

Data Visualization

Grinnell College

September 2, 2026

Goals

- Data summaries
- Types of variables
- Types of plots
 - ▶ Univariate
 - ▶ Bivariate
 - ▶ Multivariate

Summarizing Data

Data collection has made remarkable progress in the last decades, giving us a greater quantity of data than most could ever dream of

In it's raw form, it becomes nearly incomprehensible

Typically, we present either *numerical or visual summaries* of our data to facilitate interpretation

We'll be using a few datasets to help illustrate our points today

1. Tips data
2. 2019 College Survey
3. `mtcars` 1979 Motor Trend magazine

1. Univariate plots

- ▶ Useful for showing distribution of data
- ▶ Often provides insight into other relevant characteristics, according to data type

2. Bivariate plots

- ▶ Most useful for demonstrating relationship between two variables
- ▶ Often framed as independent/dependent variables

3. Multivariate plots

- ▶ Visualize relationship between three or more variables
- ▶ Help identify trends that exist across category values

Univariate Visual Summaries

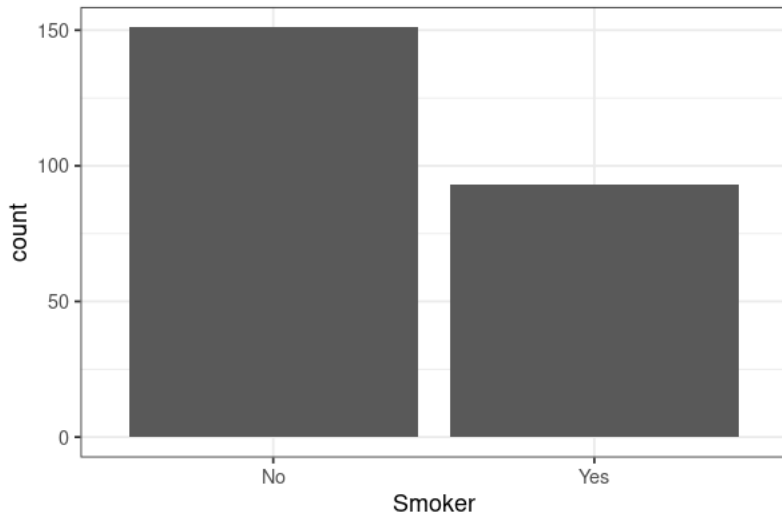
Much in the same way that all people have a height and weight, or how all combustion engines have a displacement and a number of cylinders, we can expect data and variables to have certain attributes, depending on their type

One attribute that is relevant for *all* types of data is its **distribution**.

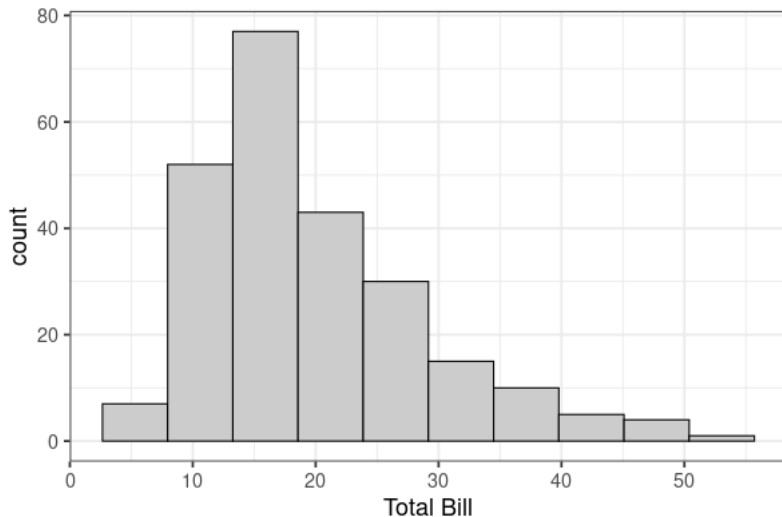
A distribution tells us two things:

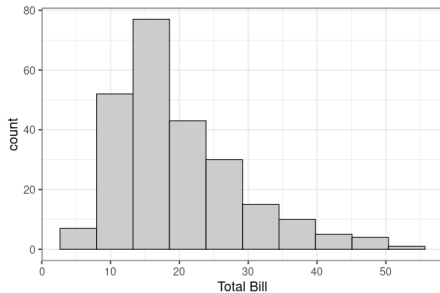
1. What values does our data take?
2. How frequently do those values appear?

Bar plots (Univariate – Categorical)



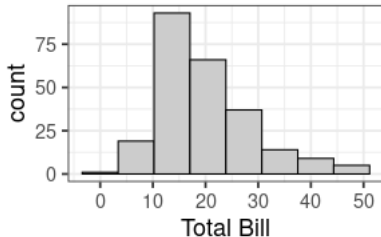
Histogram (Univariate – Quantitative)



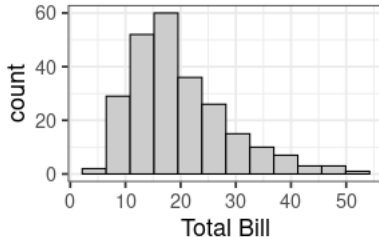


- Number of bins
- Distribution properties
 - ▶ Center
 - ▶ Spread/dispersion
 - ▶ Shape

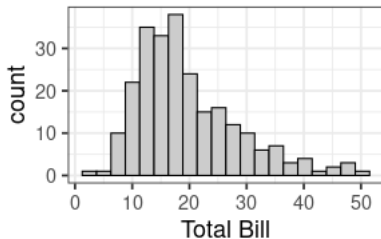
Bins = 8



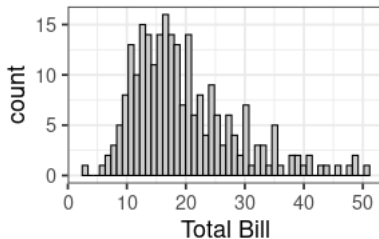
Bins = 12



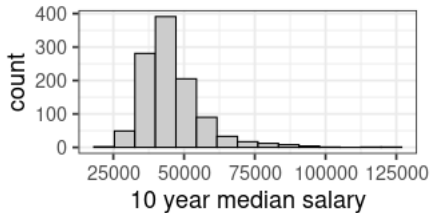
Bins = 20



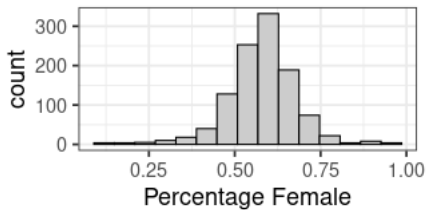
Bins = 50



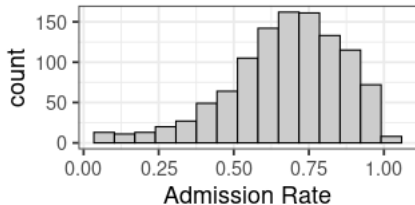
Skewed Right



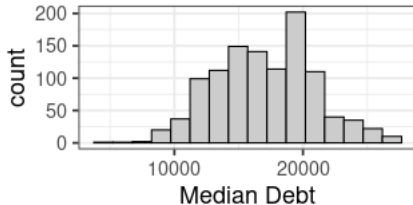
Symmetric



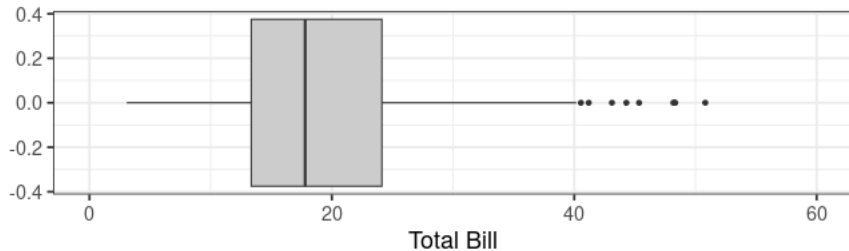
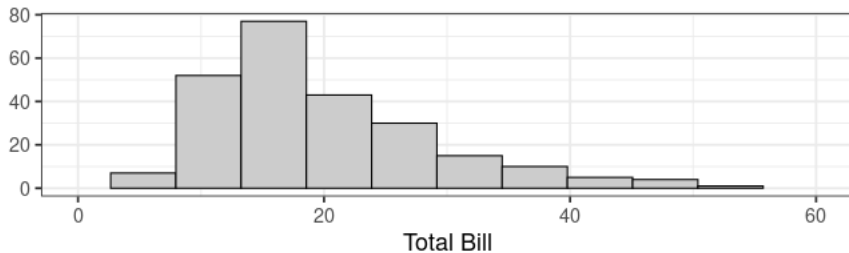
Skewed Left



Bimodal



Box plots (Univariate)



Bivariate Plots – Association

Bivariate plots are used to illustrate the *relationship* between two variables. Typically, we are interested in knowing if two variables are **associated**

We say that two variables are **associated** if knowing the value of one variable gives us information about the other

1. Are the "centers" similar between groups?
2. Does a change in one tend to suggest a systematic change in another?
3. Are the proportions of outcomes similar between categories?

Variables that are not associated are said to be **independent**

Bivariate Plots – Explanatory and Response

Often when discussing the relationship between two variables, we will designate one variable as an **explanatory/independent variable** and the other as a **response/dependent variable**

This language can be a bit misleading as it is *not* intended to suggest a causal relationship between the two, i.e., if X is our explanatory variable and y is our response, we do not mean to suggest X *causes* y

Rather, we think:

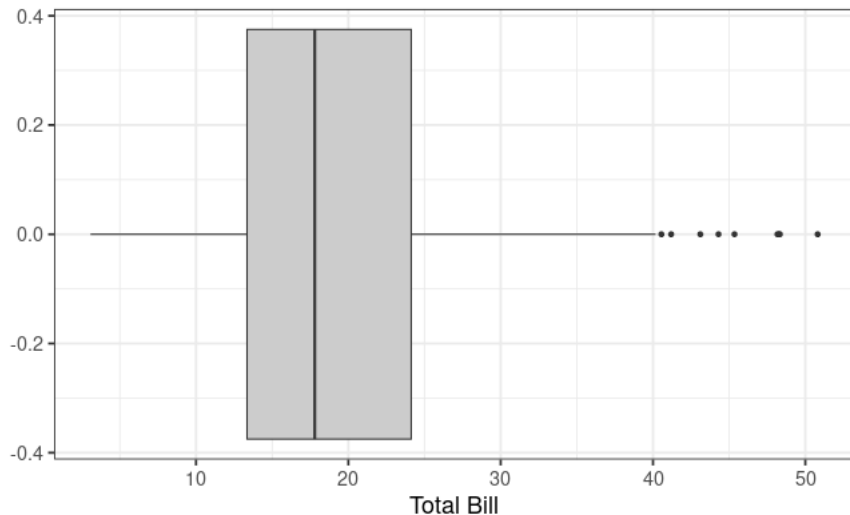
“Given this value of X , we can predict this value for y ”

Bivariate Summaries

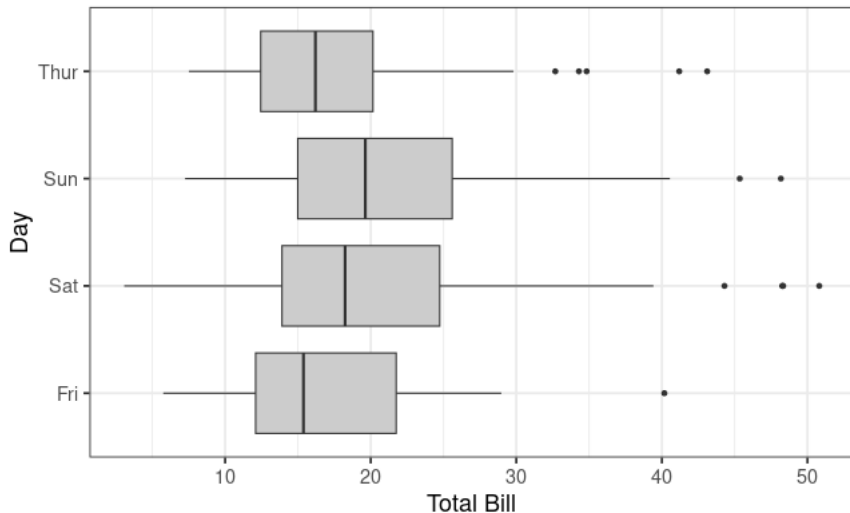
By the very nature of it, we have the following arrangements of variables and their associated plots:

1. Categorical and quantitative
 - ▶ Boxplots
2. Quantitative and quantitative
 - ▶ Scatterplots
3. Categorical and categorical
 - ▶ Stacked bar charts
 - ▶ Clustered bar charts
 - ▶ Conditional/proportional bar charts

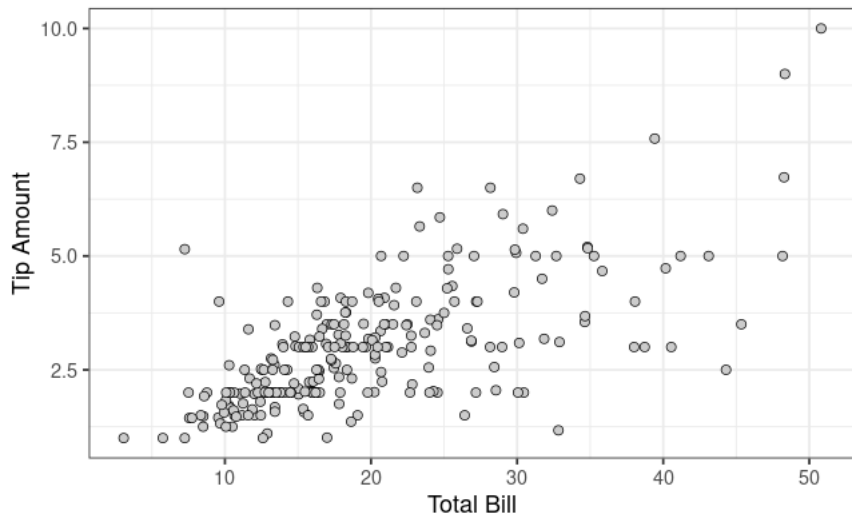
Categorical and Quantitative (Bivariate)

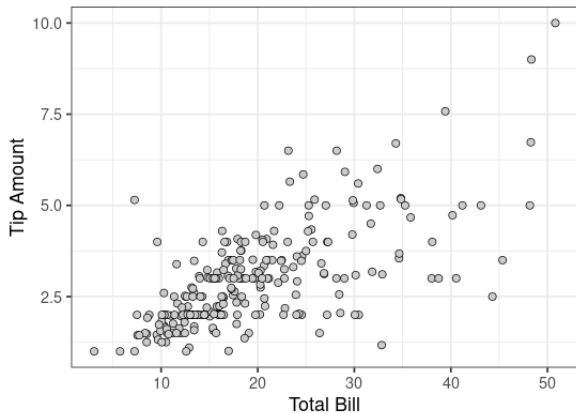


Categorical and Quantitative (Bivariate)



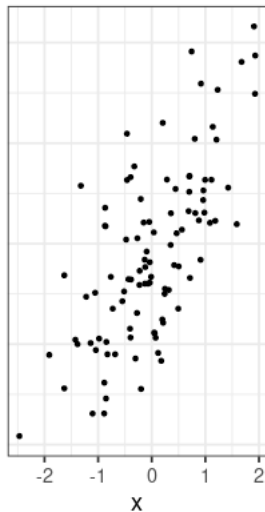
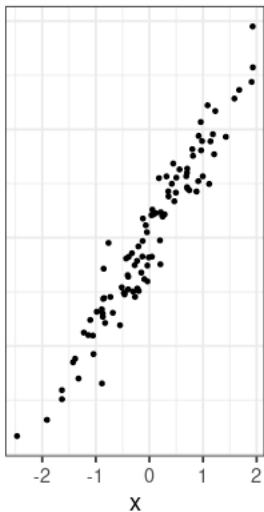
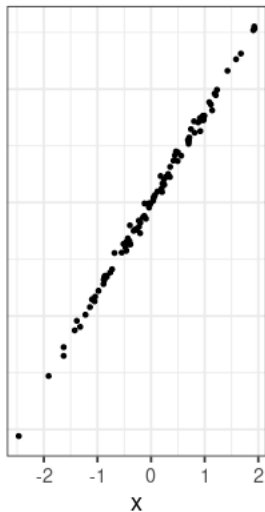
Quantitative and Quantitative (Bivariate)





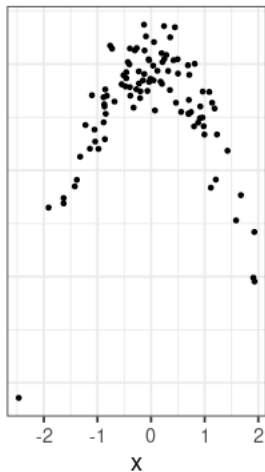
- Strength
- Form
- Direction

Strength

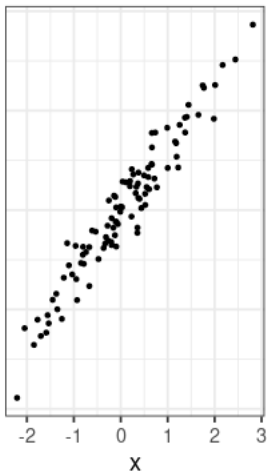


Form

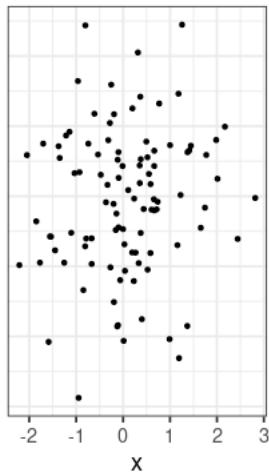
Nonlinear



Linear

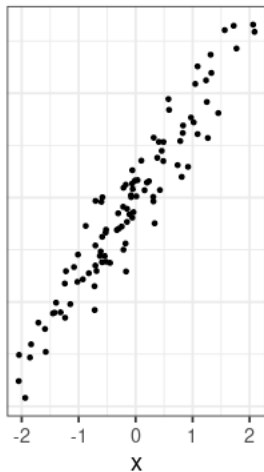


No association

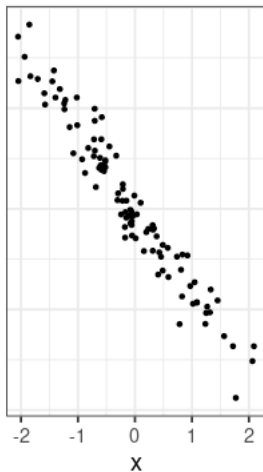


Direction

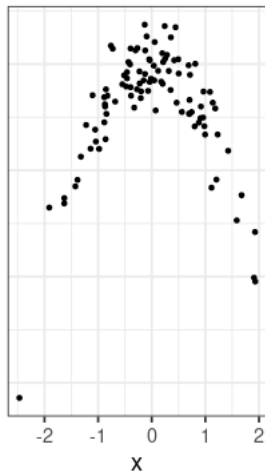
Positive



Negative



N/A (nonlinear)



Bar Plots

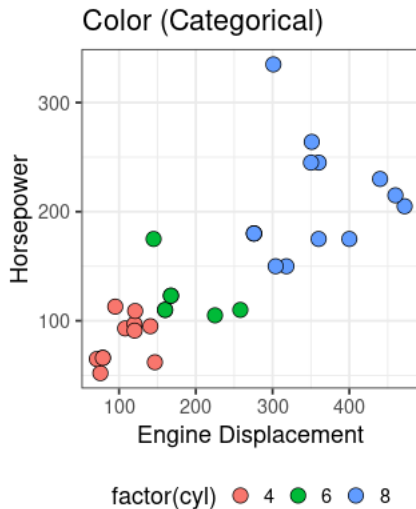
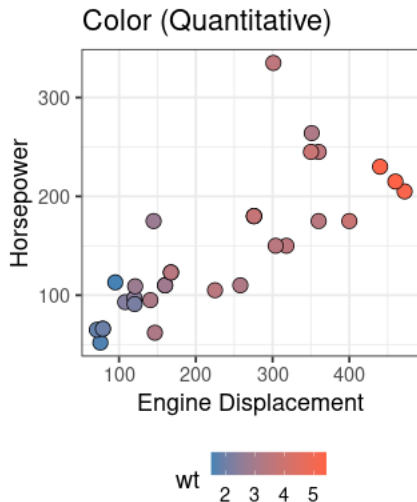
We will do this next week

Multivariate plots

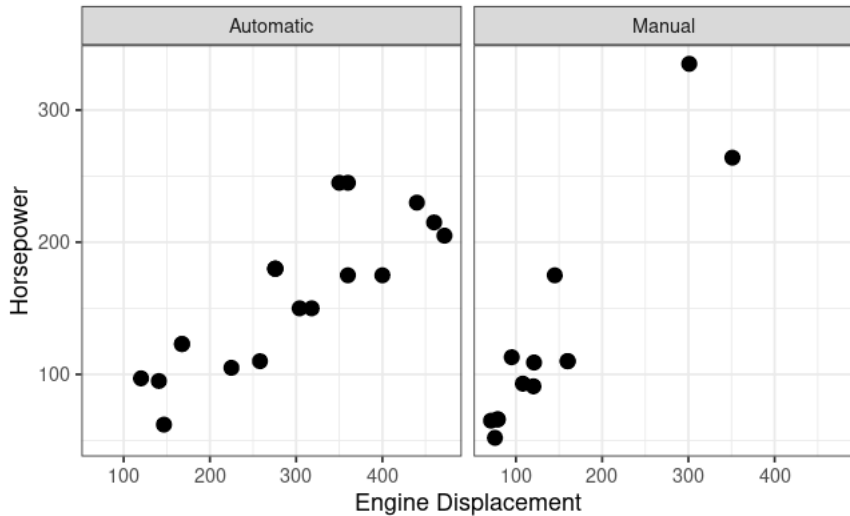
Multivariate plots are those illustrating the relationships between three or more variables

In the language of `ggplot2`, this equates to creating additional mappings from our dataset through the use of either *aesthetics* or *faceting*

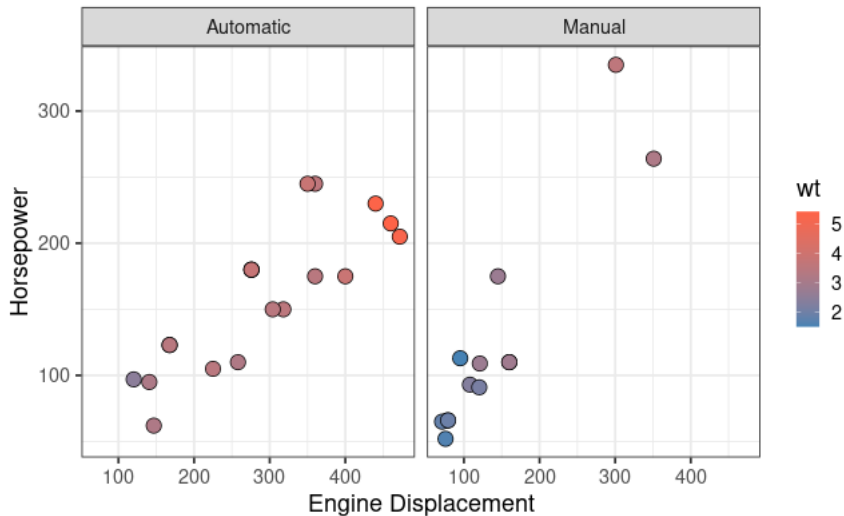
Color aesthetic



Faceting



Multivariate Plots



Summary

We need to be able to correctly identify which types of plots are associated with which types of variables

Plots are exceptionally important in helping familiarize ourselves with new datasets as they can quickly and clearly summarize large quantities of information

Questions we can ask ourselves:

- What type of variable(s) am I working with?
- What information about these variables do I want to know?
Distribution? Relationship? Other?
- What plots best convey this information to myself and others?