

# Introduction to R

## Research Methods and Skills

01/10/2024

# Who are we?

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# Group A (PSY9219M) Skills Audit

We would like to invite you to complete the Research Method Skill Audit? This should take no longer than 4 minutes. The audit is important as it helps us to tailor our teaching and support to meet your learning needs.

All answers given are anonymous and are used to reflect on your statistical and programming skills, and for us to gauge what skills shortage need addressing so that we can help you to the best of our ability. Please use the link below to complete the short audit questionnaire!

<https://forms.office.com/e/Bdt3ZE59Fi>

# Group B (PSY9251M) Skills Audit

We would like to invite you to complete the Research Method Skill Audit? This should take no longer than 4 minutes. The audit is important as it helps us to tailor our teaching and support to meet your learning needs.

All answers given are anonymous and are used to reflect on your statistical and programming skills, and for us to gauge what skills shortage need addressing so that we can help you to the best of our ability. Please use the link below to complete the short audit questionnaire!

<https://forms.office.com/e/Bdt3ZE59Fi>

# Scenario A

You've just started work in a psychology lab. You're asked to help analyse some old data. There is reaction time data from 50 participants. Each participant's data is stored in a separate text file.

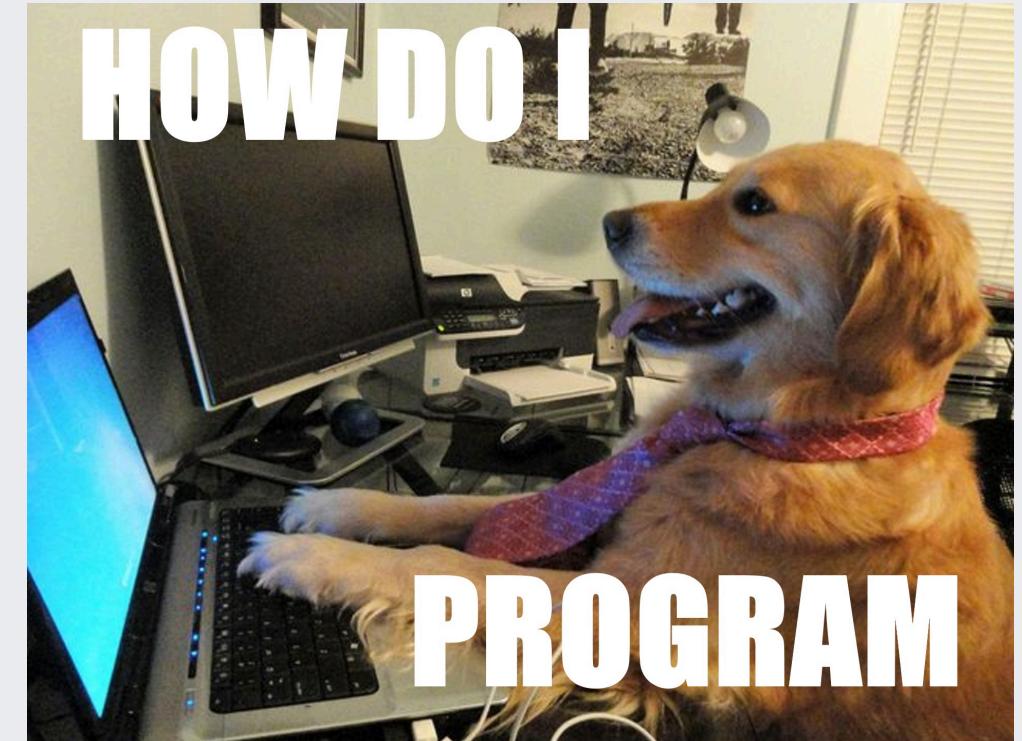
- How do you combine the data from each participant together to be able to analyse the data?
- It turns out some of the participants only completed part of the experiment - which ones, and what should you do with their data?
- What steps should you take to select and perform appropriate statistical analysis?

# Scenario B

You've been asked to design, implement, and evaluate a new treatment regime across several psychiatric institutes. Several colleagues are skeptical that it can deliver the kind of improvements in outcomes indicated in a publication describing the method.

- How do you interpret the strength of the previously published evidence?
- How do you design a rigorous test of the treatment efficacy?
- How do you evaluate and report on the outcomes of your trial?

# Research Methods and Skills



# Course outline

## Weeks 2-6

- Introduction to R
- Basic R programming
- Plotting with ggplot2
- Data import, selection and manipulation
- Describing and summarising your data

## Weeks 7-10

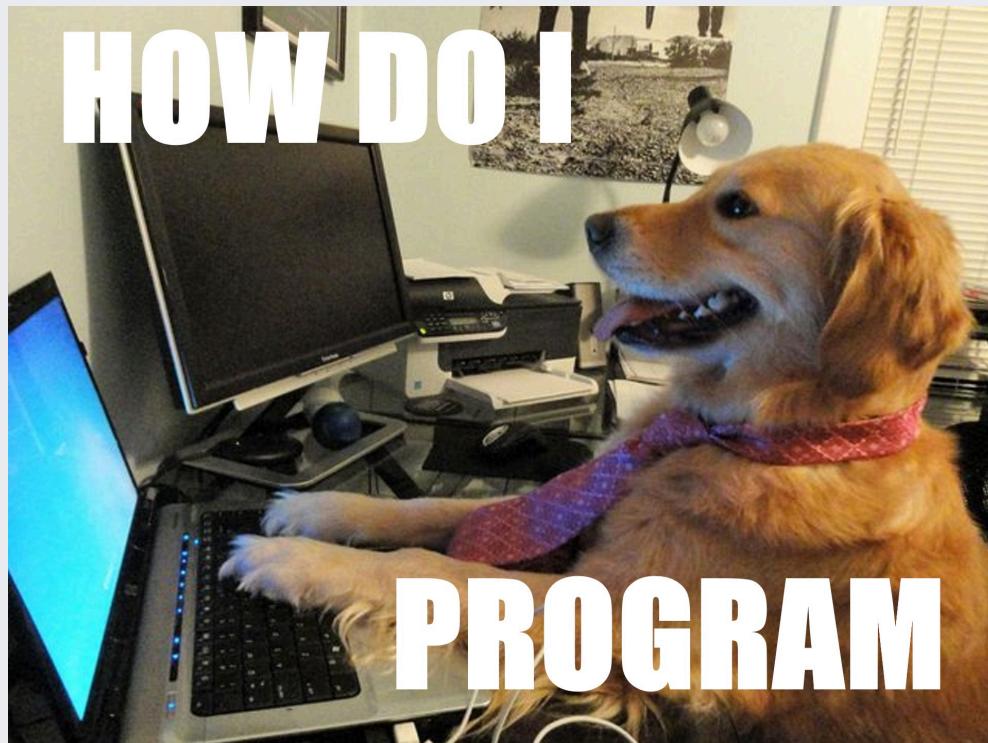
- Hypothesis testing and estimation
- *t*-tests and comparing two groups
- Correlation and linear regression
- One-way ANOVA
- Factorial ANOVA

## Weeks 11-16

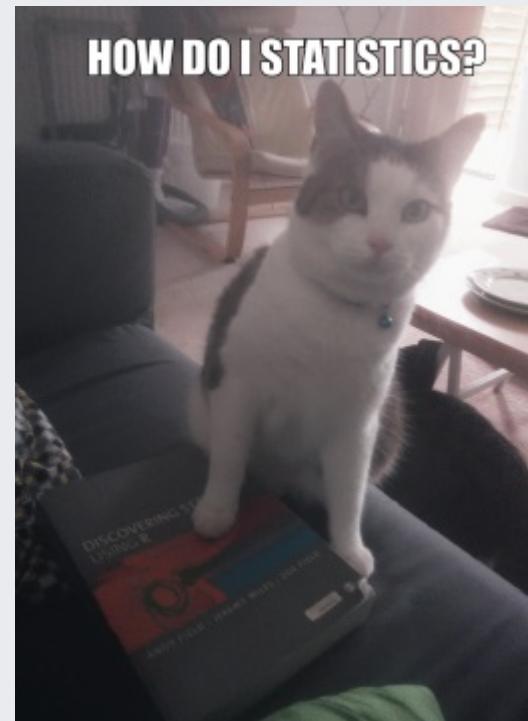
- Qualitative methods

# Course outline

Weeks 2-6

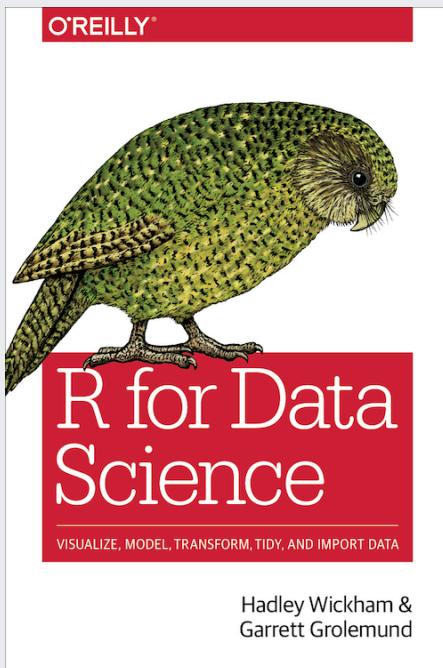


Weeks 7, 8-10

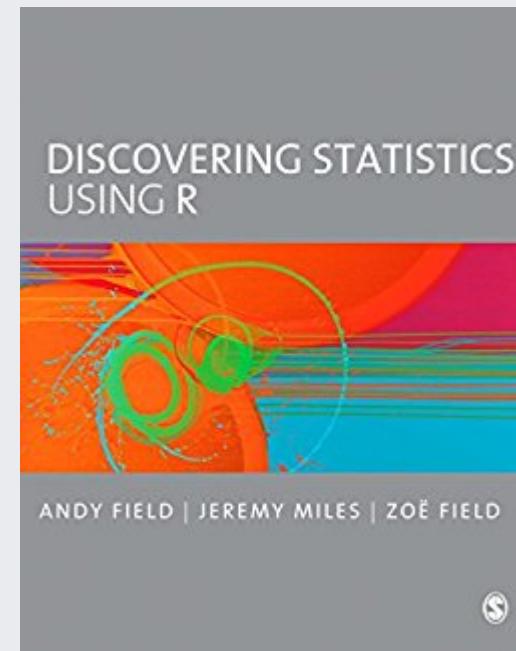


# Course outline

Weeks 2-6



Weeks 6-10



# Semester B - Advanced Research Methods and Skills (Course outline)

## Weeks 19-23

- Module Intro/Approaches to knowledge
- Generalisability and Open Science
- Systematic Literature Review
- Qual 1: Reflexivity/Intersectionality/Thematic analysis
- Qual 2: Thematic/Narrative analysis

## Weeks 24-29

- ANOVA/Linear Regression
- Logistic Regression
- Mixed effects regression
- Factor Analysis
- Handling large & messy datasets
- Visualisation/Review/Assessment Q&A

## Weeks 30-33

- Interpreting Results/Review/Assessment Q&A
- Optional drop-in

# How it's going to work

Where possible you'll be provided with a set of pre-recorded videos each week introducing the core topics for that week.

Most weeks you will be provided with some exercises to work on and complete formative assignment. The aim of the formative stage of the assignment is to enable you to produce an outline of your proposed summative for feedback from the module team.

In the timetabled sessions, we will spend the first hour (lecture) going over the topic for that week. In the second hour (workshop), you can spend the time working together on the exercises, and we'll be available to help out. You will finish up with a formative assignment for that week and receive a formative feedback before the next teaching session.

If you get stuck **ask us!**

# Introduction to R and RStudio

# What is R?

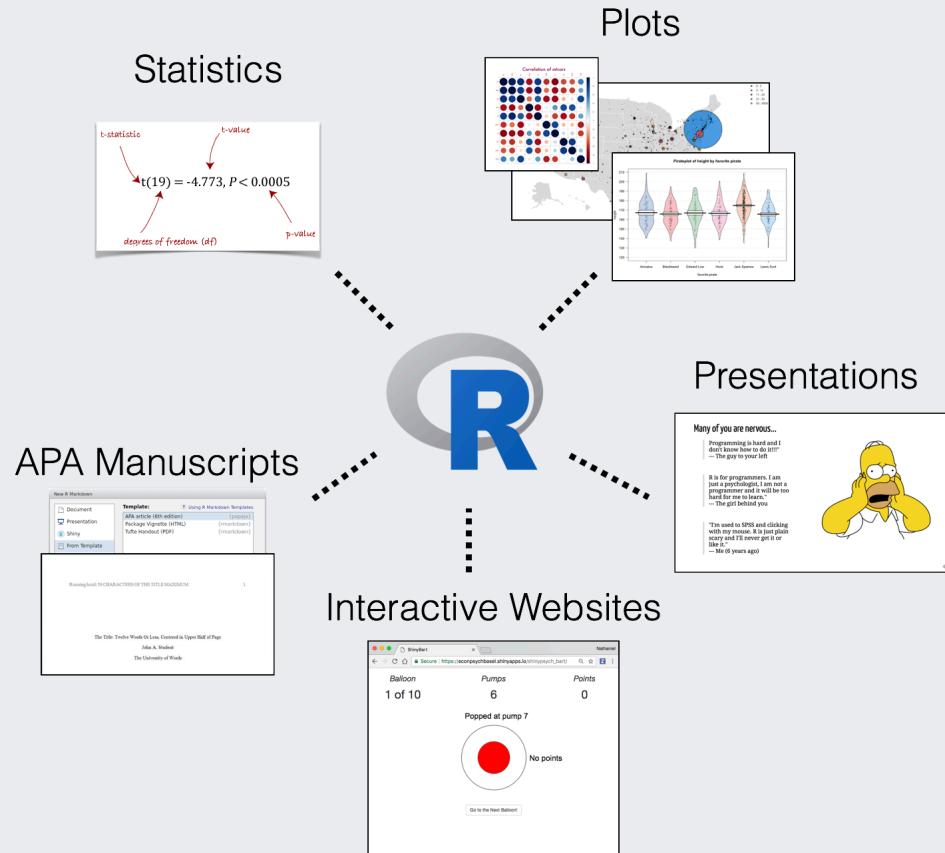


R is a statistical, mathematical programming language

- Created in 1993
- Designed from the ground up to support many statistical tasks
- Covers all aspects of data analysis from import through to production of reports
- Free, open source
  - Can be downloaded from the R-project website
- Continually evolving
  - R has over 12,000 *packages* that add additional functions

But WHY?

# What can you do with R?



Source: N. D. Phillips

# Companies that use R for Analytics



Gartner



TATA CONSULTANCY SERVICES



J.P.Morgan

Deloitte.

accenture

High performance. Delivered.



Booz | Allen | Hamilton

strategy and technology consultants

Cognizant



JOHN DEERE

BCG

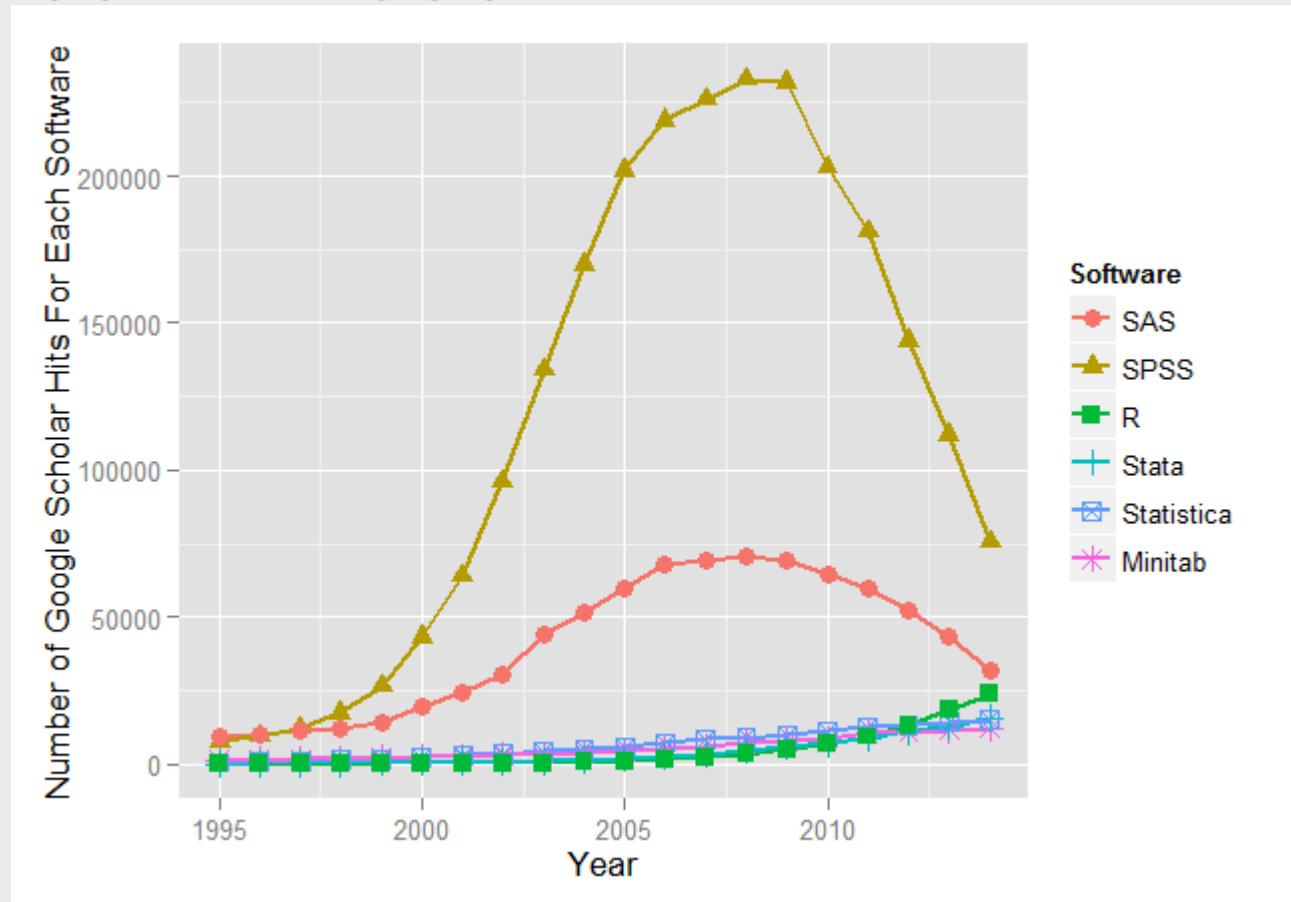
THE BOSTON CONSULTING GROUP

Tech Mahindra

IT Services and Telecom Solutions

HSBC

# Still not convinced?

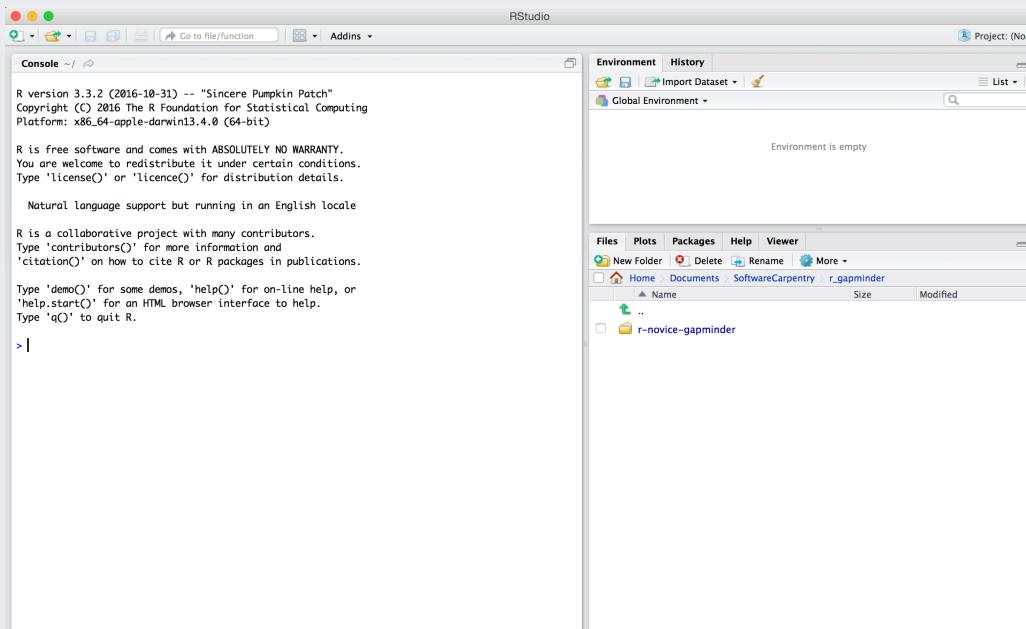


# Getting started

# What is RStudio?

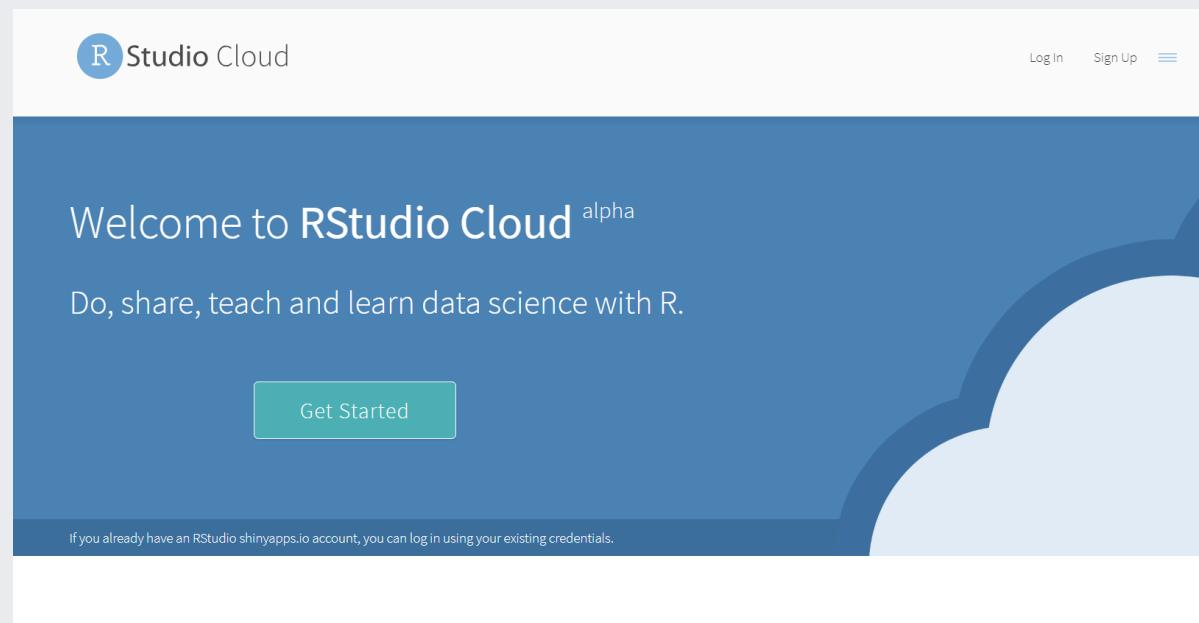


- An **Integrated Development Environment (IDE)**
- An interface for R that makes your life much, much easier
- Makes many things explicit that you would otherwise have to guess



# Getting started TODAY

1. Open up a web browser
2. Go to <https://rstudio.cloud>
3. Sign up! Use your REAL NAME, and your University of Lincoln email address.





## Spaces

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PSY9219M: Research Methods

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 By name By date created



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Go to file/function

Addins

R 3.5.0

Console Terminal Jobs

/cloud/project/

```
R version 3.5.0 (2018-04-23) -- "Joy in Playing"  
Copyright (C) 2018 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.
```

```
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.
```

&gt;

Environment History Connections



Global Environment

Environment is empty

Files Plots Packages Help Viewer

	Name	Size	Modified
<input type="checkbox"/>	..		
<input type="checkbox"/>	.Rhistory	0 B	Sep 18, 2018
<input type="checkbox"/>	project.Rproj	205 B	Sep 18, 2018

Your Workspace / Untitled Project Click to name your projectTochs  
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File Edit Code View Plots Session Build Debug Profile

Tools Help

Install Packages...

Check for Package Updates...

Version Control

Shell...

Terminal

Addins

Keyboard Shortcuts Help Shift+Alt+K

Modify Keyboard Shortcuts...

Project Options...

Global Options...

```
R version 3.5.0 (2018-04-23) -- "Joy in Playing"  
Copyright (C) 2018 The R Foundation for Statistical Computing  
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```

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```
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Type 'q()' to quit R.
```

&gt; |

R 3.5.0

Dataset Connections

Environment is empty

List

Search

Environment is empty

List

Search

Environment is empty

List

Search

New Folder Upload Delete Rename More

Cloud &gt; project

Name	Size	Modified
..		
.Rhistory	0 B	Sep 24, 2018, 11:53 AM
project.Rproj	205 B	Sep 24, 2018, 12:29 PM

RStudio Cloud

https://rstudio.cloud/project/84901

Your Workspace / Untitled Project Click to name your project

File Edit Code View Plots Session Build Debug Profile Tools Help

Console Terminal Jobs

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```
R version 3.5.0 (2018-04-23) --  
Copyright (C) 2018 The R Foundation  
Platform: x86_64-pc-linux-gnu (64-bit)
```

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'citation()' on how to cite R or  
R packages.

Type 'demo()' for some demos, 'help.start()' for an HTML browser.  
Type 'q()' to quit R.

> |

**Options**

**General**

RStudio theme: Modern

Editor Font size: 10

Appearance

Editor theme: Ambiance

Chaos

Chrome

Clouds Midnight

Clouds

Cobalt

Crimson Editor

Dawn

Dracula

Dreamweaver

Eclipse

Idle Fingers

Katzenmilch

Kr Theme

Material

Packages

R Markdown

Sweave

Spelling

Git/SVN

Publishing

Terminal

```
# plotting of R objects  
plot <- function (x, y, ...)  
{  
  if (is.function(x) &&  
      is.null(attr(x, "class")))  
  {  
    if (missing(y))  
      y <- NULL  
  
    # check for ylab argument  
    hasylab <- function(...)  
    !all(is.na(  
      pmatch(names(list(...)),  
             "ylab")))  
  
    if (hasylab(...))  
      plot.function(x, y, ...)  
  
    else  
      plot.function(  
        x, y,  
        ylab = paste(  
          deparse(substitute(x)),  
          "(x)",  
          ...)  
      )  
    else  
      UseMethod("plot")  
  }  
}
```

OK Cancel Apply

Tochi Onwuegbusi

R 3.5.0

List

Search

Empty

Renamer More

Size	Modified
0 B	Sep 24, 2018, 11:53 AM
205 B	Sep 24, 2018, 12:29 PM

# How it works!



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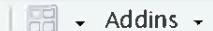
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Go to file/function



R 3.5.0

Console Terminal x Jobs x

/cloud/project/ ↵

```
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Type 'q()' to quit R.
```

&gt;

Environment History Connections



Global Environment

Environment is empty

Files Plots Packages Help Viewer



Cloud &gt; project

Name	Size	Modified
..		
.Rhistory	0 B	Sep 18, 2018
project.Rproj	205 B	Sep 18, 2018



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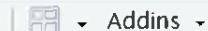
Terms and Conditions

System Status

File Edit Code View Plots Session Build Debug Profile Tools Help



Go to file/function



R 3.5.0

Console Terminal x Jobs x

/cloud/project/ ↵

```
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```

&gt;

Environment History Connections

Import Dataset ↵

Global Environment ↵

Environment is empty

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New Folder ↗ Upload ↗ Delete ↗ Rename ↗ More ↗

Cloud &gt; project

Name	Size	Modified
..		
.Rhistory	0 B	Sep 18, 2018

project.Rproj

205 B

Sep 18, 2018

REPL

# How to use R

- The R Console
  - REPL: Read/Evaluate/Print/Loop
  - Type stuff in, it tries to do it

When you see the > symbol -

```
>
```

... R is waiting for your input.

```
> 5  
[1] 5
```

# Warming up

Try using R like a calculator!

## Basic arithmetic operators

Symbol	Operation
+	addition
-	subtraction
*	multiplication
/	division
^	exponentiation
%%	modulo

# Warming up

You can break up long maths expressions over multiple lines:

```
2 + 4 + 5 +  
5 + 6 + 7 + 8 +  
10
```

```
## [1] 47
```

Note that when you do that, the ">" symbol changes to a "+"

```
> 5 +  
+ 5  
[1] 10
```

# Remember!

> means R is waiting for input.

```
>
```

+ means R is waiting for you to finish your command.

```
+
```

Either finish your command, or press the **Esc** key to cancel it.

# Text input

R can also accept text strings as input.

```
"hello world!"  
[1] "hello world!"
```

You need to use quotation marks ("") to tell R that this is text:

```
hello world!
```

```
## Error: <text>:1:7: unexpected symbol  
## 1: hello world  
##           ^
```

Otherwise, you'll receive an error like the one above.

# The assignment operator

In R, you can assign values to an **object** for subsequent use. **Objects** have names that are written as text.

The assignment operator is the two-character symbol:

```
<-
```

You assign values to objects by putting the <- sign between the name of the object and the value you want to give it:

```
example <- 5  
example
```

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

Note that R does not immediately provide output when you assign the output to an object.

# The assignment operator

Think of `<-` as meaning "is now". i.e.

```
example <- 5
```

can be read as

```
The object "example" is now 5
```

# Working with objects

Once an object is assigned, the name that you gave it *stands in* for the *value* that you assigned to it, and can be used as if it were that value:

example

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

example + 10

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

example + 13 - 1 \* 2 %% 4

```
## [1] 16
```

RStudio Cloud

https://rstudio.cloud/project/84901

Your Workspace / Untitled Project Click to name your project

File Edit Code View Plots Session Build Debug Profile Tools Help

+ Go to file/function Addins R 3.5.0

Console Terminal Jobs

/cloud/project/

```
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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.

>
> example <- 10
> hi_there <- "hi there!"
> hi_there
[1] "hi there!"
> example
[1] 10
>
```

Environment History Connections

Import Dataset

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Values
example 10
hi_there "hi there!"

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New Folder Upload Delete Rename More

Cloud > project

Name	Size	Modified
..		
.Rhistory	0 B	Sep 24, 2018, 11:53 AM
project.Rproj	205 B	Sep 24, 2018, 1:06 PM

# Environment

The screenshot shows the RStudio Cloud interface. The top navigation bar includes tabs for 'Your Workspace' and 'Untitled Project'. The main menu bar has options like File, Edit, Code, View, Plots, Session, Etc, Editor, Projects, Help, and Admins. A toolbar with various icons is at the top right. The console tab is active, displaying the R startup message and a history of commands entered by the user. The environment pane, which is highlighted with a red box, shows the 'Global Environment' with two variables: 'example' (value: 10) and 'hi\_there' (value: "hi there!"). Below the environment pane is the file browser, showing a 'Cloud > project' folder with files '.Rhistory' (0 B, Sep 24, 2018, 11:53 AM) and 'project.Rproj' (205 B, Sep 24, 2018, 1:06 PM). The bottom status bar indicates 'R 3.5.0'.

```
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'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

>
> example <- 10
> hi_there <- "hi there!"
> hi_there
[1] "hi there!"
> example
[1] 10
>
```

R RStudio Cloud

https://rstudio.cloud/project/84901

Your Workspace / Untitled Project \* Click to name your project

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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.

> > example <- 10
> hi_there <- "hi there!"
> hi_there
[1] "hi there!"
> example
[1] 10
>
```

Environment History Connections

To Console To Source

```
example <- 10
hi_there <- "hi there!"
hi_there
example
```

Files Plots Packages Help Viewer

.Rhistory 0 B Sep 24, 2018

project.Rproj 205 B Sep 24, 2018

# History

Try it out!

# Let's try a few things out!

1. Assign some values to objects using the assignment operator (<-)
2. Try using arithmetic operations (e.g. \*, /, %%) on those objects
3. Try using arithmetic operations to combine multiple numerical objects
4. Try using arithmetic operations on text

# Combining multiple things

Sometimes you want to allocate more than one value to an object. You can use the **c()** function to do this.

```
c(8, 5, 10)
```

```
## [1] 8 5 10
```

```
example <- c(8, 5, 10)  
example
```

```
## [1] 8 5 10
```

```
c("hello", "how", "are", "you")
```

```
## [1] "hello" "how"   "are"    "you"
```

**IMPORTANT: BRACKETS () AFTER A WORD MEAN THAT THIS IS A FUNCTION**

# Vectors

The function **c()** is creating **vectors**.

Vectors are simply a one-dimensional collection of things that all have the same *type* (we will cover data types next week!).

Note that mixing, for example, text and numbers, will yield a *character* vector.

```
c(5, "five", 2)
```

```
## [1] "5"     "five"   "2"
```

# Functions

Functions are commands that operate on **objects**.

For example, to calculate the *mean* of several numbers, you can use the function **mean()**. The output of functions can also be assigned to **objects** using **<-**.

```
mean(c(8, 5, 10))  
## [1] 7.666667  
  
example <- c(8, 5, 10)  
mean(example)  
  
## [1] 7.666667  
  
example_mean <- mean(example)  
example_mean  
  
## [1] 7.666667
```

# Let's try it out!

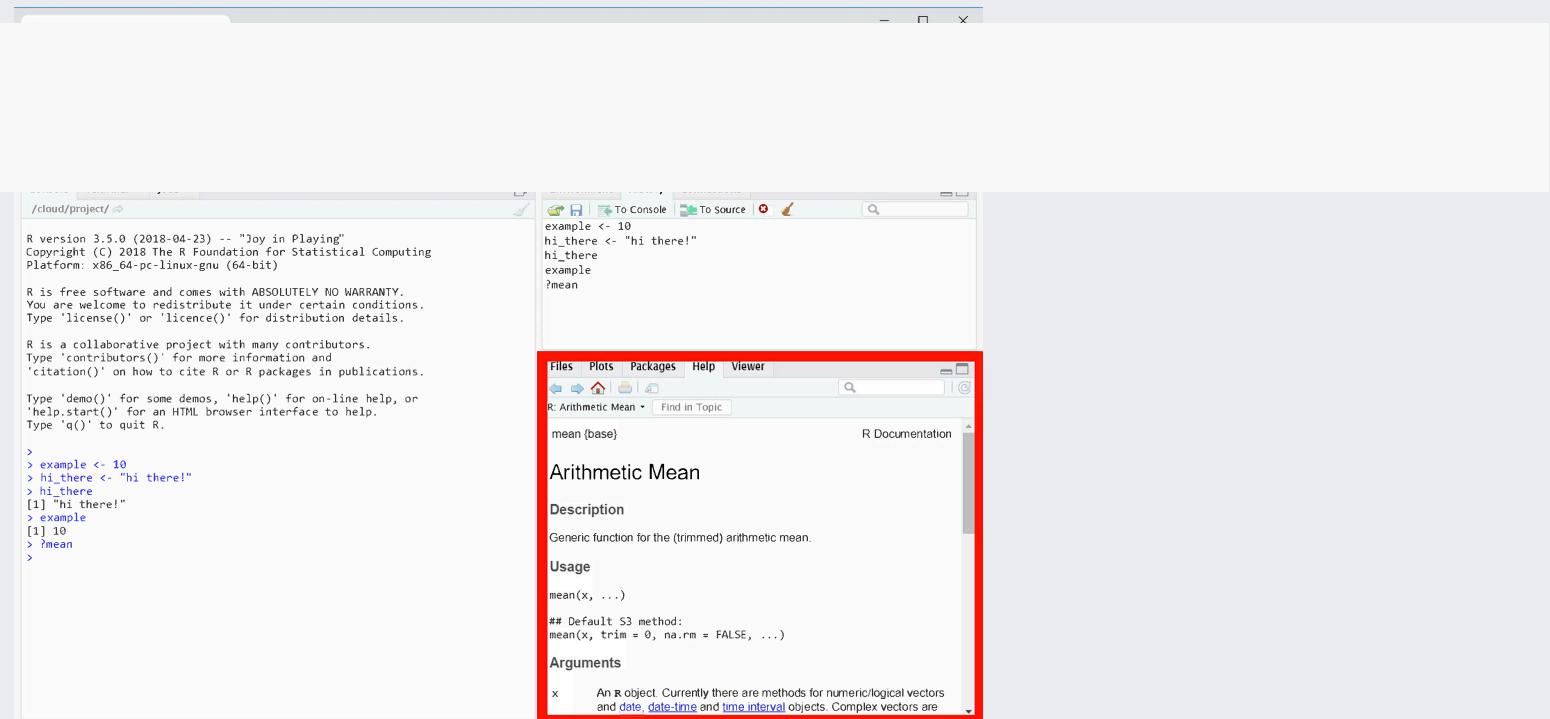
1. Use **c()** to create a vector of numbers.
2. Use **c()** to create a vector of strings.
3. Calculate the **mean()** of a vector of numbers.
4. Try guessing some other simple statistics (e.g. other types of *average*) that you can use.

# Getting help

If you don't know how to use a function, R has built-in help!

There are several ways you can access it:

```
help("mean")
?mean
??mean
```



# Packages

Packages are the key to R's versatility. Over 14000 are currently available from the **Comprehensive R Archive Network** - CRAN. The `install.packages()` function can be used to install packages.

Let's install the "cowsay" package. **cowsay** is an extraordinarily useful package, as you'll see.

One way to install the package is using the console:

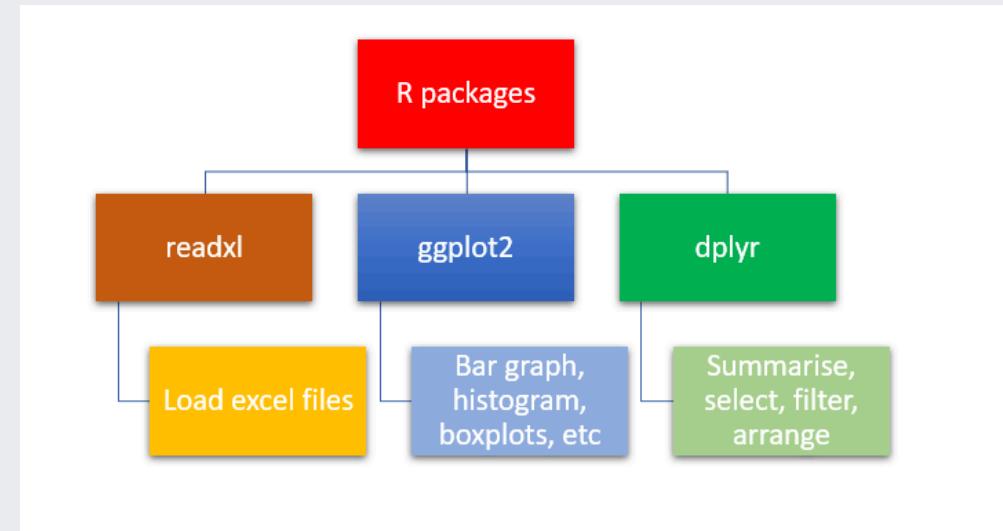
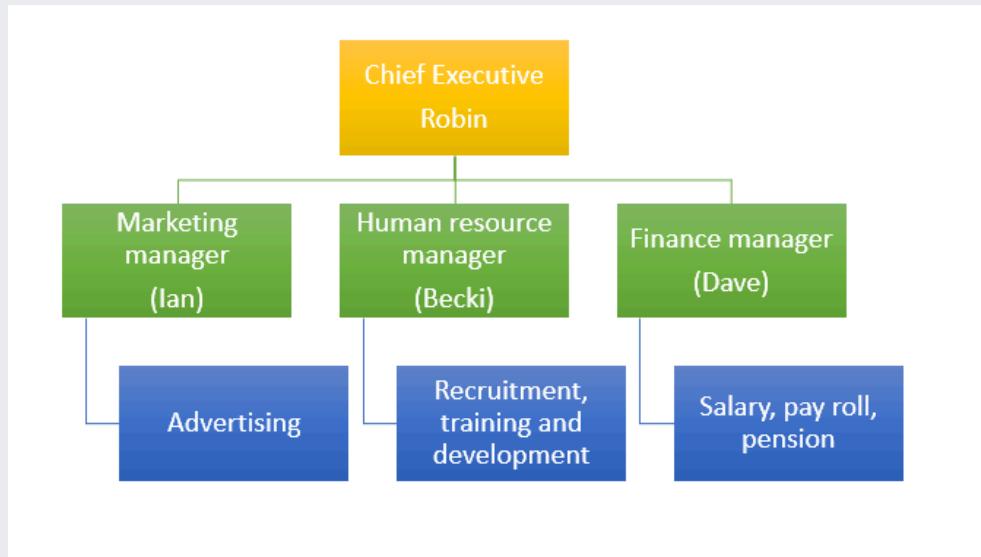
```
install.packages("cowsay")
```

Once it's installed, use the `library()` function to load the package!

```
library(cowsay)
```

But **another** way to install is using the GUI!

# Still on Packages



The image on the left is an example organisational structure of Tochs and Charlotte Plc. The second layer shows different departmental heads and their responsibilities on the third layer. If you need a query about salary, you go to the Finance manager rather than Marketing Manager. If the finance department fail to release salary, workers won't get paid.

In R, packages follow the same principle. You can't write a code to plot a barchart without first installing and loading ggplot2 package. Certain functions in R are executed using relevant packages. Image on the right shows example packages used in R and what they are use for.

RStudio Cloud

https://rstudio.cloud/project/84901

Your Workspace / Untitled Project

File Edit Code View Plots Session Build Debug Profile Tools Help

Console Terminal Jobs

/cloud/project/

```
R version 3.5.0 (2018-04-23) -- "Joy in Playing"
Copyright (C) 2018 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.

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.

>
> example <- 10
> hi_there <- "hi there!"
> hi_there
[1] "hi there!"
> example
[1] 10
> ?mean
>
```

Environment History Connections

To Console To Source

```
example <- 10
hi_there <- "hi there!"
hi_there
example
?mean
```

Files Plots Packages Help Viewer

Install Update Packrat

Name	Description	Version
boot	Bootstrap Functions (Originally by Angelo Canty for S)	1.3-20
class	Functions for Classification	7.3-14
cluster	"Finding Groups in Data": Cluster Analysis Extended Rousseeuw et al.	2.0.7-1
codetools	Code Analysis Tools for R	0.2-15
compiler	The R Compiler Package	3.5.0
datasets	The R Datasets Package	3.5.0
foreign	Read Data Stored by 'Minitab', 'S', 'SAS', 'SPSS', 'Stata', 'Systat', 'Weka', 'dBase', ...	0.8-70
graphics	The R Graphics Package	3.5.0
grDevices	The R Graphics Devices and Support for Colours and Fonts	3.5.0
grid	The Grid Graphics Package	3.5.0
KernSmooth	Functions for Kernel Smoothing Supporting Wand & Jones (1995)	2.23-15
lattice	Trellis Graphics for R	0.20-35
MASS	Support Functions and Datasets for Venables and Ripley's MASS	7.3-49

RStudio Cloud

https://rstudio.cloud/project/84901

Your Workspace / Untitled Project + Click to name your project

Tochs onwuegbusi

File Edit Code View Plots Session Build Debug Profile Tools Help

Console Terminal Jobs

/cloud/project/

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Type 'q()' to quit R.

```
>
> example <- 10
> hi_there <- "hi there!"
> hi_there
[1] "hi there!"
> example
[1] 10
> ?mean
>
```

Install Packages

Install from: Repository (CRAN, RSPM) Configuring Repositories

Packages (separate multiple with space or comma): cowsay

cowsay Library: /home/rstudio-user/R/x86\_64-pc-linux-gnu-library/3.5 [Default]

Install dependencies

Install Cancel

Environment History Connections

example <- 10  
hi\_there <- "hi there!"  
hi\_there  
example  
?mean

Packrat

	Description	Version
Bootstrap Functions (Originally by Angelo Canty for S)	1.3-20	
Functions for Classification	7.3-14	
"Finding Groups in Data": Cluster Analysis Extended Rousseeuw et al.	2.0.7-1	
Code Analysis Tools for R	0.2-15	
The R Compiler Package	3.5.0	
The R Datasets Package	3.5.0	
Read Data Stored by 'Minitab', 'S', 'SAS', 'SPSS', 'Stata', 'Systat', 'Weka', 'dBase', ...	0.8-70	
The R Graphics Package	3.5.0	
The R Graphics Devices and Support for Colours and Fonts	3.5.0	
The Grid Graphics Package	3.5.0	
Functions for Kernel Smoothing Supporting Wand & Jones (1995)	2.23-15	
Trellis Graphics for R	0.20-35	
Support Functions and Datasets for Venables and Ripley's MASS	7.3-49	

# Let's try out the cowsay package

**cowsay** adds a function called **say()**. Load the package in as follows, and look at the help for **say()**.

```
## Warning: package 'cowsay' was built under R version 4.2.2
```

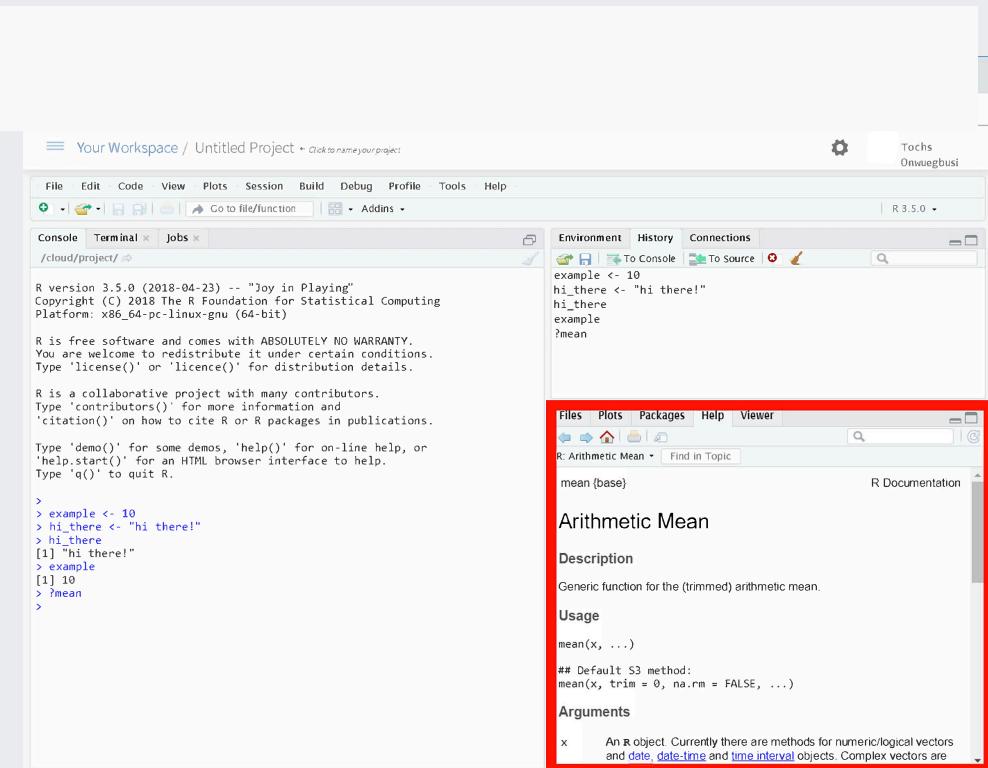
```
library(cowsay)
?say()
```

Remember that help appears in the bottom right window!

Look at **Usage** and **Arguments**

**Usage** is how to use the function.

**Arguments** are what the functions expect and understand.

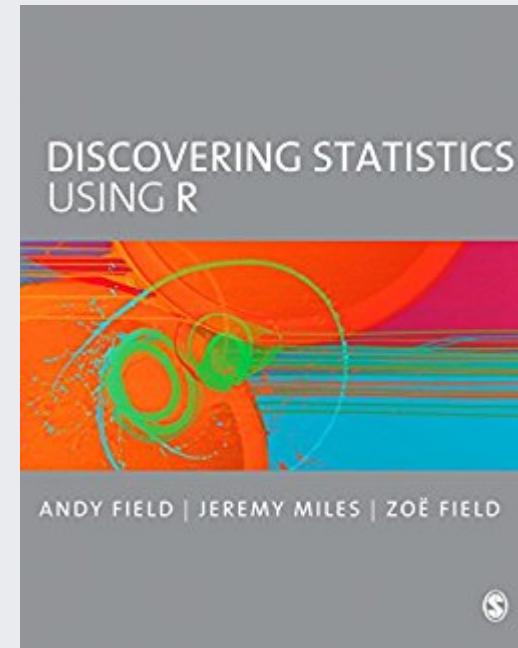
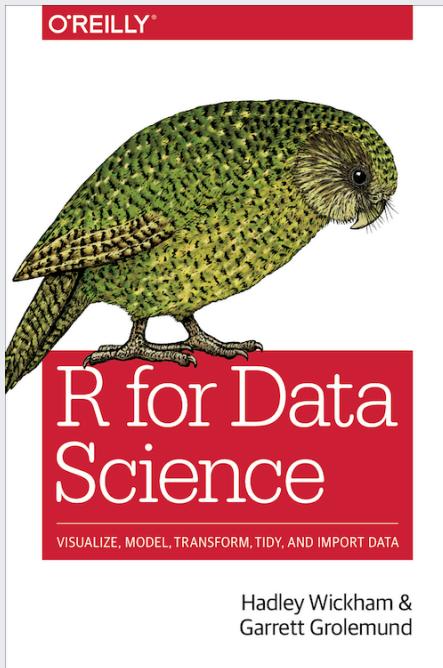


```
say(what = "Feed me, human.", by = "cat")
```

# Try out the say() function

1. Try a few different animals by changing the **by** argument
2. Change what the animals say by changing the **what** argument.

# Additional resources



There are copies of both these books in the library.

R for Data Science is available freely online at <http://r4ds.had.co.nz/>

# An additional recommendation...

## Hands-on Programming with R

Basic R programming book, also available for free online

<https://rstudio-education.github.io/hopr/index.html>



# This week's goals

1. Download R and RStudio! You'll find links and instructions on Blackboard.
2. Read through Chapter 1 of R for Data Science
3. Try out some of the introductory things mentioned in the slides, just to get a feel for using RStudio!