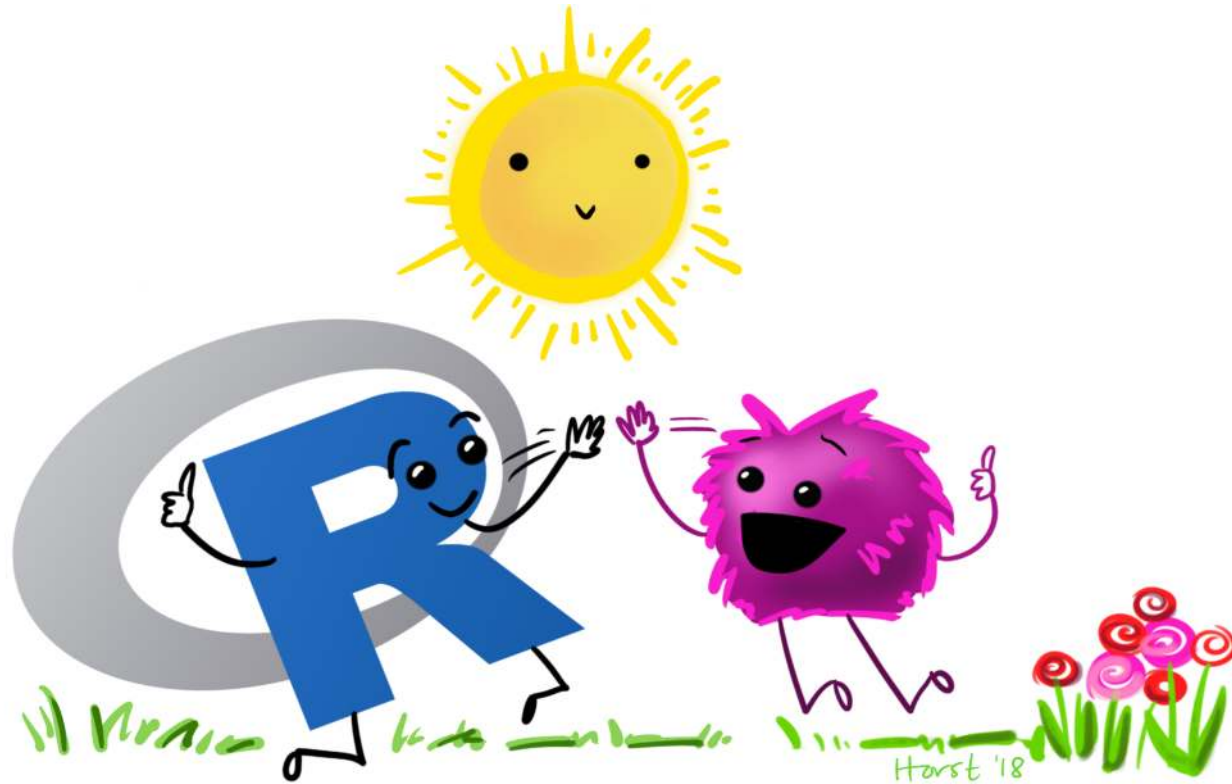


Getting started with R



Check-in

- Everyone getting emails?
 - Email about these slides?
- Everyone have access to these slides?
https://steffilazerte.ca/NRI_7350/slides.html

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

About these Labs

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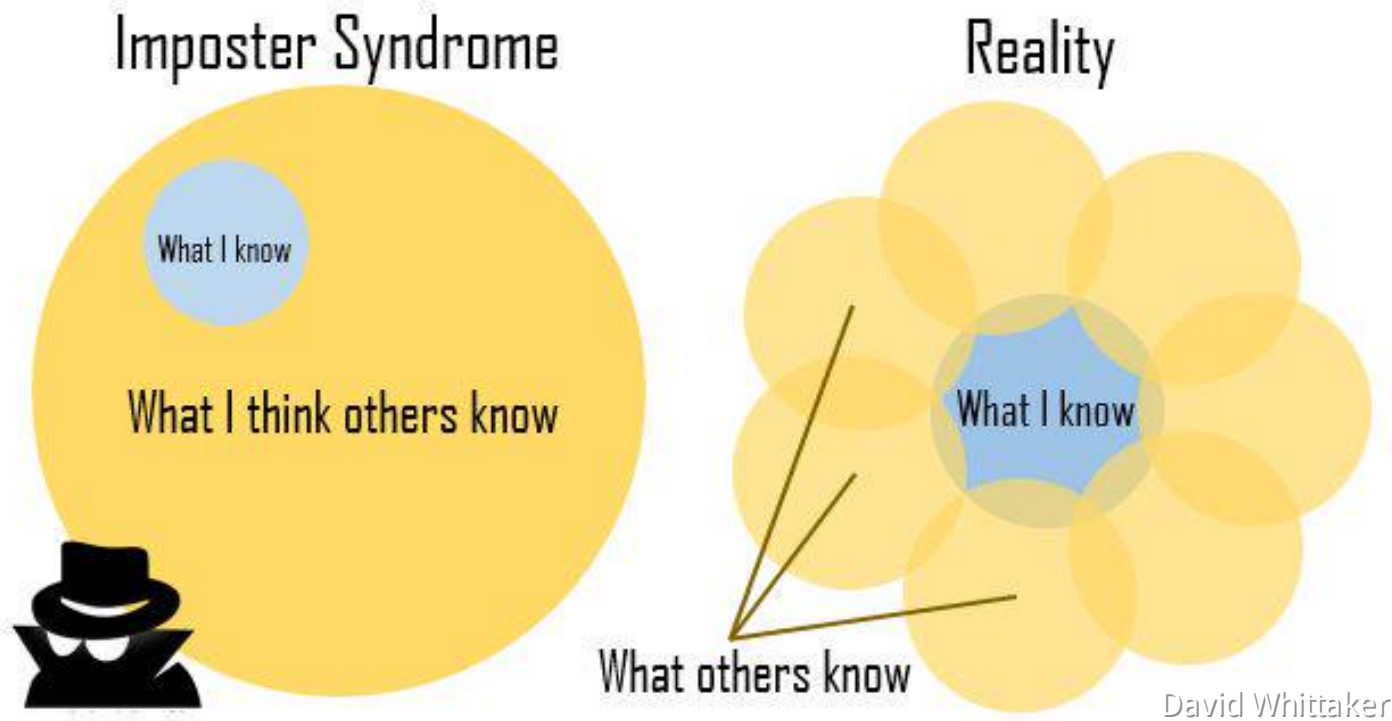
- I will provide you tools and workflow to get started with R
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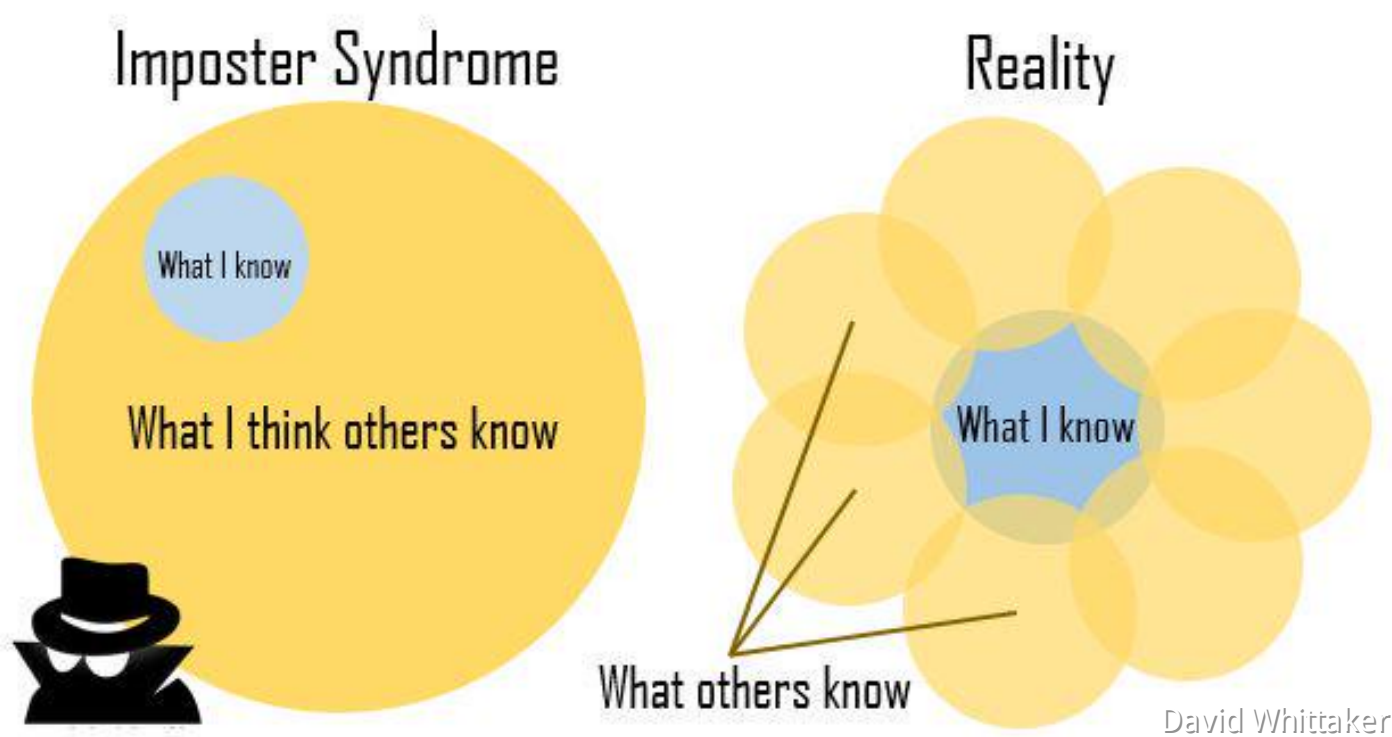
Impost Syndrome

ImpostR Syndrome



ImpostR Syndrome

ImpostR Syndrome

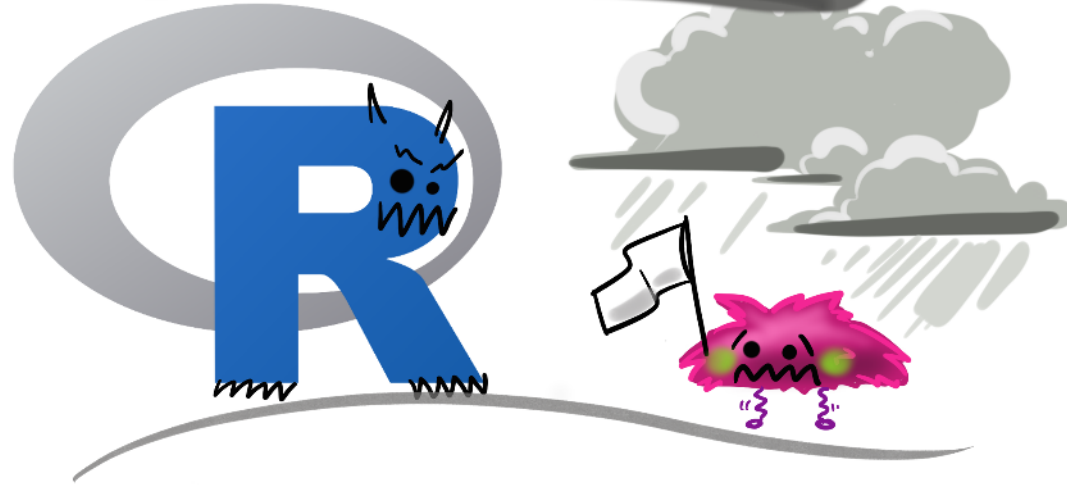


Impost^R
Syndrome

Moral of the story?

Make friends, code in groups, learn together and don't beat yourself up

at first I was like...



...but now it's like...



About R

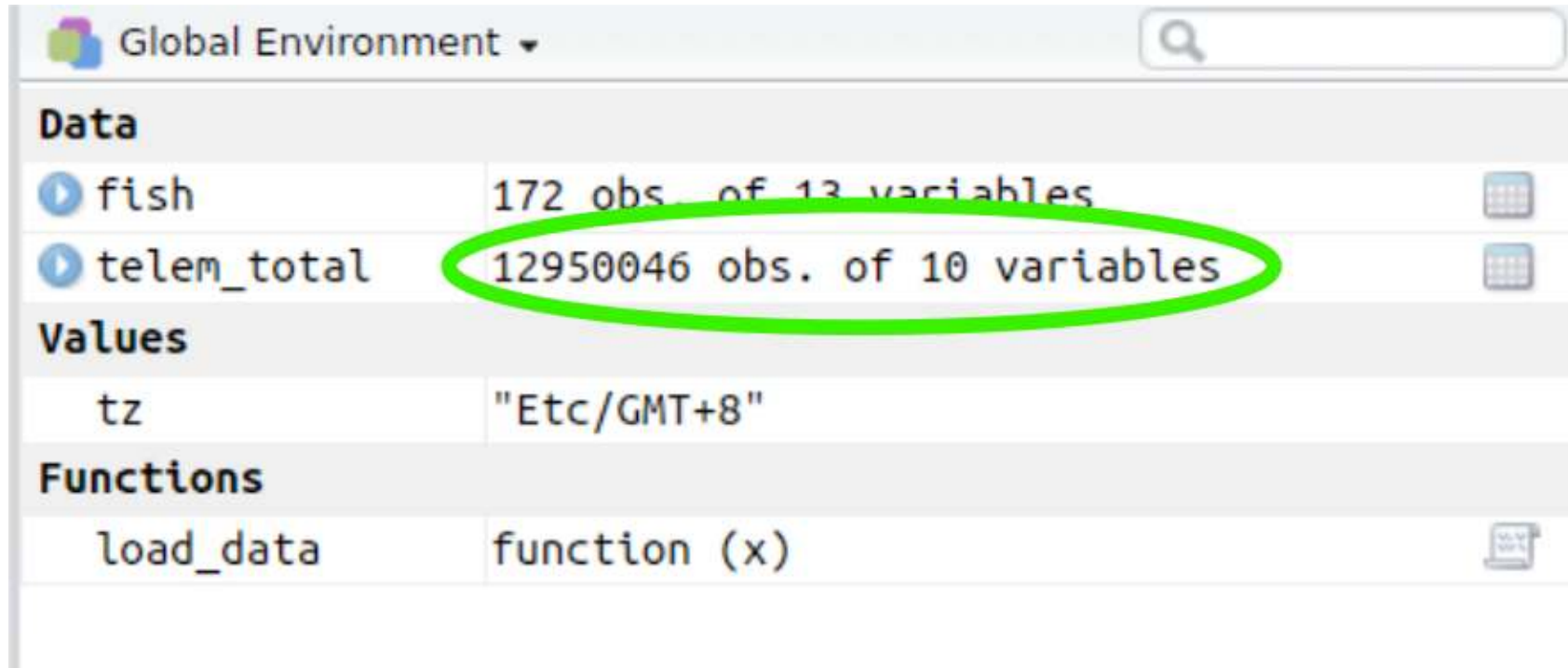
Why R?

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)!

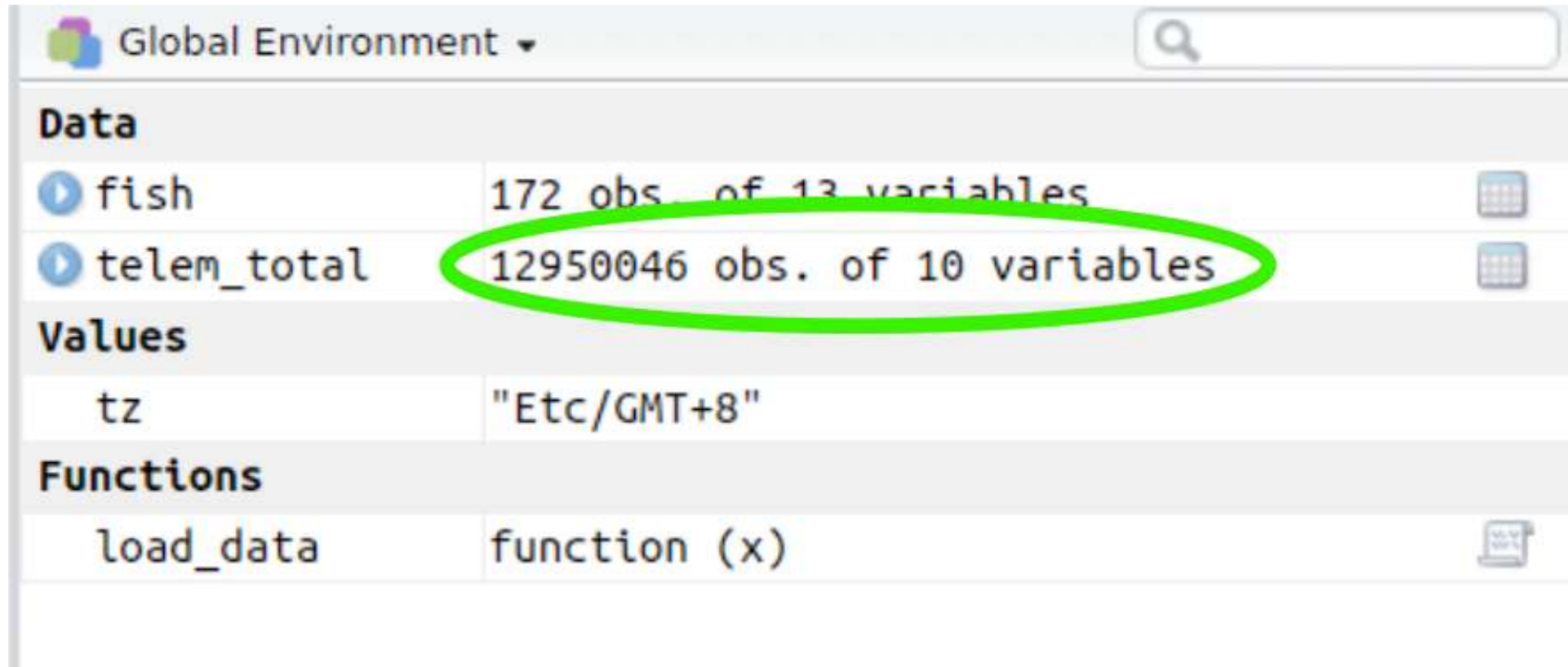


The screenshot shows the 'Global Environment' pane in an R IDE. It is divided into four sections: 'Data', 'Values', 'Functions', and 'load_data'. The 'Data' section lists two objects: 'fish' (172 obs. of 13 variables) and 'telem_total' (12950046 obs. of 10 variables). The 'Values' section shows 'tz' with the value 'Etc/GMT+8'. The 'Functions' section shows 'load_data' as a function (x). The 'telem_total' entry is circled in green.

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)!

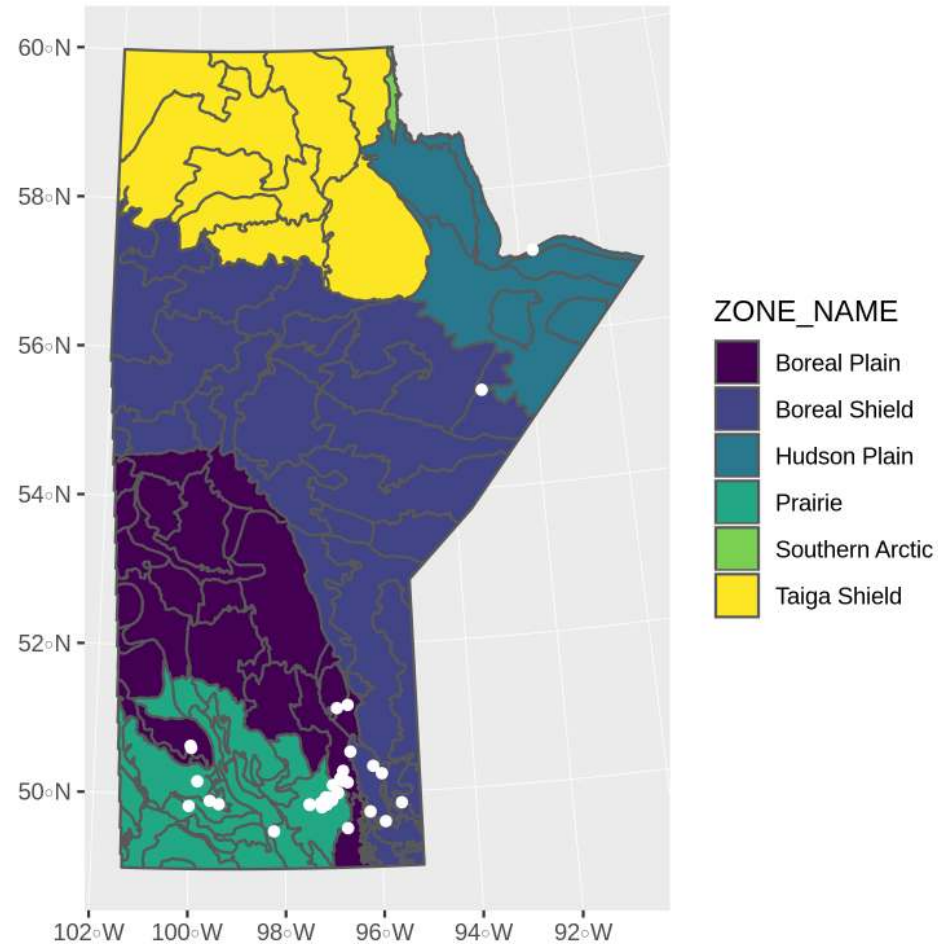


The screenshot shows the 'Global Environment' pane in an R IDE. It is divided into three sections: 'Data', 'Values', and 'Functions'. In the 'Data' section, two objects are listed: 'fish' with 172 observations and 13 variables, and 'telem_total' with 12950046 observations and 10 variables. The 'telem_total' entry is circled in green. The 'Values' section shows a single entry 'tz' with the value 'Etc/GMT+8'. The 'Functions' section shows a single entry 'load_data' which is a function of 'x'.

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?

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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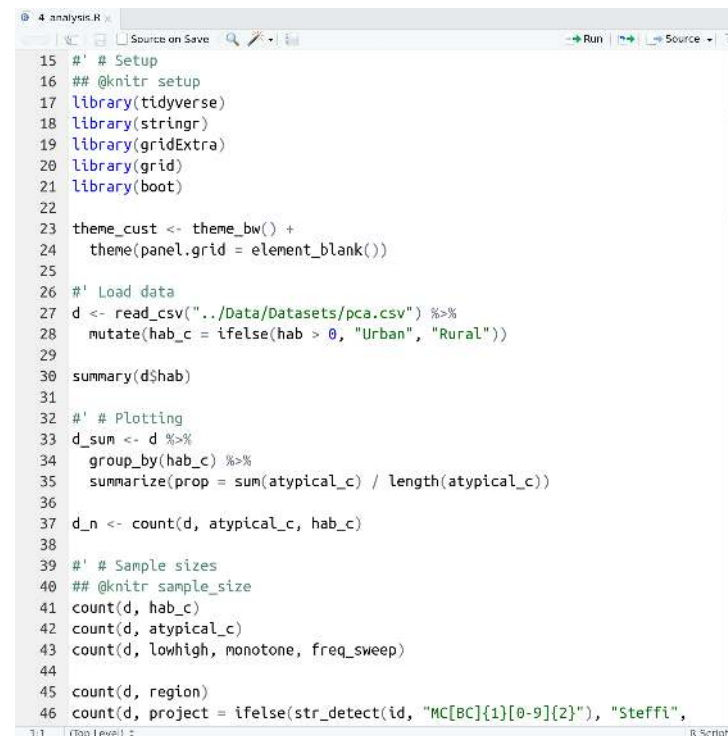
For example:

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

Code

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

Output



```
15 #' # Setup
16 ## @knitr setup
17 library(tidyverse)
18 library(stringr)
19 library(gridExtra)
20 library(grid)
21 library(boot)
22
23 theme_cust <- theme_bw() +
24   theme(panel.grid = element_blank())
25
26 #' Load data
27 d <- read_csv("../Data/Datasets/pca.csv") %>%
28   mutate(hab_c = ifelse(hab > 0, "Urban", "Rural"))
29
30 summary(d$hab)
31
32 #' # Plotting
33 d_sum <- d %>%
34   group_by(hab_c) %>%
35   summarize(prop = sum(atypical_c) / length(atypical_c))
36
37 d_n <- count(d, atypical_c, hab_c)
38
39 #' # Sample sizes
40 ## @knitr sample_size
41 count(d, hab_c)
42 count(d, atypical_c)
43 count(d, lowhigh, monotone, freq_sweep)
44
45 count(d, region)
46 count(d, project = ifelse(str_detect(id, "MC[BC]{1}[0-9]{2}"), "Steffi",
```

Script

RStudio vs. 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()
```

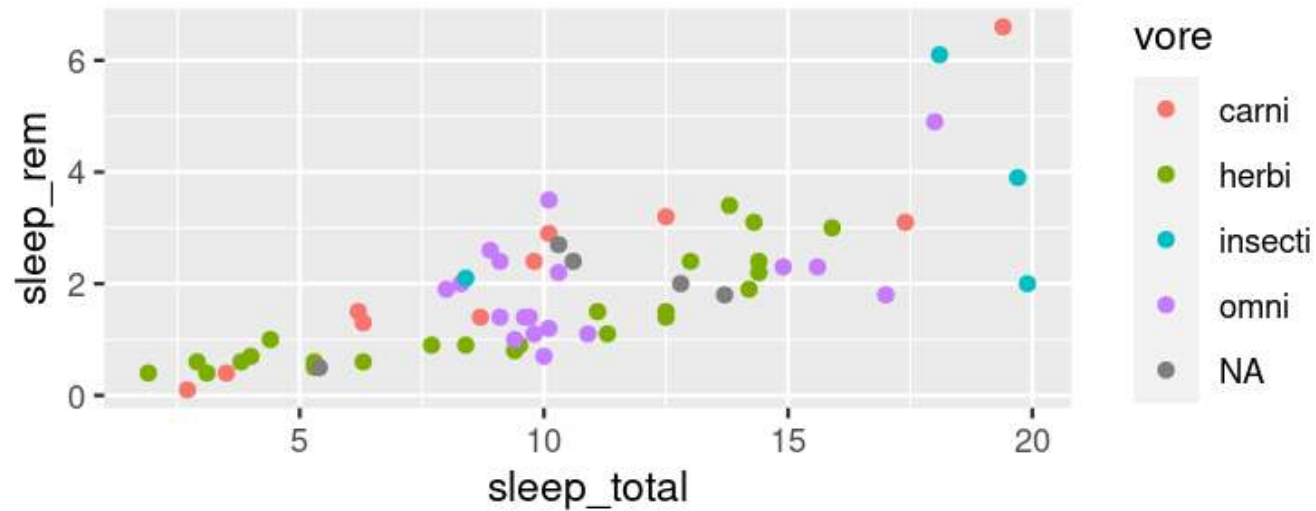
- Copy/paste or type this into the script window in RStudio
 - You may have to go to File > New File > R Script
- Click anywhere on the first line of code
- Use the 'Run' button to run this code, **or** use the short-cut **Ctrl-Enter**
 - Repeat until all the code has run

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()
```

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



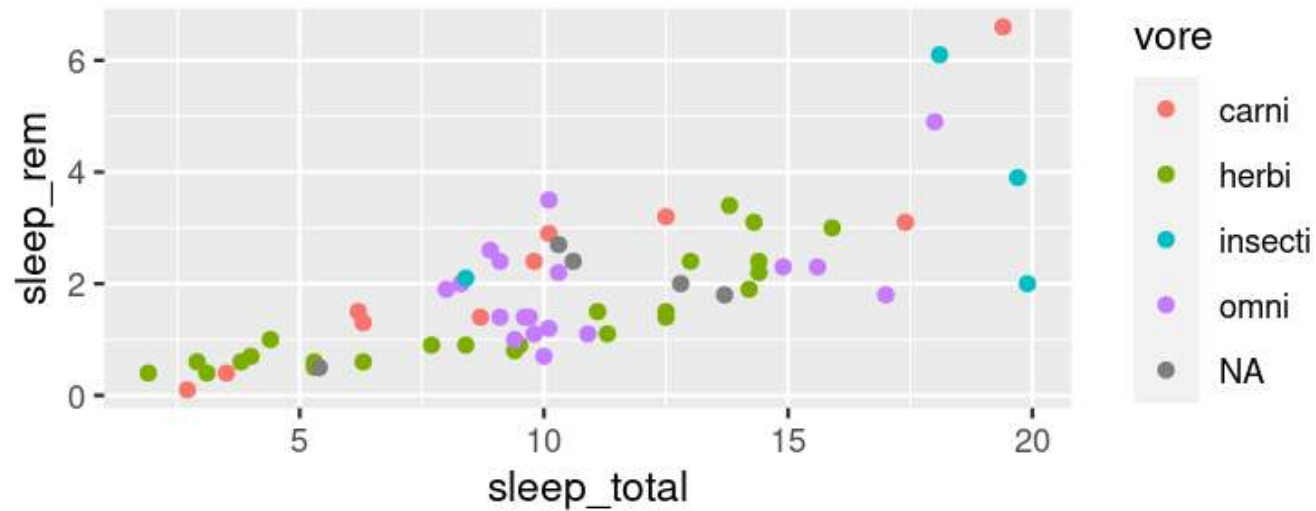
First Code

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

Package
tidyverse

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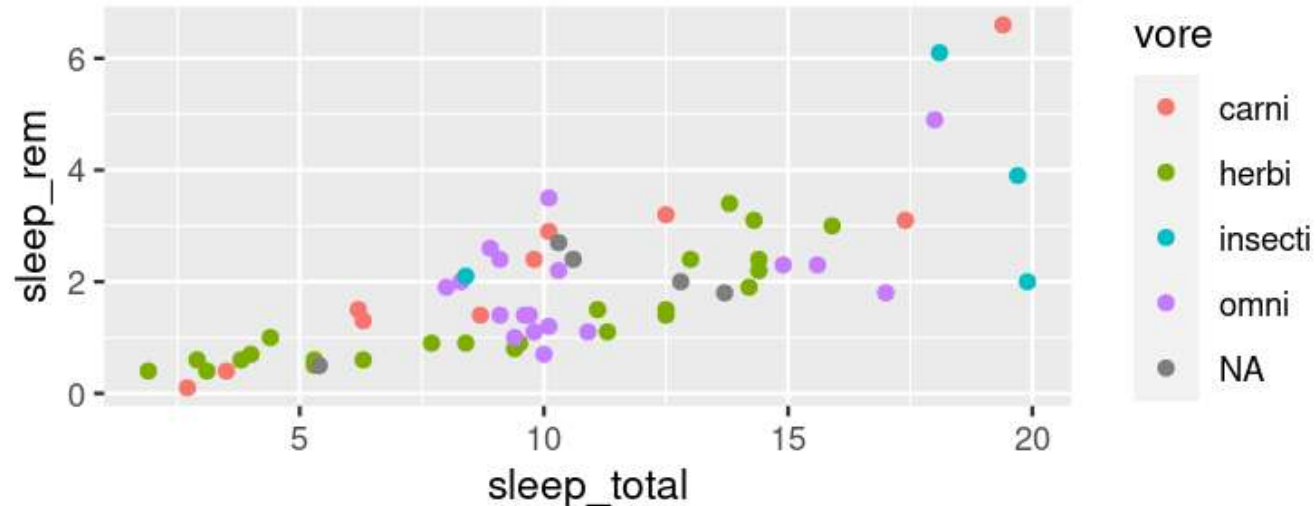
First Code

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

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

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



First Code

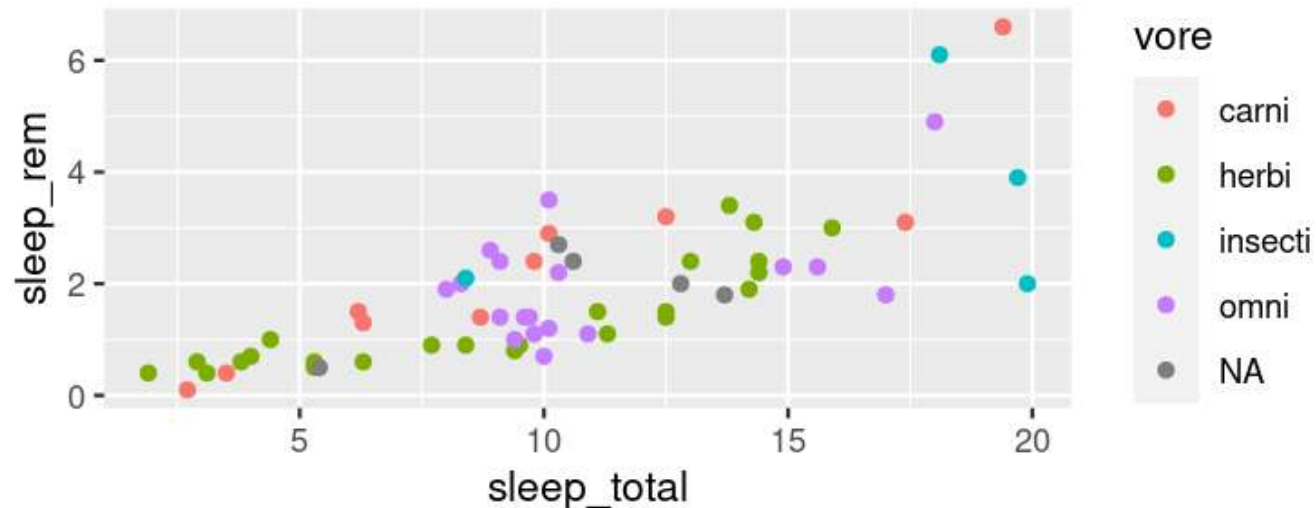
```
# First load the package  
library(tidyverse)
```

```
# Now create the figure
```

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

+
(Specific to **ggplot**)

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

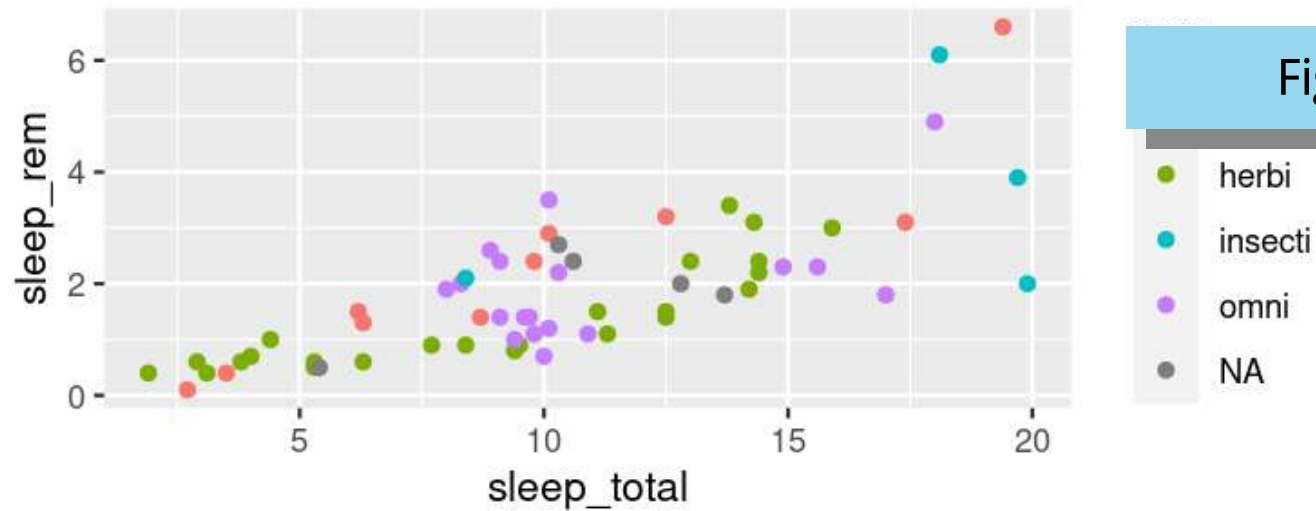


First Code

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

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

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



Figure!

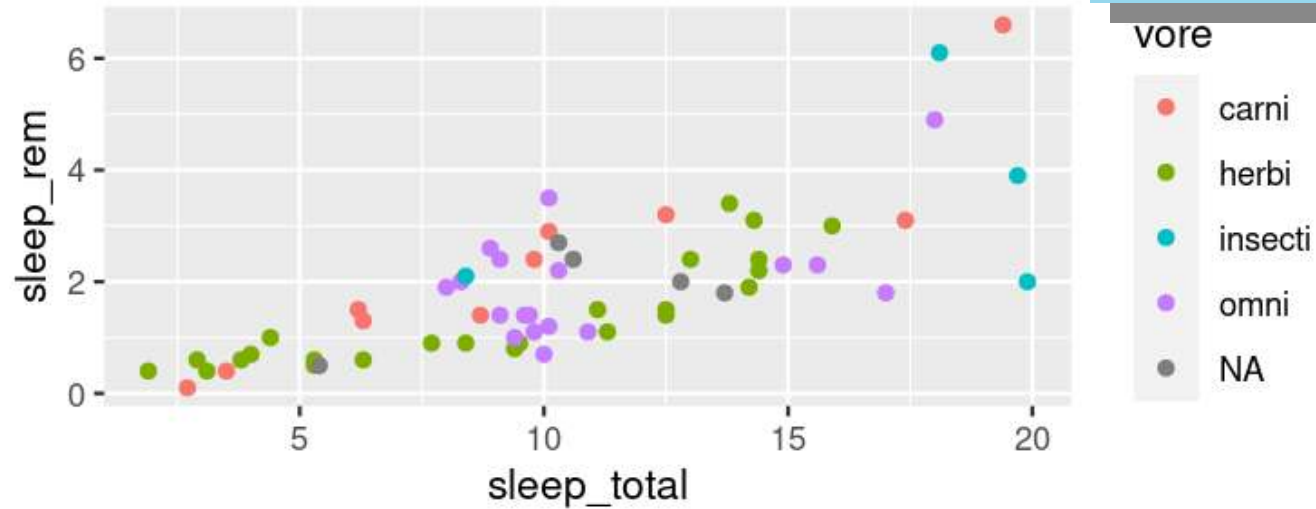
First Code

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

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

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

Warning



First Code

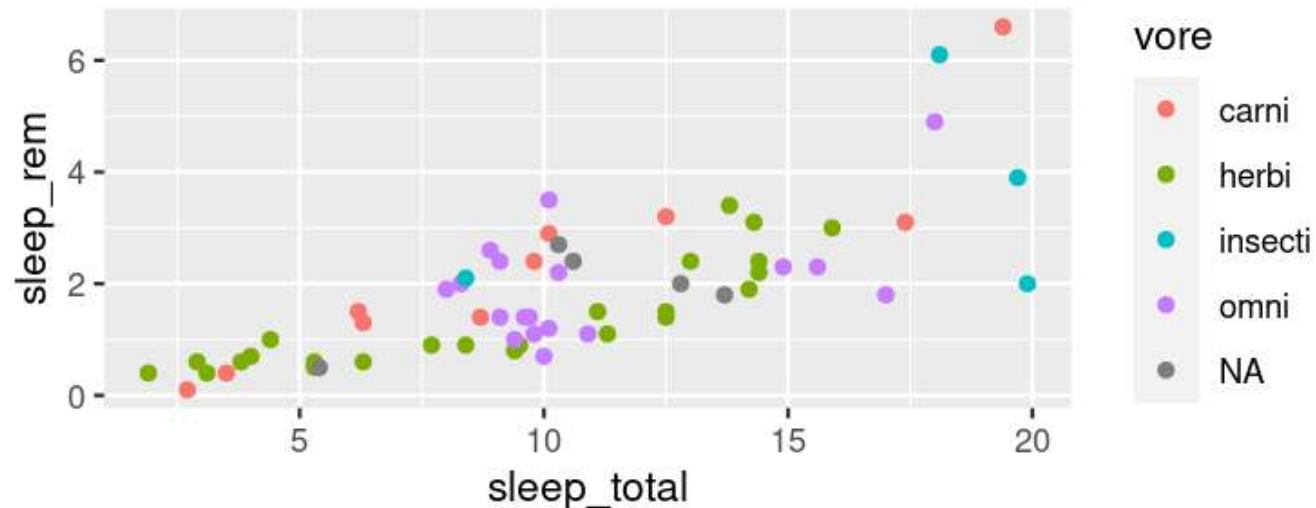
Comments

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

```
# Now create the figure
```

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

```
## 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
```

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()
```

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
```

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
```

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:

```
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
```

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

Where did **trim** come from?

R documentation

```
?mean
```

Your Turn:

Run this, what happens?
Do you see the **trim** argument?

?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 × 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 × 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"
```

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"
```


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 × 2
```

```
##       y z
```

```
##   <dbl> <chr>
```

```
## 1    101 a
```

```
## 2    102 b
```

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

```
my_vec <- c(1, 2, 3, 4, 5)  
my_vec
```

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

```
my_df <- data.frame(id = c("A", "B", "C"),  
                   age = c(25, 30, 35))  
my_df
```

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

```
wings <- c(10, 42, 18, 12, 54)
wings
```

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

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

```
sites <- data.frame(site = c("A1", "A2", "A3"),
                    vals = c(10, 51, 92))
sites
```

Miscellaneous

R has spelling and punctuation

- R cares about spelling
- R is also case sensitive! (**Apple** is not the same as **apple**)
- Commas 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
##                ^
```

R has spelling and punctuation

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

For example

This is correct:

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

>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] "2021-09-27"
```

Braces/Brackets

Round brackets: ()

- Run functions (even if there are no arguments)

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

```
## [1] "2021-09-27"
```

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

```
Sys.Date
```

```
## function ()  
## as.Date(as.POSIXlt(Sys.time()))  
## <bytecode: 0x55f2f227fa70>  
## <environment: namespace:base>
```

Braces/Brackets

Round brackets: ()

- Run functions (even if there are no arguments)

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

```
## [1] "2021-09-27"
```

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

```
Sys.Date
```

```
## function ()  
## as.Date(as.POSIXlt(Sys.time()))  
## <bytecode: 0x55f2f227fa70>  
## <environment: namespace:base>
```

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

(Well, *almost* always)

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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- R base is basic R
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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

Wrapping up: Further reading

- <http://www.cookbook-r.com>
- [R for Data Science](#)
- [R base cheatsheet](#)