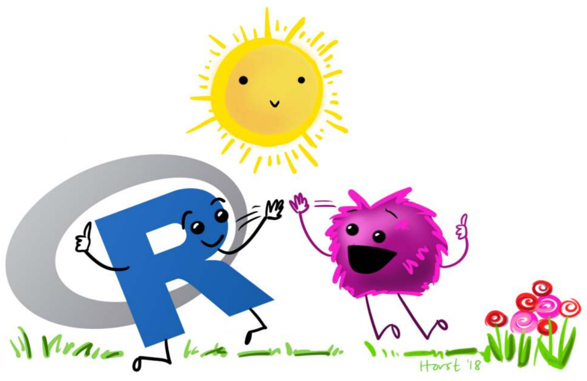
NRI 7350

Getting started with R



@allison_horst

About these Labs

Format

- I will provide you tools and workflow to get started with R
- I will go over specific statistical functions
  - How to run them
  - How to interpret the results
- We'll have hands-on, lecture, and demonstrations

R is hard: But have no fear!

- Don't expect to remember everything!
- Copy/Paste is your friend (never apologize for using it!)
- Consider these labs a resource to return to

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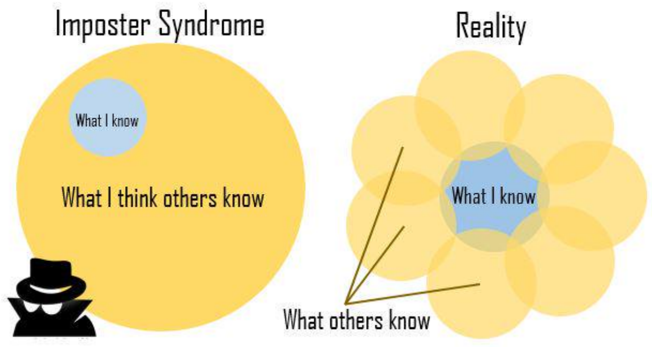
ImpostR Syndrome

Impost R
Syndrome

ImpostR Syndrome



David Whittaker

Impost R
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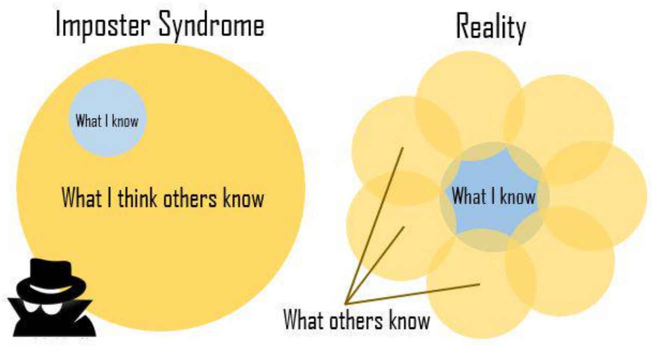
ImpostR Syndrome



David Whittaker

Impost R
Syndrome

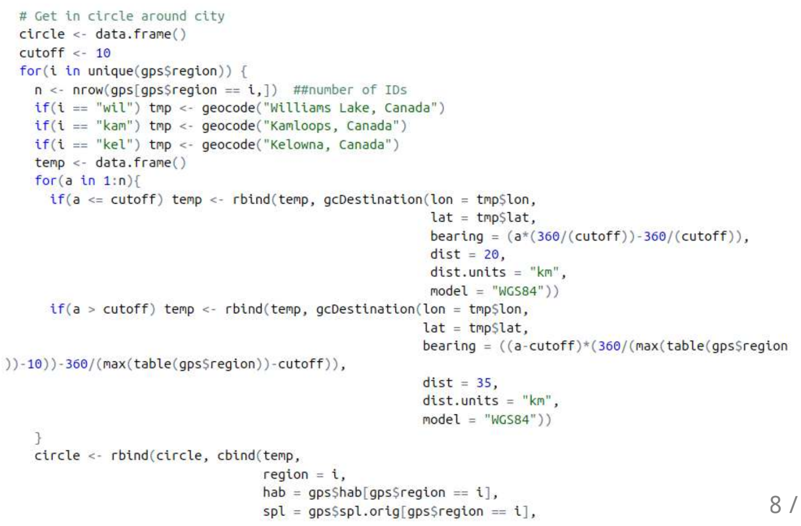
Moral of the story?
Make friends, code in groups, learn together and don't beat yourself up

@allison_horst

About R

Why R?

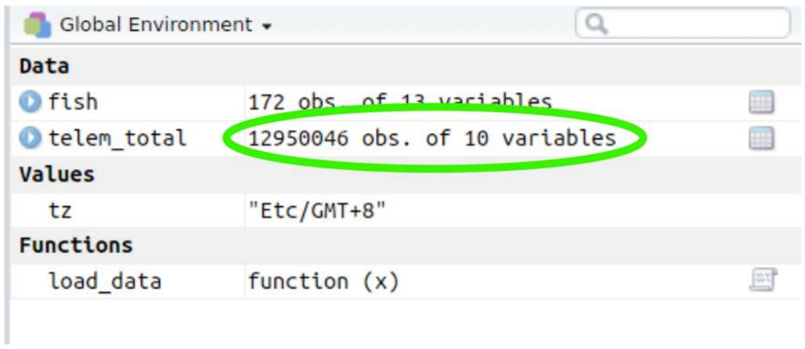
R is hard



```
# Get in circle around city
circle <- data.frame()
cutoff <- 10
for(i in unique(gps$region)) {
  n <- nrow(gps[gps$region == i,])  ##number of IDs
  if(i == "wil") tmp <- geocode("Williams Lake, Canada")
  if(i == "kam") tmp <- geocode("Kamloops, Canada")
  if(i == "kel") tmp <- geocode("Kelowna, Canada")
  temp <- data.frame()
  for(a in 1:n){
    if(a <= cutoff) temp <- rbind(temp, gcDestination(lon = tmp$lon,
                                                      lat = tmp$lat,
                                                      bearing = (a*(360/(cutoff))-360/(cutoff)),
                                                      dist = 20,
                                                      dist.units = "km",
                                                      model = "WGS84"))
    if(a > cutoff) temp <- rbind(temp, gcDestination(lon = tmp$lon,
                                                     lat = tmp$lat,
                                                     bearing = ((a-cutoff)*(360/(max(table(gps$region
))-10))-360/(max(table(gps$region))-cutoff)),
                                                     dist = 35,
                                                     dist.units = "km",
                                                     model = "WGS84"))
  }
  circle <- rbind(circle, cbind(temp,
                              region = i,
                              hab = gps$hab[gps$region == i],
                              spl = gps$spl.orig[gps$region == i],
```

Why R?

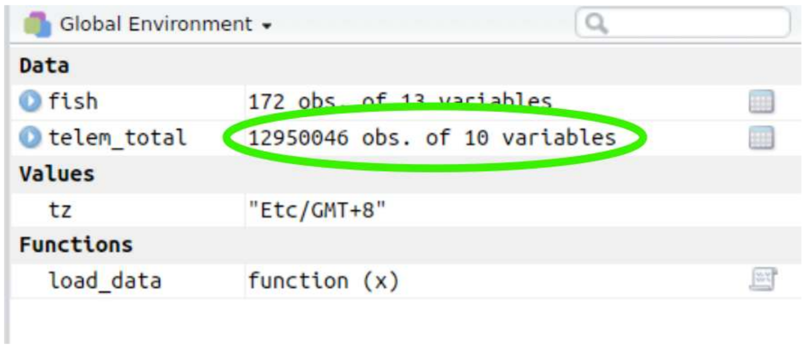
But R is powerful (and reproducible)!



```
Global Environment ▾
Data
fish          172 obs. of 13 variables
telem_total   12950046 obs. of 10 variables
Values
tz            "Etc/GMT+8"
Functions
load_data     function (x)
```

Why R?

But R is powerful (and reproducible)!



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Data
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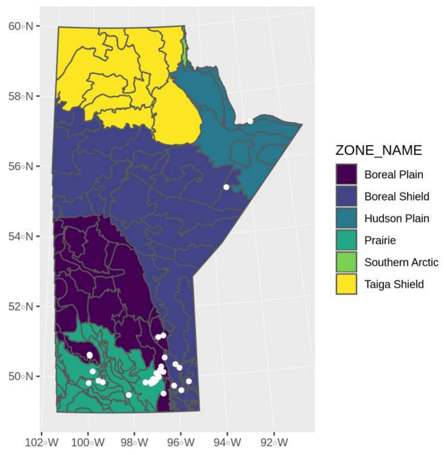
load_data     function (x)
```

(I made these slides with **R**markdown)

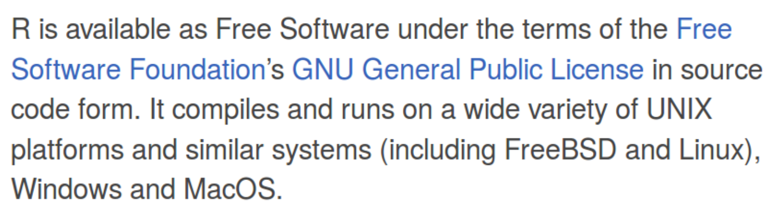
Why R?

R is also beautiful



Why R?

R is affordable (i.e., free!)



R is available as Free Software under the terms of the Free Software Foundation's GNU General Public License in source code form. It compiles and runs on a wide variety of UNIX platforms and similar systems (including FreeBSD and Linux), Windows and MacOS.

What is R?

R is Programming language

> A programming **language** is a way to give instructions in order to get a computer to do something

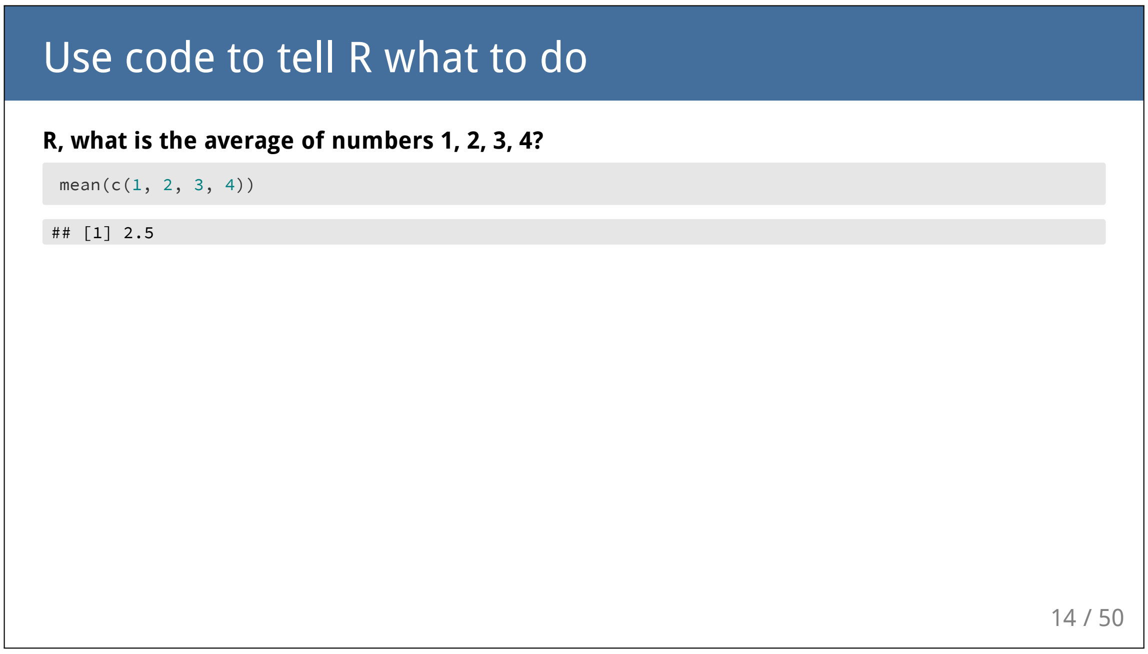
- You need to know the language (i.e., the code)
- Computers don't know what you mean, only what you type (unfortunately)
- Spelling, punctuation, and capitalization all matter!

For example

R, what is 56 times 5.8?

```
56 * 5.8
```

```
## [1] 324.8
```

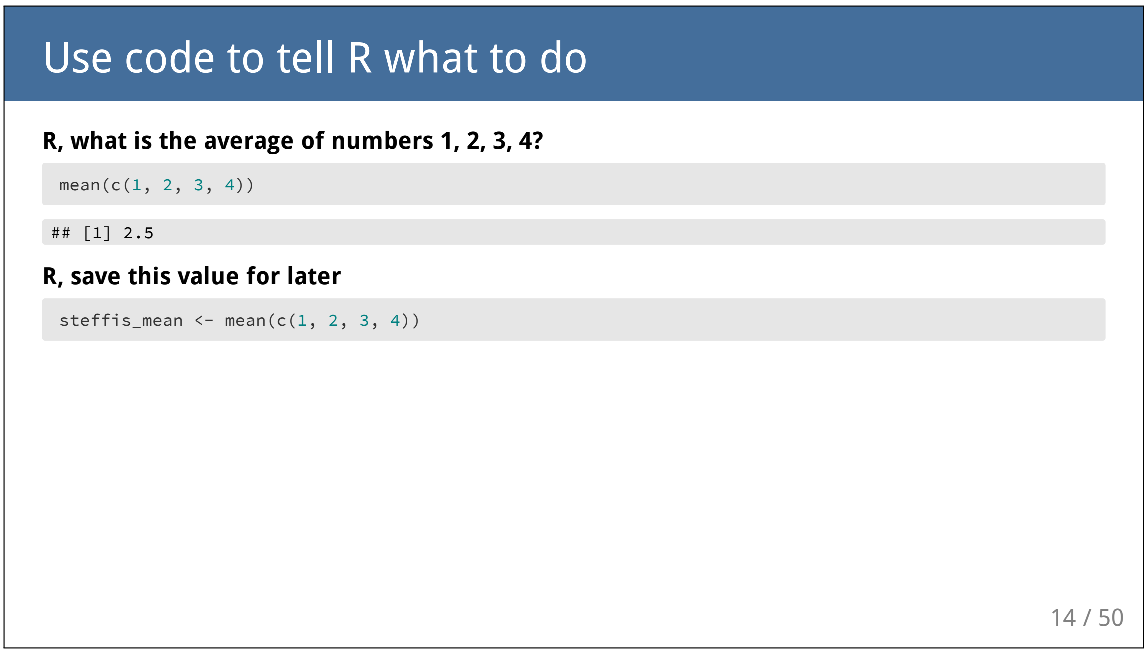


Use code to tell R what to do

R, what is the average of numbers 1, 2, 3, 4?

```
mean(c(1, 2, 3, 4))
```

```
## [1] 2.5
```



Use code to tell R what to do

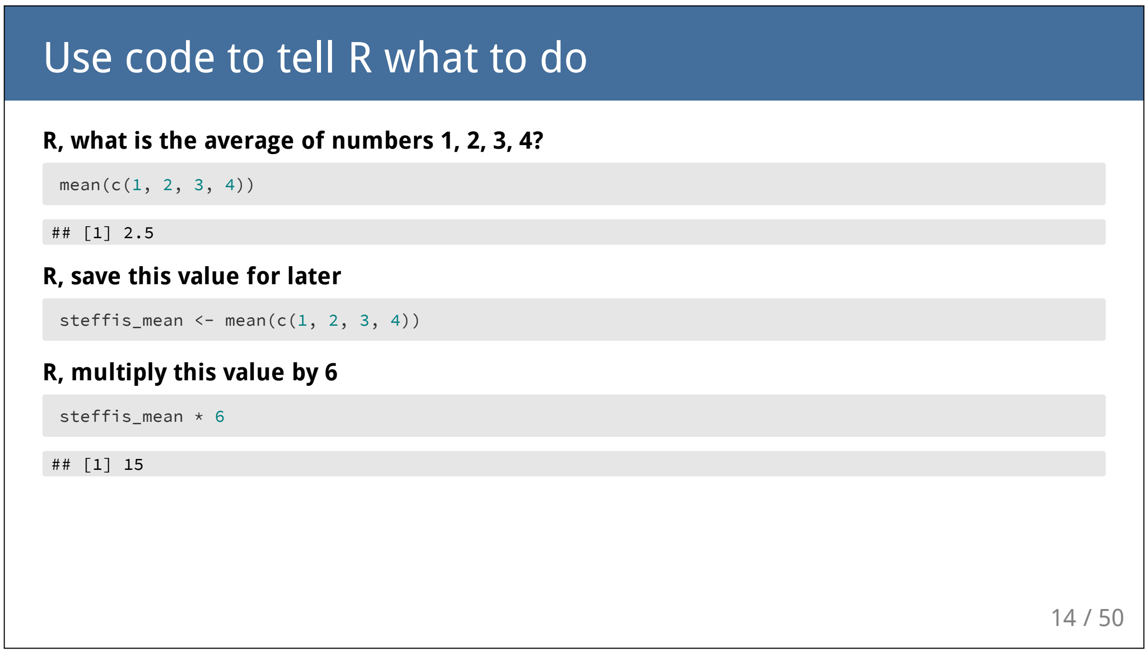
R, what is the average of numbers 1, 2, 3, 4?

```
mean(c(1, 2, 3, 4))
```

```
## [1] 2.5
```

R, save this value for later

```
steffis_mean <- mean(c(1, 2, 3, 4))
```



Use code to tell R what to do

R, what is the average of numbers 1, 2, 3, 4?

```
mean(c(1, 2, 3, 4))
```

```
## [1] 2.5
```

R, save this value for later

```
steffis_mean <- mean(c(1, 2, 3, 4))
```

R, multiply this value by 6

```
steffis_mean * 6
```

```
## [1] 15
```

Code, Output, Scripts

Code

- The actual commands

Output

- The result of running code or a script

Script

- A text file full of code that you want to run
- You should always keep your code in a script

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For example:

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mean(c(1, 2, 3, 4))
```
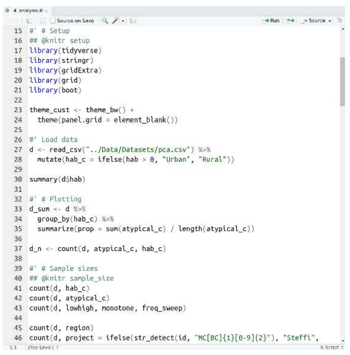

Code

```
## [1] 2.5
```

Output



```
#' # Setup
## @knitr setup
library(tidyverse)
library(stringr)
library(gridExtra)
library(grid)
library(boot)

theme_cust <- theme_bw() +
  theme(panel.grid = element_blank())

#' Load data
d <- read_csv("../Data/Datasets/pca.csv") %>%
  mutate(hab_c = ifelse(hab > 0, "Urban", "Rural"))

summary(d$hab)

#' # Plotting
d_sum <- d %>%
  group_by(hab_c) %>%
  summarize(prop = sum(atypical_c) / length(atypical_c))

d_n <- count(d, atypical_c, hab_c)

#' # Sample sizes
## @knitr sample_size
count(d, hab_c)
count(d, atypical_c)
count(d, lowhigh, monotone, freq_sweep)

count(d, region)
count(d, project = ifelse(str_detect(id, "MC[BC]{1}[0-9]{2}"), "Steffi",
```

Script

RStudio vs. R

RStudio

R

- **RStudio** is not **R**
- RStudio is a User Interface or IDE (integrated development environment)
  - (i.e., Makes coding simpler)
- But sometimes tries to be **too** helpful

RStudio Features

Changing Options: Tools > Global Options

- General > Restore RData into workspace at startup (NO!)
- General > Save workspace to on exit (NEVER!)
- Code > Insert matching parens/quotes (Personal preference)

Projects

- Handles working directories
- Organizes your work

Packages

- Can use the package manager to install packages
- Can use the manager to load them as well, but not recommended
  - Load packages in your script so you remember which ones you used!

Let's take a look at RStudio

Set up a Project for this course

Your first *real* code!

First Code

```
# First load the package
library(tidyverse)

# Now create the figure
ggplot(data = msleep, aes(x = sleep_total, y = sleep_rem, colour = vore)) +
  geom_point()
```

- Copy/paste or type this into the script window in RStudio
    - You may have to go to File > New File > R Script
- Click anywhere on the first line of code
- Use the 'Run' button to run this code, **or** use the short-cut `Ctrl-Enter`
    - Repeat until all the code has run

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ggplot(data = msleep, aes(x = sleep_total, y = sleep_rem, colour = vore)) +
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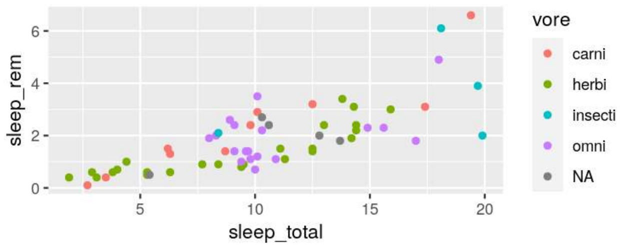
```

```
## Warning: Removed 22 rows containing missing values (geom_point).
```



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Package
`tidyverse`

```
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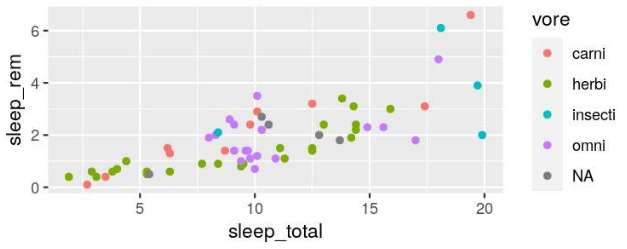

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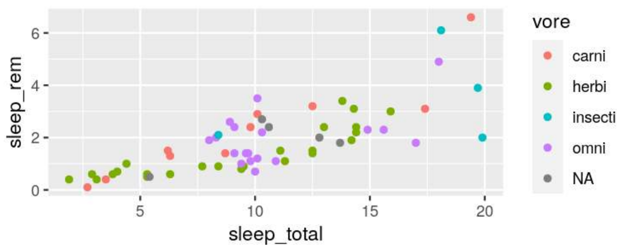
```

Functions:
`library()`, **`ggplot()`**
`aes()`, and **`geom_point()`**

```
## Warning: Removed 22 rows containing missing values (geom_point).
```



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```

`+`
(Specific to **`ggplot`**)

```
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```

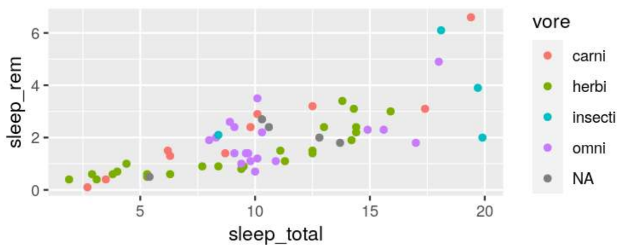

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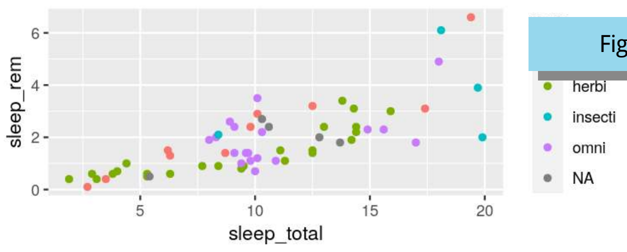

Figure!

First Code

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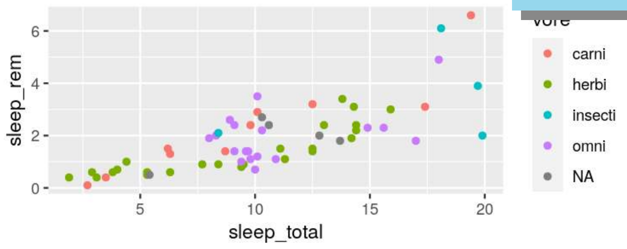
Warning



First Code

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# Now create the figure
ggplot(data = msleep, aes(x = sleep_total, y = sleep_rem, colour = vore)) +
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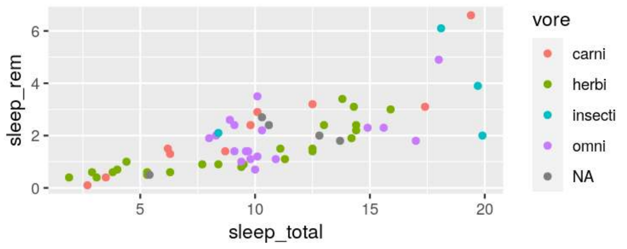
```

Comments

```
## Warning: Removed 22 rows containing missing values (geom_point).
```



R Basics: Objects

Objects are *things* in the environment
(Check out the **Environment** pane in RStudio)

functions()

Do things, Return things

Does something but returns nothing

e.g., **`write_csv()`** - Saves the **`mtcars`** data frame as a csv file

```
write_csv(mtcars, path = "mtcars.csv")
```

Does something and returns something

e.g., **`sd()`** - returns the standard deviation of a vector

```
sd(c(4, 10, 21, 55))
```

```
## [1] 22.78157
```

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functions()

- Functions can take **arguments** (think 'options')
- **`data`**, **`x`**, **`y`**, **`colour`**

```
ggplot(data = msleep, aes(x = sleep_total, y = sleep_rem, colour = vore)) +
  geom_point()
```

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functions()

- Functions can take **arguments** (think 'options')
- **`data`**, **`x`**, **`y`**, **`colour`**

```
ggplot(data = msleep, aes(x = sleep_total, y = sleep_rem, colour = vore)) +
  geom_point()
```

- Arguments defined by **name** or by **position**
- With correct position, do not need to specify by name

By name:

```
mean(x = c(1, 5, 10))
```

```
## [1] 5.333333
```

By order:

```
mean(c(1, 5, 10))
```

```
## [1] 5.333333
```

30 / 50

functions()

- Functions can take **arguments** (think 'options')
- **data**, **x**, **y**, **colour**

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```

```
## [1] 5.333333
```

By order:

```
mean(c(1, 5, 10))
```

```
## [1] 5.333333
```

Note that **c()** is also a function: combine or concatenate

functions()

Watch out for 'hidden' arguments

By name:

```
mean(x = c(1, 5, 10, NA),
     na.rm = TRUE)
```

```
## [1] 5.333333
```

functions()

Watch out for 'hidden' arguments

By name:

```
mean(x = c(1, 5, 10, NA),
     na.rm = TRUE)
```

```
## [1] 5.333333
```

By order:

```
mean(c(1, 5, 10, NA),
     TRUE)
```

```
## Error in mean.default(c(1, 5, 10, NA), TRUE): 'trim'
must be numeric of length one
```

functions()

Watch out for 'hidden' arguments

By name:

```r
mean(x = c(1, 5, 10, NA),
     na.rm = TRUE)
```

```
## [1] 5.333333
```

By order:

```r
mean(c(1, 5, 10, NA),
     TRUE)
```

```
## Error in mean.default(c(1, 5, 10, NA), TRUE): 'trim'
must be numeric of length one
```

This error states that we've assigned the argument **`trim`** to a non-valid argument

Where did **`trim`** come from?

R documentation

```r
?mean
```

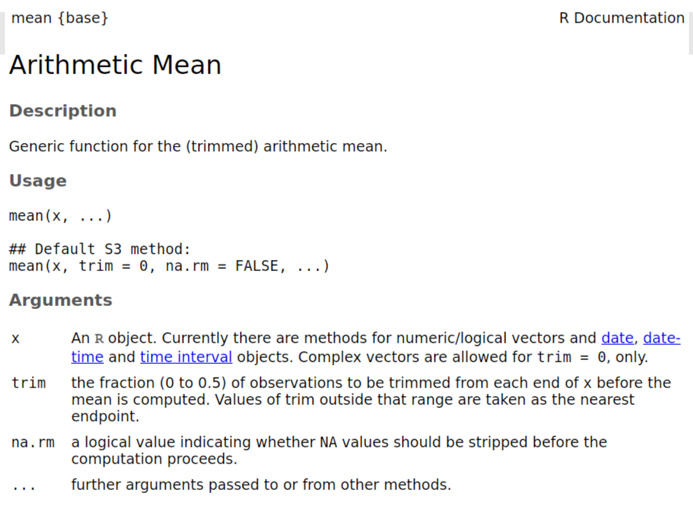
Your Turn:

Run this, what happens?

Do you see the **`trim`** argument?

R documentation

```r
?mean
```



mean {base} R Documentation

Arithmetic Mean

Description

Generic function for the (trimmed) arithmetic mean.

Usage

```
mean(x, ...)

## Default S3 method:
mean(x, trim = 0, na.rm = FALSE, ...)
```

Arguments

`x`	An R object. Currently there are methods for numeric/logical vectors and date, date-time and time interval objects. Complex vectors are allowed for `trim = 0`, only.
`trim`	the fraction (0 to 0.5) of observations to be trimmed from each end of x before the mean is computed. Values of trim outside that range are taken as the nearest endpoint.
`na.rm`	a logical value indicating whether NA values should be stripped before the computation proceeds.
`...`	further arguments passed to or from other methods.

Data

Generally kept in **`vectors`** or **`data.frames`/`tibbles`**

- These are objects with names (like functions)
- We can use **`<-`** to assign values to objects (assignment)

Vector (1 dimension)

```
a <- c("a", "b", "c")
a
```

```
## [1] "a" "b" "c"
```

Data frame (2 dimensions)

rows x columns

```
d <- data.frame(letters = c("a", "b", "c"),
                numbers = c(1, 2, 3),
                treat = c("control", "control",
"control"))
d
```

```
##   letters numbers   treat
## 1       a       1 control
## 2       b       2 control
## 3       c       3 control
```

Vectors

Use `c()` to create a vector

```
a <- c("apples", 12, "bananas")
```

Use `x[index]` to access part of a vector

```
a[3] # [1] "bananas"
```

Vectors contain one type of variable

(Even if you try to make it with more)

```
class(a) # [1] "character"
```

Data frames (also tibbles)

Create with `data.frame()`/`tibble()`

```
my_data <- tibble(x = c("s1", "s2", "s3",
"s4"),
                  y = c(101, 102, 103, 104),
                  z = c("a", "b", "c", "d"))
my_data
```

```
## # A tibble: 4 x 3
##   x         y z
##   <chr> <dbl> <chr>
## 1 s1      101 a
## 2 s2      102 b
## 3 s3      103 c
## 4 s4      104 d
```

(**`dbl`** = "Double" = Computer talk for non-integer number)

Data frames (also tibbles)

Create with `data.frame()`/`tibble()`

```
my_data <- tibble(x = c("s1", "s2", "s3",
"s4"),
                  y = c(101, 102, 103, 104),
                  z = c("a", "b", "c", "d"))
my_data
```

```
## # A tibble: 4 x 3
##   x         y z
##   <chr> <dbl> <chr>
## 1 s1      101 a
## 2 s2      102 b
## 3 s3      103 c
## 4 s4      104 d
```

(`dbl` = "Double" = Computer talk for non-integer number)

Cols have different types of variables

```
str(my_data)
```

```
## tibble [4 × 3] (S3: tbl_df/tbl/data.frame)
##  $ x: chr [1:4] "s1" "s2" "s3" "s4"
##  $ y: num [1:4] 101 102 103 104
##  $ z: chr [1:4] "a" "b" "c" "d"
```

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Data frames (also tibbles)

`x$colname` to pull out column

```
my_data$x
```

```
## [1] "s1" "s2" "s3" "s4"
```

Or use `pull()` (from `tidyverse`)

```
pull(my_data, x)
```

```
## [1] "s1" "s2" "s3" "s4"
```

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Data frames (also tibbles)

`x$colname` to pull out column

```
my_data$x
```

```
## [1] "s1" "s2" "s3" "s4"
```

Or use `pull()` (from `tidyverse`)

```
pull(my_data, x)
```

```
## [1] "s1" "s2" "s3" "s4"
```

`x[row, col]` to access rows and columns of a data frame

```
my_data[1:2, 2:3]
```

```
## # A tibble: 2 x 2
##       y z
##   <dbl> <chr>
## 1   101 a
## 2   102 b
```

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Your Turn: Vectors and Data frames

1) Create a vector with 5 numbers and look at it

- Find it in the "Global Environment" pane (upper right)
- Type its name in the console and hit enter

```
     <- c(  ,  ,  ,  ,  )
     
```

2) Create a data frame with `data.frame()` or `tibble()`

- Click on it's name in the "Global Environment"
- Type its name in the console and hit enter

```
     <-           (     = c("  ", "  ", "  "),
                       = c(  ,  ,  ))
     
```

Miscellaneous

R has spelling and punctuation

- R cares about spelling
- R is also case sensitive! (`Apple` is not the same as `apple`)
- Comma's are used to separate arguments in functions

For example

This is correct:

```
mean(c(5, 7, 10))  # [1] 7.333333
```

This is **not** correct:

```
mean(c(5 7 10))
```

```
## Error: <text>:1:10: unexpected numeric constant
## 1: mean(c(5 7
##              ^
```

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>80% of learning R is learning to **troubleshoot**

This is **not** correct:

```
mean(c(5 7 10))
```

```
## Error: <text>:1:10: unexpected numeric constant
## 1: mean(c(5 7
##              ^
```

R has spelling and punctuation

Spaces usually don't matter unless they change meanings

```
5>=6     # [1] FALSE
5 >=6    # [1] FALSE
5 >= 6   # [1] FALSE
5 > = 6  # Error: unexpected '=' in "5 > ="
```

Periods don't matter either, but can be used in the same way as letters

(But for complex programming reasons... don't)

```
apple.oranges <- "fruit"
```

Assignments and Equal signs

Use `<-` to assign values to objects

```
a <- "hello"
```

Use `=` to set function arguments

```
mean(x = c(4, 9, 10))
```

Use `==` to determine equivalence (logical)

```
10 == 10 # [1] TRUE
10 == 9  # [1] FALSE
```

Braces/Brackets

Round brackets: ()

- Run functions (even if there are no arguments)

```
Sys.Date() # Get the Current Date
```

```
## [1] "2020-09-10"
```

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Braces/Brackets

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```
Sys.Date() # Get the Current Date
```

```
## [1] "2020-09-10"
```

- Without the (), R spits out information on the function:

```
Sys.Date
```

```
## function ()
## as.Date(as.POSIXlt(Sys.time()))
## <bytecode: 0x56324e6ac428>
## <environment: namespace:base>
```

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Braces/Brackets

Round brackets: ()

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Sys.Date() # Get the Current Date
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```
## [1] "2020-09-10"
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Sys.Date
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## function ()
## as.Date(as.POSIXlt(Sys.time()))
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## <environment: namespace:base>
```

() must be associated with a **function**

(Well, *almost* always)

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Braces/Brackets

Square brackets: `[]`

- Extract parts of objects

```
LETTERS
```

```
##  [1] "A" "B" "C" "D" "E" "F" "G" "H" "I" "J" "K" "L" "M" "N" "O" "P" "Q" "R" "S"
## [20] "T" "U" "V" "W" "X" "Y" "Z"
```

```
LETTERS[1]
```

```
## [1] "A"
```

```
LETTERS[26]
```

```
## [1] "Z"
```

Braces/Brackets

Square brackets: `[]`

- Extract parts of objects

```
LETTERS
```

```
##  [1] "A" "B" "C" "D" "E" "F" "G" "H" "I" "J" "K" "L" "M" "N" "O" "P" "Q" "R" "S"
## [20] "T" "U" "V" "W" "X" "Y" "Z"
```

```
LETTERS[1]
```

```
## [1] "A"
```

```
LETTERS[26]
```

```
## [1] "Z"
```

`[]` have to be associated with an **object** that has dimensions

(Always)

Improving code readability

Use spaces like you would in sentences:

```
a <- mean(c(4, 10, 13))
```

is easier to read than

```
a<-mean(c(4,10,13))
```

(But they are equivalent, coding-wise)

Improving code readability

Don't be afraid to use line breaks ('Enters') to make the code more readable

```
a <- data.frame(exp = c("A", "B", "A", "B", "A", "B"),
                sub = c("A1", "A1", "A2", "A2", "A3", "A3"),
                res = c(10, 12, 45, 12, 12, 13))
```

vs.

```
a <- data.frame(exp = c("A", "B", "A", "B", "A", "B"), sub = c("A1", "A1", "A2", "A2", "A3", "A3"),
res = c(10, 12, 45, 12, 12, 13))
```

Reproducible research

What is reproducible research?

Remembering what you've done (and sharing)

- Keep scripts
- Annotate scripts (use comments)
- Date scripts!
- Compile scripts into reports or notebooks
- Include version information
    - `devtools::session_info()`

We can use the "Compile Report" button in RStudio to create an HTML report of your work

tidyverse?

R base vs. tidyverse

R base

- R base is basic R
- Most packages used are installed and loaded by default

R base vs. tidyverse

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`tidyverse`

- Collection of 'new' packages developed by a team closely affiliated with RStudio
- Packages designed to work well together
- Use a slightly different syntax
- Among others, includes packages used for data transformations and visualizations:
  - e.g., `ggplot2`, `dplyr`, `tidyr`

R base vs. tidyverse

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> Can be helpful to understand whether functions are `tidyverse` or R base functions

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Wrapping up: Further reading

- http://www.cookbook-r.com
- R for Data Science
- R base cheatsheet

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