

Introduction to R

Research Methods and Skills

03/10/2023

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/2Gq7ivhvVS>

Group B (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/HBCxEwnAyP>

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.

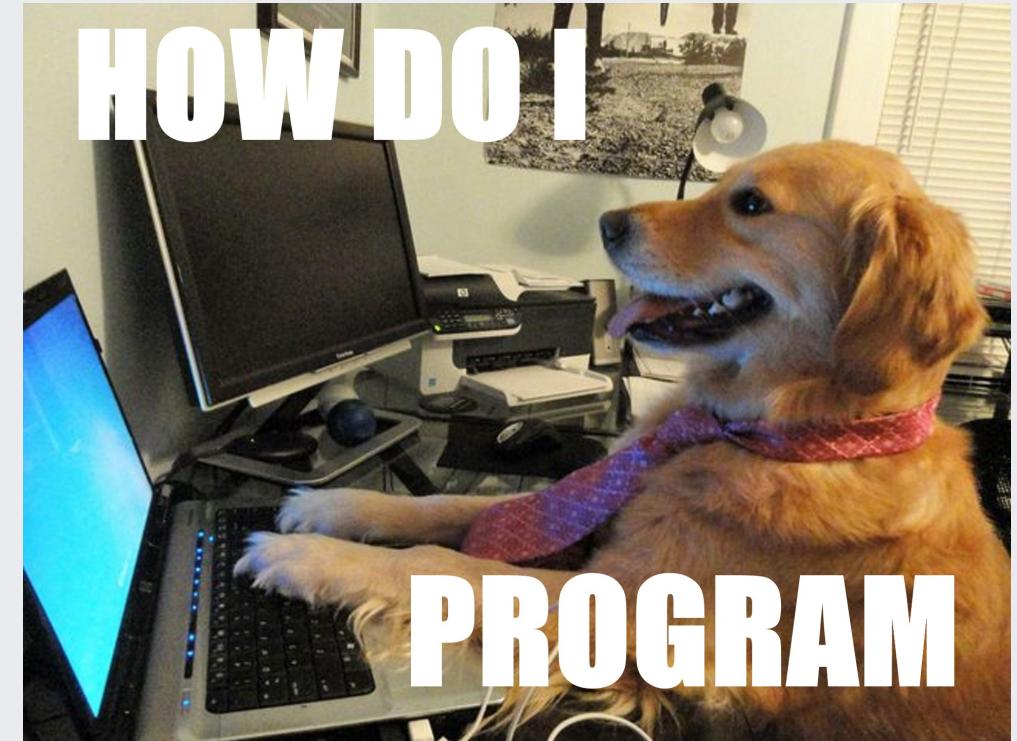
- How do you combine the data from each participant together to be able to analyse the data?
- It turns out some of the participants only completed part of the experiment - which ones, and what should you do with their data?
- What steps should you take to select and perform appropriate statistical analysis?

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

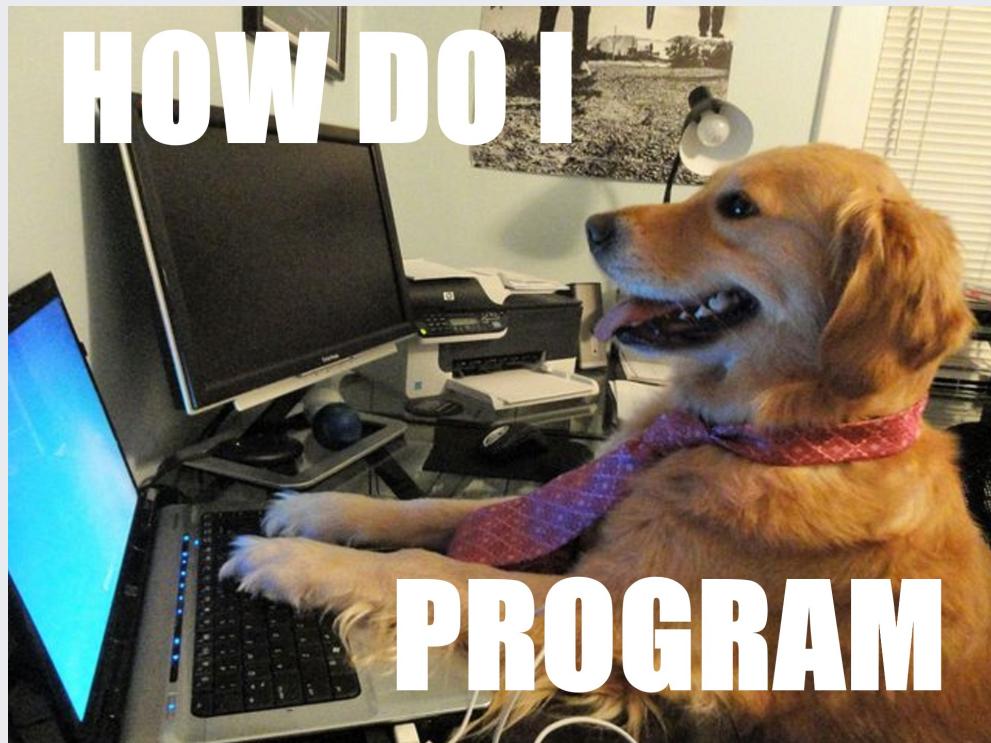
- Hypothesis testing and estimation
- *t*-tests and comparing two groups
- Correlation and linear regression
- One-way ANOVA
- Factorial ANOVA

Weeks 11-16

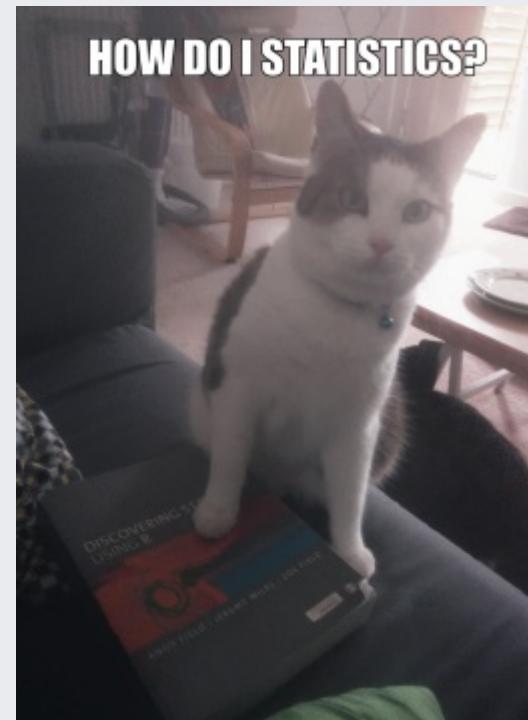
- Qualitative methods

Course outline

Weeks 2-6

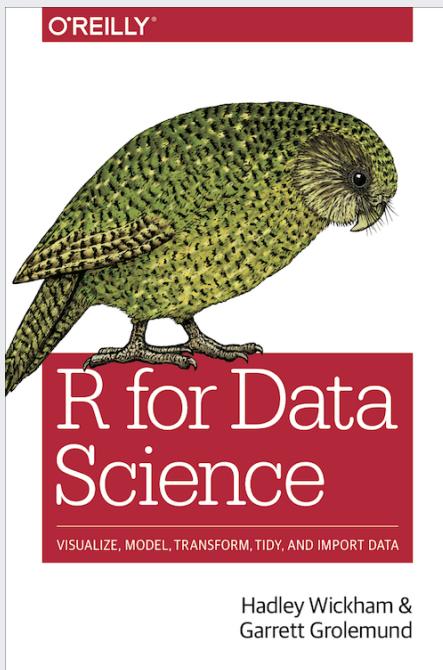


Weeks 7, 8-10

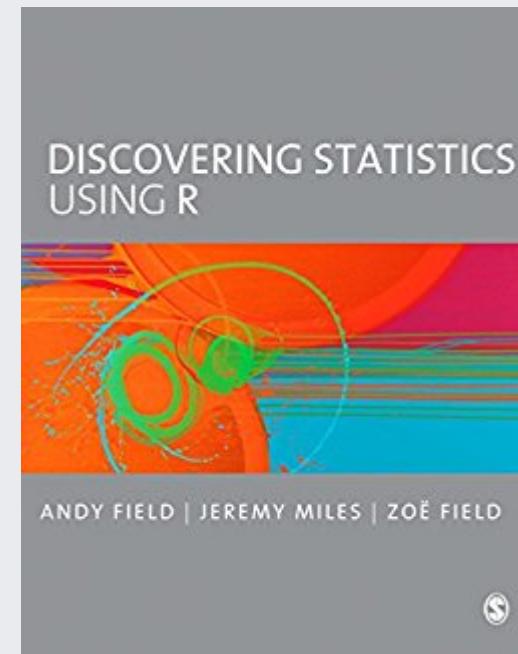


Course outline

Weeks 2-6



Weeks 6-10



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 (lecture) sessions we will spend the first hour 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.

If you get stuck **ask us!**

Introduction to R and RStudio

What is R?

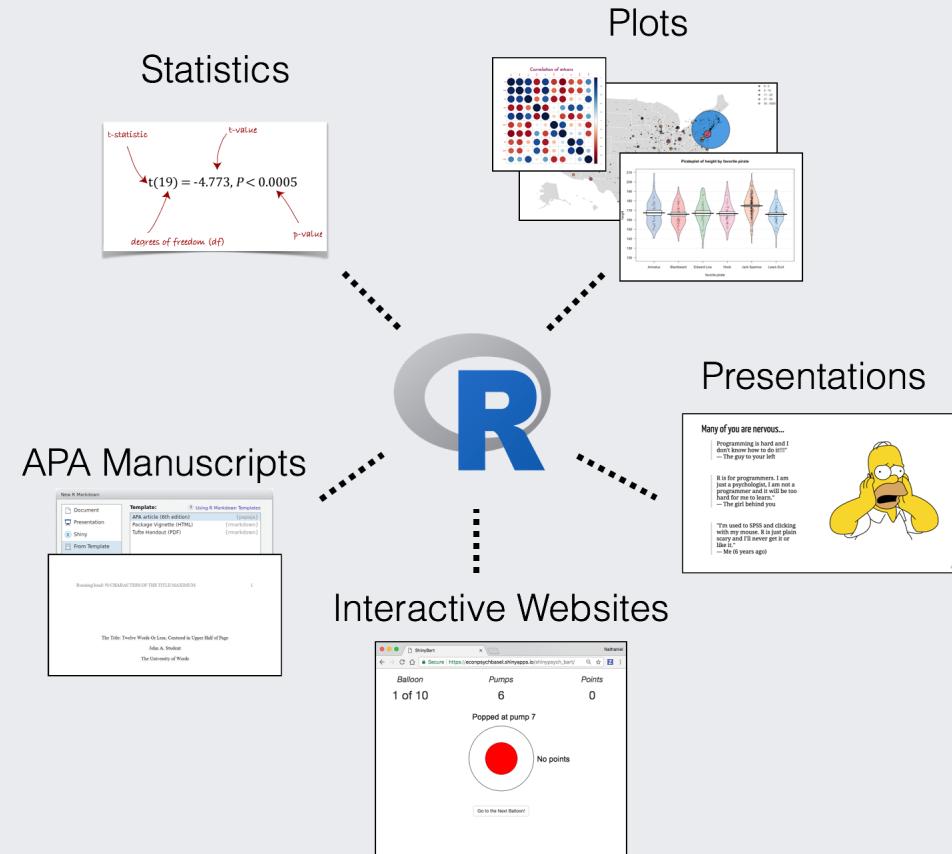


R is a statistical, mathematical programming language

- 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



TATA CONSULTANCY SERVICES

J.P.Morgan

Deloitte.

accenture
High performance. Delivered.

snapdeal

Booz | Allen | Hamilton

strategy and technology consultants

Cognizant

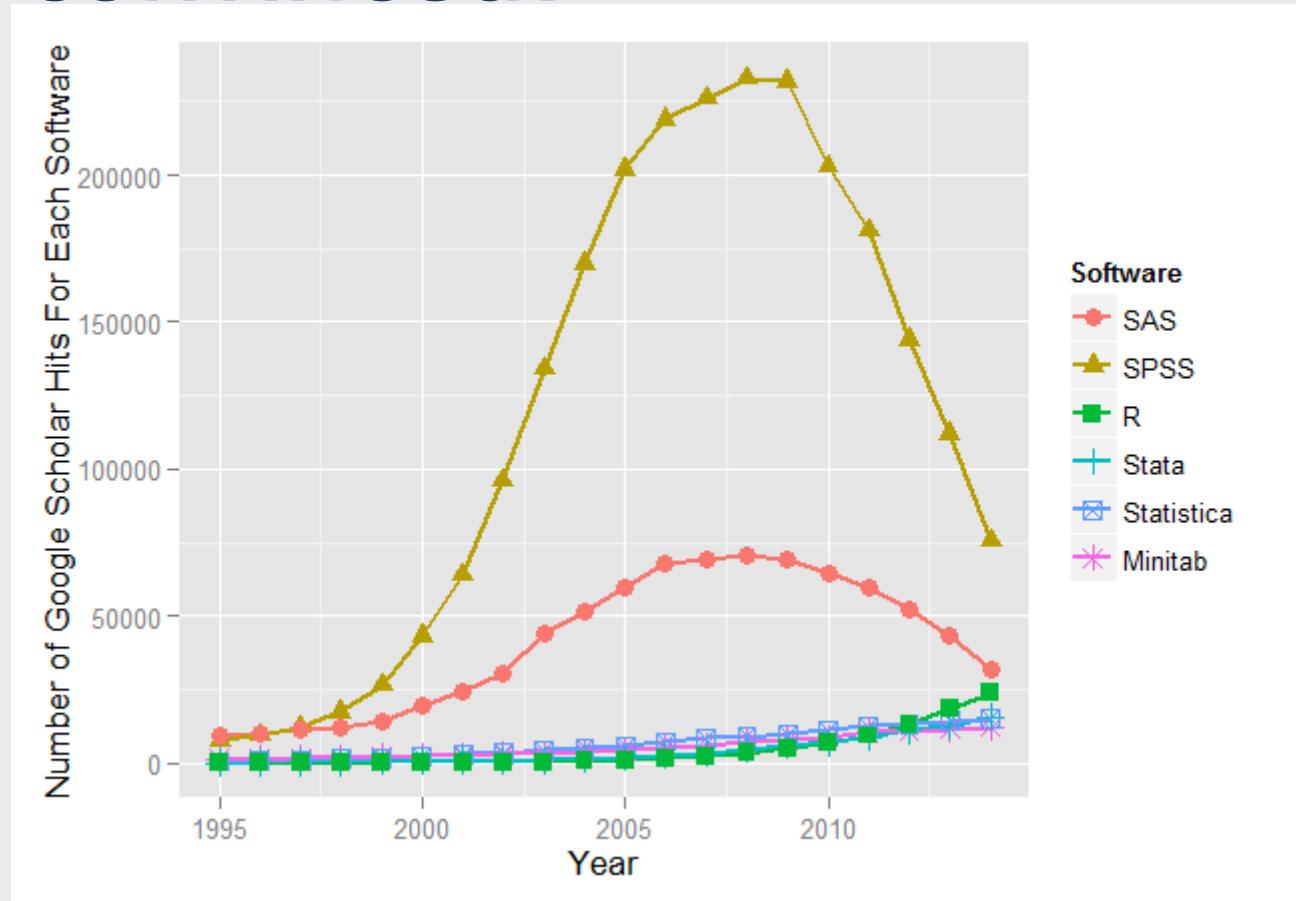
hp

JOHN DEERE

BCG
THE BOSTON CONSULTING GROUPTech Mahindra
IT Services and Telecom Solutions

HSBC

Still not convinced?

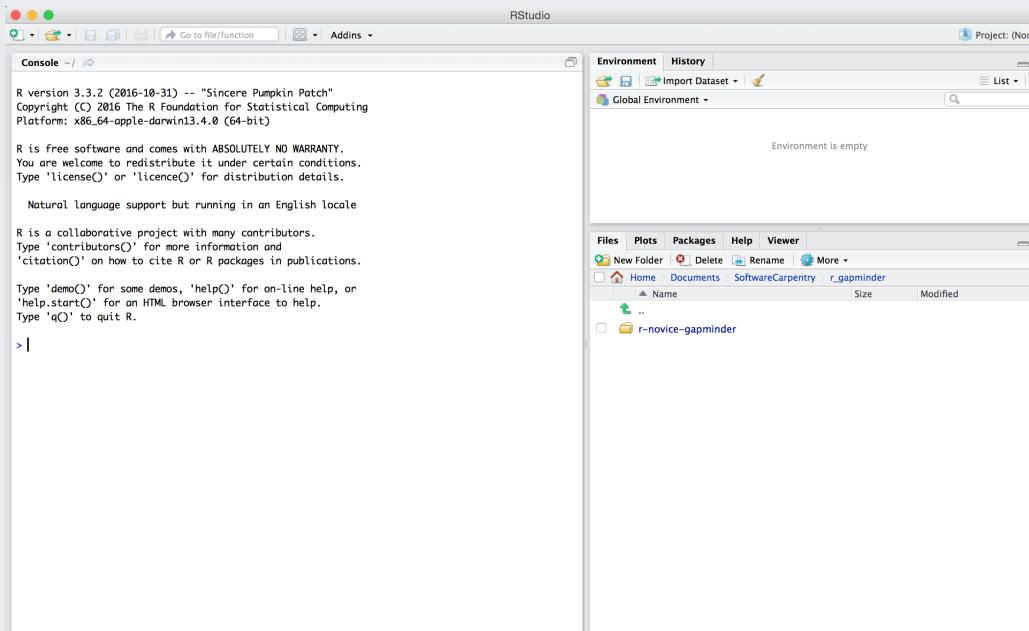


Getting started

What is RStudio?

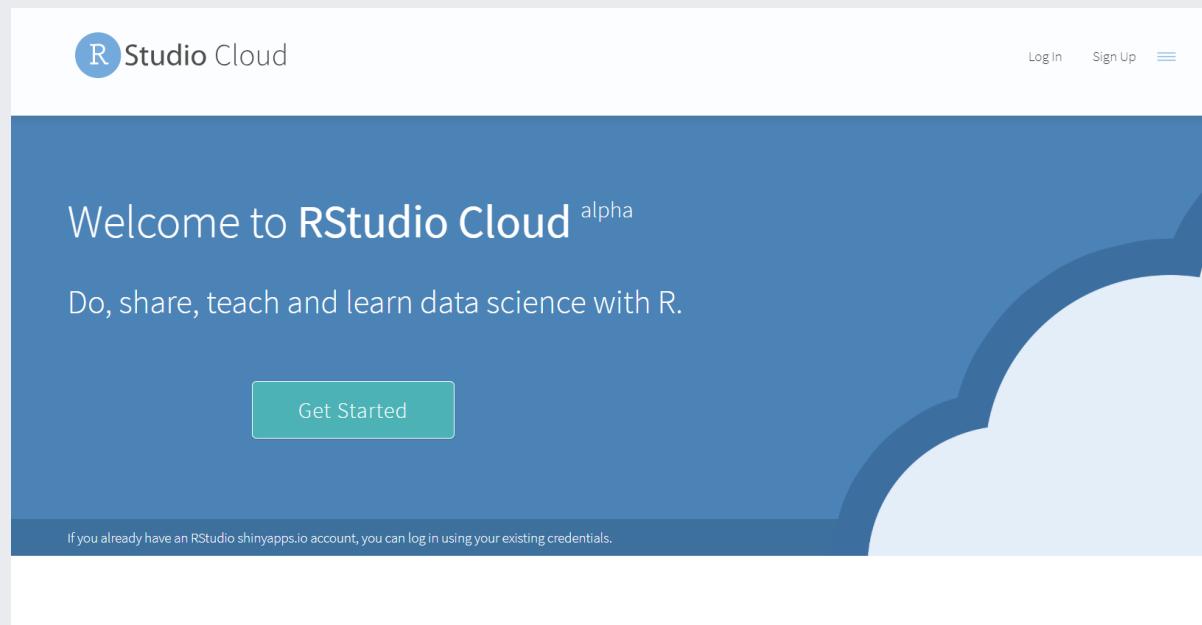


- An **Integrated Development Environment (IDE)**
- An interface for R that makes your life much, much easier
- Makes many things explicit that you would otherwise have to guess



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.





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Your Workspace / Untitled Project Click to name your project

File Edit Code View Plots Session Build Debug Profile Tools Help



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.
```

>

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
Onwuegbusi

File Edit Code View Plots Session Build Debug Profile

Go to file/function

Console Terminal x Jobs x

/cloud/project/

```
R version 3.5.0 (2018-04-23) -- "Joy in Playing"  
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```
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'help.start()' for an HTML browser interface to help.  
Type 'q()' to quit R.
```

> |

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

List

Environment is empty

Pages Help Viewer			
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, 12:29 PM	

Your Workspace / Untitled Project Click to name your project

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File Edit Code View Plots Session Build Debug Profile Tools Help

+ Go to file/function Addins

Console Terminal Jobs

/cloud/project/

R version 3.5.0 (2018-04-23) --
Copyright (C) 2018 The R Foundation
Platform: x86_64-pc-linux-gnu (6

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R is a collaborative project with
Type 'contributors()' for more info
'citation()' on how to cite R or

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

> |

Options

General

Code

Appearance

Pane Layout

Packages

R Markdown

Sweave

Spelling

Git/SVN

Publishing

Terminal

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")
}
```

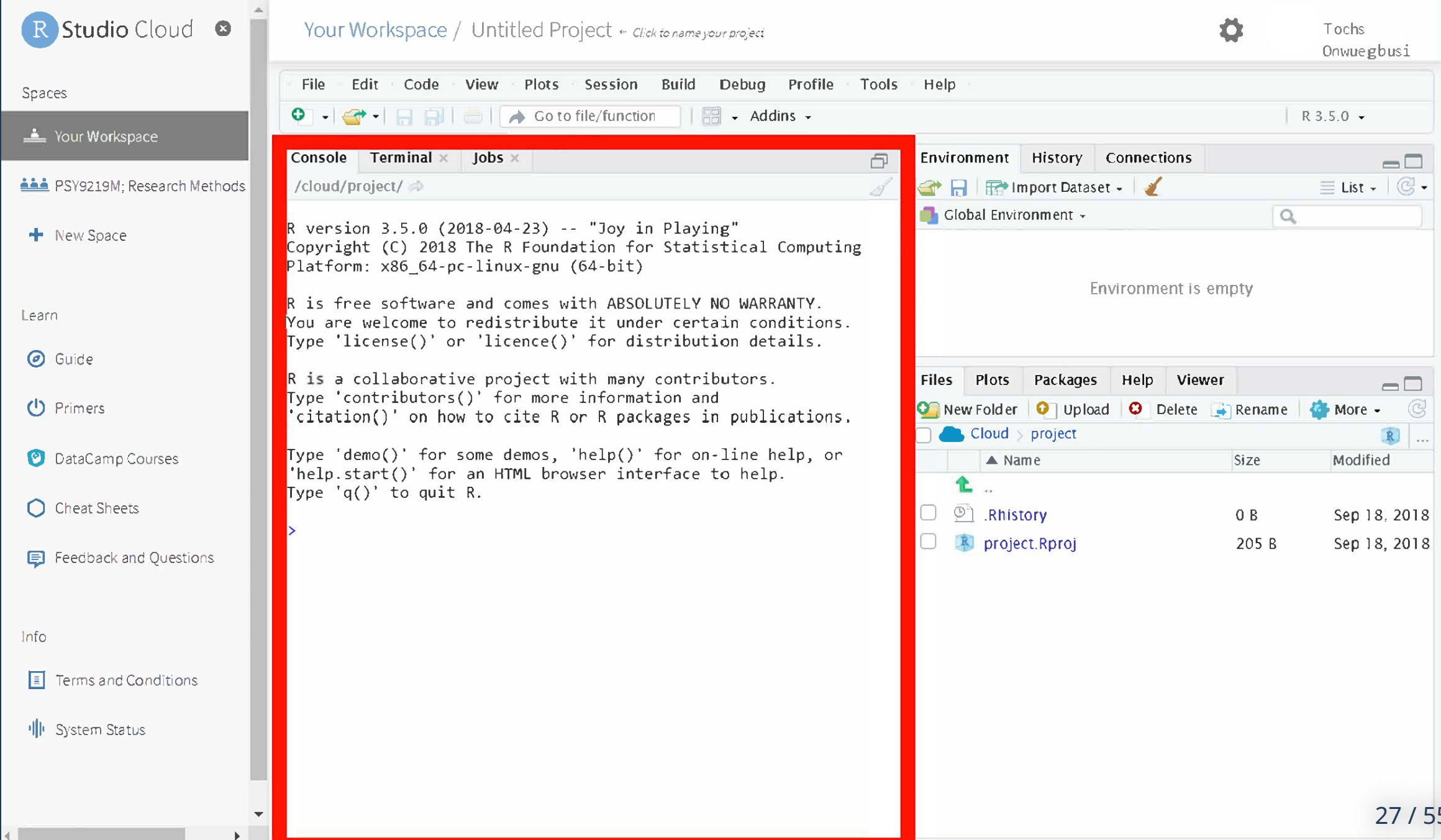
OK

Cancel

Apply

The screenshot shows the RStudio Cloud interface with the 'Options' dialog box open. The 'Appearance' tab is selected in the left sidebar of the dialog. The 'Editor theme' dropdown is open, displaying a list of themes including Ambiance, Chaos, Chrome, Clouds Midnight, Clouds, Cobalt, Crimson Editor, Dawn, Dracula, Dreamweaver, Eclipse, Idle Fingers, Katzenmilch, Kr Theme, and Material. The main workspace shows the R console output for version 3.5.0, followed by a series of welcome messages. To the right of the console is a file browser window titled 'List' showing two files: one with 0B size modified on Sep 24, 2018, 11:53 AM, and another with 205B size modified on Sep 24, 2018, 12:29 PM.

How it works!





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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"  
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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.
```

>

Environment History Connections

Import Dataset ↻

Global Environment ↻

Environment is empty

Files Plots Packages Help Viewer

New Folder Upload Delete Rename More ...

Cloud > 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

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Console Terminal Jobs

/cloud/project/

```
R version 3.5.0 (2018-04-23) -- "Joy in Playing"
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Platform: x86_64-pc-linux-gnu (64-bit)

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'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
> |
```

Environment History Connections

Import Dataset

Global Environment

Values

example	10
hi_there	"hi there!"

Files Plots Packages Help Viewer

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

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R 3.5.0

The screenshot shows the RStudio Cloud interface. The top navigation bar includes tabs for File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. Below the navigation bar is a toolbar with various icons for file operations like Open, Save, Print, and Help. The main workspace is divided into several panes: a Console pane showing R startup messages and a history of commands entered; a Terminal and Jobs pane; a Global Environment pane (highlighted with a red box) showing variable assignments for 'example' (value 10) and 'hi_there' ("hi there!"); and a Files pane showing a directory structure for the current project, including files like '.Rhistory' and 'project.Rproj'. The status bar at the bottom indicates R version 3.5.0.

Environment

The screenshot shows the RStudio Cloud interface. The top navigation bar includes tabs for 'Console', 'Terminal', and 'Jobs'. The main area displays the R environment, starting with the R version information:

```
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)
```

Followed by the license notice:

```
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.
```

Information about contributors and citation:

```
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.
```

Demos and help information:

```
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.
```

Console history:

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

The 'Environment' pane, which is highlighted with a red box, shows the current global environment with two objects defined:

Values	
example	10
hi_there	"hi there!"

The 'Files' pane shows the contents of the 'project' folder in the cloud:

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

R Studio Cloud

https://rstudio.cloud/project/84901

Your Workspace / Untitled Project Click to name your project

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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

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

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
```

The screenshot shows the RStudio interface with two panes. The left pane is the R Console, displaying the command history and the output of the help command for 'mean'. The right pane is the Help Viewer, which displays detailed documentation for the 'mean' function. A red box highlights the Help Viewer window.

Console Output:

```
/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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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
>
```

Help Viewer Content (highlighted by a red box):

Arithmetic Mean

Description

Generic function for the (trimmed) arithmetic mean.

Usage

```
mean(x, ...)
```

Arguments

x An R object. Currently there are methods for numeric/logical vectors and [date-time](#) and [time-interval](#) objects. Complex vectors are

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!

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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>
> 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

+ 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.
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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.

Type 'demo()' for some demos, 'help()' for on-line help,
'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

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	

Let's try out the cowsay package

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

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

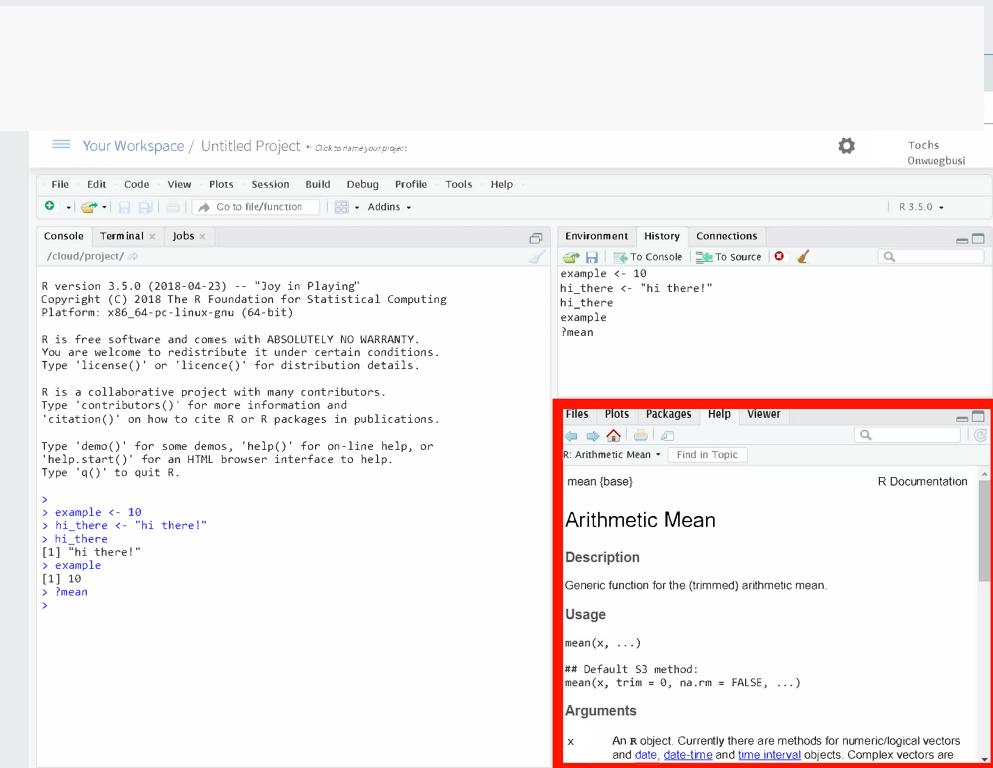
```
library(cowsay)
?say()
```

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.



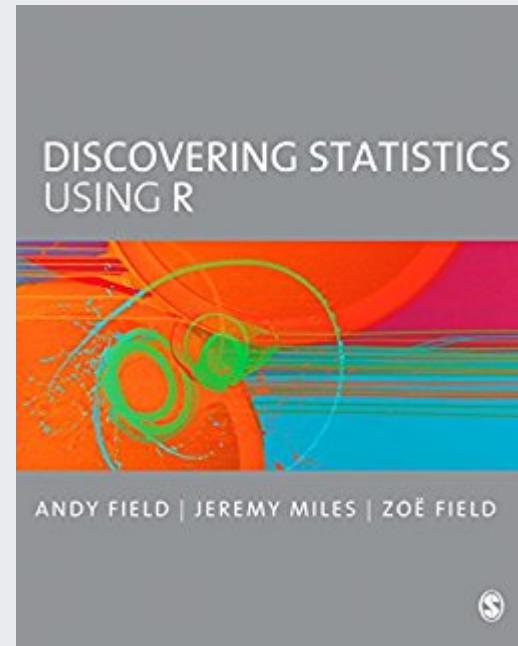
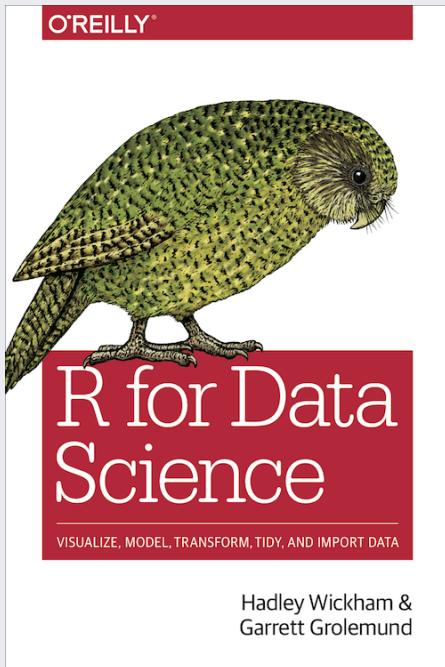
```
say(what = "Feed me, human.", by = "cat")
```

```
##  
## -----  
## Feed me, human.  
## -----  
##      \  
##      \|/  
##      \  /  
##      ==) \_ / | ==  
##          \   ^  /  
##          )=★=(  
##          /     \  
##          |     |  
##          /     |  
##          \     |  
##          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.

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!