Exploratory Data Analysis

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Topics

Exploratory Data Analysis[1]

"In statistics, exploratory data analysis (EDA) is an approach to analyzing data sets to summarize their main characteristics, often with visual methods."

[1]Source:
https://en.Wikipedia.org/wiki/Exploratory_data_analysis

Exploratory Data Analysis[1]

> *"In statistics, exploratory data analysis (EDA) is an approach to analyzing data sets to summarize their main characteristics, often with visual methods."*

—

Goals

- Suggest hypotheses about the causes of observed phenomena
- Assess assumptions on which statistical inference will be based
- Support the selection of appropriate statistical tools and techniques
- Provide a basis for further data collection through surveys or experiments

[1]Source: `https://en.Wikipedia.org/wiki/Exploratory_data_analysis`

Exploratory Analysis

Data-centric approach

- Informal–no defined model or assumptions
- Learn about the data, underlying structure
- Gather information to inform modelling choices
- Generate questions

Confirmatory Analysis

Model-centric approach

- Formal–rigorous statistical methods
- Dependent on assumptions (random, normal, iid, linear, etc.)
- Model Specification (regressions, ANOVA)
- Parameter estimation & hypothesis testing

Motivating Example

"Anscombe's quartet comprises four data sets that have nearly identical simple descriptive statistics, yet appear very different when graphed. Each data set consists of eleven (x,y) points. They were constructed in 1973 by the statistician Francis Anscombe to demonstrate both the importance of graphing data before analyzing it and the effect of outliers on statistical properties."[2]

[2] Source: `http://en.wikipedia.org/wiki/Anscombe's_quartet`

Anscombe's Quartet

Access built-in data sets[3]

```
> data("anscombe")
> head(anscombe)
```

	x1	x2	x3	x4	y1	y2	y3	y4
1	10	10	10	8	8.04	9.14	7.46	6.58
2	8	8	8	8	6.95	8.14	6.77	5.76
3	13	13	13	8	7.58	8.74	12.74	7.71
4	9	9	9	8	8.81	8.77	7.11	8.84
5	11	11	11	8	8.33	9.26	7.81	8.47
6	14	14	14	8	9.96	8.10	8.84	7.04

[3] ?datasets for more

Anscombe's Quartet

```
       x1              y1
 Min.    : 4.0    Min.    : 4.260
 1st Qu.: 6.5    1st Qu.: 6.315
 Median : 9.0    Median : 7.580
 Mean    : 9.0    Mean    : 7.501
 3rd Qu.:11.5    3rd Qu.: 8.570
 Max.    :14.0    Max.    :10.840

             x1        y1
var: 11.000000 4.127269
sd:   3.316625 2.031568

 correlation
   0.8164205
```

Anscombe's Quartet

```
      x2              y2
 Min.   : 4.0   Min.   :3.100
 1st Qu.: 6.5   1st Qu.:6.695
 Median : 9.0   Median :8.140
 Mean   : 9.0   Mean   :7.501
 3rd Qu.:11.5   3rd Qu.:8.950
 Max.   :14.0   Max.   :9.260

            x2       y2
var: 11.000000 4.127629
sd:   3.316625 2.031657

 correlation
   0.8162365
```

Anscombe's Quartet

```
      x3             y3
 Min.   : 4.0   Min.   : 5.39
 1st Qu.: 6.5   1st Qu.: 6.25
 Median : 9.0   Median : 7.11
 Mean   : 9.0   Mean   : 7.50
 3rd Qu.:11.5   3rd Qu.: 7.98
 Max.   :14.0   Max.   :12.74

            x3       y3
var: 11.000000 4.122620
sd:   3.316625 2.030424

 correlation
   0.8162867
```

Anscombe's Quartet

```
      x4               y4
 Min.   : 8    Min.   : 5.250
 1st Qu.: 8    1st Qu.: 6.170
 Median : 8    Median : 7.040
 Mean   : 9    Mean   : 7.501
 3rd Qu.: 8    3rd Qu.: 8.190
 Max.   :19    Max.   :12.500
```

```
            x4       y4
var: 11.000000 4.123249
sd:   3.316625 2.030579
```

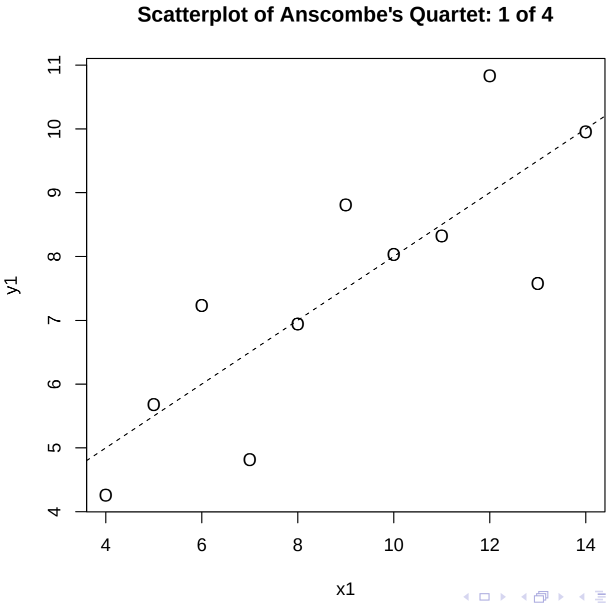
```
 correlation
   0.8165214
```

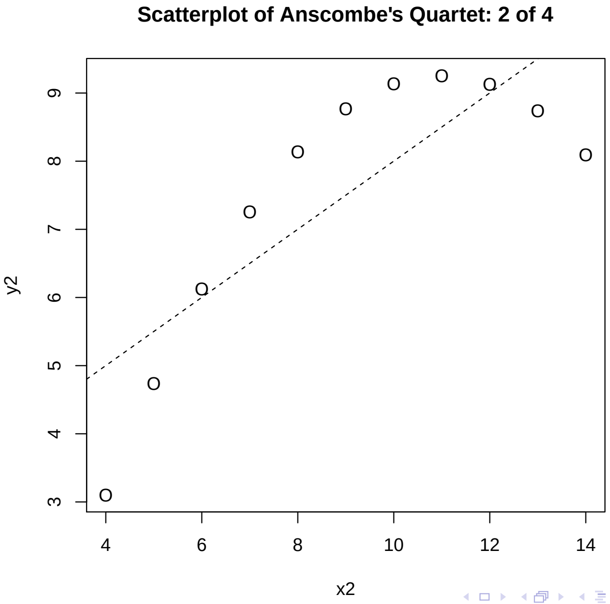
Anscombe's Quartet[4]

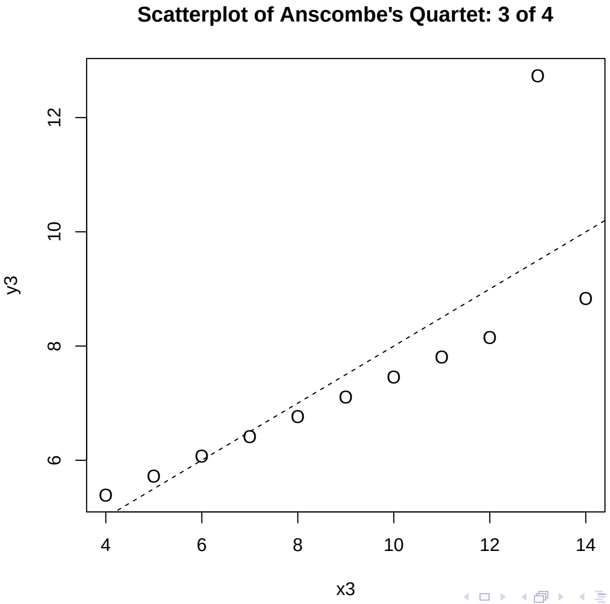
Table: Statistical Similarities (for all four data sets)

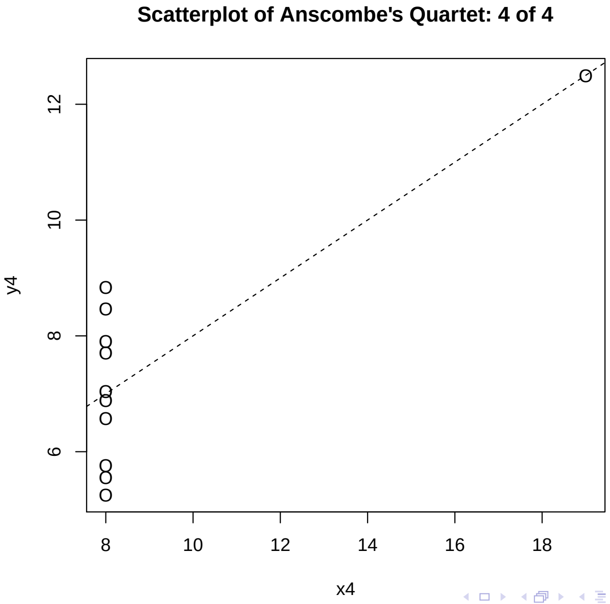
Property	Value	Accuracy
mean(x)	9	exact
var(x)	11	exact
mean(y)	7.50	to 2 decimal places
var(y)	4.125	plus/minus 0.003
cor(x, y)	0.816	to 3 decimal places
regression	$y = 3.00 + 0.500x$	2 and 3 decimals

[4] Source: https://en.wikipedia.org/wiki/Anscombe's_quartet


Scatterplot of Anscombe's Quartet: 1 of 4
y1
x1
4
5
6
7
8
9
10
11
4
6
8
10
12
14


Scatterplot of Anscombe's Quartet: 2 of 4
y2
3
4
5
6
7
8
9
x2
4
6
8
10
12
14

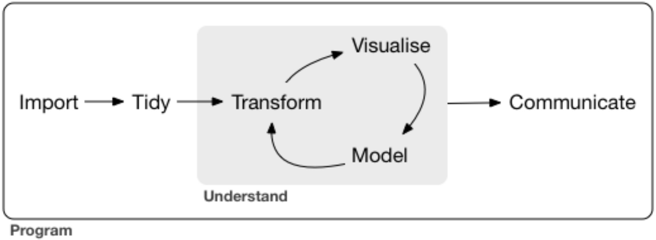

Scatterplot of Anscombe's Quartet: 3 of 4
y3
x3
4
6
8
10
12
14
6
8
10
12


Scatterplot of Anscombe's Quartet: 4 of 4
y4
6
8
10
12
x4
8
10
12
14
16
18

Takeaways

- Statistical similarity $\neq$ Data similarity
- Look at your data, visualize
- CYA: check your assumptions

The Data Analysis Process[5]



- Have a question in mind
- Write code to carry out each step
- Save the code so you can reproduce (and share) your work

[5]Source: R for Data Science `http://r4ds.had.co.nz/`

Toolbox

- Statistical Summaries
  - Extremes: range, minimum, maximum
  - Location: median, mean
  - Spread: quartiles, variance, standard deviation
  - Shape: skew, modality
  - Interactions: tables, correlations
- Visualizations
  - Box plot
  - Scatter plot
  - Line plot
  - Bar plot
  - Histogram
- Transformations
  - Subset / Select
  - Create Variables
  - Aggregate
  - Merge

Statistical Functions

- `min()`, `max()`
- `mean()`, `median()`
- `sd()`, `var()`
- `quantile()`, `IQR()`
- `cov()`, `cor()`
- `summary()`
- `table()`
- etc., see `?stats` for more

Review using functions: unnamed arguments

```
> sum(1, 2, 3)        # correct
[1] 6
```

Review using functions: unnamed arguments

```
> sum(1, 2, 3)        # correct
[1] 6
> mean(1, 2, 3)       # incorrect
[1] 1
```

Review using functions: unnamed arguments

```
> sum(1, 2, 3)          # correct
[1] 6
> mean(1, 2, 3)         # incorrect
[1] 1
> mean(c(1, 2, 3))      # correct, but why?
[1] 2
```

Review using functions: unnamed arguments

```
> sum(1, 2, 3)          # correct
[1] 6
> mean(1, 2, 3)         # incorrect
[1] 1
> mean(c(1, 2, 3))      # correct, but why?
[1] 2
```

The first unnamed argument of `mean()` is assumed to be an input vector, the rest are considered options. All of the unnamed arguments to `sum()` are assumed to be input vectors.

```
> ?sum
> ?mean
```

Review using functions: named arguments

```
>  # missing values are "contagious"
> 1 + 2 + 3 + NA

[1] NA

> sum(1, 2, 3, NA)

[1] NA

> mean(c(1, 2, 3, NA))

[1] NA
```

Review using functions: named arguments

```
>  # missing values are "contagious"
> 1 + 2 + 3 + NA
[1] NA
> sum(1, 2, 3, NA)
[1] NA
> mean(c(1, 2, 3, NA))
[1] NA
> # cure: exclude missing values
> sum(1, 2, 3, NA, na.rm = TRUE)
[1] 6
> mean(c(1, 2, 3, NA), na.rm = TRUE)
[1] 2
```

Data: Motor Trend Car Road Tests

```
> data(mtcars) # load built-in data
> str(mtcars)  # view structure

'data.frame':        32 obs. of  11 variables:
 $ mpg : num  21 21 22.8 21.4 18.7 18.1 14.3 24.4 22.8 19.2
 $ cyl : num  6 6 4 6 8 6 8 4 4 6 ...
 $ disp: num  160 160 108 258 360 ...
 $ hp  : num  110 110 93 110 175 105 245 62 95 123 ...
 $ drat: num  3.9 3.9 3.85 3.08 3.15 2.76 3.21 3.69 3.92 3.
 $ wt  : num  2.62 2.88 2.32 3.21 3.44 ...
 $ qsec: num  16.5 17 18.6 19.4 17 ...
 $ vs  : num  0 0 1 1 0 1 0 1 1 1 ...
 $ am  : num  1 1 1 0 0 0 0 0 0 0 ...
 $ gear: num  4 4 4 3 3 3 3 4 4 4 ...
 $ carb: num  4 4 1 1 2 1 4 2 2 4 ...
```

Example Data: Motor Trend Car Road Tests

```
> ?mtcars       # view documentation

A data frame with 32 observations on 11 variables.
[, 1]  mpg  Miles/(US) gallon
[, 2]  cyl  Number of cylinders
[, 3]  disp  Displacement (cu.in.)
[, 4]  hp     Gross horsepower
[, 5]  drat  Rear axle ratio
[, 6]  wt     Weight (1000 lbs)
[, 7]  qsec  1/4 mile time
[, 8]  vs     V/S
[, 9]  am     Transmission (0 = automatic, 1 = manual)
[,10]  gear  Number of forward gears
[,11]  carb  Number of carburetors
```

Try it

```
> data(mtcars) # load bult-in data
> str(mtcars)  # view structure
> head(mtcars)
> ?mtcars
```

Running individual summary functions

```
> min(mtcars$mpg)
[1] 10.4
> mean(mtcars$mpg)
[1] 20.09062
> median(mtcars$mpg)
[1] 19.2
> max(mtcars$mpg)
[1] 33.9
> quantile(mtcars$mpg)
    0%    25%    50%    75%   100%
10.400 15.425 19.200 22.800 33.900
> quantile(mtcars$mpg, probs = c(0.25, 0.75)) # use option
   25%    75%
15.425 22.800
```

Shortcut: the summary() function

```
> # Input a vector
> summary(mtcars$mpg)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  10.40   15.42   19.20   20.09   22.80   33.90
```

Shortcut: the summary() function

```
> # Input a data frame
> summary(mtcars[, 1:3])
      mpg             cyl             disp      
 Min.   :10.40   Min.   :4.000   Min.   : 71.1  
 1st Qu.:15.43   1st Qu.:4.000   1st Qu.:120.8  
 Median :19.20   Median :6.000   Median :196.3  
 Mean   :20.09   Mean   :6.188   Mean   :230.7  
 3rd Qu.:22.80   3rd Qu.:8.000   3rd Qu.:326.0  
 Max.   :33.90   Max.   :8.000   Max.   :472.0  
```

Try it

```
> summary(mtcars)
```

Tabulate counts with table()

```
> table(mtcars$cyl)                    # input 1 vector
 4  6  8
11  7 14
```

Tabulate counts with table()

```
> table(mtcars$cyl)                    # input 1 vector

 4  6  8
11  7 14

> table(mtcars$cyl, mtcars$am)         # input 2 vectors

     0  1
  4  3  8
  6  4  3
  8 12  2
```

Tabulate counts with table()

```
> table(mtcars$cyl)                    # input 1 vector

 4  6  8
11  7 14
> table(mtcars$cyl, mtcars$am)         # input 2 vectors

     0  1
  4  3  8
  6  4  3
  8 12  2
> table(Cylinders = mtcars$cyl,        # input 2 vectors
+       Manual    = mtcars$am)         # set labels

         Manual
Cylinders  0  1
        4  3  8
        6  4  3
        8 12  2
```

Tabulate counts with table()

```
> table(mtcars[, c("cyl", "am")])  # input data frame

   am
cyl  0  1
  4  3  8
  6  4  3
  8 12  2
```

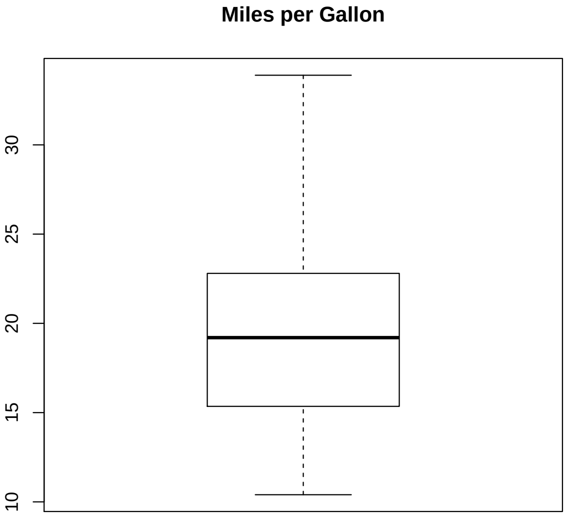
Plotting Functions

R has several distinct plotting systems

- Base R functions
  - `hist()`
  - `barplot()`
  - `boxplot()`
  - `plot()`
- lattice package
- ggplot2 package

Boxplot

```
> boxplot(mtcars$mpg,
+         main = "Miles per Gallon")
```


Miles per Gallon
30
25
20
15
10

Boxplot Interpretation

Compare:

```
> boxplot(mtcars$mpg)
```

- vs -

```
> summary(mtcars$mpg)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  10.40   15.42   19.20   20.09   22.80   33.90
```

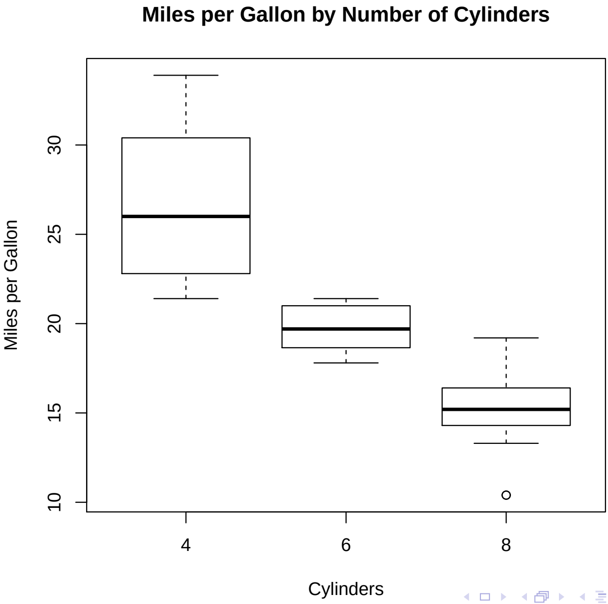
The boxplot function can also take a *formula*[6] as an argument
`mpg ~ cyl` "mpg conditional on cyl"

```
> boxplot(mpg ~ cyl,
+          data = mtcars,
+          main = "Miles per Gallon by Number of Cylinders",
+          xlab = "Cylinders",
+          ylab = "Miles per Gallon")
```

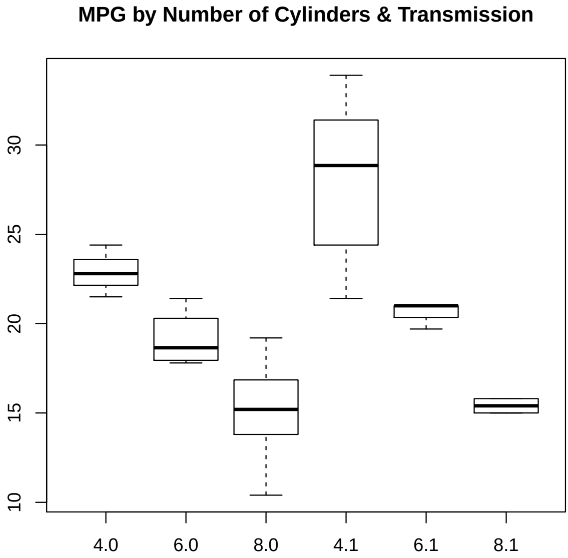
[6] an expression using vectors and the ∼ operator. See `?formula` or `?~` for more

Try it

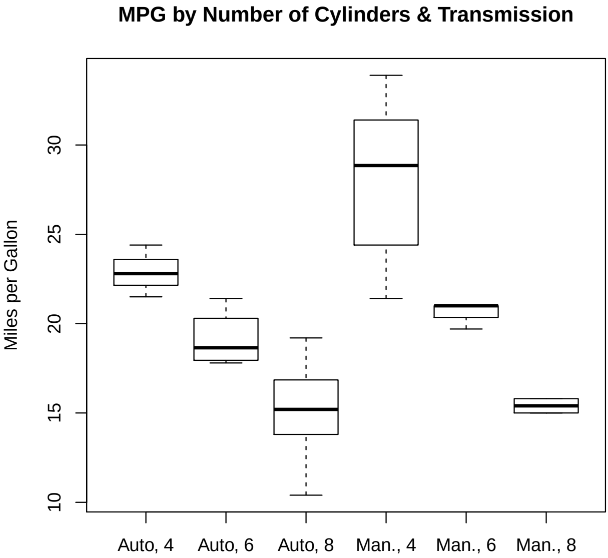
```
> boxplot(mpg ~ cyl,
+         data = mtcars,
+         main = "Miles per Gallon by Number of Cylinders",
+         xlab = "Cylinders",
+         ylab = "Miles per Gallon")
```


Miles per Gallon by Number of Cylinders
Miles per Gallon
10
15
20
25
30
4
6
8
Cylinders

```
> # Expand the formula
> boxplot(mpg ~ cyl + am,
+         data = mtcars,
+         main = "MPG by Number of Cyliinders & Transmissi
```


MPG by Number of Cylinders & Transmission
10
15
20
25
30
4.0
6.0
8.0
4.1
6.1
8.1

```
> # Relabel the x axis
>
> xaxis <- c("Auto, 4", "Auto, 6", "Auto, 8",
+               "Man., 4", "Man., 6", "Man., 8")
> boxplot(mpg ~ cyl + am,
+           data = mtcars,
+           main = "MPG by Number of Cylinders & Transmissio
+           xlab = " ",
+           ylab = "Miles per Gallon",
+           names = xaxis)
```


MPG by Number of Cylinders & Transmission
Miles per Gallon
10
15
20
25
30
Auto, 4
Auto, 6
Auto, 8
Man., 4
Man., 6
Man., 8

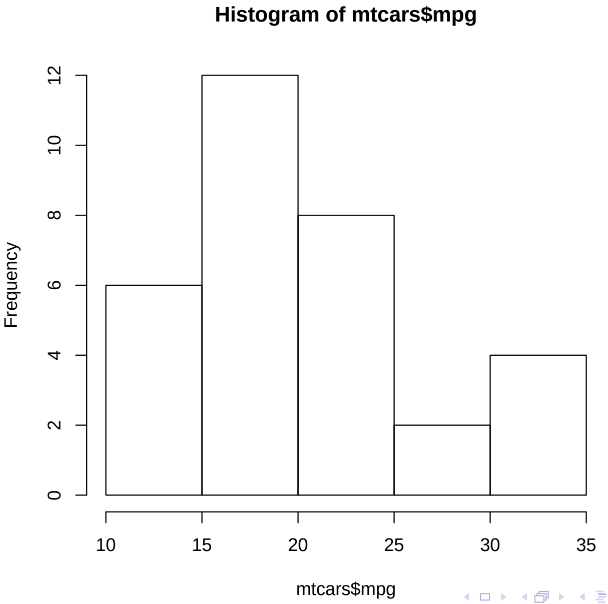
Try it

```
> boxplot(mpg ~ cyl,
+          data = mtcars,
+          main = "Miles per Gallon by Number of Cylinders",
+          xlab = "Cylinders",
+          ylab = "Miles per Gallon")
```

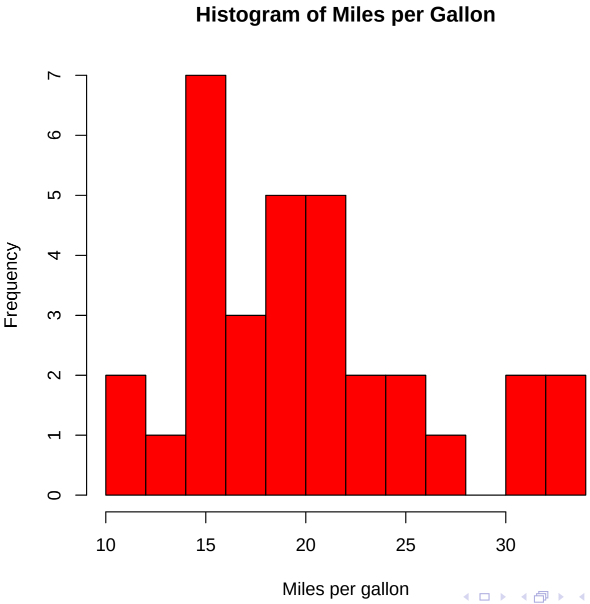
Histogram

Takes a vector, and plots the distribution of values

```
> hist(mtcars$mpg)
```


Histogram of mtcars$mpg
Frequency
0
2
4
6
8
10
12
10
15
20
25
30
35
mtcars$mpg

```
> # Add options
> hist(mtcars$mpg,
+       breaks = 10,
+       main = "Histogram of Miles per Gallon",
+       xlab = "Miles per gallon",
+       col = "red")
```


Histogram of Miles per Gallon
Frequency
0
1
2
3
4
5
6
7
10
15
20
25
30
Miles per gallon

Try it

```
> hist(mtcars$mpg,
+       breaks = 10,
+       main = "Histogram of Miles per Gallon",
+       xlab = "Miles per gallon",
+       col = "red")
```

Bar Plot

Takes a named vector and plots it

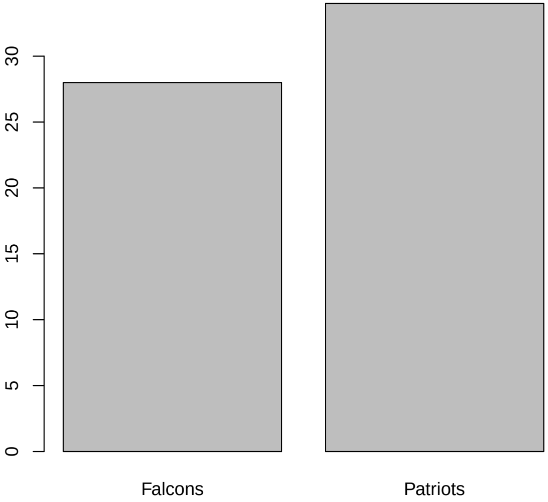
```
> scores <- c(Falcons  = 28,
+             Patriots = 34)
```

Bar Plot

Takes a named vector and plots it

```
> scores <- c(Falcons  = 28,
+             Patriots = 34)
> barplot(scores)
```

Plotting Functions



Bar Plot[7]

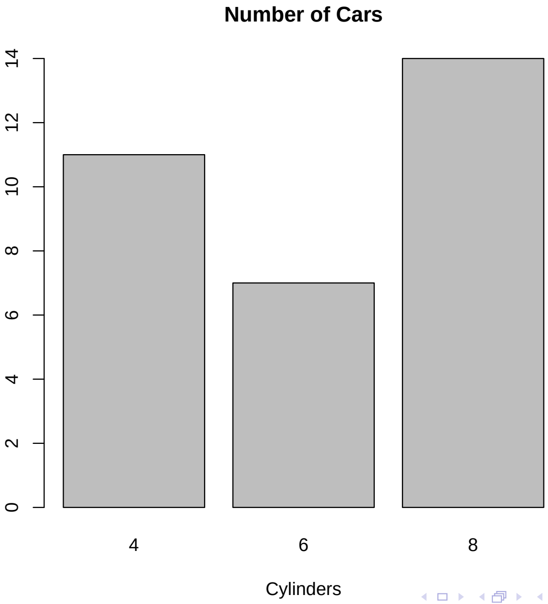
Use the table function create named vector with counts

```
> counts <- table(mtcars$cyl)
> counts

 4  6  8
11  7 14

> barplot(counts,
+         main = "Number of Cars",
+         xlab = "Cylinders")
```

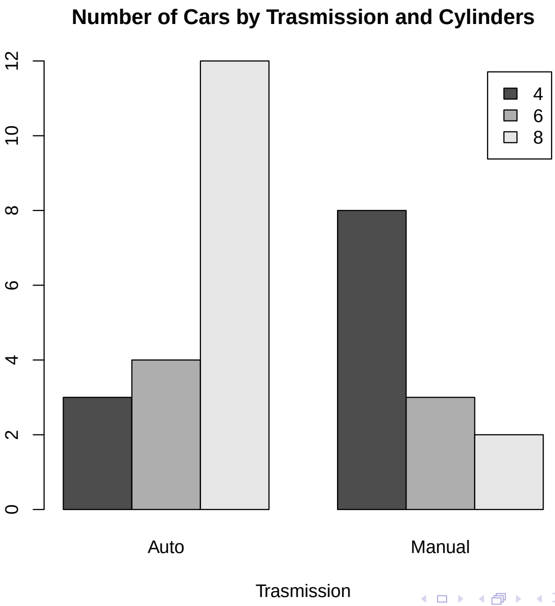
[7] Adapted from: http://www.statmethods.net/graphs/bar.html


Number of Cars
0
2
4
6
8
10
12
14
4
6
8
Cylinders

Use the table function to create a two-way frequency table, and plotting options to group bars

```
> counts <- table(mtcars$cyl, mtcars$am)
> colnames(counts) <- c("Auto", "Manual")

> barplot(counts,
+       main = "Number of Cars by Trasmission and Cylinders
+       xlab = "Trasmission",
+       beside = TRUE,
+       legend = rownames(counts))
>
```

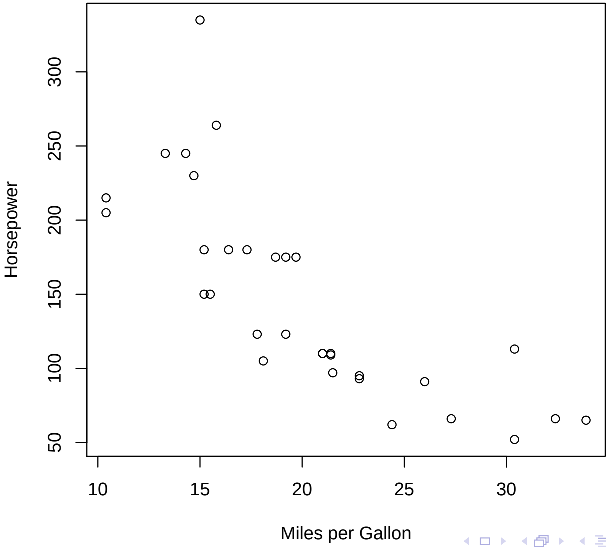

Number of Cars by Trasmission and Cylinders
0
2
4
6
8
10
12
4
6
8
Auto
Manual
Trasmission

Try it

```
> # Tabulate
> counts <- table(mtcars$cyl, mtcars$am)
> colnames(counts) <- c("Auto", "Manual")
> # Plot
> barplot(counts,
+       main = "Number of Cars by Trasmission and Cylinders
+       xlab = "Trasmission",
+       beside = TRUE,
+       legend = rownames(counts))
```

Scatterplot

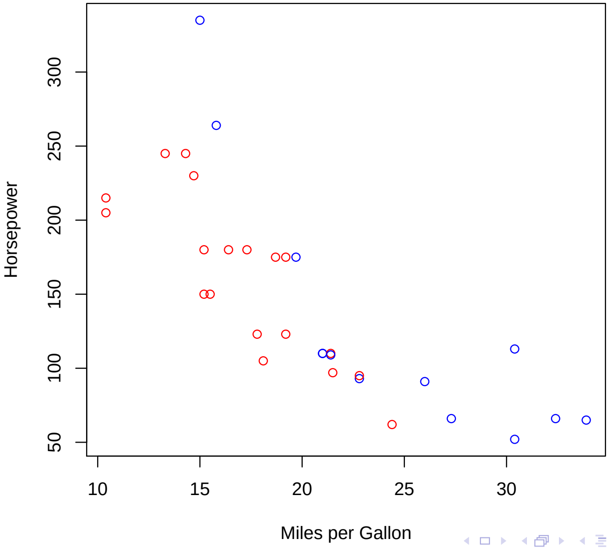
```
> plot(mtcars$mpg,
+      mtcars$hp,
+      xlab = "Miles per Gallon",
+      ylab = "Horsepower")
```


Horsepower
50
100
150
200
250
300
10
15
20
25
30
Miles per Gallon

Try it

```
> plot(mtcars$mpg,
+       mtcars$hp,
+       xlab = "Miles per Gallon",
+       ylab = "Horsepower")
```

```
> # create a vector for conditional color coding
> colorcode <- ifelse(mtcars$am == 0, "red", "blue")
> plot(mtcars$mpg,
+       mtcars$hp,
+       xlab = "Miles per Gallon",
+       ylab = "Horsepower",
+       col = colorcode)
```


Horsepower
50
100
150
200
250
300
10
15
20
25
30
Miles per Gallon

Line Plot

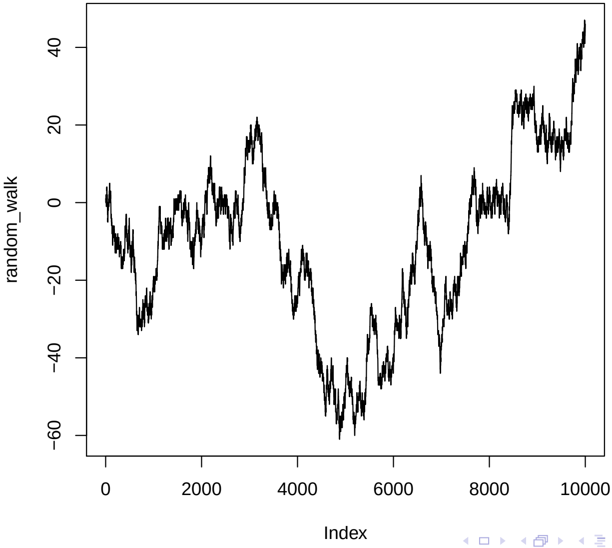
```
> set.seed(2017)
> random_step <- sample(c(-1, 0, 1), 10000, replace = TRUE
> head(random_step)

[1]  1  0  0 -1  1  1

> random_walk <- cumsum(random_step)
> head(random_walk)

[1] 1 1 1 0 1 2

> plot(random_walk,
+      type = "l")
```


random_walk
Index
40
20
0
−20
−40
−60
0
2000
4000
6000
8000
10000

Data Transformation

- subset rows
- subset columns
- make new variables
- aggregate rows
- merge data sets

Subset Rows: subset()

```
> big_block <- subset(mtcars, disp > 328)
```

Subset Rows: subset()

```
> big_block <- subset(mtcars, disp > 328)
> dim(mtcars)
[1] 32 11
> dim(big_block)
[1]  8 11
```

Subset Columns: subset()

```
> size_metrics <- subset(mtcars,
+                        select = c("disp", "cyl", "wt"))
```

Subset Columns: subset()

```
> size_metrics <- subset(mtcars,
+                        select = c("disp", "cyl", "wt"))
> dim(mtcars)
[1] 32 11
> dim(size_metrics)
[1] 32  3
```

Make New Variables: <-

- Use subset operators to isolate the column,
- Use the assignment operator to give it a new value.
- If the target variable doesn't exist yet, it will be added.

```
> mtcars$power_wt_ratio <- mtcars$hp / mtcars$wt
```

Make New Variables: <-

- Use subset operators to isolate the column,
- Use the assignment operator to give it a new value.
- If the target variable doesn't exist yet, it will be added.

```
> mtcars$power_wt_ratio <- mtcars$hp / mtcars$wt
> dim(mtcars)
[1] 32 12
> head(mtcars[, c("hp", "wt", "power_wt_ratio")])
                   hp    wt power_wt_ratio
Mazda RX4         110 2.620       41.98473
Mazda RX4 Wag     110 2.875       38.26087
Datsun 710         93 2.320       40.08621
Hornet 4 Drive    110 3.215       34.21462
Hornet Sportabout 175 3.440       50.87209
Valiant           105 3.460       30.34682
```

Make New Variables

Three styles to choose from. All of the subset operators work for this purpose.

```
> mtcars$power_wt_ratio        <- mtcars$hp / mtcars$wt
> mtcars[["power_wt_ratio"]] <- mtcars$hp / mtcars$wt
> mtcars[, "power_wt_ratio"] <- mtcars$hp / mtcars$wt
```

Try it

Compute horsepower to weight ratio

```
> mtcars$power_wt_ratio <- mtcars$hp / mtcars$wt
> head(mtcars[, c("hp", "wt", "power_wt_ratio")])
```

Make New Variables: examples

How might we go about creating variables to identify:

- fast cars (low 0-to-60 times)
- heavy cars (above averge weight)
- domestic vs import (based on make & model name)

Make New Variables: Assigning to a subset

Use the `[i, j]` format to subset rows. Only the observations specified by the `i` expression are affected. Repeat as neccessary

Make New Variables: Assigning to a subset

Use the `[i, j]` format to subset rows. Only the observations specified by the `i` expression are affected. Repeat as neccessary

```
> # quantile threshold values
> q20 <- quantile(mtcars$qsec, probs = .20)
> q80 <- quantile(mtcars$qsec, probs = .80)
```

Make New Variables: Assigning to a subset

Use the `[i, j]` format to subset rows. Only the observations specified by the `i` expression are affected. Repeat as neccessary

```
> # quantile threshold values
> q20 <- quantile(mtcars$qsec, probs = .20)
> q80 <- quantile(mtcars$qsec, probs = .80)
> # pick rows for fast cars
> # write to the new variable "quickness"
> mtcars[mtcars$qsec <= q20, "quickness"]  <- "fast"
```

Make New Variables: Assigning to a subset

Use the [i, j] format to subset rows. Only the observations specified by the i expression are affected. Repeat as neccessary

```
> # quantile threshold values
> q20 <- quantile(mtcars$qsec, probs = .20)
> q80 <- quantile(mtcars$qsec, probs = .80)
> # pick rows for fast cars
> # write to the new variable "quickness"
> mtcars[mtcars$qsec <= q20, "quickness"]  <- "fast"
> # only fast cars affected
> head(subset(mtcars, select = "quickness"))
```

```
                  quickness
Mazda RX4              fast
Mazda RX4 Wag          <NA>
Datsun 710             <NA>
Hornet 4 Drive         <NA>
Hornet Sportabout      <NA>
```

Assigning to a subset of rows

Repeat for remaining subsets

```
> # pick rows for moderate cars
> # write to the existing variable "quickness"
> i <- q20 < mtcars$qsec & mtcars$qsec <= q80
> mtcars[i, "quickness"] <- "normal"
```

Assigning to a subset of rows

Repeat for remaining subsets

```
> # pick rows for moderate cars
> # write to the existing variable "quickness"
> i <- q20 < mtcars$qsec & mtcars$qsec <= q80
> mtcars[i, "quickness"] <- "normal"

> # only moderate cars are affected
> head(subset(mtcars, select = "quickness"))
```

```
                  quickness
Mazda RX4              fast
Mazda RX4 Wag        normal
Datsun 710           normal
Hornet 4 Drive         <NA>
Hornet Sportabout    normal
Valiant                <NA>
```

Make New Variables: Assigning to a subset

Repeat for last subset

```
> mtcars[mtcars$qsec > q80, "quickness"]    <- "slow"
> head(subset(mtcars, select = "quickness"))
```

```
                  quickness
Mazda RX4              fast
Mazda RX4 Wag        normal
Datsun 710           normal
Hornet 4 Drive         slow
Hornet Sportabout    normal
Valiant                slow
```

Make New Variables: vectorized condition

Alternate approach: `ifelse()` function

```
> mean_wt <- mean(mtcars$wt)
> mtcars$weight_class <- ifelse(mtcars$wt <= mean_wt,
+                               "light",   # true cases
+                               "heavy")   # false cases
> # result assigned conditionally
> head(subset(mtcars, select = c("wt", "weight_class")))
```

```
                     wt weight_class
Mazda RX4         2.620        light
Mazda RX4 Wag     2.875        light
Datsun 710        2.320        light
Hornet 4 Drive    3.215        light
Hornet Sportabout 3.440        heavy
Valiant           3.460        heavy
```

Aggregation: aggregate()

aggregate(): Splits the data into subsets, computes summary statistics for each, and returns the result[8]

```
> aggregate(mtcars$mpg,                  # data
+           by = list(mtcars$cyl),       # grouping variables
+           mean)                        # function
```

```
  Group.1        x
1       4 26.66364
2       6 19.74286
3       8 15.10000
```

[8] R documentation: ?aggregate()

Aggregation: aggregate()

Multiple grouping variables can be used.

```
> df <- aggregate(mtcars$mpg,
+                 by = list(mtcars$cyl, mtcars$am),
+                 mean)
> names(df) <- c("cyl", "am", "avg_mpg")
> df

  cyl am  avg_mpg
1   4  0 22.90000
2   6  0 19.12500
3   8  0 15.05000
4   4  1 28.07500
5   6  1 20.56667
6   8  1 15.40000
```

Merging

Combine data frames based on shared values

Merging

Combine data frames based on shared values

```
> # Sample Data
> print(A)

  x1 x2
1  a  1
2  b  2
3  c  3

> print(B)

  x1    x3
1  a  TRUE
2  b FALSE
3  d  TRUE
```

Merging

Shared values of `x1` only

```
> df <- merge(A, B, by = "x1")
```

Merging

Shared values of `x1` only

```
> df <- merge(A, B, by = "x1")
> print(df)
  x1 x2    x3
1  a  1  TRUE
2  b  2 FALSE
```

Merging

All values of `x1` from both/either

```
> df <- merge(A, B, by = "x1", all = TRUE)
```

Merging

All values of `x1` from both/either

```
> df <- merge(A, B, by = "x1", all = TRUE)
> print(df)
  x1 x2    x3
1  a  1  TRUE
2  b  2 FALSE
3  c  3    NA
4  d NA  TRUE
```

Merging

All values of `x1` in A

```
> df <- merge(A, B, by = "x1", all.x = TRUE)
```

Merging

All values of x1 in A

```
> df <- merge(A, B, by = "x1", all.x = TRUE)

> print(df)

  x1 x2    x3
1  a  1  TRUE
2  b  2 FALSE
3  c  3    NA
```

Merging

All values of x1 in B

```
> df <- merge(A, B, by = "x1", all.y = TRUE)
```

Merging

All values of `x1` in B

```
> df <- merge(A, B, by = "x1", all.y = TRUE)
> print(df)
  x1 x2    x3
1  a  1  TRUE
2  b  2 FALSE
3  d NA  TRUE
```

Merging: insert rows

`rbind()` “Stacks” one data frame on top of the other. Required: same column names in both

```
> A$x3 <- NA            # add x3 column to A
> B$x2 <- NA            # add X2 column to B
> df <- rbind(A, B)
```

Merging: insert rows

`rbind()` "Stacks" one data frame on top of the other. Required: same column names in both

```
> A$x3 <- NA            # add x3 column to A
> B$x2 <- NA            # add X2 column to B
> df <- rbind(A, B)

> print(df)

  x1 x2    x3
1  a  1    NA
2  b  2    NA
3  c  3    NA
4  a NA  TRUE
5  b NA FALSE
6  d NA  TRUE
```

Get Data

`read.table()` family of functions: read raw data saved in delimited text files, and return a data frame object.

```
> ?read.table()
> ?read.csv()
> ?read.delim()
```