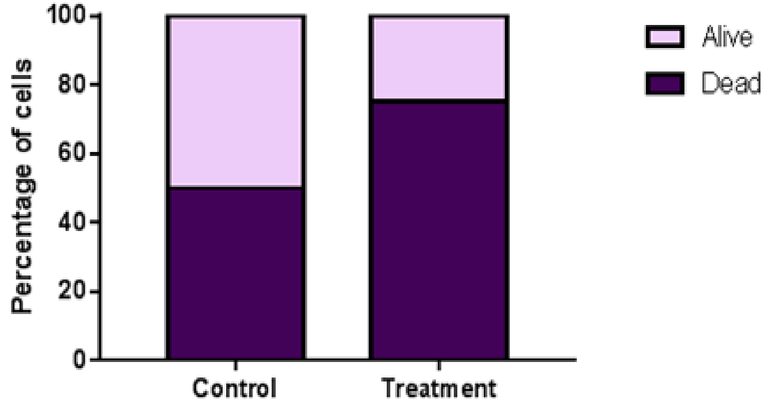

Question
Experimental Design
Sample Size
Experiment
Data Collection/Storage
Data Exploration
Data Analysis
Results

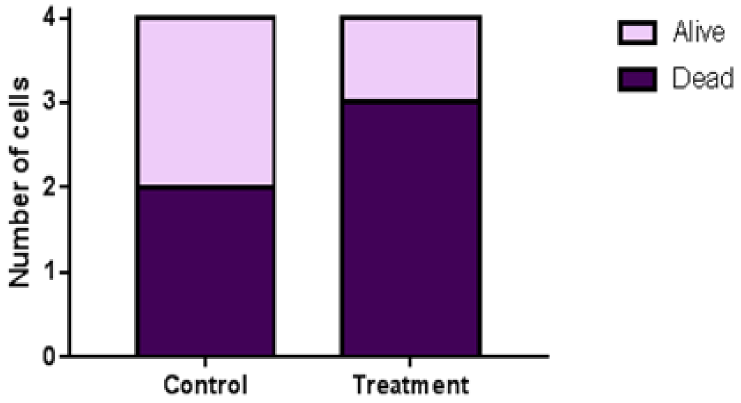
Data Exploration

Categorical data



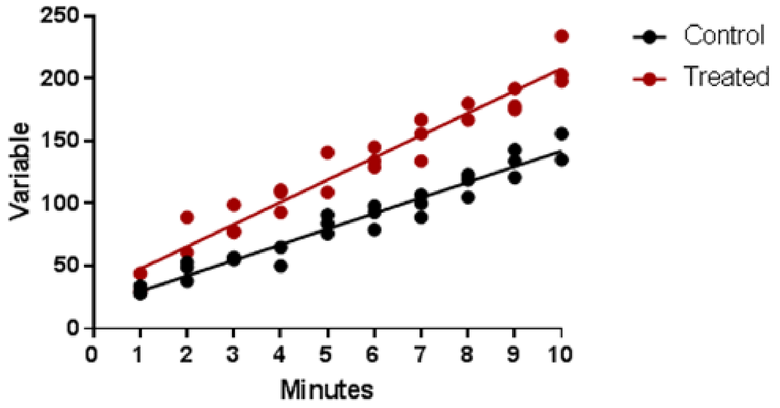


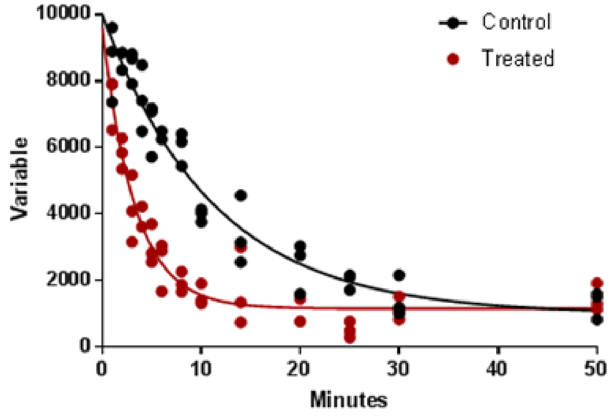


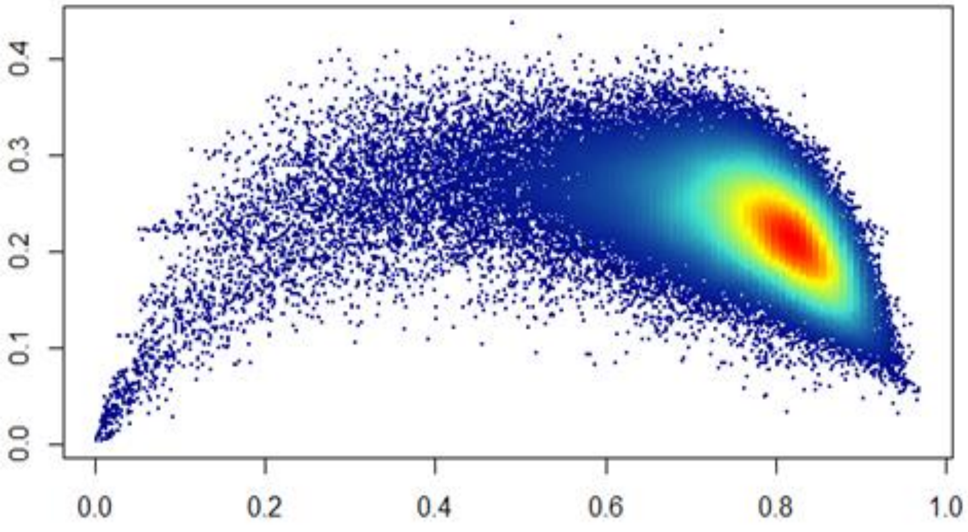


Data Exploration

Quantitative data: Scatterplot



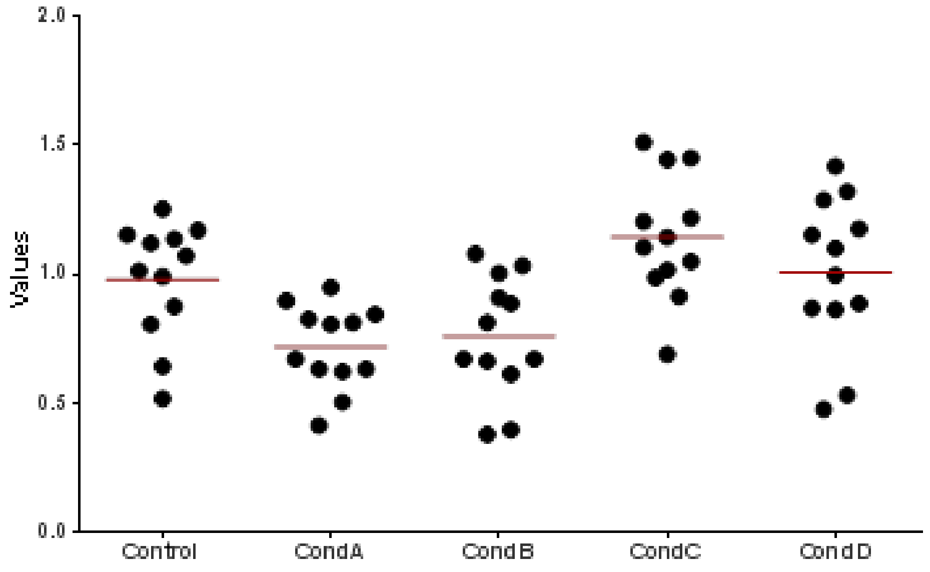




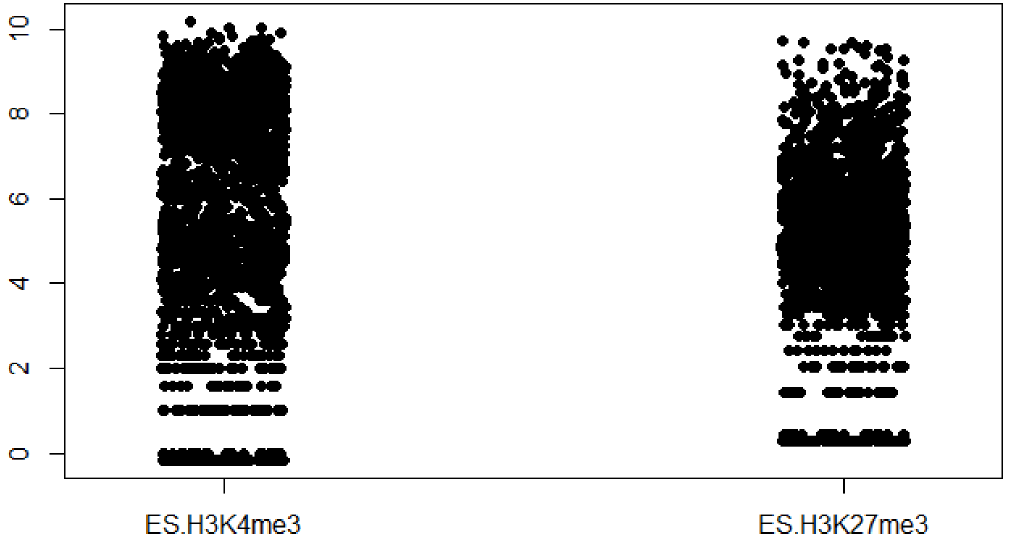
Data Exploration

Quantitative data:

Scatterplot/stripchart



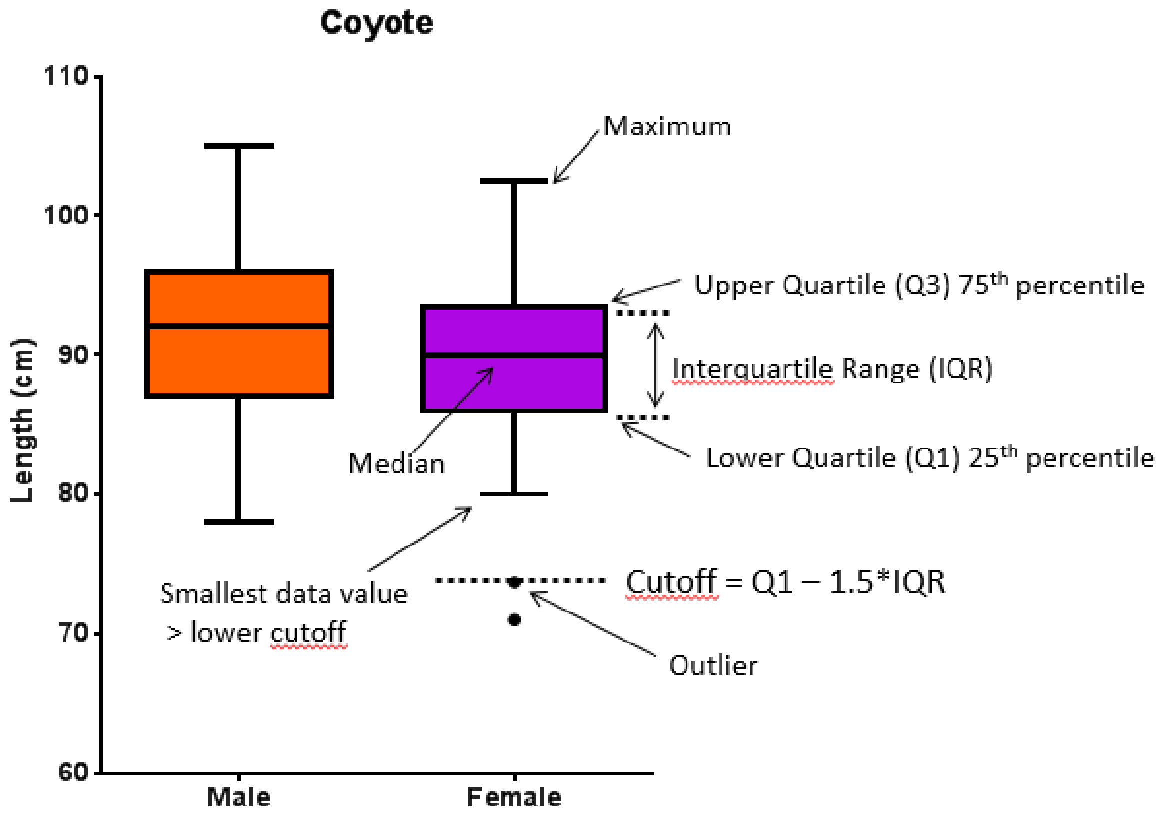
Small sample

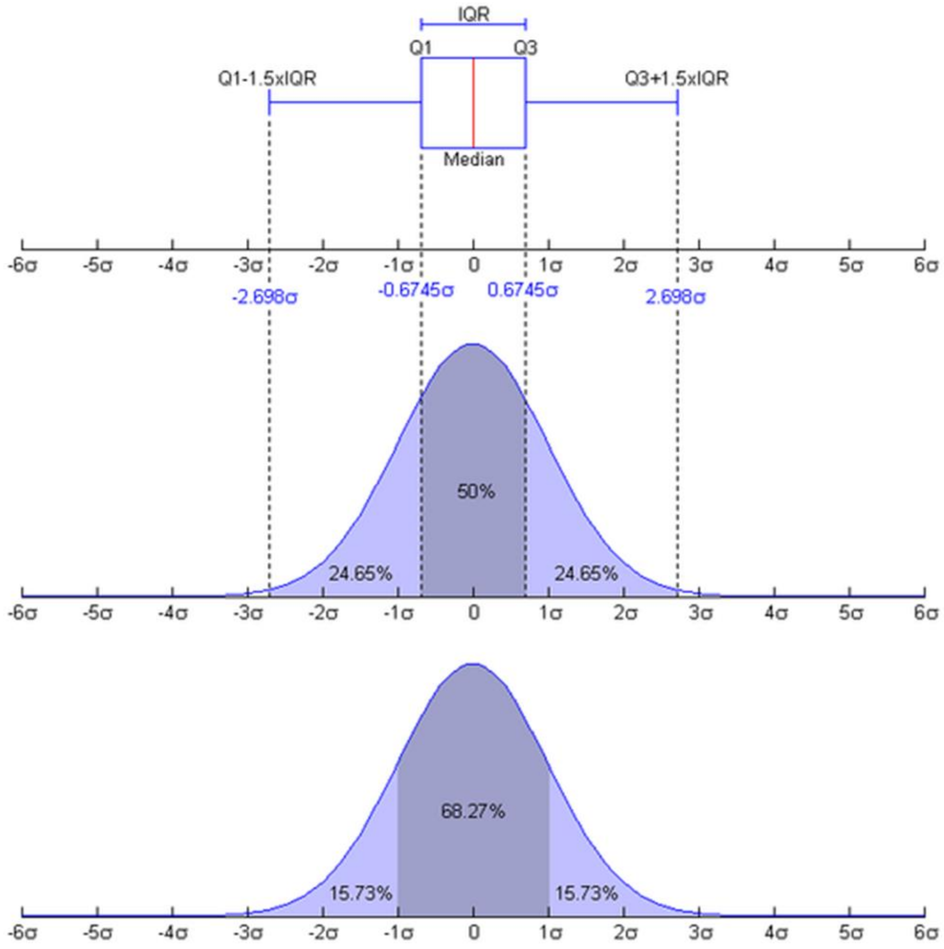


Big sample

Data Exploration

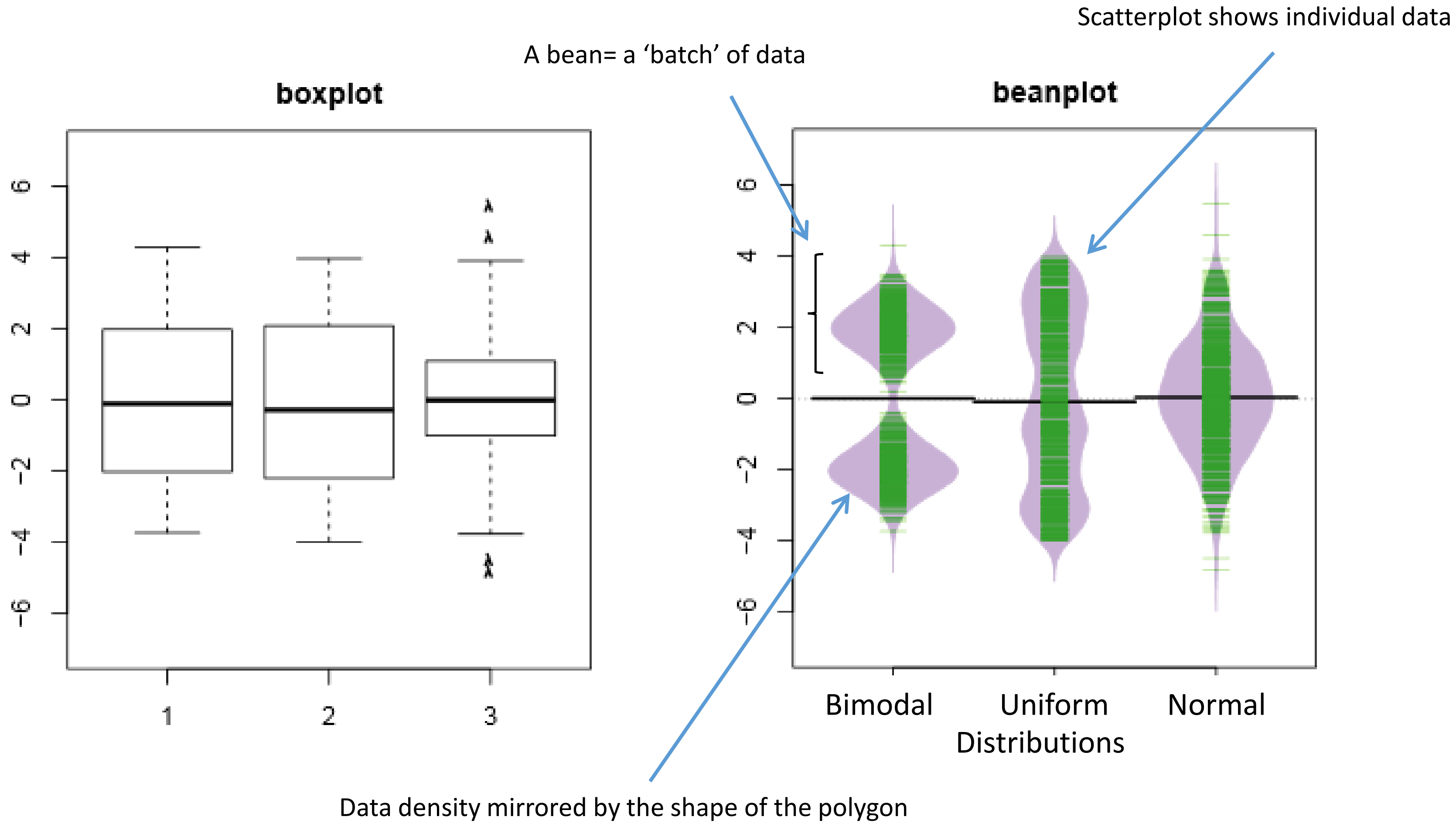
Quantitative data: Boxplot





Quantitative data:

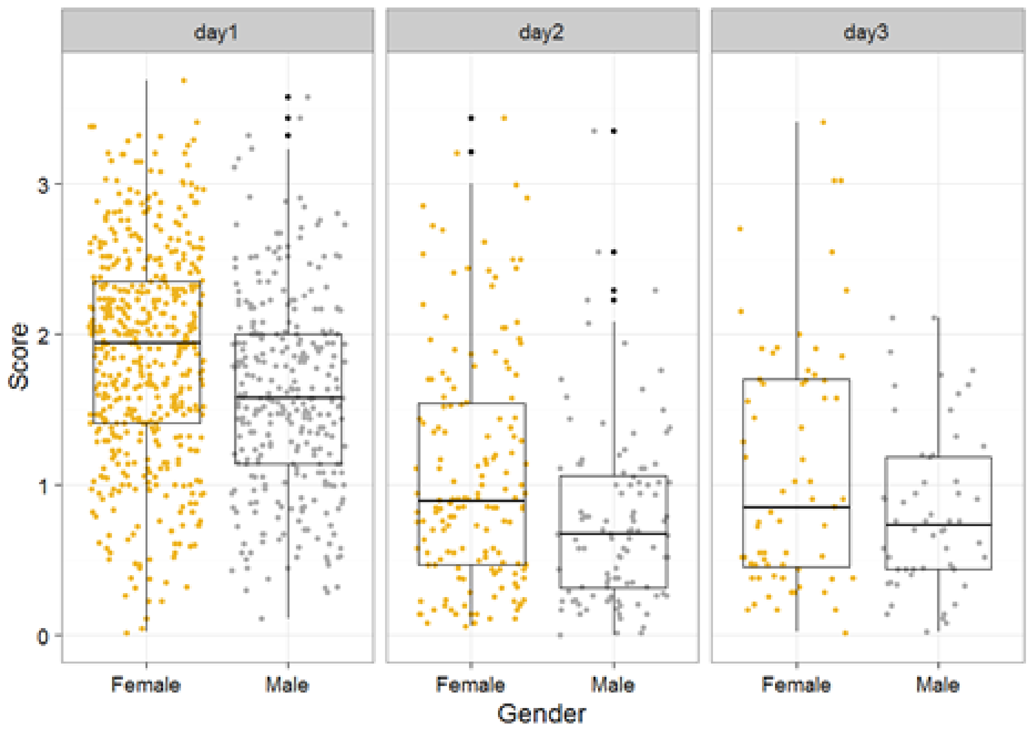
Boxplot <u>or</u> Beanplot

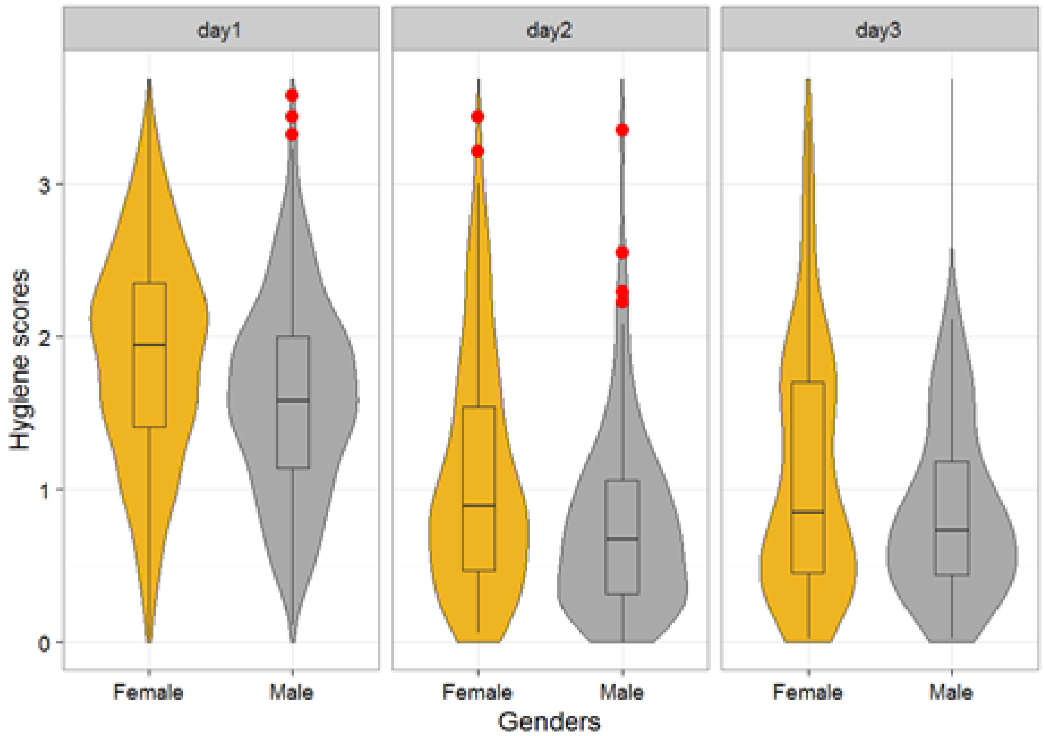


Data Exploration

Quantitative data:

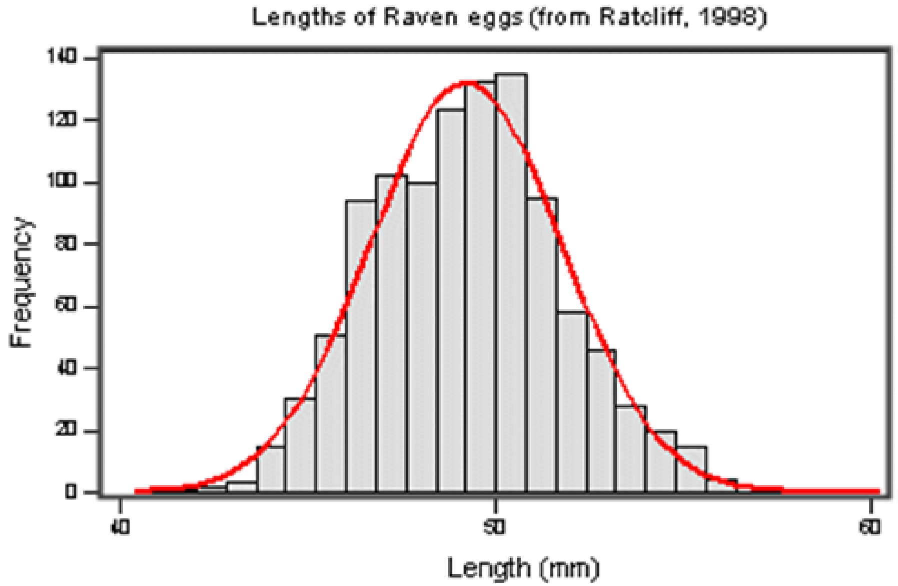
Boxplot and Beanplot and Scatterplot



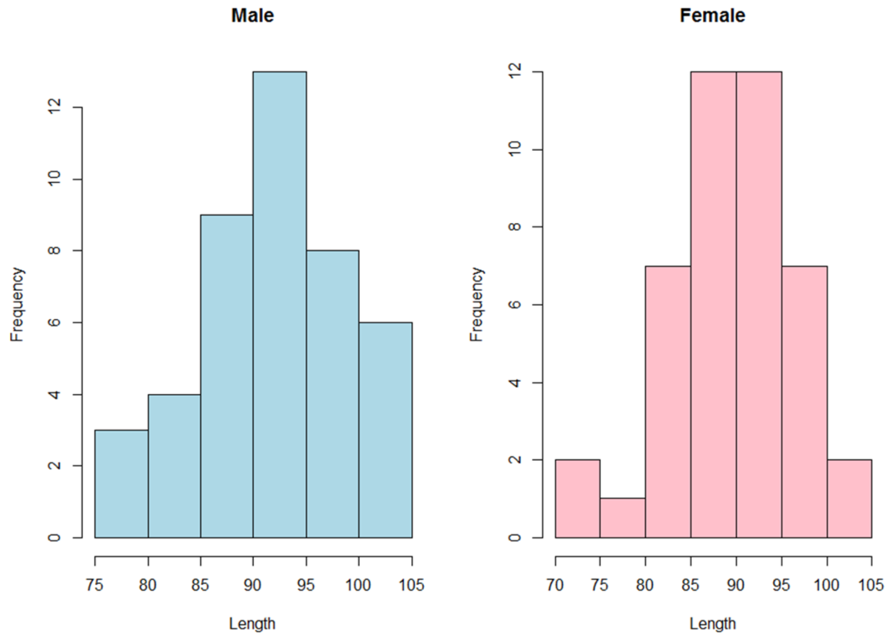


Data Exploration

Quantitative data: Histogram



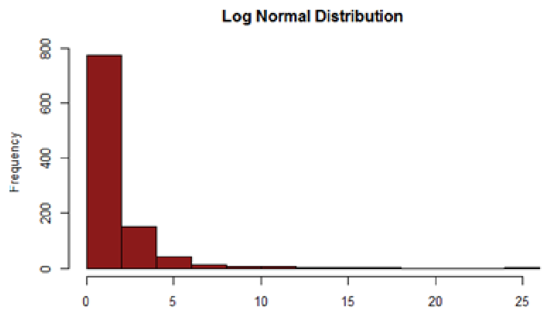
Big sample

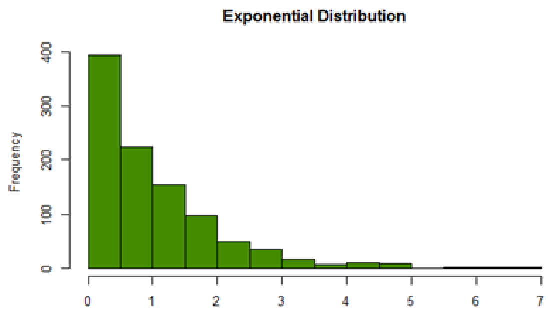


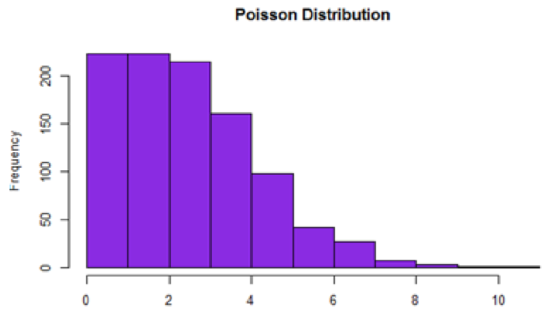
Small sample

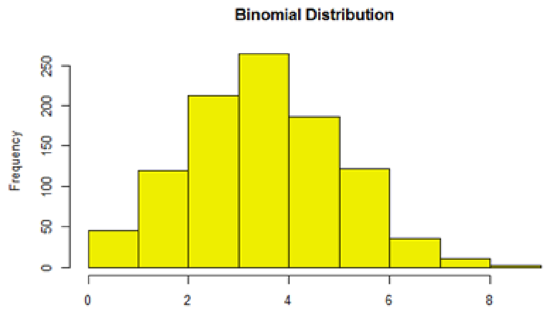
Data Exploration

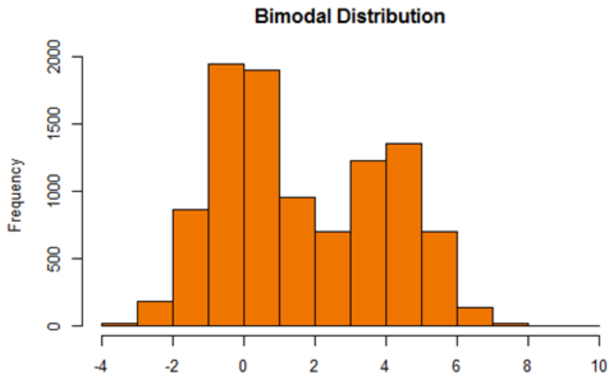
Quantitative data: Histogram (distribution)











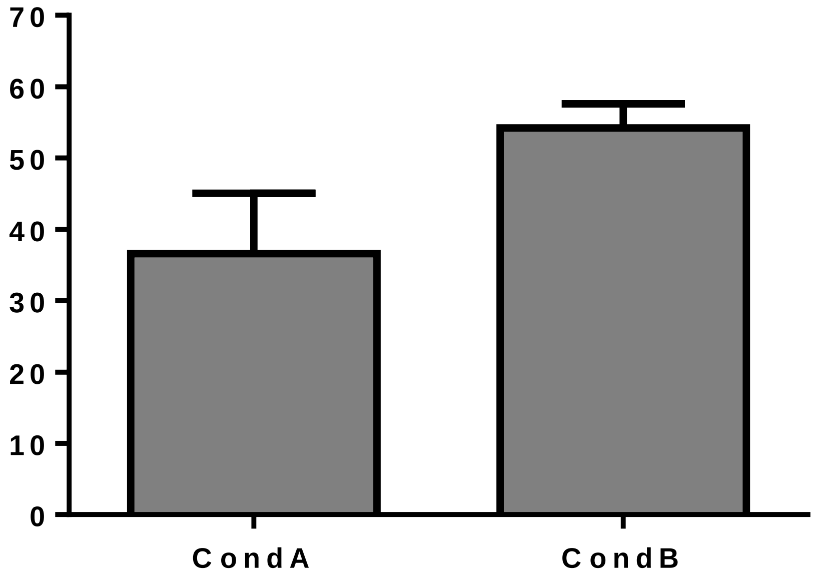
Data exploration $\neq$ plotting data

Data Exploration

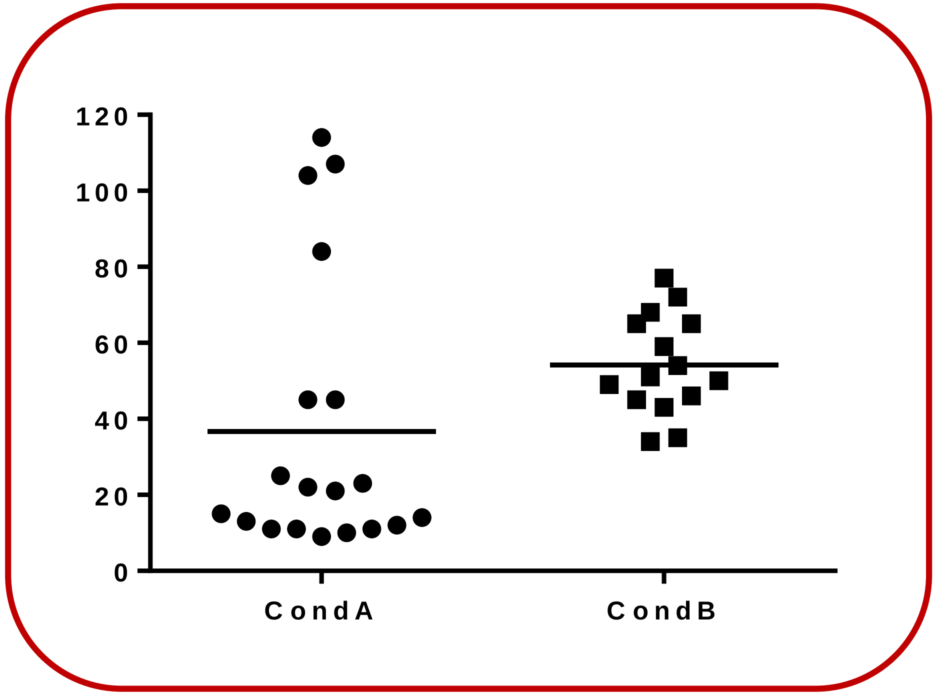
Plotting is not the same thing as exploring

- <u>One experiment</u>: change in the variable of interest between CondA to CondB.
  - ❖ Data plotted as a **bar chart**.

The fiction



The truth

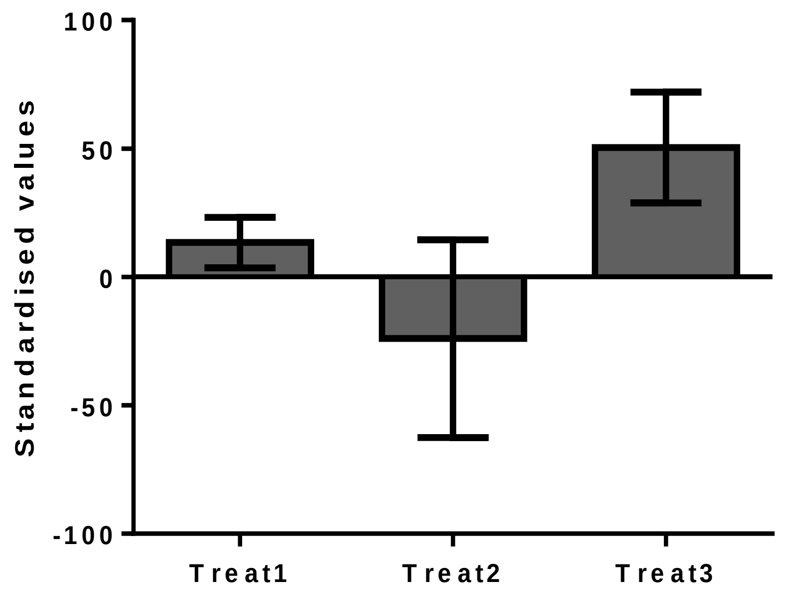


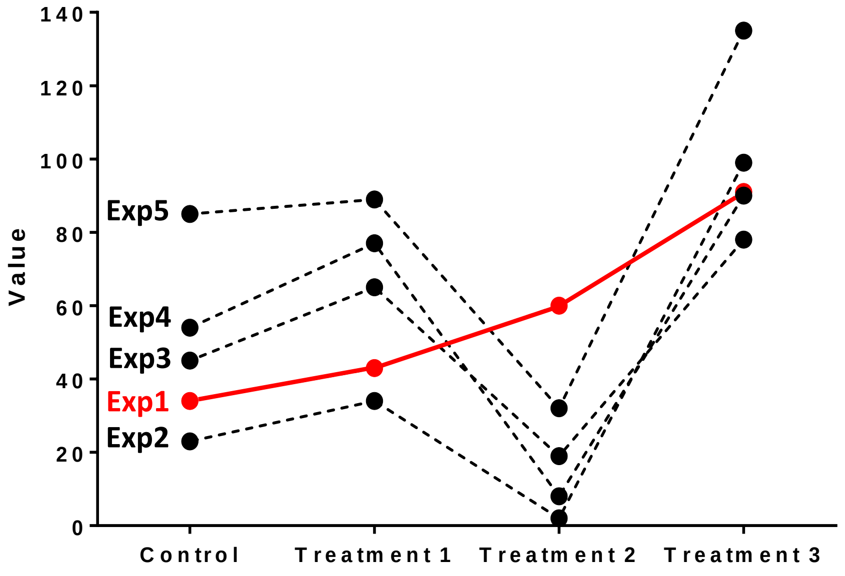
Data Exploration

Plotting (and summarising) is (so) not the same thing as exploring

- Five experiments: change in the variable of interest between 3 treatments and a control.
  - ❖ Data plotted as a **bar chart**.

The truth (if you are into bar charts)



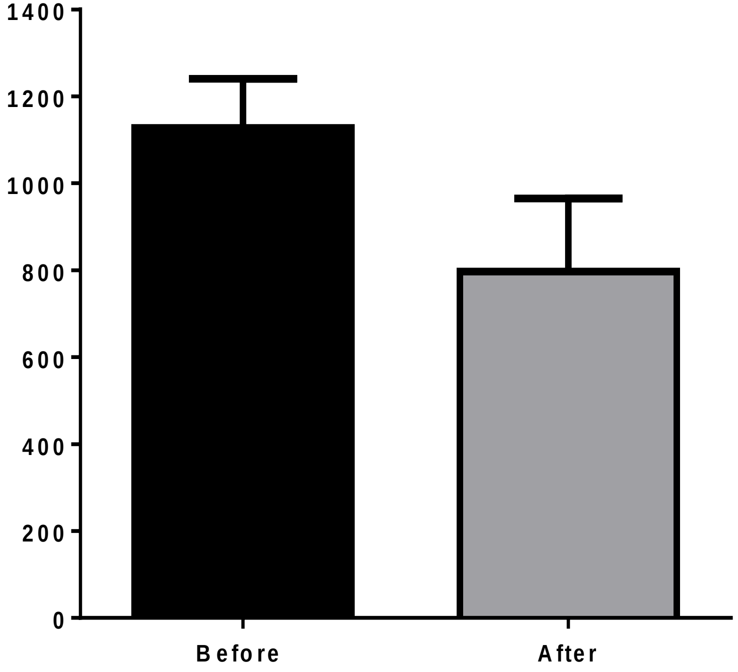


Data Exploration

Plotting (and summarising and choosing the wrong graph) is (definitely) not the same thing as exploring

- Four experiments: Before-After treatment effect on a variable of interest.
- Hypothesis: Applying a treatment will decrease the levels of the variable of interest.
  - ❖ Data plotted as a **bar chart**.

The fiction



The truth