Topic 2

R basics

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2. R Basics

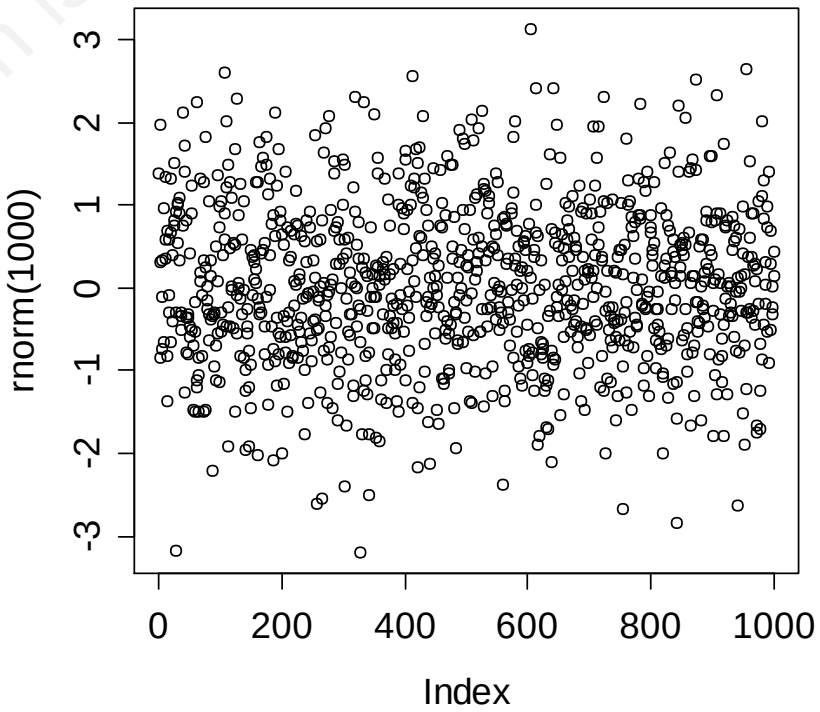
2.1. First steps

The command line

- R works by the question-and-answer model
- Commands are entered at the prompt sign in the command line, e.g.:

```
> plot(rnorm(1000))
```

1000 numbers drawn from a normal distribution



R is a "calculator on steroids"

```
> 2 + 2
[1] 4
> exp(-2)
[1] 0.1353353
> rnorm(10)
[1] -0.505 1.728 -0.323
[4] -1.900 1.808 -1.898
[7] -1.108 -1.215 1.092
[10] -0.759
```

The assignment operator <-

```
> x  <- 2
> x
[1] 2
> x + x
[1] 4
> y <- 5
> x * y
[1] 10
```

Naming rules:

- Names can be built from any symbols, but:
- No variable names starting with dot “ . ” and no spaces in names
- No names starting from numbers
- Names are case sensitive, e.g. `WT` and `wt` would be treated as different
- Don’t use system-reserved names, i.e.
  - `c`, `q`, `t`, `C`, `D`, `F`, `I`, and `T`
  - `diff`, `df`, `pt`, and some other names

Vectors – sets of values of the same type

- R can handle data vectors as single objects:

```
> weight <- c(60, 72, 57, 90, 95, 72)
> weight
[1] 60 72 57 90 95 72
```

`c(...)` – concatenation function

- One can do calculations with vectors just like ordinary numbers:

```
> height <- c(1.75, 1.80, 1.65, 1.90,
              1.74, 1.91)
> bmi <- weight/height^2
> bmi
 [1] 19.592 22.2222 20.937 24.931 31.378 19.736
```

Using vectors, we can easily perform some typical statistical calculations

- Calculating average `weight`:

```
> xbar <- sum(weight)/length(weight)
> xbar
[1] 74.333
```

- Calculating the standard deviation:

$$SD = \sqrt{\sum (x_i - \bar{x})^2 / (n-1)}$$

```
> SD <- sqrt(sum((weight - xbar)^2) /
          (length(weight) - 1))
> SD
[1] 15.422
```

Of course, we could've calculated the mean and SD much faster!

```
> mean(weight)
[1] 74.33333

> sd(weight)
[1] 15.42293
```

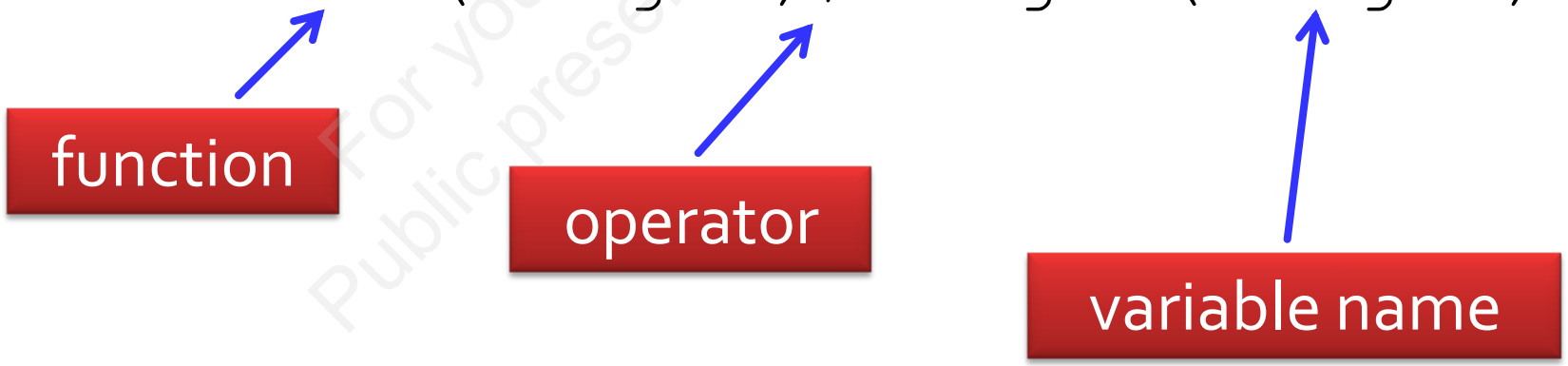
2. R Basics

2.2. R language essentials

Expressions

- What we enter into the command line has a more general name – expression
- Expressions typically include variable names, operators, and function calls:

```
xbar <- sum(weight)/length(weight)
```



Objects

- Expressions work on objects
- Basically, everything we create in R can be called “object”

`x`, `y`, `weight`, `height`, `SD` – all are objects

R is one of the object-oriented languages

Types of R objects

- Data objects – contain data (i.e. vectors, matrices, lists, and data frames)
- Function objects - functions

2.2. R language essentials

Functions

Functions and arguments

- Function – a named set of commands that perform specific operation(s) with other objects

```
plot(), c(), sum(), mean()...
```

- Actual function arguments – objects that a function is applied to

```
plot(height, weight)
```

- Formal function arguments – specific parameters that control function's behavior

```
plot(height, weight, pch = 2)
```

Parentheses in a function call

- Must be used at all times, even though there may be no arguments in the function call

Typical example: `ls()`

2.2. R language essentials

Vectors

Vectors – sets of objects of the same type

- Numeric

```
> c(2, 7, 10)
[1] 2  7  10
```

- Character

```
> c("Treatment 1","Treatment 2")
[1] "Treatment 1" "Treatment 2"
```

- Logical: take the value `TRUE` or `FALSE`

```
> b <- bmi > 25
> b
[1] FALSE FALSE FALSE FALSE TRUE FALSE
```

Missing values

- Often occur in practical data analysis
- In R such values are denoted as `NA`

```
> c(2, NA, 10)
[1] 2  NA  10
```

- Operations on `NA` yield `NA`, and thus in many cases `NAs` have to be excluded from calculations (…discussed later)

```
> mean(c(2, NA, 10))
[1] NA
```

Functions that create vectors: c ()

- Examples of concatenation:

```
> c(42,57,12,39,1,3,4)
[1] 42 57 12 39 1 3 4
> x <- c(1, 2, 3)
> y <- c(10, 20)
> c(x, y)
[1] 42 57 12 39 1 3 4 10 20
> c("abc", 10, 20)
[1] "abc" "10" "20"
```

Functions that create vectors: `seq()`

- A numeric sequence:

```
> seq(from = 4, to = 10)
[1] 4 5 6 7 8 9 10
```

- Command with the same outcome:

```
> 4:10
```

- Sequence with step 2:

```
> seq(from = 4, to = 10, by = 2)
[1] 4 6 8 10
```

Functions that create vectors: `rep()`

- Repeated pattern:

```
> z <- c(2, 4, 6)
> rep(z, 2)
[1] 2 4 6 2 4 6
```

- Try also these commands:

```
> rep(z, 1:3)
> rep(1:2, c(3, 6))
> rep(1:2, each = 10)
```

2.1. R language essentials

Matrices

Matrices

- Matrix – two-dimensional array of numbers
- Widely used in theoretical and practical statistics
- Can be used to store data

Creating matrices with `matrix()`

- Creating a matrix

```
> h <- matrix(1:12, nrow=3,byrow=TRUE)
> h
```

- Assigning names to rows and columns:

```
> rownames(h) <- c("A", "B", "C")
> colnames(h) <- c("V1", "V2", "V3", "V4")
> h
```

- Matrix transposition:

```
> t(h)
```

Creating matrices by combining vectors

- Binding several vectors by columns:

```
> cbind(A = 1:4, B = 5:8, C = 9:12)
```

- Binding several vectors by rows:

```
> rbind(A = 1:4, B = 5:8, C = 9:12)
```

2.2. R language essentials

Factors

Factors

- Factor – categorical variable indicating some subdivision of data (e.g., by sex, sampling location, treatment group, etc.)
- Factor levels – specific categories of a factor (e.g., male and female)

Creating a factor

```
> sex <- c("male", "male",
  "female", "female", "female")
> sex  <- factor(sex)
> sex
[1] male male female female female
Levels: female male
> levels(sex)
[1] "female" "male"
> as.numeric(sex)
[1] 2 2 1 1 1
```

Creating a factor

Also works, but better not to use:

```
> sex <- c(0, 0, 1, 1, 1)
> sex <- factor(sex)
> sex
[1] 0 0 1 1 1
Levels: 0 1
```

2.2. R language essentials

Lists

Lists

- List – collection of R objects of any type

```
> sex <- c("male", "male",
  "female")
> weight <- c(80, 85, 60)
> height <- c(1.75, 1.80, 1.68)
> data <- list(Sex = sex,
    Weight = weight,
    Height = height)
```

Lists

```
> data
$Sex
 [1] "male" "male" "female"

$Weight
 [1] 80 85 60

$Height
 [1] 1.75 1.80 1.68
```

Extraction of list components

```
> data$Sex
[1] "male" "male" "female"

> data$Weight
[1] 80 85 60
```

and so on…

2.2. R language essentials

Data frames

Data frames

- Data frame – a list of vectors and/or factors of the same length that are related "across" such that data in the same position come from the same experimental unit (subject, animal, etc.). In addition, it can have a unique set of row names

Creating a data frame

```
> data <- data.frame(
  Sex = sex,
  Weight = weight,
  Height = height)
> data
     Sex    Weight  Height
  1 male    80      1.75
  2 male    85      1.80
  3 female  60      1.68
```

Extracting data frame components

```
> names(data)
[1] "Sex" "Weight" "Height"
> data$Sex
[1] male male female
Levels: female male
> data$Height
[1] 1.75 1.80 1.68
```

2.2. R language essentials

Indexing

Indexing of vectors

- Extracting particular values from a vector:

```
> weight[2]
[1] 85
> height[c(1, 3)]
[1] 1.75 1.68
> i <- c(2, 3)
> weight[i]
[1] 85 60
> height[-i]
[1] 1.75
```

Indexing of vectors

- Conditional selection

```
> height[height < 1.80]
[1] 1.75 1.68
> weight[weight>=80 & weight<=85]
[1] 80 85
```

Other logical operators to use:

| (logical “or”)

! (logical “not”)

Indexing of data frames

- Value from the 2nd row and 3rd column:

```
> data[2, 3]
[1] 1.8
```

- Entire 2nd row:

```
> data[2, ]
  Sex  Weight Height
2 male 85     1.8
```

- Entire 3rd column:

```
> data[, 3]
[1] 1.75 1.80 1.68
```

Indexing of data frames

- All data for males:

```
> data[data$Sex == "male", ]
   Sex     Weight  Height
1 male     80        1.75
2 male     85        1.80

> data$Sex == "male"
[1] TRUE TRUE FALSE
```

Indexing of data frames

- Data from the 1st and 3rd columns:

```
> data[, c(1, 3)]
   Sex    Height
1 male   1.75
2 male   1.80
3 female 1.68
```

Indexing of data frames

- Very useful for large data frames:

```
> head(data, n = 2)
   Sex   Weight  Height
1  male  80      1.75
2  male  85      1.80

> tail(data, n = 2)
...
```

2. R Basics

2.3. The R environment

2.3. The R environment

The workspace

The workspace

- Workspace – part of the computer memory where all the objects created during a R session are stored (temporarily, until saved!)
- Checking what's in the workspace:

```
> ls()
...
```

In **RStudio**, check the tab "Workspace"

The workspace

- When it gets messy, tide up!

```
> rm(i)
```

- To remove everything (! careful):

```
> rm(list = ls())
```

In **RStudio**:
tab “Workspace”, button “Clear All”

The workspace

- To save the current workspace for later usage (creates an `.Rdata` file in the current *working directory*):

```
> save.image()
```

- A better approach (in **RStudio**):
- Tab "Workspace"
- Option "Save Workspace As…"

The working directory

- Working directory – path where R automatically goes to load files from and to save files to
- Checking the current working directory:

```
> getwd()
[1] "D:/DOCS"
```

- Setting up a working directory:

```
> setwd("D:/DOCS/Analysis")
```

or in RStudio:

Tools/Set Working Directory/Choose Directory

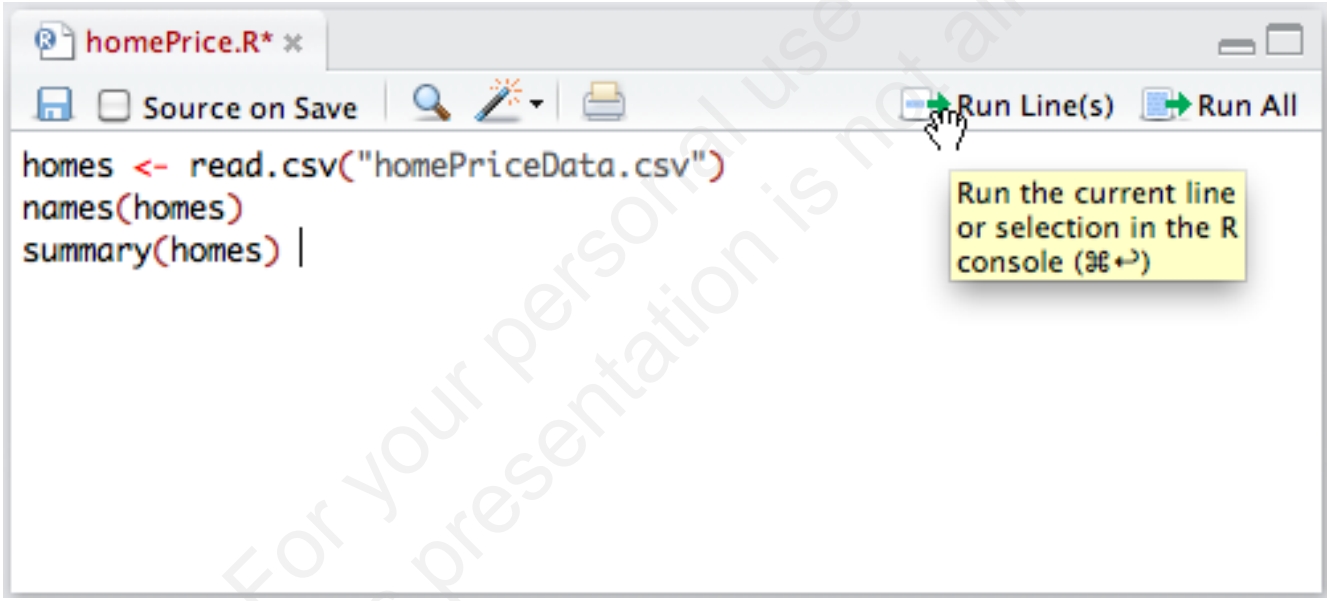
2.3. The R environment

Scripting

Scripting

- After a certain level of complexity, it's better to have R working line by line from a script (i.e., a collection of commands)
- Option 1: function `source()` – takes a file with commands as its input and runs them
- Option 2: script editor window – allows users to submit one or several code lines to R at a time

Executing a single line from the script editor in RStudio



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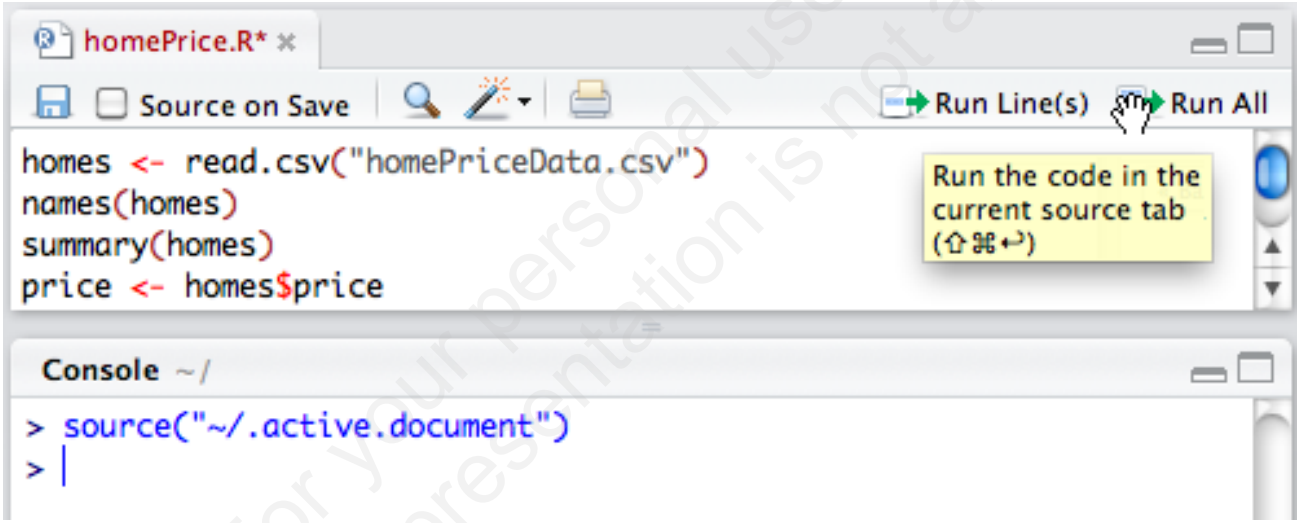
Executing all lines from the script editor in RStudio



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2.3. The R environment

Getting help

Getting help

- R has extensive online help:

```
> help.start()
```

or go to Help tab in **RStudio**

- Getting help on a specific function:

```
> help(plot)  # or equivalently
> ?plot
```

- Getting help on a specific topic:

```
> help.search("correlation")
```

2.3. The R environment

Packages

Packages

- Package – a collection of functions designed for specific operations, or collection of data sets. Go to Packages tab in **RStudio** to check what's available
- To load a (already installed) package for work:

```
> library(package)
```

- To install a new package (needs live Internet connection):

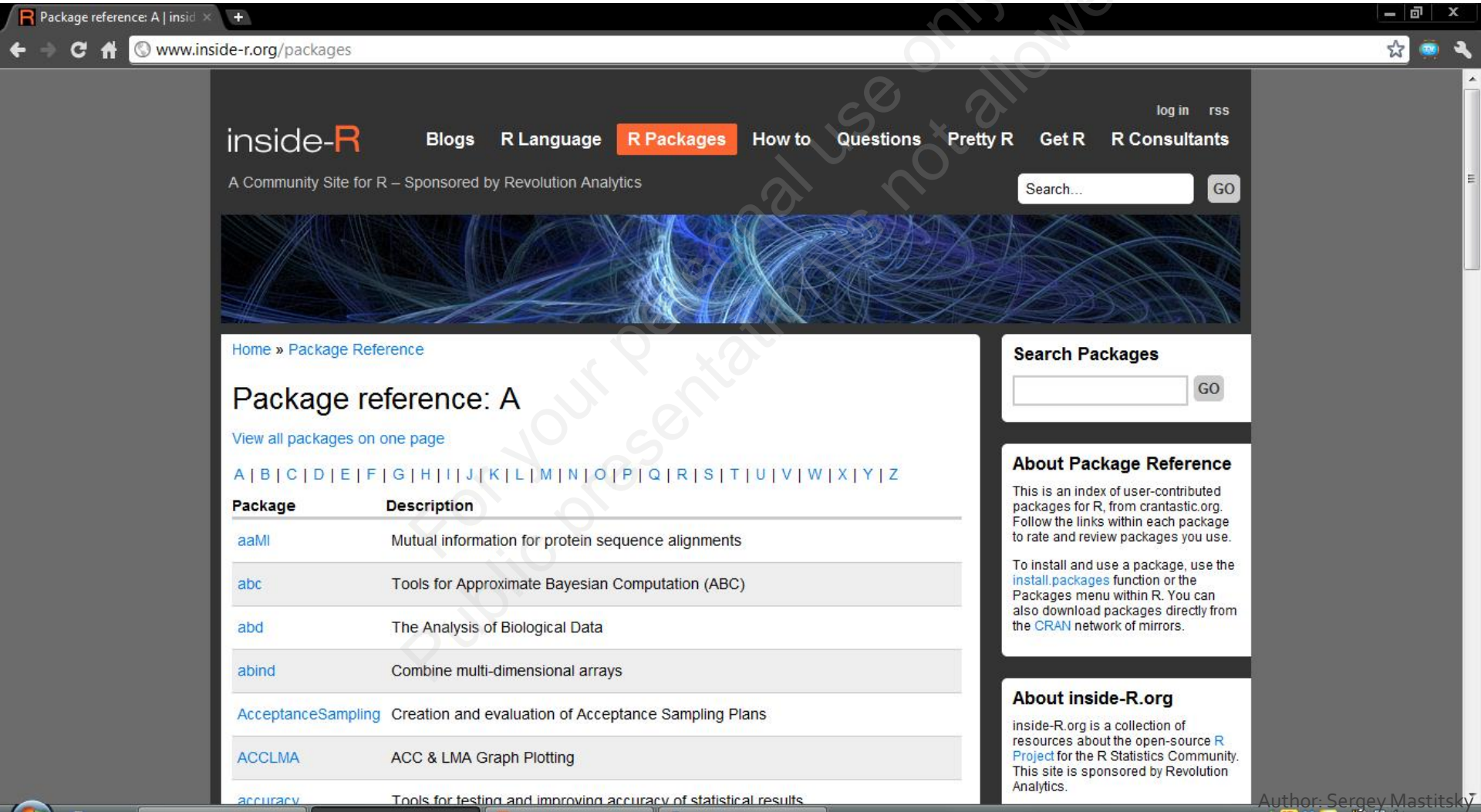
```
> install.packages("package")
```

We will use a few extra packages

```
> install.packages("ISwR")
> install.packages("HSAUR2")
```

CRAN Task Views

http://www.inside-r.org/packages



Exercises

- Go to the CRAN Task Views and explore what's available
- Go to the Inside-R website and explore the list of packages