# R Basics

J. Alexander Branham

Fall 2016

# What is R?

# R is a computer programming language

```
R version 3.3.0 (2016-05-03) -- "Supposedly Educational"
Copyright (C) 2016 The R Foundation for Statistical Computing
Platform: x86_64-pc-linux-gnu (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

  Natural language support but running in an English locale

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> 
```

# What is R?

- R is a language and environment for statistical computing and graphics.

# What is R?

- R is a language and environment for statistical computing and graphics.
- Derived from S, designed at Bell Laboratories

# What is R?

- R is a language and environment for statistical computing and graphics.
- Derived from S, designed at Bell Laboratories
    - S first appeared in 1976!

# What is R?

- R is a language and environment for statistical computing and graphics.
- Derived from S, designed at Bell Laboratories
    - S first appeared in 1976!
- Full language, but flexible and (can be) simple

```
mtcars
```

```
##                    mpg cyl  disp  hp drat    wt  qsec vs am gear car
## Mazda RX4         21.0   6 160.0 110 3.90 2.620 16.46  0  1    4
## Mazda RX4 Wag     21.0   6 160.0 110 3.90 2.875 17.02  0  1    4
## Datsun 710        22.8   4 108.0  93 3.85 2.320 18.61  1  1    4
## Hornet 4 Drive    21.4   6 258.0 110 3.08 3.215 19.44  1  0    3
## Hornet Sportabout 18.7   8 360.0 175 3.15 3.440 17.02  0  0    3
## Valiant           18.1   6 225.0 105 2.76 3.460 20.22  1  0    3
## Duster 360        14.3   8 360.0 245 3.21 3.570 15.84  0  0    3
## Merc 240D         24.4   4 146.7  62 3.69 3.190 20.00  1  0    4
## Merc 230          22.8   4 140.8  95 3.92 3.150 22.90  1  0    4
## Merc 280          19.2   6 167.6 123 3.92 3.440 18.30  1  0    4
## Merc 280C         17.8   6 167.6 123 3.92 3.440 18.90  1  0    4
## Merc 450SE        16.4   8 275.8 180 3.07 4.070 17.40  0  0    3
```

```r
mean(mtcars$mpg)
```

```
## [1] 20.09062
```

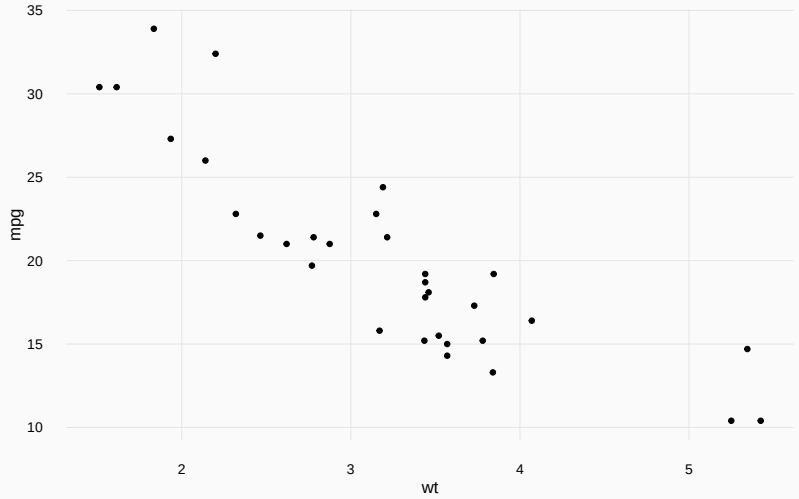
```r
summary(mtcars$mpg)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   10.40   15.42   19.20   20.09   22.80   33.90
```

```r
table(mtcars$cyl)
```

```
##
##  4  6  8
## 11  7 14
```

```
ggplot(mtcars, aes(wt, mpg)) + geom_point()
```



# Advantages of R

- It's free, open-source, and available on nearly every platform

# Advantages of R

- It's free, open-source, and available on nearly every platform
    - Stata, the main competitor with R in our department, is between $55/year and $235/year for students, depending on what you need

# Advantages of R

- It's free, open-source, and available on nearly every platform
    - Stata, the main competitor with R in our department, is between $55/year and $235/year for students, depending on what you need
- Unparalleled in the number of packages (groups of functions)

# Advantages of R

- It's free, open-source, and available on nearly every platform
    - Stata, the main competitor with R in our department, is between $55/year and $235/year for students, depending on what you need
- Unparalleled in the number of packages (groups of functions)
- More than 8,500 packages on CRAN as of June 2016,

# Advantages of R

- It's free, open-source, and available on nearly every platform
    - Stata, the main competitor with R in our department, is between $55/year and $235/year for students, depending on what you need
- Unparalleled in the number of packages (groups of functions)
- More than 8,500 packages on CRAN as of June 2016,
- Great community help (e.g. #rstats on twitter, stackoverflow.com, R-bloggers)

# Advantages of R

- It's free, open-source, and available on nearly every platform
    - Stata, the main competitor with R in our department, is between $55/year and $235/year for students, depending on what you need
- Unparalleled in the number of packages (groups of functions)
- More than 8,500 packages on CRAN as of June 2016,
- Great community help (e.g. #rstats on twitter, stackoverflow.com, R-bloggers)
    - `gov-r@utlists.utexas.edu` - departmental R listserv

# Advantages of R

- It's free, open-source, and available on nearly every platform
    - Stata, the main competitor with R in our department, is between $55/year and $235/year for students, depending on what you need
- Unparalleled in the number of packages (groups of functions)
- More than 8,500 packages on CRAN as of June 2016,
- Great community help (e.g. #rstats on twitter, stackoverflow.com, R-bloggers)
    - `gov-r@utlists.utexas.edu` - departmental R listserv
- You can combine documents and r code together (rmarkdown or knitr)

# Advantages of R

- It's free, open-source, and available on nearly every platform
    - Stata, the main competitor with R in our department, is between $55/year and $235/year for students, depending on what you need
- Unparalleled in the number of packages (groups of functions)
- More than 8,500 packages on CRAN as of June 2016,
- Great community help (e.g. #rstats on twitter, stackoverflow.com, R-bloggers)
    - `gov-r@utlists.utexas.edu` - departmental R listserv
- You can combine documents and r code together (rmarkdown or knitr)
    - For example, this presentation is written in rmarkdown

# R Editors

- No one likes using R in a terminal, so everyone uses an editor

# R Editors

- No one likes using R in a terminal, so everyone uses an editor
- Most popular is probably RStudio

# R Editors

- No one likes using R in a terminal, so everyone uses an editor
- Most popular is probably RStudio
- Emacs with ESS also very good choice

# RStudio Layout

- Bottom left: Console

# RStudio Layout

- Bottom left: Console
    - This is where you can enter R code to execute

# RStudio Layout

- Bottom left: Console
    - This is where you can enter R code to execute
- Top left: editor window

# RStudio Layout

- Bottom left: Console
    - This is where you can enter R code to execute
- Top left: editor window
    - You can have open R scripts or rmarkdown files here to edit

# RStudio Layout

- Bottom left: Console
  - This is where you can enter R code to execute
- Top left: editor window
  - You can have open R scripts or rmarkdown files here to edit
- Top right: environment, history, (git)

# RStudio Layout

- Bottom left: Console
  - This is where you can enter R code to execute
- Top left: editor window
  - You can have open R scripts or rmarkdown files here to edit
- Top right: environment, history, (git)
  - Environment will list everything that R is “remembering”

# RStudio Layout

- Bottom left: Console
  - This is where you can enter R code to execute
- Top left: editor window
  - You can have open R scripts or rmarkdown files here to edit
- Top right: environment, history, (git)
  - Environment will list everything that R is “remembering”
  - History lists all commands entered in that “project”

# RStudio Layout

- Bottom left: Console
  - This is where you can enter R code to execute
- Top left: editor window
  - You can have open R scripts or rmarkdown files here to edit
- Top right: environment, history, (git)
  - Environment will list everything that R is “remembering”
  - History lists all commands entered in that “project”
- Bottom right: files, plots, packages, help

# R Projects

- You can set up different “projects” from within Rstudio

# R Projects

- You can set up different “projects” from within Rstudio
- This will automatically change the working directory to where you put the project

# R Projects

- You can set up different “projects” from within Rstudio
- This will automatically change the working directory to where you put the project
- I use a project for each paper, for example

# Working directory

- What is a directory?

# Working directory

- What is a directory?
- What is a working directory?

# Working directory

- What is a directory?
- What is a working directory?
- Run `getwd()` in R. What does it return?

# Working directory

- What is a directory?
- What is a working directory?
- Run `getwd()` in R. What does it return?
    - This is where R will save/load files from

# Using R

# Calculator

R is a great calculator

```
3 + 2
```

```
## [1] 5
```

```
1.7729 ^ 4 * (1930 / 4)
```

```
## [1] 4766.881
```

# Algebra & functions

R can do algebra and functions

```
a <- 1
b <- 2
a + b
```

```
## [1] 3
```

```
A <- 3
a + b - A
```

```
## [1] 0
```

```
factorial(3)
```

# You try!

What will be the output of:

```
round(round(2.391) + 7.21)
```

# Assignment

R uses `<-` for assignment.

```
a <- 4
a + 7
```

```
## [1] 11
```

```
a <- a + 2
a + 7
```

```
## [1] 13
```

`a` is now referred to as an "object." Pretty much anything R remembers is an object.

# Functions

Functions take arguments

```
myvector <- c(1, 5, 2, 7, 9, NA, 1)
mean(myvector, na.rm = TRUE)
```

```
## [1] 4.166667
```

```
?rnorm
rnorm(5, 0, 1)
```

# You try!

What's the square root of 3?

What's $e^3$

# Scalars, vectors, and matrices

# Scalars

```
12
```

```
## [1] 12
```

# Vectors

Created with `c` (create) function:

```
c(1, 4, 2, -1)
```

```
## [1]  1  4  2 -1
```

created with the `matrix` function:

```
matrix(c(1, 2, 3, 4, 2, 1), nrow = 3)
```

```
##      [,1] [,2]
## [1,]    1    4
## [2,]    2    2
## [3,]    3    1
```

# Data Types

# You try!

What kinds of data exist here?

```
head(mtcars)
```

```
##                   mpg cyl disp  hp drat    wt  qsec vs am gear carb
## Mazda RX4         21.0   6  160 110 3.90 2.620 16.46  0  1    4    4
## Mazda RX4 Wag     21.0   6  160 110 3.90 2.875 17.02  0  1    4    4
## Datsun 710        22.8   4  108  93 3.85 2.320 18.61  1  1    4    1
## Hornet 4 Drive    21.4   6  258 110 3.08 3.215 19.44  1  0    3    1
## Hornet Sportabout 18.7   8  360 175 3.15 3.440 17.02  0  0    3    2
## Valiant           18.1   6  225 105 2.76 3.460 20.22  1  0    3    1
```

# Basic Data Structures

We'll talk about four kinds of data

# Logical

Something that is (TRUE) or isn't (FALSE)

```
4 == 6
```

```
## [1] FALSE
```

```
class(TRUE)
```

```
## [1] "logical"
```

# Numeric

A number

```
class(7.12)
```

```
## [1] "numeric"
```

```
a <- 2.192
class(a)
```

```
## [1] "numeric"
```

# Character

Character data is R's way of remembering letters

```
"My name is Alex"
```

```
## [1] "My name is Alex"
```

```
class("3.218")
```

```
## [1] "character"
```

```
class("TRUE")
```

```
## [1] "character"
```

# Factor

Factors are R's way of remembering categories and labels

```
myfactor <- factor(c("a", "b", "c", "c", "b", "A"))
myfactor
```

```
## [1] a b c c b A
## Levels: a A b c
```

# You try!

What class are the following:

```
x <- 3.18
```

```
"x"
x
```

Make a vector that contains a number, a letter, and FALSE. What's the class of the vector?

# Coercion

- Anything can get coerced to a character

# Coercion

- Anything can get coerced to a character
- Coercing logical to numeric means TRUE = 1, FALSE = 0

# You try

What type will result:

```
c(5, "a")
c(TRUE, "FALSE")
TRUE + 7
```

A matrix can have only one data type:

```
matrix(c(1, 2, 3, "a", "b", "c", TRUE, FALSE, TRUE), ncol = 3)
```

```
##      [,1] [,2] [,3]
## [1,] "1"  "a"  "TRUE"
## [2,] "2"  "b"  "FALSE"
## [3,] "3"  "c"  "TRUE"
```

Lists and data frames allow for multiple data types

A list is a one-dimensional group of objects:

```
mylist <- list(1, "r", FALSE)
class(mylist)
```

```
## [1] "list"
```

```
length(mylist)
```

```
## [1] 3
```

# Lists

Elements in a list can be anything - including vectors and lists:

```
mylist2 <- list(c(1, 2, 3), TRUE, list(c(4, 5, 6), FALSE))
```

```
## [[1]]
## [1] 1 2 3
##
## [[2]]
## [1] TRUE
##
## [[3]]
## [[3]][[1]]
## [1] 4 5 6
##
## [[3]][[2]]
## [1] FALSE
```

Accessing elements of a list is a little weird:

```
mylist2[1]
```

```
## [[1]]
## [1] 1 2 3
```

```
mylist2[[1]]
```

```
## [1] 1 2 3
```

# You try!

Return the vector (4, 5, 6) from this list:

```
mylist2 <- list(c(1, 2, 3), TRUE, list(c(4, 5, 6), FALSE))
```

# You try (answer)

```
mylist2[[3]][[1]]
```

```
## [1] 4 5 6
```

# Names

Objects in lists can have names:

```
mylist2 <- list(element1 =  c(1, 2, 3),
                element2 = TRUE,
                element3 = list(c(4, 5, 6), FALSE))
```

Note: since `mylist2` already exists, we could have modified the names directly by calling:

```
names(mylist2) <- c("element1", "element2", "element3")
```

Which make them easier to access:

```
mylist2$element3
```

```
## [[1]]
## [1] 4 5 6
##
## [[2]]
## [1] FALSE
```

```
mydata <- data.frame(x = 1:3,
                     y = c(5, 11, 4),
                     z = c("some", "fancy", "text"))
mydata
```

```
##   x  y     z
## 1 1  5  some
## 2 2 11 fancy
## 3 3  4  text
```

```r
mean(mydata$x)
```

```
## [1] 2
```

```r
mean(mydata[, 1])
```

```
## [1] 2
```

```r
mean(mydata[, "x"])
```

```
## [1] 2
```

# You try!

Make a data frame containing:

`var1` - integers from 1 through 10

`var2` - the sequence TRUE, FALSE repeated 5 times (hint: `?rep`)

What's the mean of `var1`? The mean of `var2`?

# Types and Dimensions

| | Single type | Multiple types |
|---|---|---|
| 1D | Vector | List |
| 2D | Matrix | Data frame |
| nD | Array | |

# Packages

# Packages

- Packages extend R's functionality

```
install.packages("ggplot2")
```

# Packages

- Packages extend R's functionality
- CRAN hosts many packages and R can install packages from CRAN easily:

```
install.packages("ggplot2")
```