



UNIVERSITY OF
LINCOLN

PSY9219M - Research Methods and Skills

Dr Matt Craddock

25/09/2018

Who am I?



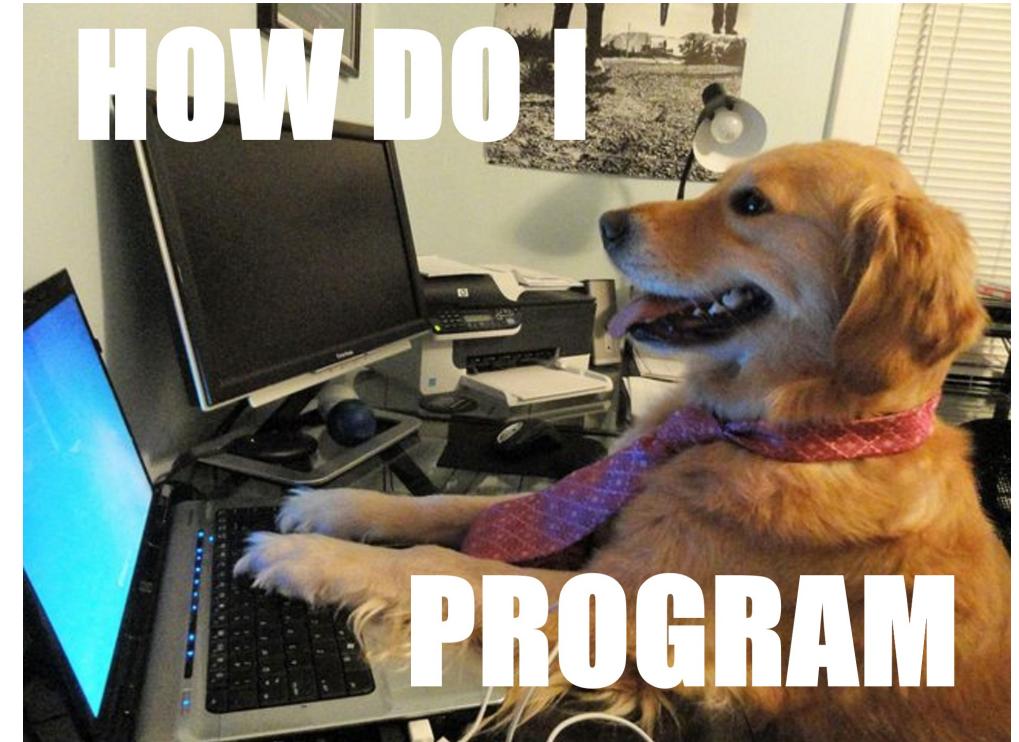
Dr Matt Craddock

- Research background in cognitive neuroscience
 - EEG, fMRI, non-invasive brain stimulation
- Programming in R, Matlab, Python
- Past experience with SPSS, SigmaPlot, Excel

Sarah Swift Building Room 2226

mcraddock@lincoln.ac.uk

PSY9219M - Research Methods and Skills



Course outline

Weeks 1-5

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

Weeks 5-6, 8-10

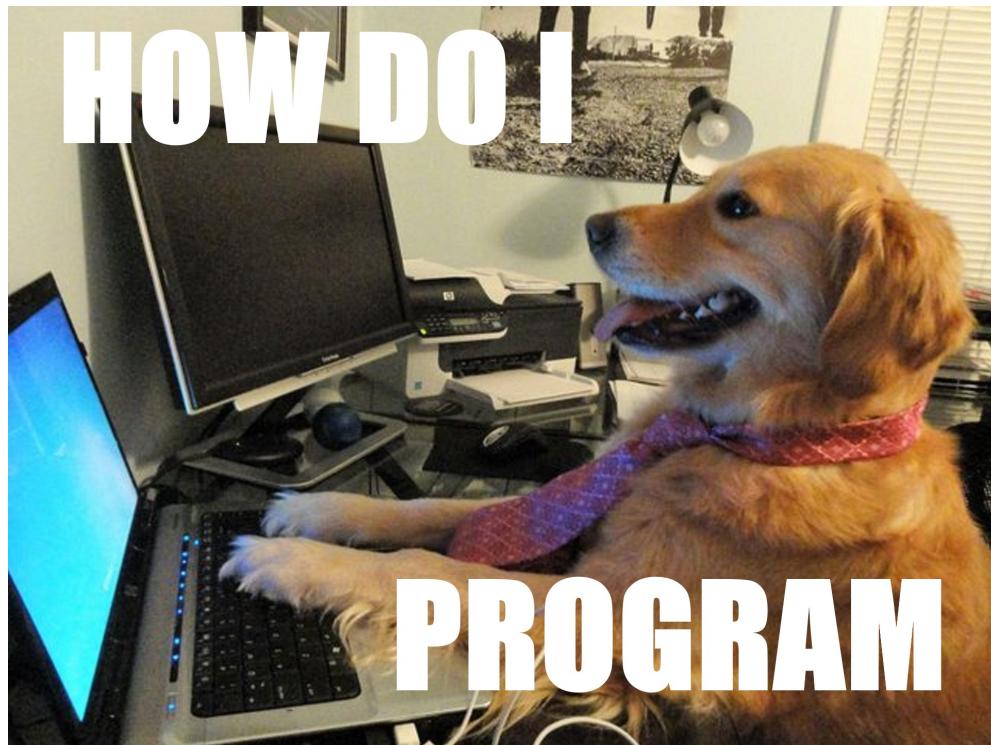
- Hypothesis testing and estimation
- *t*-tests and comparing two groups
- Correlation and linear regression
- One-way ANOVA
- Factorial ANOVA

Weeks 11-13

- Qualitative methods

Course outline

Weeks 1-5

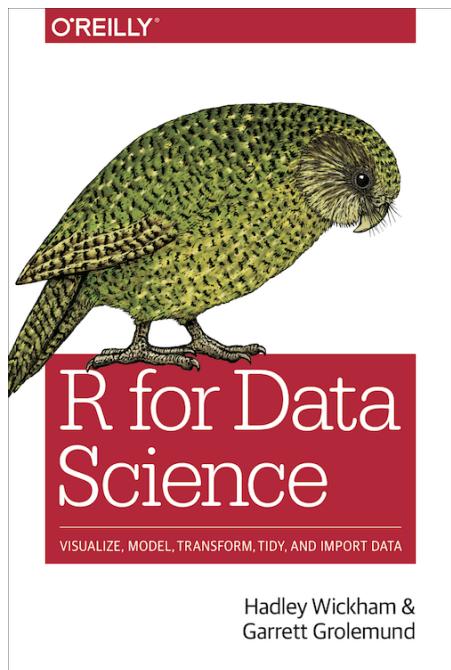


Weeks 5-6, 8-10

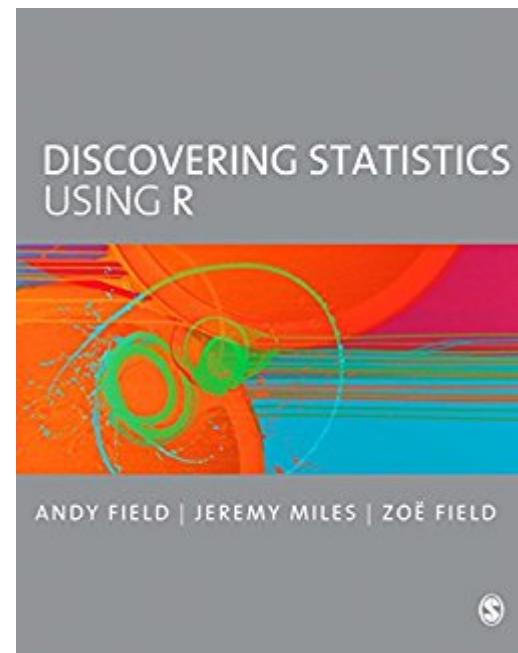


Course outline

Weeks 1-5



Weeks 5-10



Introduction to R and RStudio

What is R?

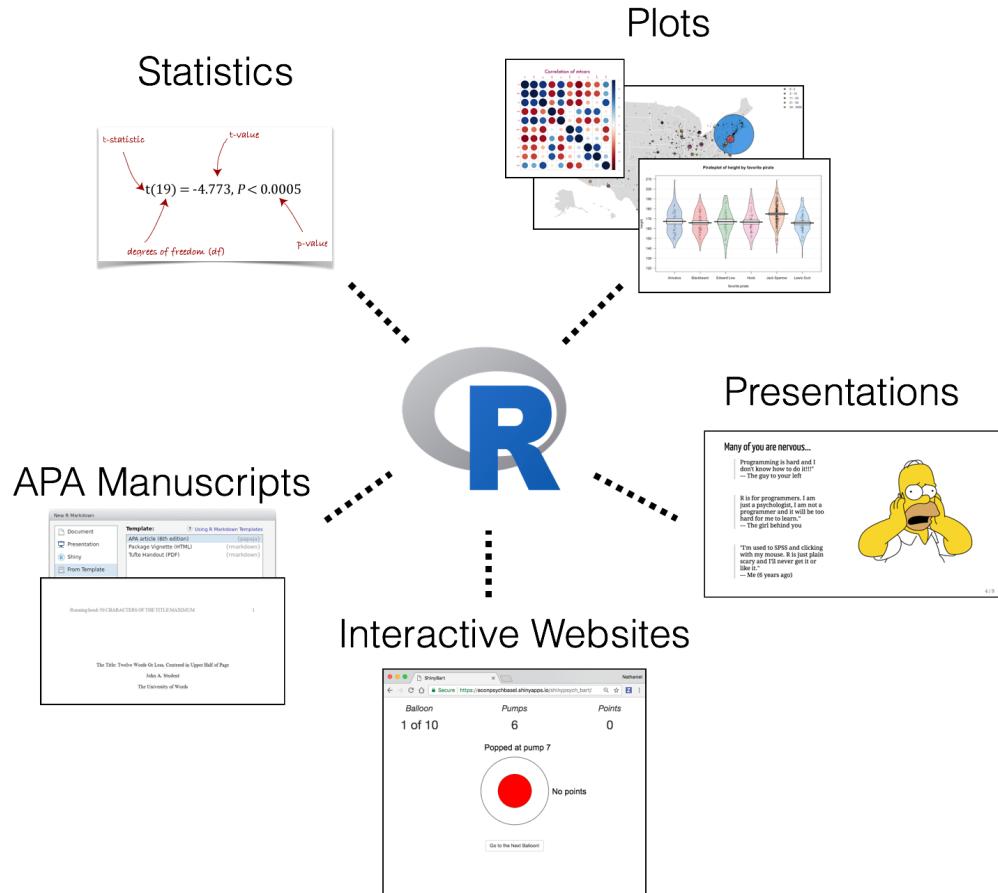


R is a statistical, mathematical programming language

- 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?



Companies that use R for Analytics



ORBITZ

McKinsey&Company

KPMG



Gartner



trulia

Mindtree
Welcome to possible

genpact



UBER



iTOPS for Business Outcomes



TATA CONSULTANCY SERVICES



Morgan Stanley

J.P.Morgan

The New York Times



Deloitte.

accenture

High performance. Delivered.



snapdeal

Booz | Allen | Hamilton

strategy and technology consultants

Cognizant



JOHN DEERE

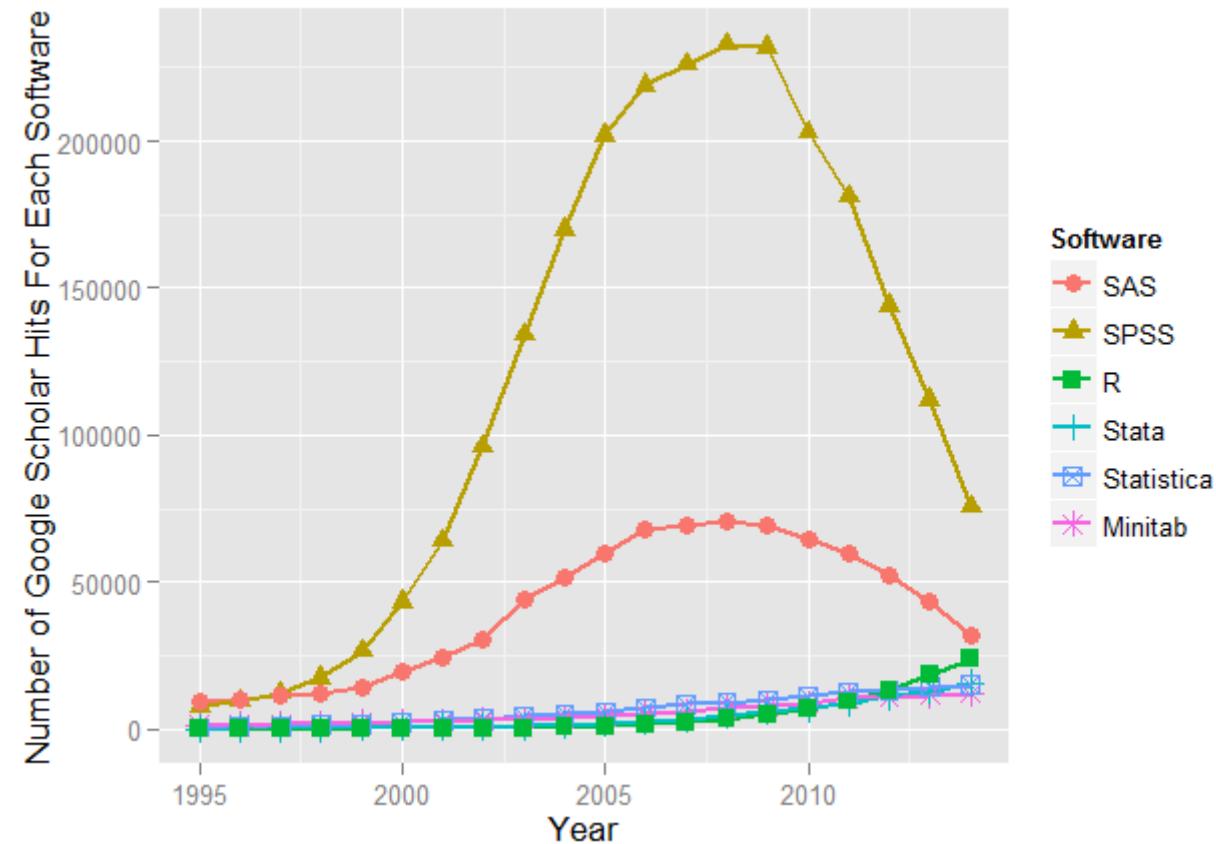
BCG

THE BOSTON CONSULTING GROUP

Tech Mahindra
IT Services and Telecom Solutions

HSBC

Still not convinced?



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.

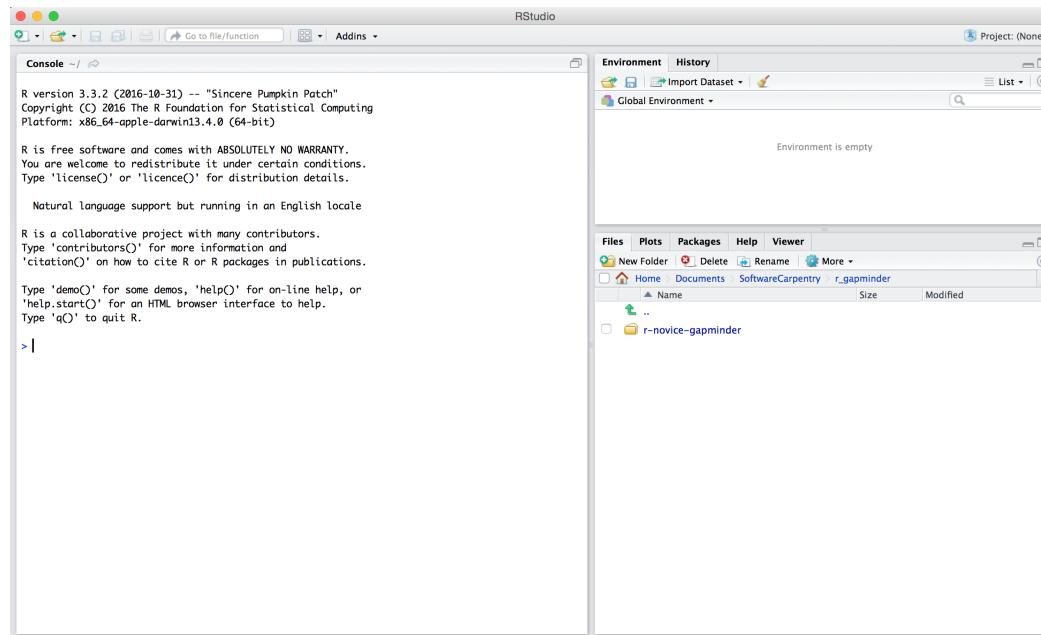
- How do you interpret the strength of the previously published evidence?
- How do you design a rigorous test of the treatment efficacy?
- How do you evaluate and report on the outcomes of your trial?

Getting started

What is RStudio?

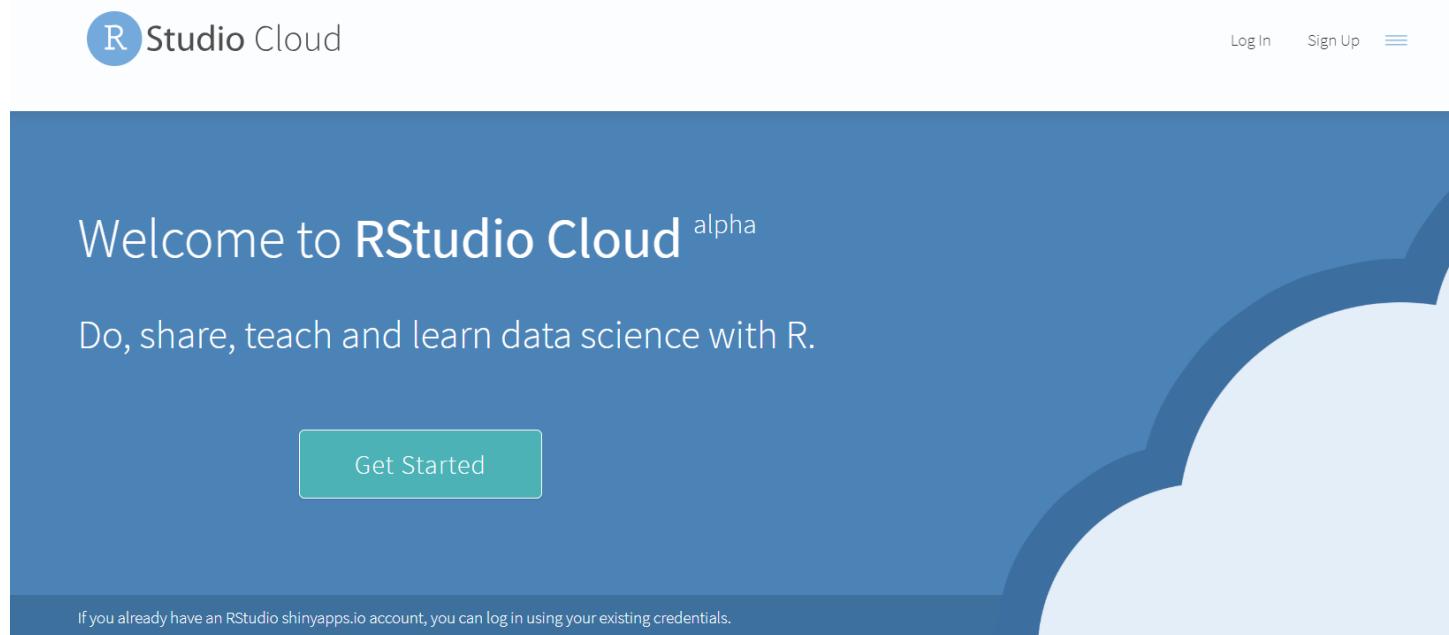


- An **Integrated Development Environment (IDE)**
- An interface for R that makes your life much, much easier
- Makes many things explicit that you would otherwise have to guess



Getting started

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.





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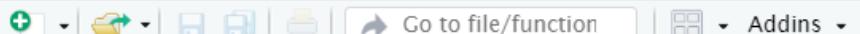
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Go to file/function

Addins

R 3.5.0

Console Terminal x Jobs x

/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)
```

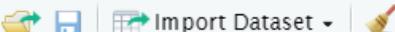
```
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You are welcome to redistribute it under certain conditions.  
Type 'license()' or 'licence()' for distribution details.
```

```
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.
```

>

Environment History Connections



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Cloud > project



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

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```
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```

> |

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 3.5.0

Dataset Connections

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Cloud > project

Name	Size	Modified
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project.Rproj	205 B	Sep 24, 2018, 12:29 PM

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https://rstudio.cloud/project/84901

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R packages.

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

> |

Options

RStudio theme: Modern

Editor Font size: 10

Editor theme: Ambiance, Chaos, Chrome, Clouds Midnight, Clouds, Cobalt, Crimson Editor, Dawn, Dracula, Dreamweaver, Eclipse, Idle Fingers, Katzenmilch, Kr Theme, Material

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

R 3.5.0

List

Search

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How it works!



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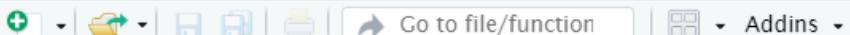
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R 3.5.0

Console Terminal x Jobs x

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```
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>

Environment History Connections

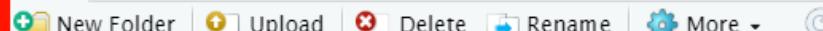


Global Environment



Environment is empty

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



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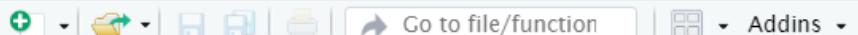
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R 3.5.0

Console Terminal x Jobs x

/cloud/project/ ↵

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

>

Environment History Connections

Import Dataset ↵

Global Environment ↵

Environment is empty

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New Folder	Upload	Delete	Rename	More
Cloud > project				...
Name	Size	Modified		
..	0 B	Sep 18, 2018		
.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.

Why is there an error?

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

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Type 'q()' to quit R.

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

Environment History Connections

Import Dataset

Global Environment

Values	
example	10
hi_there	"hi there!"

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New Folder Upload Delete Rename More

Cloud > project

Name	Size	Modified
..		
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project.Rproj	205 B	Sep 24, 2018, 1:06 PM

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Type 'q()' to quit R.

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

Global Environment

	Values
example	10
hi_there	"hi there!"

Cloud > project

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

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```
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>
> 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
```

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.Rhistory 0 B Sep 24, 2018

project.Rproj 205 B Sep 24, 2018

History

Try it out!

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
```

Try it out!

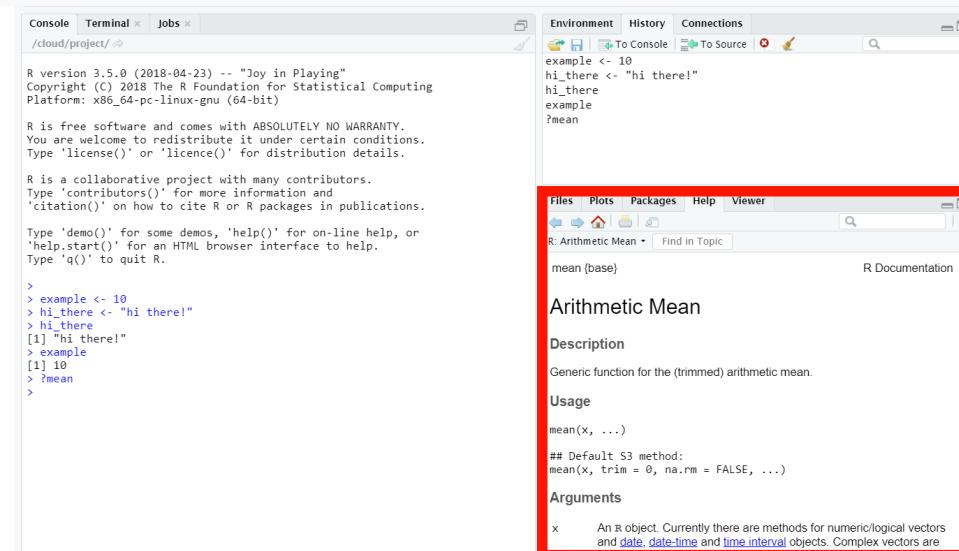
1. Use **c()** to create a vector of numbers.
2. Use **c()** to create a vector of strings.
3. Calculate the **mean()** of a vector of numbers.
4. Try guessing some other simple statistics (e.g. other types of *average*) that you can use.

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 12000 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!

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```
>
> 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

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

Environment History Connections

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

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

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Try out the cowsay package

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

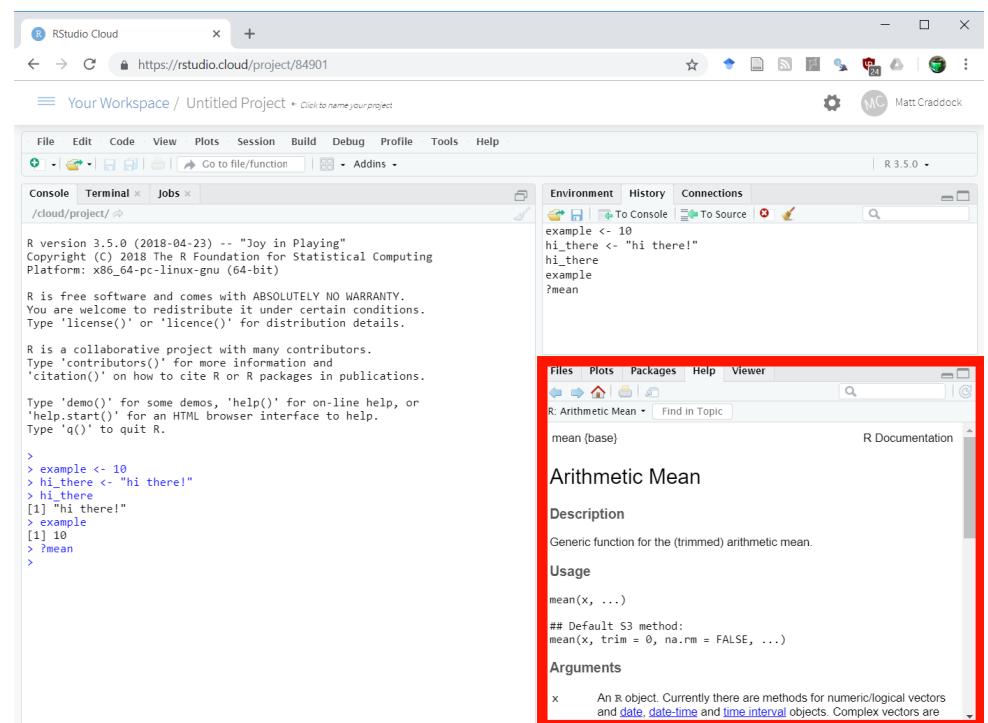
```
library(cowsay)  
?say()
```

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.

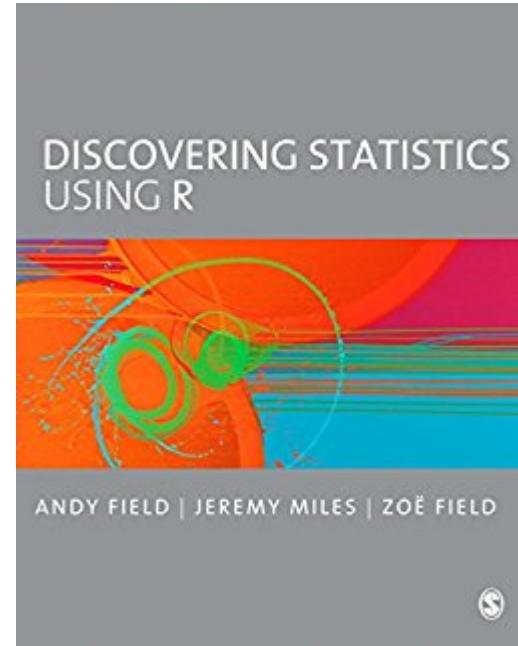
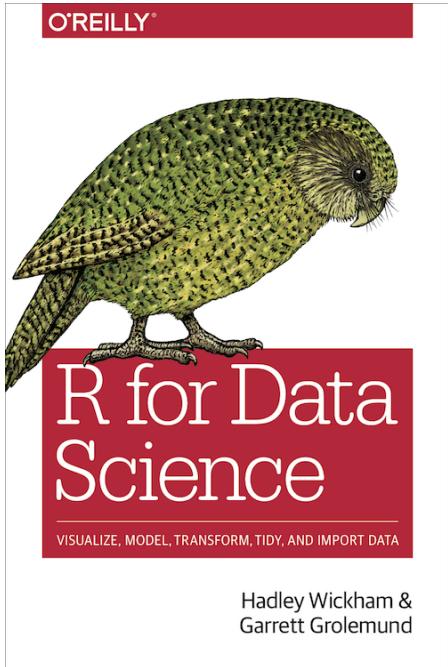


```
say(what = "Feed me, human.", by = "cat")  
  
## Colors cannot be applied in this environment :( Try using a terminal or RStudio.  
  
## -----  
## Feed me, human.  
## -----  
##      \  
##      \|  
##      \|  
##      | \|_--/|  
##      ==) ^Y^ (==  
##      \^ /  
##      )=*=(  
##      / \  
##      | |  
##      /| | | |\\  
##      \| | | _| /\  
##      jgs //_-// ___/  
##                  \_)  
##
```

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.
3. Assign the output to an object using the <- operator.
4. Print out the value that you assigned to the object.

Additional resources



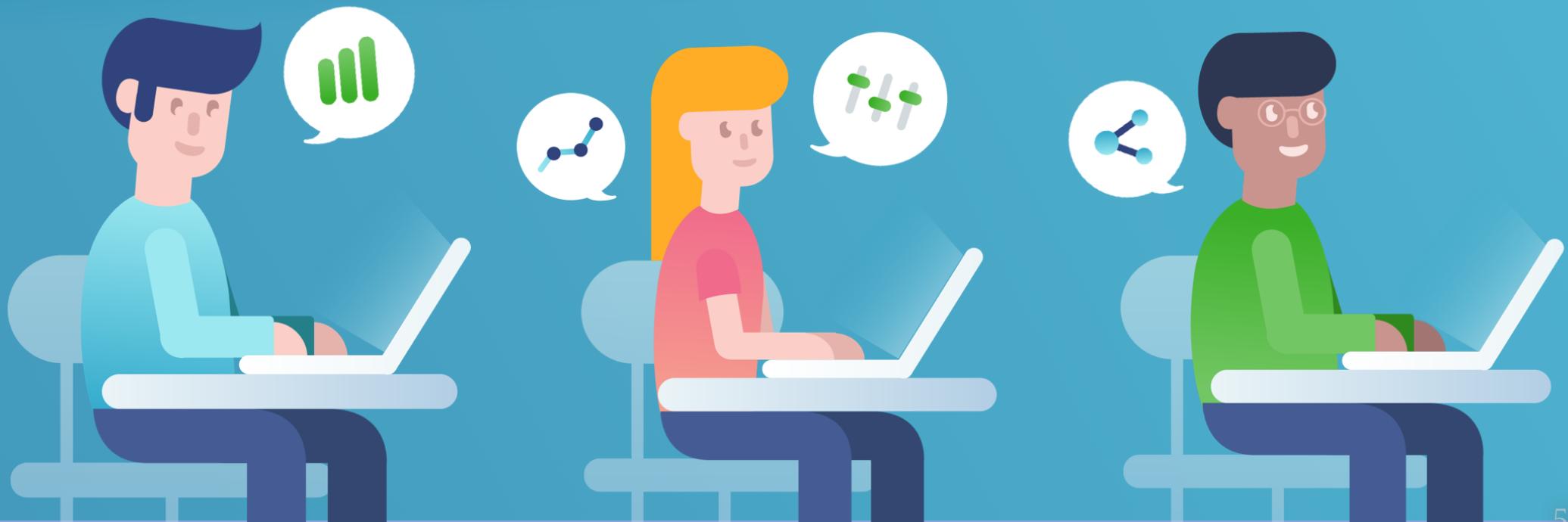
There are copies of both these books in the library.

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



DataCamp

FOR THE CLASSROOM



DataCamp

DataCamp provides a huge number of practical exercises across many different languages, not least of which is R.

Get signed up for DataCamp!

<https://tinyurl.com/DatacampSignup>

Homework!

1. If you didn't get properly signed up with RStudio.cloud today, do it!
2. Get signed up with DataCamp using the link provided
3. Read through Chapter 1 of R for Data Science
4. Try out some of the introductory exercises



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Scenario C

You've collected data from 100 participants using an online questionnaire with 20 questions. Some responses are free text (i.e. they can write whatever they like). Some responses use a Likert scale. For those responses, you also have a set of standard values that represent population averages.

- What kind of statistical analyses are appropriate for these data?
- How do you get the data into a format you can analyse it?
- How do you combine it with and compare it against the data from the broader population?