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Getting started with R

A beginner's guide to R and R Studio

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Statistical Computing & Empirical Methods (EMATM0061)

MSc in Data Science, Teaching block 1, 2021.

What will we cover today?

- We will introduce R and RStudio
- We will learn about the basic objects and operations
- We will learn how to write a simple function in R with control flow statements
- We will see how R facilitates a functional paradigm with call-by-value semantics
- We have a brief look at lazy evaluation
- We will give a few signposts for where to learn more.

Why R?

- R is a free, open source programming language designed for Statistical Computing.
- R provides a fantastic ecosystem for:
 - a) Graphics and data visualization
 - b) Efficient data wrangling
 - c) Statistical inference
 - d) Machine Learning
- Vast online community of contributors and enthusiasts!
- Remark: Python & Julia provide increasingly competitive alternatives.

Why RStudio?

- RStudio is a free, open source *integrated development environment* for R.
- RStudio provides:
 - a) A console with a command line interface
 - b) A source editor for writing, executing and debugging R scripts
 - c) Syntax highlighting, code completion, smart indentation
 - d) Reproducible analysis via knitr & R Markdown.
 - e) Convenient interface for version control via Git

Installing R and RStudio

- You can install both R and RStudio in Windows, Linux or Mac OS X.
- First download and install R from the Comprehensive R Archive Network:

<http://www.r-project.org>

- Then download and install Rstudio:

<http://www.rstudio.com/download>

- I recommend that you pause the video here to install R & Rstudio.

Your first R session

SCEMCourseSlides - master - RStudio

File Edit Code View Plots Session Build Debug Profile Tools Help

Go to file/function

Source on Save

number Next Prev All num Replace All

☐ In selection ☐ Match case ☐ Whole word ☐ Regex ☒ Wrap

```
22 ^  
23 ^ }  
24  
25 return(t_val) # return the truth value which says whether or not num is prime  
26 ^ }  
27  
28 for(i in 0:100){  
29  
30 if(is_prime(i)){  
31 print(i)  
32 ^ }  
33  
34 ^ }  
35  
36  
37  
38  
39
```

5:34 is_prime(num)

Console Terminal R Markdown Jobs

C:/Users/henry/OneDrive/Desktop/Bristol/Teaching/RCode/SCEMCourseSlides/

```
[1] 19  
[1] 23  
[1] 29  
[1] 31  
[1] 37  
[1] 41  
[1] 43  
[1] 47  
[1] 53  
[1] 59  
[1] 61  
[1] 67  
[1] 71  
[1] 73  
[1] 79  
[1] 83  
[1] 89  
[1] 97  
> |
```

Environment History Connections Git Tutorial

Import Dataset

Global Environment

Data

my_list List of 3

Values

a	2
b	2
i	100L

Functions

f1	function (x)
f2	function (x)
is_prime	function (num)
subtraction_functi...	function (num_to_sub)

Files Plots Packages Help Viewer

Install Update

Name	Description	Version
acepack	ACE and AVAS for Selecting Multiple Regression Transformations	1.4.1
askpass	Safe Password Entry for R, Git, and SSH	1.1
assertthat	Easy Pre and Post Assertions	0.2.1
babynames	US Baby Names 1880-2017	1.0.0
backports	Reimplementations of Functions Introduced Since R-3.0.0	1.1.7
base64enc	Tools for base64 encoding	0.1-3
BH	Boost C++ Header Files	1.72.0-3
bitops	Bitwise Operations	1.0-6
blob	A Simple S3 Class for Representing Vectors of Binary Data ('BLOBS')	1.2.1
broom	Convert Statistical Analysis Objects into Tidy Tibbles	0.5.6
callr	Call R from R	3.4.3
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colorspace	A Toolbox for Manipulating and Assessing Colors and Palettes	1.4-1
crayon	Colored Terminal Output	1.3.4

Your first R session

The screenshot displays the RStudio interface with the following components:

- Source Editor:** Contains an R script with a function `is_prime` and a loop. The cursor is at line 39, `is_prime(num)`.
- Environment:** Shows the global environment with a list `my_list` containing values 2, 2, and 100L. It also lists functions `f1`, `f2`, `is_prime`, and `subtraction_functi...`.
- Files:** Shows the file explorer with a search bar and a list of files.
- Plots:** Shows the plot viewer.
- Packages:** Shows the package manager with a list of installed and available packages.
- Console:** Shows the output of the script, which is a sequence of numbers from 19 to 97.

1. Console

Your first R session

The screenshot displays the RStudio IDE interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The toolbar contains icons for file operations and running code. The script editor shows a function `is_prime` with a `return` statement and a `for` loop. The console at the bottom shows the output of the function for various inputs. The environment pane on the right lists variables and functions in the global environment.

1. Console

```
[1] 19
[1] 23
[1] 29
[1] 31
[1] 37
[1] 41
[1] 43
[1] 47
[1] 53
[1] 59
[1] 61
[1] 67
[1] 71
[1] 73
[1] 79
[1] 83
[1] 89
[1] 97
> |
```

2. Environment and variables

Global Environment	
Data	
my_list	
Values	
a	2
b	2
i	100L
Functions	
f1	function (x)
f2	function (x)
is_prime	function (num)
subtraction_functi...	function (num_to_sub)

User Library			
Name	Description	Version	
acepack	ACE and AVAS for Selecting Multiple Regression Transformations	1.4.1	
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Your first R session

The screenshot shows the RStudio IDE interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The toolbar contains icons for file operations and running code. The main window is divided into three panes:

- Scripting window (3. Scripting window):** Contains the R script `isPrime.R`. The code defines a function `is_prime` that checks if a number is prime. The function uses a `for` loop from 0 to 100 and a `return` statement. The console output shows the function being called with `is_prime(2)` and returning `[1] 19`.
- Environment and variables (2. Environment and variables):** Shows the Global Environment with a data object `my_list` and a function object `is_prime`. The values of `my_list` are `a = 2`, `b = 2`, and `i = 100L`. The functions listed are `f1`, `f2`, `is_prime`, and `subtraction_functi...`.
- Console (1. Console):** Shows the output of the R script, including the function definition and the result of the `is_prime` function call.

The bottom pane shows the **Files** tab with a list of installed packages, including `acepack`, `askpass`, `assertthat`, `babynames`, `backports`, `base64enc`, `BH`, `bitops`, `blob`, `broom`, `callr`, `checkmate`, `cli`, `clipr`, `colorspace`, and `crayon`.

Vectors

```
x <- c(3,7,4,2,1,2,-4,-5) # vector of numbers (use "<-" for assignment )  
x
```

```
## [1] 3 7 4 2 1 2 -4 -5
```

```
y <- seq(5) # A vector of numbers generated as a sequence  
y
```

```
## [1] 1 2 3 4 5
```

```
x[3] # You can access an element of a vector like this
```

```
## [1] 4
```

```
x[c(2,3)] # Or several elements like this
```

```
## [1] 7 4
```

```
x[1:4] # Or the first four elements like this
```

```
## [1] 3 7 4 2
```

Vectors

```
z <- c("Bristol", "Bath", "London") # You can have a vector of strings
z
```

```
## [1] "Bristol" "Bath"    "London"
```

```
w <- c(TRUE, FALSE, TRUE, FALSE) # Or a vector of Booleans
w
```

```
## [1] TRUE FALSE TRUE FALSE
```

```
a <- c(TRUE, 3, "Bristol") # You can't have a vector of mixed type!
a
```

```
## [1] "TRUE"    "3"       "Bristol"
```

```
mode(a) # You can test the type like this
```

```
## [1] "character"
```

Lists

```
first_list <- list(TRUE, 3, "Bristol") # lists can be of mixed type
first_list
```

```
## [[1]]
## [1] TRUE
##
## [[2]]
## [1] 3
##
## [[3]]
## [1] "Bristol"
```

```
second_list <- list( t_value=TRUE, num_value=3, city = "Bristol") # lists members can be named like a dictionary
second_list$t_value
```

```
## [1] TRUE
```

```
second_list$num_value
```

```
## [1] 3
```

Matrices

```
M <- matrix(seq(10), 2, 5) # You can generate a 2 by 5 matrix  
M
```

```
##      [,1] [,2] [,3] [,4] [,5]  
## [1,]    1    3    5    7    9  
## [2,]    2    4    6    8   10
```

```
M[2,3] # The third element of the second row can be accessed directly
```

```
## [1] 6
```

```
M[,4] # Or we can inspect the entire four column
```

```
## [1] 7 8
```

```
is.vector(M[2,]) # We can check that a selected row or column is a vector
```

```
## [1] TRUE
```

Data frames

- Data frames are powerful objects for representing and manipulating tabular data.

```
city_name <- c( "Bristol", "Manchester", "Birmingham", "London") # vector of city names
population <- c(0.5,0.5,1,9) # vector of populations

first_data_frame <-data.frame(city_name,population) # we can generate a data frame like this
first_data_frame
```

```
##      city_name population
## 1      Bristol        0.5
## 2 Manchester        0.5
## 3 Birmingham        1.0
## 4      London        9.0
```

- Unlike matrices, columns are named & different columns may be of different type
- However, the cells within a column must be of the same type.

Arithmetic operations

```
((4+2-1)*4)/2^2 # Arithmetic operations - addition, subtraction, multiplication, division, exponentiation etc..
```

```
## [1] 100
```

```
a<-matrix(sample(1:10, 6, replace=T),2,3) # a random 2 by 3 matrix  
b<-matrix(sample(1:10, 6, replace=T),2,3) # a second random 2 by 3 matrix  
a*b # this performs element wise multiplication
```

```
##      [,1] [,2] [,3]  
## [1,]   15   49   15  
## [2,]    6   20    9
```

```
a%*%t(b) # t(b) computes the transpose of b and %*% performs matrix multiplication
```

```
##      [,1] [,2]  
## [1,]   79   49  
## [2,]   65   35
```

Boolean operations

```
a<-c(TRUE,TRUE,FALSE,FALSE) # a vector of Booleans  
b<-c(TRUE,FALSE,TRUE,FALSE) # another vector of Booleans
```

```
!a # not a
```

```
## [1] FALSE FALSE TRUE TRUE
```

```
a&b # a and b
```

```
## [1] TRUE FALSE FALSE FALSE
```

```
a|b # the inclusive or between a and b
```

```
## [1] TRUE TRUE TRUE FALSE
```

```
xor(a,b) # the exclusive or between a and b
```

```
## [1] FALSE TRUE TRUE FALSE
```


Now take a break!



Your first R script

The screenshot displays the RStudio interface with the following components:

- Scripting window:** Contains an R script with a function `is_prime` and a `for` loop. A blue box highlights the text "Scripting window".
- Environment pane:** Shows the global environment with a list `my_list` containing values `a` (2), `b` (2), and `i` (100L). It also lists functions `f1`, `f2`, `is_prime`, and `subtraction_functi...`.
- Files pane:** Shows the file explorer with tabs for Install, Update, and a search bar.
- Console:** Displays the output of the script, showing the execution of the `is_prime` function for values 19, 23, 29, 31, 37, 41, 43, 47, 53, 59, 61, 67, 71, 73, 79, 83, 89, and 97.

```
22 ^  
23 ^ }  
24  
25 return(t_val) # return the truth value which says whether or not num is prime  
26 ^ }  
27  
28 for(i in 0:100){  
29  
30 if(is_prime(i)){  
31 print(i)  
32 ^ }  
33  
34 ^ }  
35  
36  
37  
38  
39
```

Environment

Global Environment

Data

my_list List of 3

Values

a	2
b	2
i	100L

Functions

f1	function (x)
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Files

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Console

Terminal R Markdown Jobs

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```
[1] 19  
[1] 23  
[1] 29  
[1] 31  
[1] 37  
[1] 41  
[1] 43  
[1] 47  
[1] 53  
[1] 59  
[1] 61  
[1] 67  
[1] 71  
[1] 73  
[1] 79  
[1] 83  
[1] 89  
[1] 97  
>
```

Functions

```
is_prime <- function(num) {  
  
  # Function which takes as input a positive integer and outputs Boolean - TRUE if and only if the input is prime.  
  
  stopifnot(is.numeric(num), num%%1==0, num>=0) # Stop if the input is not a positive integer  
  
  t_val <- TRUE # Initialise truth value output with TRUE  
  
  if(num<2) {  
  
    t_val<-FALSE # Output FALSE if input is either 0 or 1  
  
  } else if(num>2) {  
  
    for(i in 2:sqrt(num)) { # Check possible divisors i no greater than sqrt(num)  
  
      if(num%%i==0) {  
        t_val<-FALSE  
        break # if i divides num then num is not prime  
      }  
    }  
  }  
  
  return(t_val) # return the truth value which says whether or not num is prime  
}  
  
is_prime(39) #Now we can use our function to check if 39 is prime.
```

```
## [1] FALSE
```

Call by value semantics

- In R arguments in functions are passed with call-by-value semantics.

```
a<-seq(5,2) # Create a vector

demo_func_1 <- function(x){

  x[2]<- -10 # Set the second value of the input to -10
  print(x)

}

demo_func_1(a) # Apply demo_func_1 to a
```

```
## [1] 5 -10 3 2
```

```
a # Note that the value of a is unchanged.
```

```
## [1] 5 4 3 2
```

- This facilitates a functional programming style with limited side effects.

Lazy evaluation

- Lazy evaluation enables efficiency but has some surprising consequences.

```
subtraction_function <- function(num_to_sub){  
  output_function <- function(x){  
    return (x-num_to_sub)  
  } # a function with input x and output x minus num_to_sub  
  return(output_function) #output this function  
}  
  
a<-1 # initialise a  
f1 <- subtraction_function(a) # construct a function which subtracts a  
print(f1(2)) # evaluate function at 2
```

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

```
a<-2 # modify a  
print(f1(2)) # doesn't change the function
```

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

Lazy evaluation

```
subtraction_function <- function(num_to_sub){  
  output_function <- function(x){  
    return (x-num_to_sub)  
  } # a function with input x and output x minus num_to_sub  
  return(output_function) #output this function  
}  
  
a<-1 # initialise a  
f1 <- subtraction_function(a) # construct a function which subtracts a  
print(f1(2)) # evaluate function at 2
```

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

```
a<-2 # modify a  
print(f1(2)) # doesn't change the function
```

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

```
b<-1 # now initialise a new variable b  
f2 <- subtraction_function(b) # construct a function which outputs b  
b<-2 # change the value of b  
print(f2(2)) # evaluating the function reveals that the second choice of b was used.
```

```
## [1] 0
```

How can we learn more?

- Almost every R function has an associated help function which can be accessed via

```
> ?name_of_function
```

```
> help(name_of_function)
```

- A fantastic resource to learn more about R is the Swirl package:

```
> install.packages("swirl")
```

```
> library(swirl)
```

- Another great resource is StackOverflow for R:

<https://stackoverflow.com/questions/tagged/r>

What have we covered?

- We installed R and RStudio and started our first session.
- We learned about the basic objects – vectors, lists, matrices & data frames.
- We considered basic operations – arithmetic and Boolean
- We learnt how to write a simple function with control flow statements
- We saw that R facilitates a functional paradigm with call-by-value semantics
- We briefly looked at lazy evaluation and its surprising consequences
- We discussed a few resources for learning more – the help function, Swirl, stack etc.

That's plenty for today! – now onto the exercises.



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Thanks for listening,

Henry W J Reeve

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Include EMATM0061 in the subject of your email.

Statistical Computing & Empirical Methods