Intro2R

R Environment and Syntax

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Course materials: https://github.com/xp-song/Intro2R
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Before we begin...

1. Navigate to course webpage and read background information
   https://github.com/xp-song/Intro2R

2. Ensure that you have installed **R** on your computer, followed by **R Studio**
   (follow links under 'Instructions' section of webpage)

3. Download workshop materials
   (green button on webpage)

Outline

What is R?

- Programming language and software environment with a command line interface
- RStudio is often used as a software client
- Both R and RStudio are open source software
- Huge library of packages created by the R community

About this crash course

What it IS

- Designed for those with minimal coding experience
- Give you a taste of what R can do

What it is NOT

- A substitute to practicing the fundamentals of the language
- A lesson in statistics

Outline

Course materials

Intro2R

/notes [1]

/data

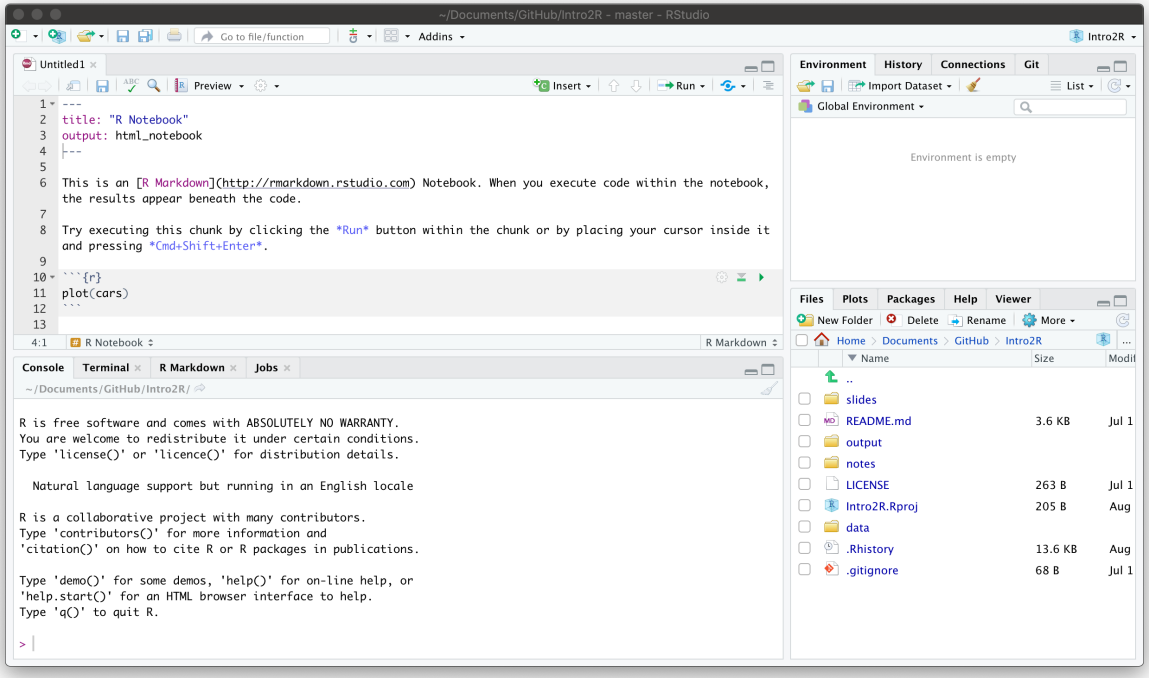
/output

PDF slide decks

Intro2R.Rproj

[1] View in your web browser by opening the '*.html*' files

R Studio Client



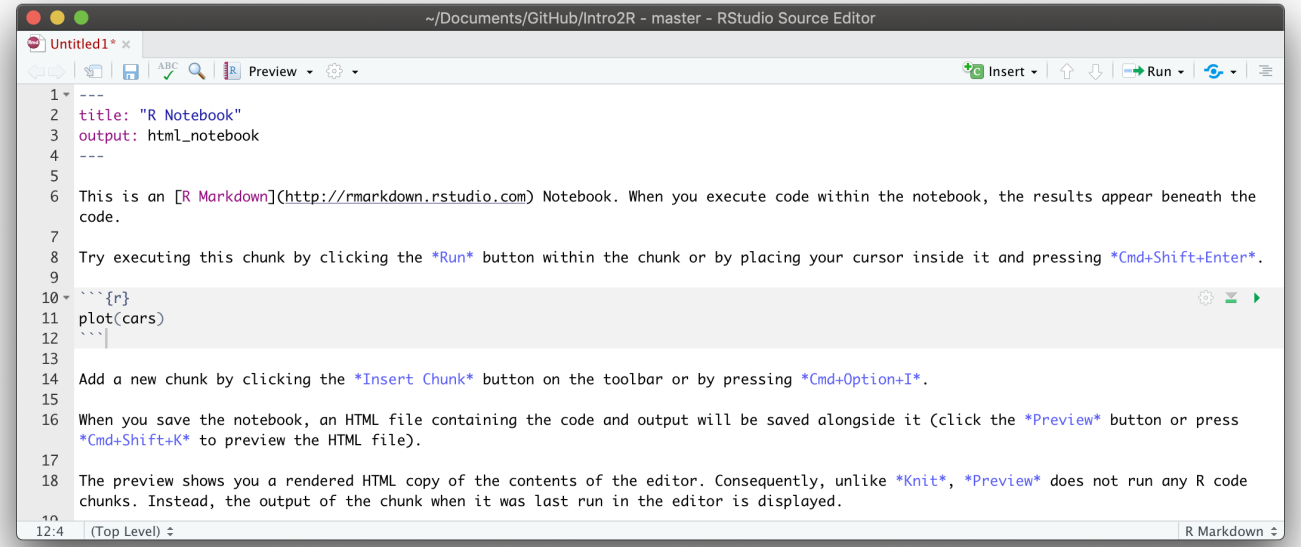
- **Console:** Command line input/output
- **Script editor:** View/edit files that contain code
- **Environment/History**
- **Files/Plots/Packages/Help/Viewer**

What are R Notebooks?

- R Notebooks (a.k.a. R Markdown Notebooks) are files ending with '*.Rmd*'.
- Compared to basic '*.R*' scripts, they allows us to:
  - Write normal text alongside code
  - Interact with code within a single document
  - Generate (i.e. '*knit*') different types of files

Try creating a new R Notebook `File > New File > R Notebook`

R Notebooks

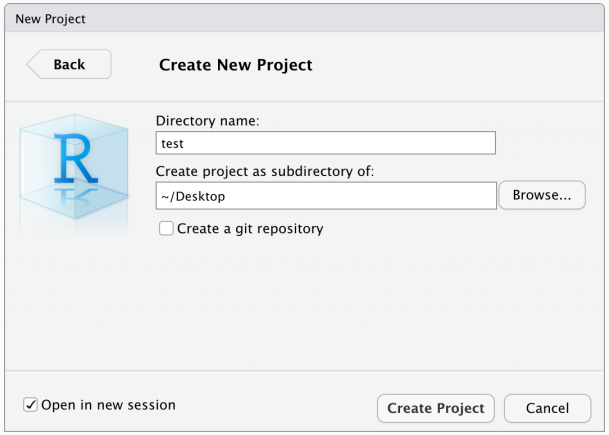


- **Header section:** specify document parameters
- **Normal text**
- **Code chunk:** write code and specify code parameters

Save our new file as *'myanalysis.Rmd'*

RStudio Projects

Try creating a new RStudio Project `File > New Project > New Directory > New Project`



What are RStudio Projects?

- RStudio Projects help organise your work into separate 'R sessions'.
- Each project has it's own workspace a.k.a. 'working directory' (separate configuration, history, etc.)
- The location of the '*.RProj*' file defines the 'working directory'
  - **Type `getwd()` in the *console* of our new project**
  - This returns the absolute path to our working directory
    e.g. `/Users/<computer_username>/Desktop/test`

RStudio Projects

🌟 Best Practice

- Use *relative* paths in your script, based on *.RProj* file location
    - **Try reading in data in your R Notebook**

      `read.csv("<path to Intro2R folder>/Intro2R/data/ozone_data.csv")`

      `read.csv("data/ozone_data.csv")`
- Keep all project items in the working directory

Outline

General Syntax

Operators

Arithmetic

Solve the following:

$$\frac{(1+2)*(4-5)}{50}$$

```
(1+2)*(4-5)/50
```

```
## [1] -0.06
```

General Syntax

Operators

Logical

Check if `1e3` is larger or equal to `1*10^3`
What is the output?

```
1e3 >= 1*10^3
```

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

General Syntax

Operators

Variables

Variables are named objects used to store data

- `<-` is used to assign variable names in R (e.g. `x <- 4`)
- Print variables by name (`x` vs. `"x"`)
- Assigning data to an existing variable overwrites it (`x <- 10`)

🌟**Best Practice**

- Clear and consistent names
- Avoid numbers/symbols/whitespace

General Syntax

Operators

Variables

Data types and examples:

- Numeric (`3.142`), Integer (`5L`)
- Character (`"hello"`)
- Logical (`TRUE, FALSE`)
- Complex

Let's assign new variables `name`, `age`, and `weight`

Check the data type for each variable using the function `is.numeric()`, `is.integer()`, `is.character()`

Outline

Data Structures

Vectors

- Linear collection of data
- Must be of the *same* data type

Assign a *vector* of names to the variable `name`
(use the concatenate function `c()`)

```
name <- c("Me", "Tom", "Dick", "Harry", "Susan") # character vector
```

Assign a *vector* of numbers to the variable `age`

```
age <- c(20, 25, 30, 35, 40) # numeric vector
```

Data Structures

Vectors

- Linear collection of data
- Must be of the *same* data type
- *Operations in R are vectorised*

Subtract 5 from the vector `age`

```
age-5
```

```
## [1] 15 20 25 30 35
```

Add together two vectors

```
age+age
```

```
## [1] 40 50 60 70 80
```

Data Structures

Vectors

Lists

- Linear collection of data
- Can contain of different *types* and *structure* of data

Create a list with a mix of data types and variables

```
myteam <- list(name, age, "Group 1", 2019)
```

Data Structures

Vectors

Lists

- Linear collection of data
- Can contain of different *types* and *structure* of data

```
myteam
```

```
## [[1]]
## [1] "Me"    "Tom"   "Dick"  "Harry" "Susan"
##
## [[2]]
## [1] 20 25 30 35 40
##
## [[3]]
## [1] "Group 1"
##
## [[4]]
## [1] 2019
```

Data Structures

Vectors

Lists

Factors

- A special kind of vector that represents categorical data with discrete levels

Let's code the sex of each person in the variable `name`
(use the functions `factor()` and `c()`)

```
sex <- factor(c("M","M","M","M","F"))
```

```
sex
```

```
## [1] M M M M F
## Levels: F M
```

Data Structures

Vectors

Lists

Factors

- A special kind of vector that represents categorical data with discrete levels

Let's code the performance of each person in `name`

```
perform <- factor(c("High", "Low", "Med", "Med", "High"))
```

```
perform
```

```
## [1] High Low  Med  Med  High
## Levels: High Low Med
```

What is wrong with this output?

Data Structures

Vectors

Lists

Factors

Define the order using the `levels=` argument in `factor()`

```
perform <- factor(c("High", "Low", "Med", "Med", "High"),
                  levels = c("Low", "Med", "High"))
perform
```

```
## [1] High Low  Med  Med  High
## Levels: Low Med High
```

Data Structures

Vectors

Lists

Factors

Matrices

- Tabular data (rows & columns)
- Must be of the *same* data type

Create a 4 by 3 matrix of sequential numbers

Use `matrix()` and the `:` operator to create a sequence

```
m <- matrix(1:12, nrow = 4)
```

```
m
```

```
##      [,1] [,2] [,3]
## [1,]    1    5    9
## [2,]    2    6   10
## [3,]    3    7   11
## [4,]    4    8   12
```

Data Structures

Vectors

Lists

Factors

Matrices

Dataframes

- Tabular data (rows & columns)
- Rows represent data entries, columns represent different variables

Import the dataset `ozone_data.csv` into your R Notebook using `read.csv()`

```
ozone <- read.csv("data/ozone_data.csv") # column headers in first row
```

Data Structures

Vectors

Lists

Factors

Matrices

Dataframes

View the first few rows of `ozone`

```
head(ozone) #print first few rows
```

Check the dimensions of `ozone`

```
dim(ozone)
```

```
## [1] 111   4
```

Data Structures

Check the names of `ozone` using `dimnames()`, `rownames()` and `colnames()`

```
dimnames(ozone)
```

```
## [[1]]
##   [1] "1"   "2"   "3"   "4"   "5"   "6"   "7"   "8"   "9"   "10"  "11"  "12"  "1
##  [17] "17"  "18"  "19"  "20"  "21"  "22"  "23"  "24"  "25"  "26"  "27"  "28"  "2
##  [33] "33"  "34"  "35"  "36"  "37"  "38"  "39"  "40"  "41"  "42"  "43"  "44"  "4
##  [49] "49"  "50"  "51"  "52"  "53"  "54"  "55"  "56"  "57"  "58"  "59"  "60"  "6
##  [65] "65"  "66"  "67"  "68"  "69"  "70"  "71"  "72"  "73"  "74"  "75"  "76"  "7
##  [81] "81"  "82"  "83"  "84"  "85"  "86"  "87"  "88"  "89"  "90"  "91"  "92"  "9
##  [97] "97"  "98"  "99"  "100" "101" "102" "103" "104" "105" "106" "107" "108" "1
##
## [[2]]
## [1] "rad"   "temp"  "wind"  "ozone"
```

Data Structures

Vectors

Lists

Factors

Matrices

Dataframes

Extract data by colnames using `$`

(output is a vector)

```
ozone$temp
```

```
##   [1] 67 72 74 62 65 59 61 69 66 68 58 64 66 57 68 62 59 73 61 61 67 81 79 76 82
##  [33] 76 84 85 81 83 83 88 92 92 89 73 81 80 81 82 84 87 85 74 86 85 82 86 88 86
##  [65] 90 86 82 80 77 79 76 78 78 77 72 79 81 86 97 94 96 94 91 92 93 93 87 84 80
##  [97] 71 78 67 76 68 82 64 71 81 69 63 70 75 76 68
```

Data Structures

Create a dataframe with the vectors `name`, `sex`, `age` and `perform`

```
team_details <- data.frame(name, age, sex, perform)
```

```
team_details
```

Back to operators...

Subsetting in R

What is 5th element in the vector `name`?

```
name[5]
```

```
## [1] "Susan"
```

What is the 4th element of the column `name` in the dataframe `team_details`?
(hint: use `$` to extract columns as vectors)

```
team_details$name[4]
```

```
## [1] "Harry"
```

Back to operators...

Subsetting in R

Extract the element in the 2nd row and 4th col in `team_details`

```
team_details[2,4]
```

```
## [1] Low
## Levels: Low Med High
```

Extract 2nd row and all cols in `team_details`

```
team_details[2,]
```

Extract the 4th col and all rows except the 2nd in `team_details`

```
team_details[-2,4]
```

```
## [1] High Med  Med  High
## Levels: Low Med High
```

Back to operators...

Subsetting in R

Extract rows 1 to 3 in `team_details`

```
team_details[1:3,]
```

Extract rows 1 and 3 in `team_details`

```
team_details[c(1,3),]
```

Back to operators...

Subsetting in R: Quick test!⚡

Extract R's built-in dataset `data(mtcars)`

Extract data on cars with a fuel efficiency of at least 20 mpg, and that are more than 108 hp

- **Hint:** `mtcars[ & , ]`
- **Hint:** `mtcars[mtcars$mpg >= 20 & , ]`
- **Answer:** `mtcars[mtcars$mpg >= 20 & mtcars$hp > 108, ]`

Outline

Functions

Overview

Functions have inputs and outputs (look up details with `?`)

E.g. Plot the performance distribution in `team_details`

```
plot(team_details$perform)
```

Functions

Overview

Functions have inputs and outputs (look up details with `?`)

E.g. Find the mean age in `team_details`

```
mean(team_details$age)
```

```
## [1] 30
```

E.g. Find the number of people (rows) in `team_details`

```
nrow(team_details)
```

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

Functions

General structure when defining a function:

```
functionname <- function(inputs){
  # calculations...
  output
  }
```

Subsequent calls to the function:

```
functionname(inputs)
```

Functions

Overview

E.g. Load `data/grades.csv` and assign it the name `grades`

User-defined

Functions

Overview

User-defined

$$\frac{\sum_{i=1}^{n} gradepoint_i \times credits_i}{\sum_{i=1}^{n} credits_i}$$

Manually calculate the GPA in R using the formula

```
sum(grades$grade_point * grades$credits) / sum(grades$credits)
```

```
## [1] 3.22
```

Functions

Overview

User-defined

Create a function named `scorer` that:

- Takes a dataframe as input
- Outputs a calculation based on the colnames `grade_point` and `credits`

```
scorer <- function(x){
  sum(x$grade_point*x$credits) / sum(x$credits)
}
```

```
scorer(grades) #use function
```

```
## [1] 3.22
```

Functions

- Loop functions repeat code `i` number of times
- Most common type: `for` loop

Functions

Prepare our data inputs to the `for` loop:

Get the grades of others team members within `/data` folder

```
grades_tom <- read.csv("data/grades_tom.csv")
grades_dick <- read.csv("data/grades_dick.csv")
grades_harry <- read.csv("data/grades_harry.csv")
grades_susan <- read.csv("data/grades_susan.csv")
```

Put all these dataframes into a list named `team_grades`

```
team_grades <- list(grades, grades_tom, grades_dick, grades_harry, grades_sus
```

Functions

For every item (person) in the list `team_grades`, use the function `scorer()` and append results to new column "GPA" in `team_details`

```
for(i in 1:length(team_grades)){
  team_details$GPA[i] <- scorer(team_grades[[i]])
  }
#the named object "i" changes in value with iteration of the loop
```

Who has the best grades in the team?

Functions

Loop functions in base R

`lapply(x, FUN)`: Apply a function on each element of `x`, returns a *list*
`apply(x, MARGIN, FUN)`: Apply a function to tabular data by rows (`1`), cols (`2`), or both `c(1,2)`

Find the mean value for *each* numeric column in `team_details`

```
apply(team_details[,c(2,5)], 2, mean) #apply mean() function across columns
```

```
##       age       GPA
## 30.000000  4.122947
```

Functions

Quick test!⚡

Calculate the mean for each numeric variable in `data(mtcars)`

Answer:

```
apply(mtcars, 2, mean)
```

```
##        mpg        cyl       disp         hp       drat         wt       qsec
##  20.090625   6.187500 230.721875 146.687500   3.596563   3.217250  17.848750   0
##       gear       carb
##   3.687500   2.812500
```

Questions?

Useful Resources

Online tutorials

- R for Data Science
- Quick R
- R for cats (blog post)
- swirl (good for practice)

Online courses

- Introuction to R by Datacamp
- R Programming by Coursera

Online Q&A

- Stack Overflow
- How to ask a good question online
- Remember to check your `sessionInfo()` when troubleshooting!

Others

- Use R/RStudio from an external drive (if you don't have admin rights to install software)