UNIVERSITAT POLITÈCNICA DE CATALUNYA
BARCELONATECH
Departament d'Estadística
i Investigació Operativa

ACADEMIC YEAR 2024-25

STATISTICAL INFERENCE AND MODELLING – MASTER OF DATA SCIENCE

Introduction to R: EDA

Introduction to R software

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September 2024 – Version 1.1

MASTER OF DATA SCIENCE

1. LAB SESSIONS

- 2 hours every 1 week, in a PC's classroom.
- Practical assignments posted through ATENEA - TASKS. Formative assessment will be given by the lecturer before the next laboratory session when deliverable is indicated.
- Guidelines for laboratory session posted in ATENEA Course webpage
- Datasets posted on ATENEA Course webpage.

FIRST SESSION: Introduction to *R and R Studio statistical software*

R Core Team (2023). _R: A Language and Environment for Statistical Computing_. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.

2. UNITS 1-2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

⇒Davis data: davis.RData (data.frame) - Use comands in davis.R for basics

```
> library(car)
Loading required package: MASS
Loading required package: nnet

> data(Davis)
> ls()
[1] "Davis"

> attributes(Davis)
$names
[1] "sex"    "weight" "height" "repwt"  "repht"

$class
[1] "data.frame"

$row.names
  [1] "1"   "2"   "3"   "4"   "5"   "6"   "7"   "8"   "9"   "10"  "11"  "12"
 …
[193] "193" "194" "195" "196" "197" "198" "199" "200"

>
```

UNITS 1 AND 2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

2.1 Univariate descriptive analysis – Numeric data

- ***Missing* and *Outliers might occur***
- **Numerical values**
  - Measures of Central Tendency: *Mean, Median, Mode*
  - Measures of Dispersion: *Variance, Standard Deviation, Quartiles, IQR, Maximum, Minimum.*
- **Graphical Representations**
  - Histogram, Cumulative Histogram. Absolute or relative.
  - *BoxPlot.*
  - *Dotplot*

UNITS 1 AND 2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

2.1.1 Continuous Univariate Descriptive Analysis: Numeric statistics

```
> summary(dataframe)  # R command
```

- Mean $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$
- Median: Value of the *variable* such that

  50% Observations are < Median (Q2) & 50% Observations are > Median (Q2)
- Quartile Q1 of the 25% and quartile Q3 of the 75%: Values of the variable that

  25% Observations are < Q1 & 75% Observations are > Q1

  75% Observations are < Q3 & 25% Observations are > Q3
- Variance $s_x^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2$
- Standard Deviation s_x (square root of variance)

UNITS 1 AND 2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

⇒Davis data: davis.RData (data.frame) - Use comands in davis.R for basics

```
> summary(Davis)
 sex          weight          height          repwt           repht
 F:112   Min.   : 39.0   Min.   : 57.0   Min.   : 41.00   Min.   :148.0
 M: 88   1st Qu.: 55.0   1st Qu.:164.0   1st Qu.: 55.00   1st Qu.:160.5
         Median : 63.0   Median :169.5   Median : 63.00   Median :168.0
         Mean   : 65.8   Mean   :170.0   Mean   : 65.62   Mean   :168.5
         3rd Qu.: 74.0   3rd Qu.:177.2   3rd Qu.: 73.50   3rd Qu.:175.0
         Max.   :166.0   Max.   :197.0   Max.   :124.00   Max.   :200.0
                                         NA's   :17       NA's   :17
> var(Davis[,3:4])
           weight    height
weight 227.85930  34.37588
height  34.37588 144.19055
```

- **Missing data: Do not miss them! Track them.**

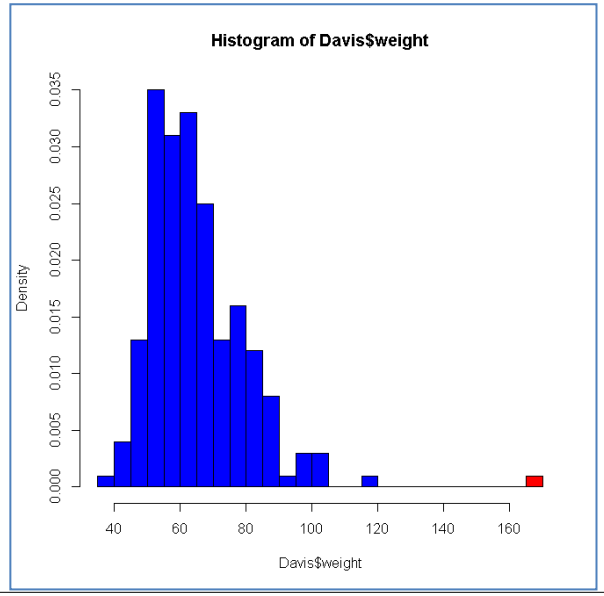
```
NA: Not available – Missing data

NaN: Not available for numerical reasons (divided by 0)
```

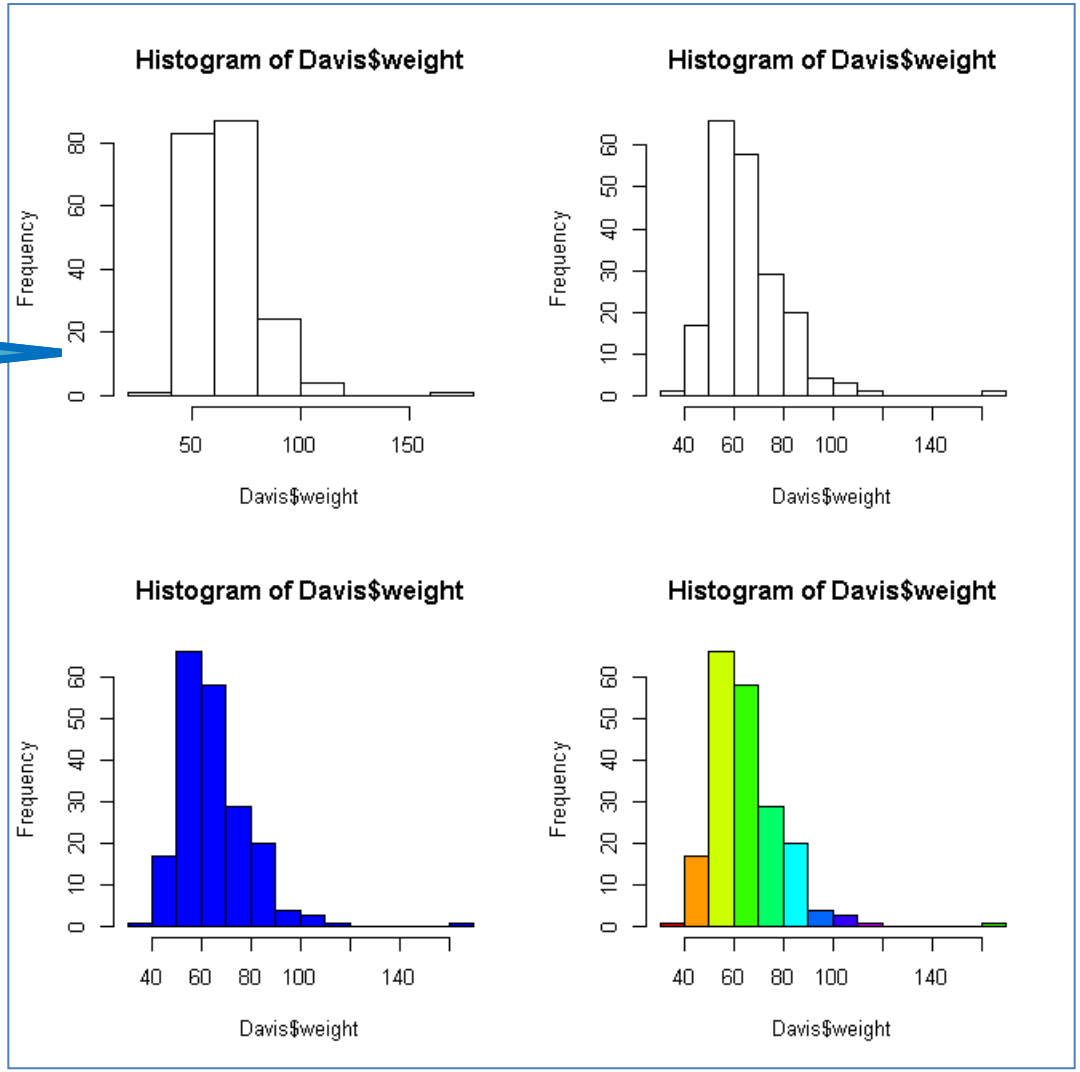
UNITS 1 AND 2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

2.1.2 Continuous Univariate Analysis Description: Histogram

Histogram (non-acumulative):

```
par(mfrow=c(2,2))
hist(Davis$weight)
hist(Davis$weight,10)
hist(Davis$weight,10,col="blue")
hist(Davis$weight,10,col=rainbow(10))

hist(Davis$weight,freq=F)   # Proportions
hist(Davis$weight,freq=F,
        col=…,breaks=seq(35,170,5))
```



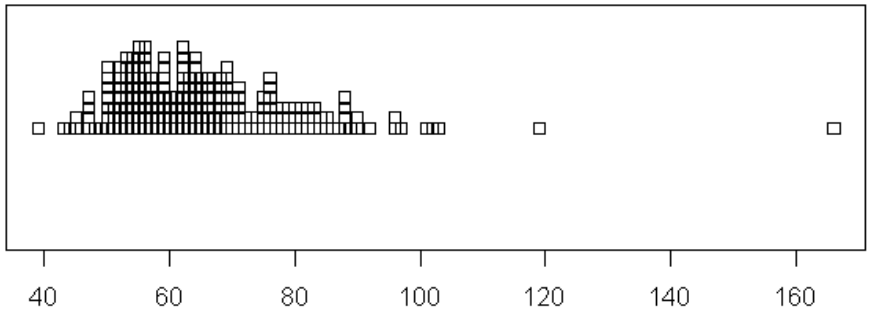


UNITS 1 AND 2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

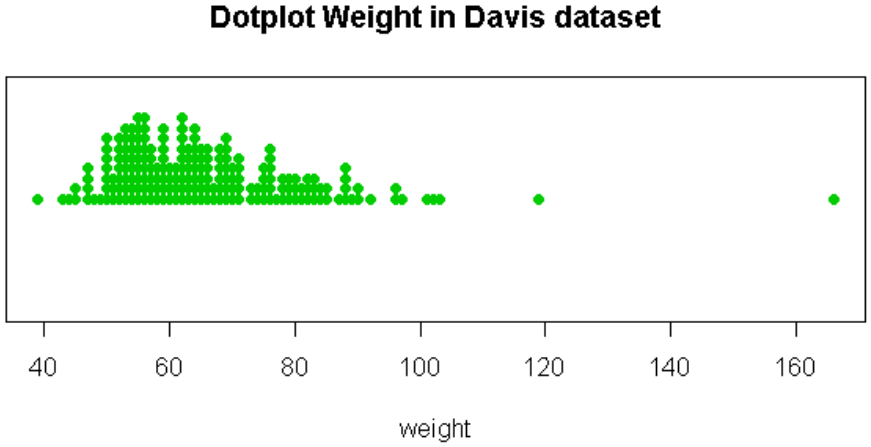
2.1.3 Continuous Univariate Analysis Description: Dotplot

Dotplot:

```
# Dotplot
par(mfrow=c(2,1))
stripchart(Davis$weight,method="stack")
```




```
stripchart(Davis$weight,method="stack"
     ,xlab="weight",pch=19,
     col=3,
     main="Dotplot Weight in Davis dataset")
```

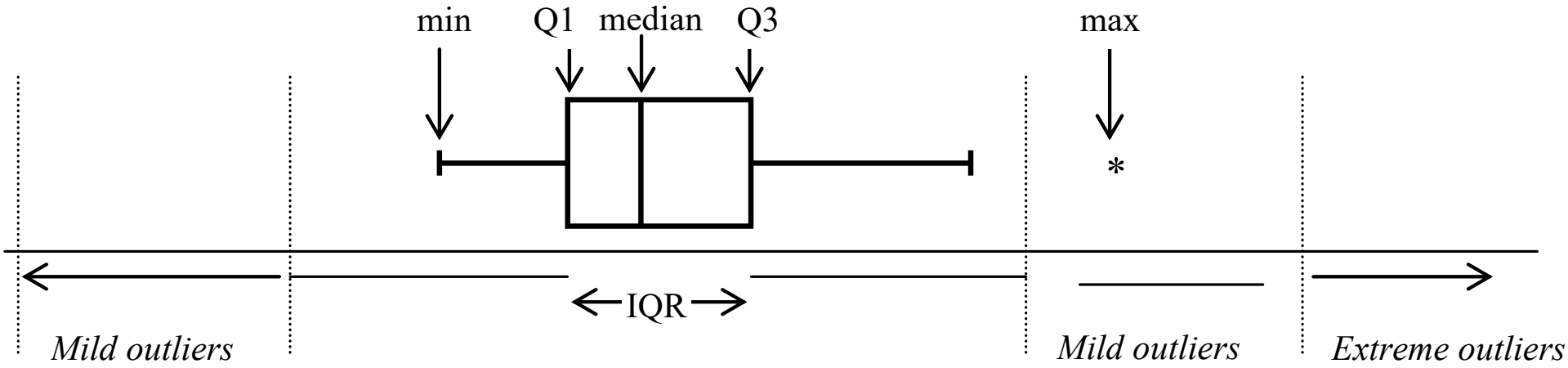


UNITS 1 AND 2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

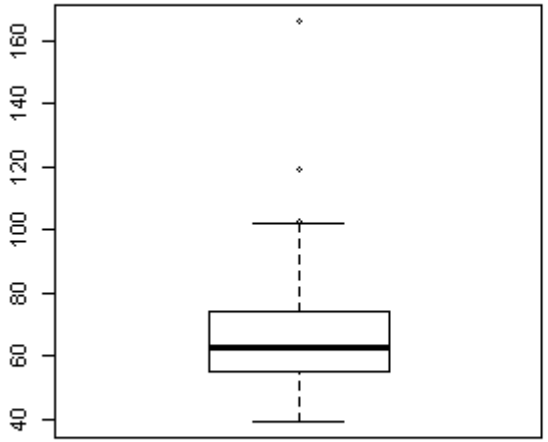
2.1.4 Continuous Univariate Analysis Description: Boxplot

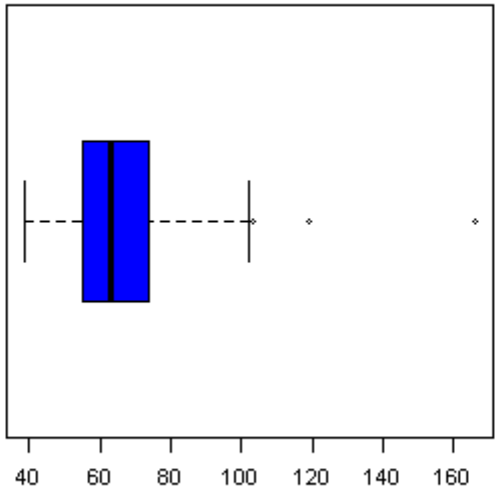
Boxplot: Basic implementation in boxplot() method, recommended Boxplot() method in car library

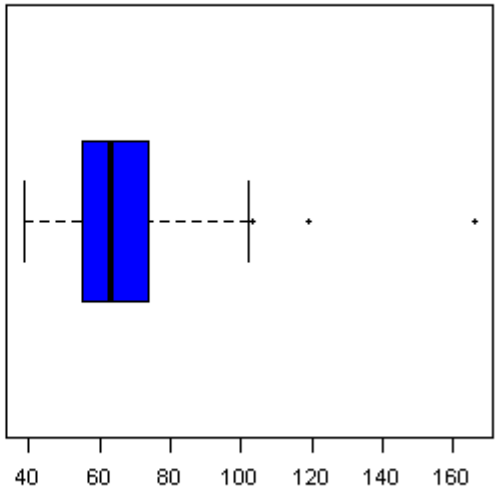
"Five issues Summary" (Min, Q1, Me, Q3, Max) for Univariate EDA, useful to detect the presence of outliers.

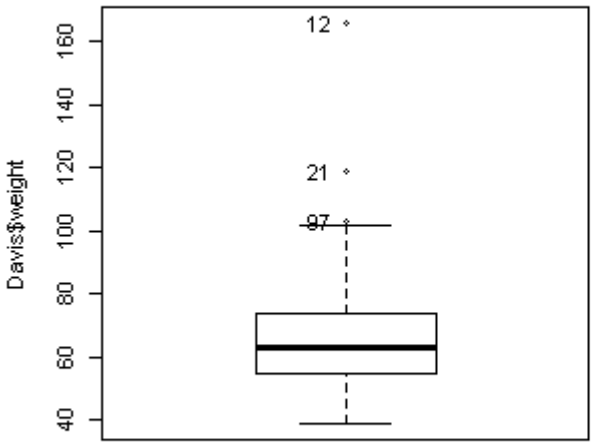


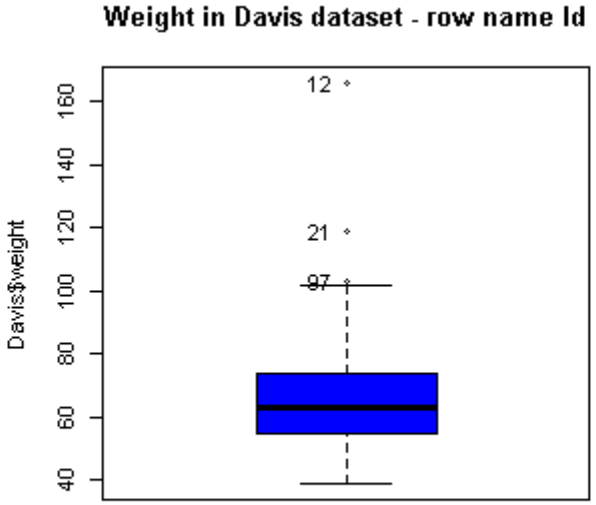

```
# Boxplot
par(mfrow=c(2,3))
boxplot(Davis$weight)
boxplot(Davis$weight,col="blue",horizontal = TRUE)
boxplot(Davis$weight,col="blue",horizontal = TRUE, pch=19,labels=Davis$weight)
Boxplot(Davis$weight)
Boxplot(Davis$weight,col="blue",main= "Weight in Davis dataset - row name Id")
Boxplot(Davis$weight,col="blue",main=" Boxplot Weight - Weight Label for
Outliers",labels=Davis$weight)
```

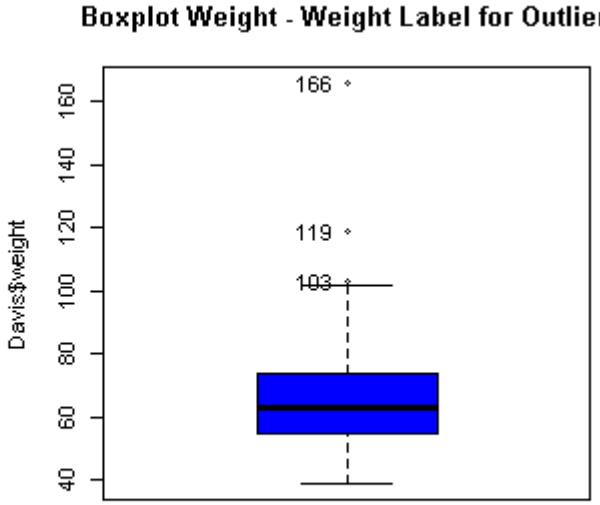

40
60
80
100
120
140
160


40
60
80
100
120
140
160


40
60
80
100
120
140
160


Davis$weight
40
60
80
100
120
140
160
12
21
97


Weight in Davis dataset - row name Id
Davis$weight
40
60
80
100
120
140
160
12
21
97

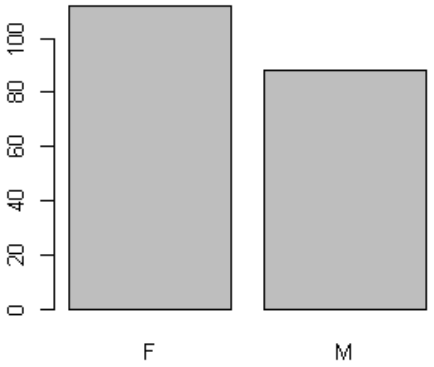

Boxplot Weight - Weight Label for Outliers
Davis$weight
40
60
80
100
120
140
160
166
119
103

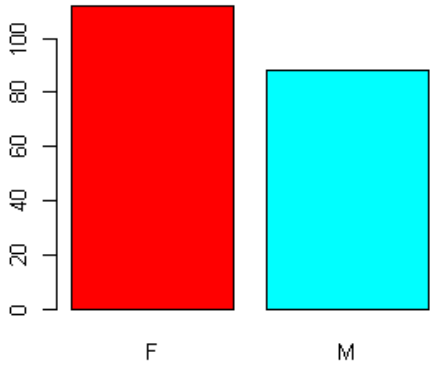
UNITS 1 AND 2: EXPLORATORY DATA ANALYSIS (EDA)-UNIVARIATE

2.2 Univariate descriptive analysis – Categorical data

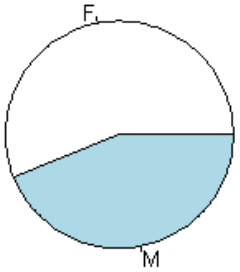
Description of categorical variables: only 'missings' might occur. Graphical representations:

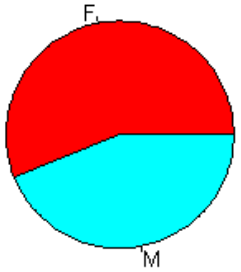
- **barplot** (a) absolute or relative (proportions) b) density or accumulated.
  - Suitable for graphical description of discrete-qualitative data (factor) with a few levels or categories.
- *Pie Chart.*





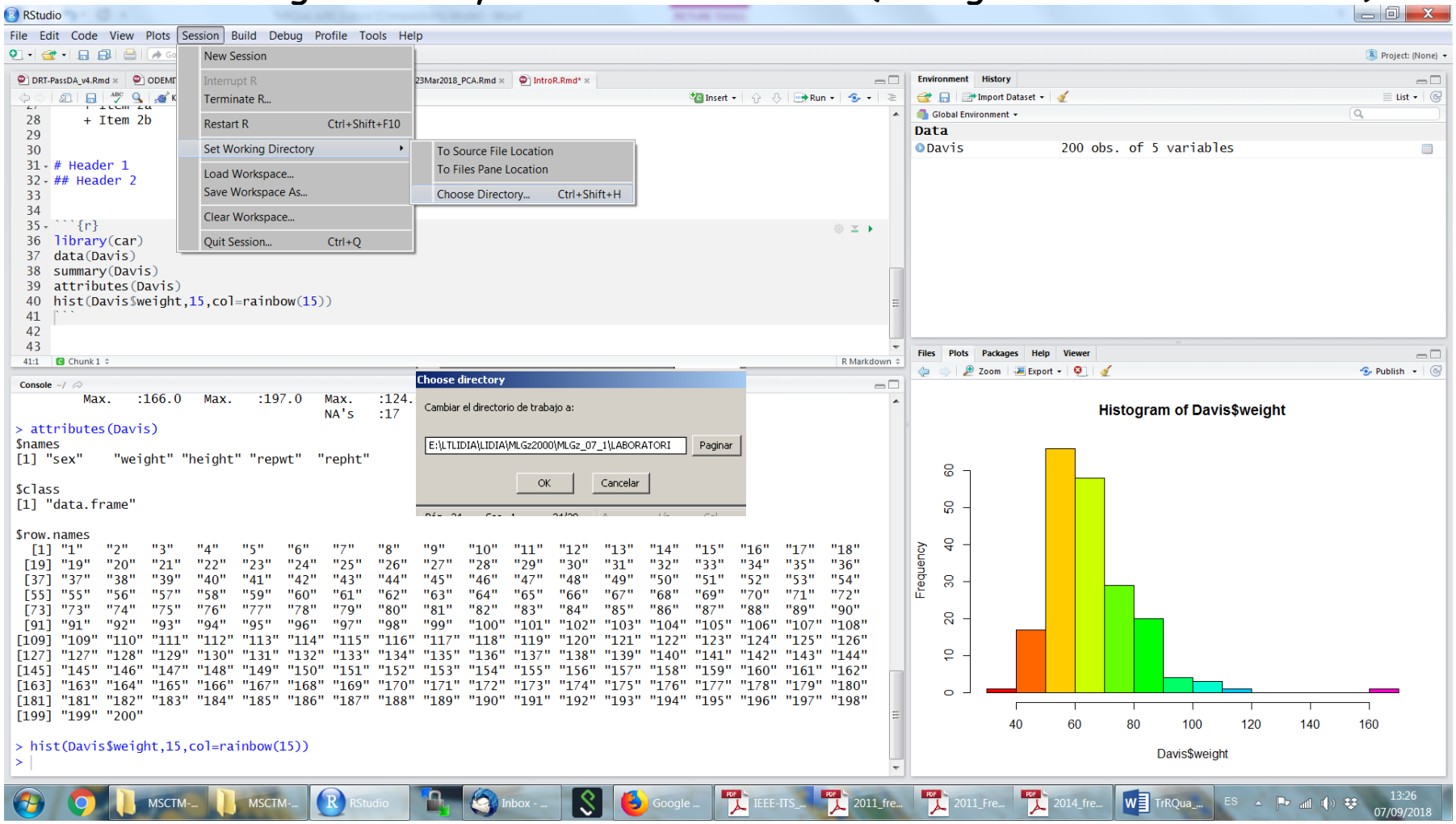

```
table(Davis$sex)
margin.table(table(Davis$sex))
prop.table(table(Davis$sex))

par(mfrow=c(2,2))
barplot(table(Davis$sex))
barplot(table(Davis$sex),col=rainbow(2))
pie(table(Davis$sex))
pie(table(Davis$sex),col=rainbow(2))
```



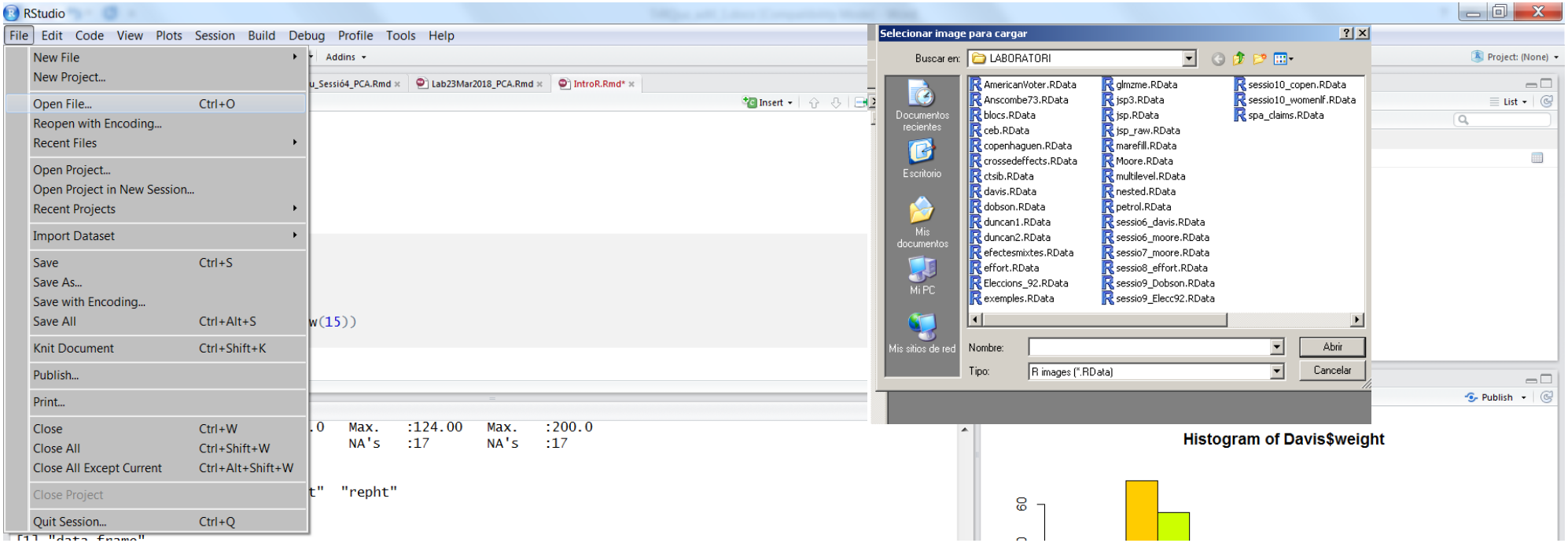


3. INTRODUCTION TO R

- *RStudio* for Windows: Basic Input/Output (R is *case sensitive*)
- Select working directory in R console window (Change dir / Cambiar dir …)



INTRODUCTION TO R: LOAD WORKSPACE (RETRIEVE PREVIOUS USED DATA)



- Open (load) and Save Workspace – *File* Menu (*Archivo*)

  File/Archivo → *Cargar área de trabajo (load workspace)*

  File/Archivo → *Guardar área de trabajo (save workspace)*

  Example: Open/Load Davis.RData from a Workspace.

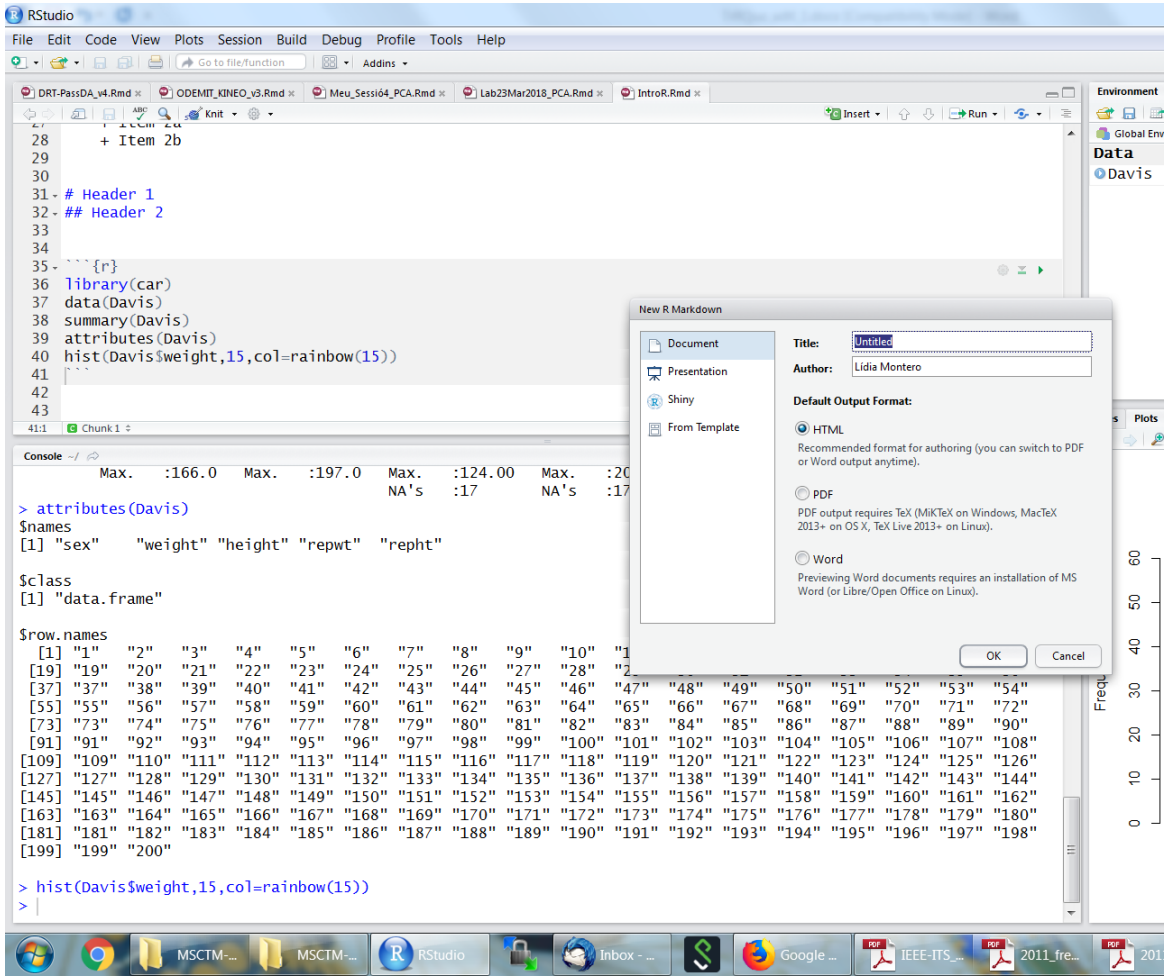
- To exit: *File/Archivo* → Salir or quit() command in R Console

INTRODUCTION TO R: SCRIPTS

From Archivo (File) menu: you can **open, close, save, create a new, save as** scripts.

Scripts are text files containing R command. Always use them to track lab session commands

Markdown documents are dynamic documents combining ordinary text and R commands. They can be interpreted to produce an output: html, pdf or word.

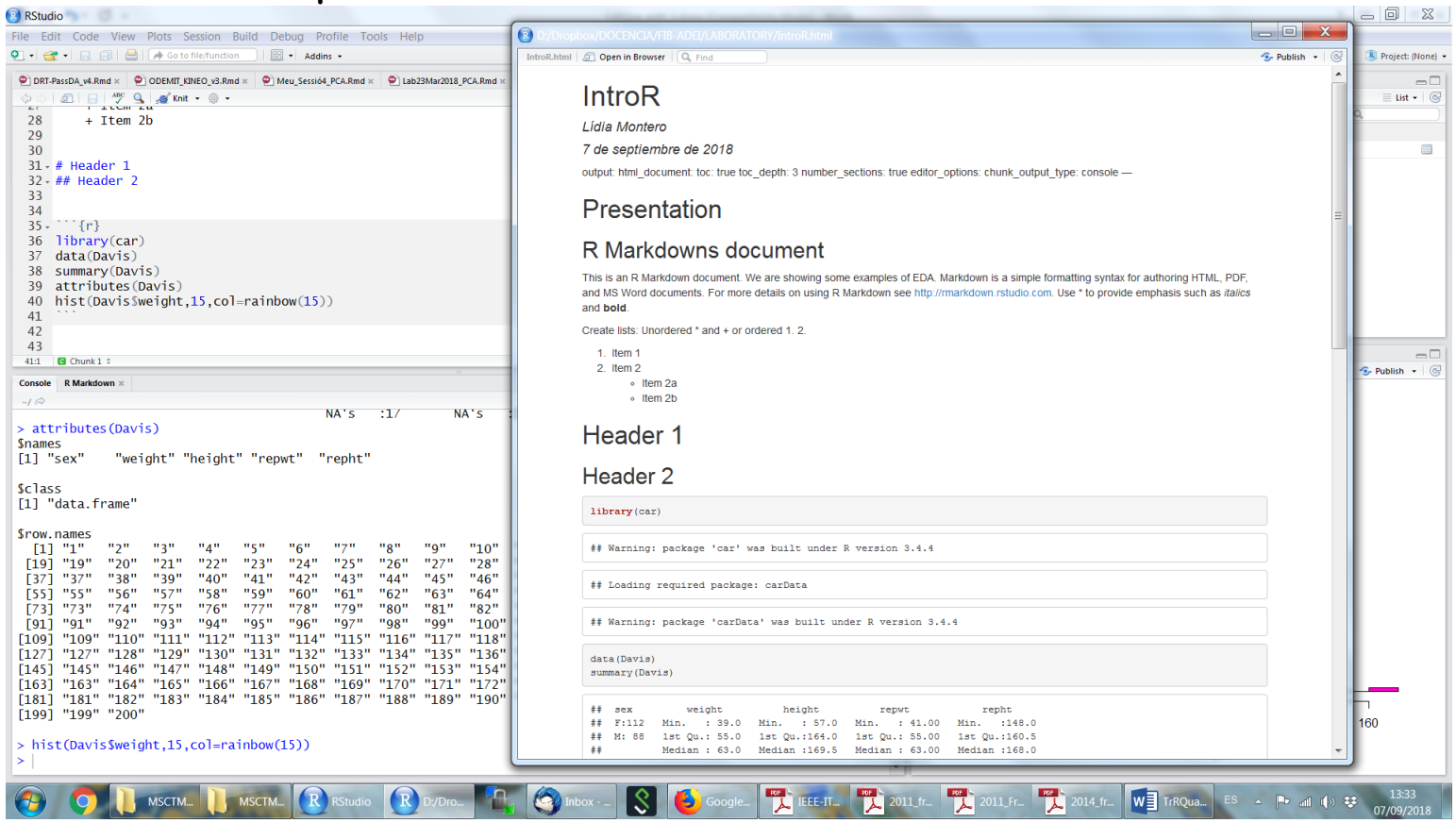


INTRODUCTION TO R: FILE MENU

Knit to produce R Markdown output:

Critical *Elements* in R:

- Expressions and Objects (escalars, vectors, matrices, lists, etc)
- The basic object is a list: list().
- Data matrix – rows are individuals and columns are variables: *data.frame*.



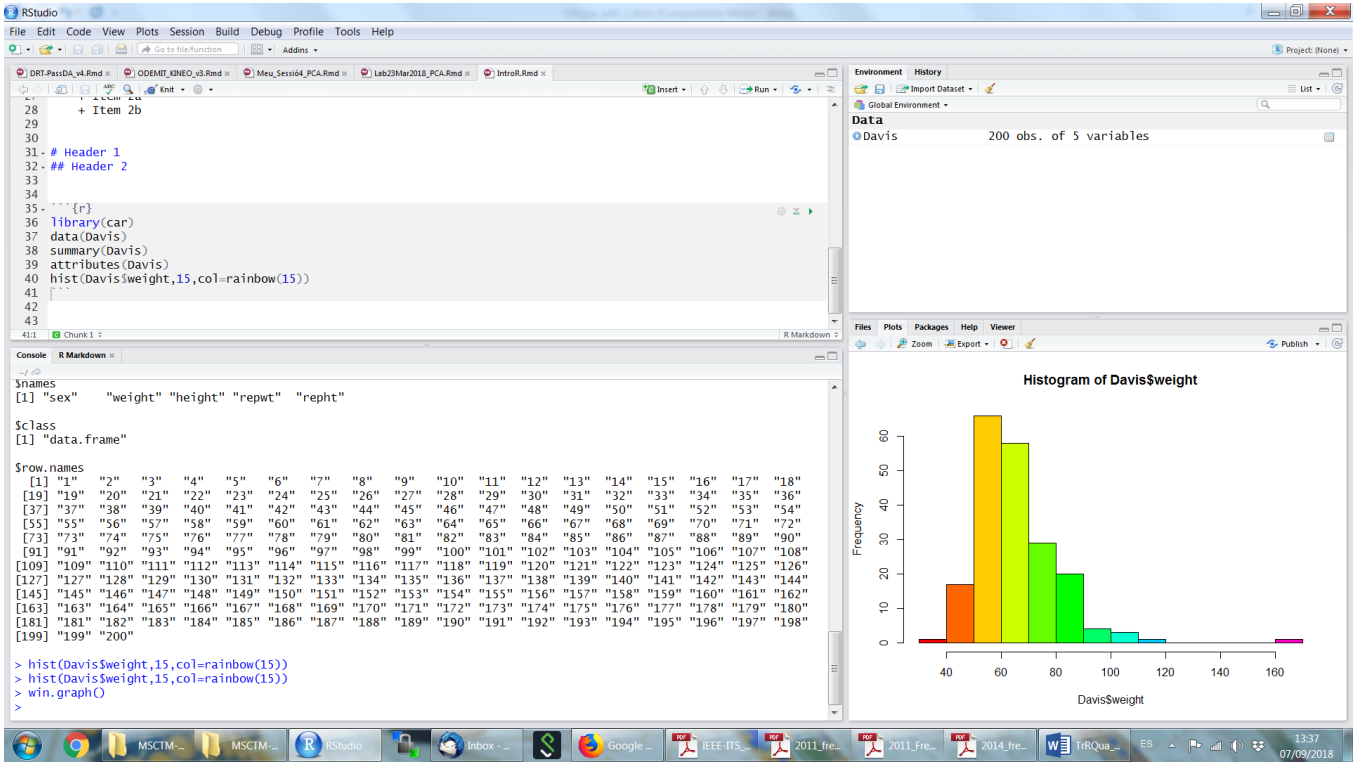
INTRODUCTION TO R: CONSOLE, DEVICES AND SCRIPTS

Available ones:

R Console (to write command and obtain results)

As many script windows as you want.

Data



Command `win.graph()` to create a new graphic device.

Graphic Devices: *R graphics* has a matrix structure that allows to obtain several figures: for ex. 2 rows and 2 columns

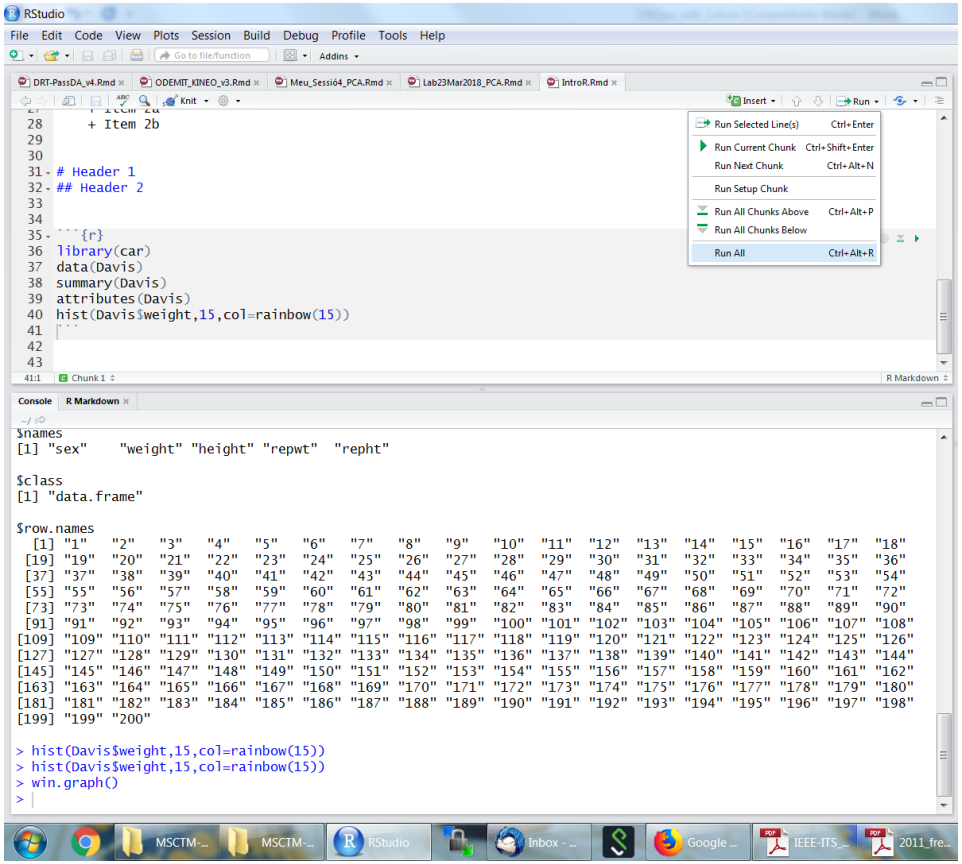
```
par(mfrow=c(2,2))
```

INTRODUCTION TO R: COMMAND STRUCTURE

R Command structure:

› *Command* parameters <CR>

› *Command* parameters ; *Command* parameters <CR>



To be written in *R console* or any *script or inside a chunk in R Markdown.*

To execute a command line included in a script: press **<ctrl- Enter>**.

To execute several command lines: select and **<ctrl- Enter>**.

To execute one or several chunks use R Studio menu.

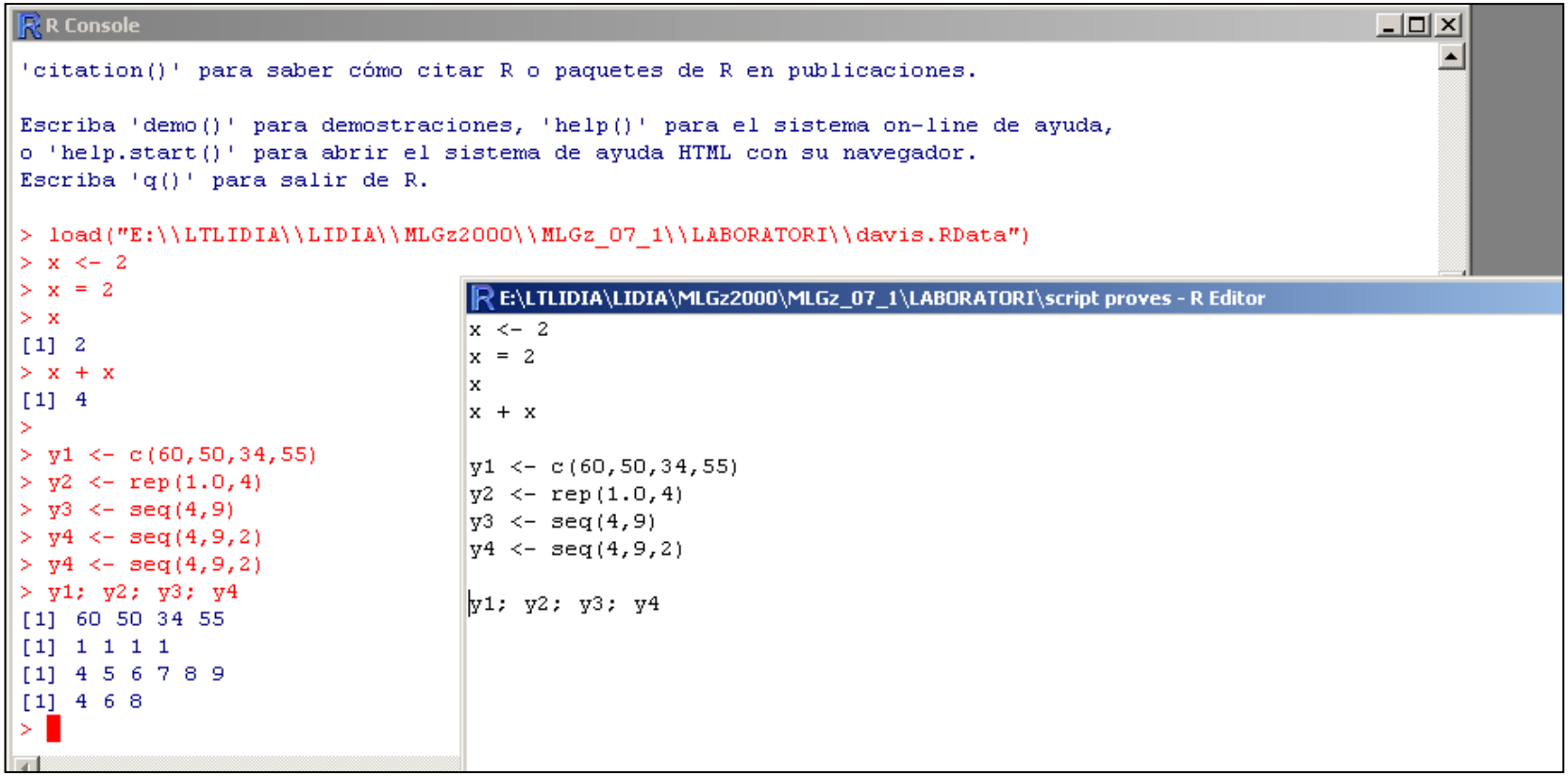
INTRODUCTION TO R: SEQUENCES …

Example: create a vector with 4 integer elements

Concatenation: `c(.)`

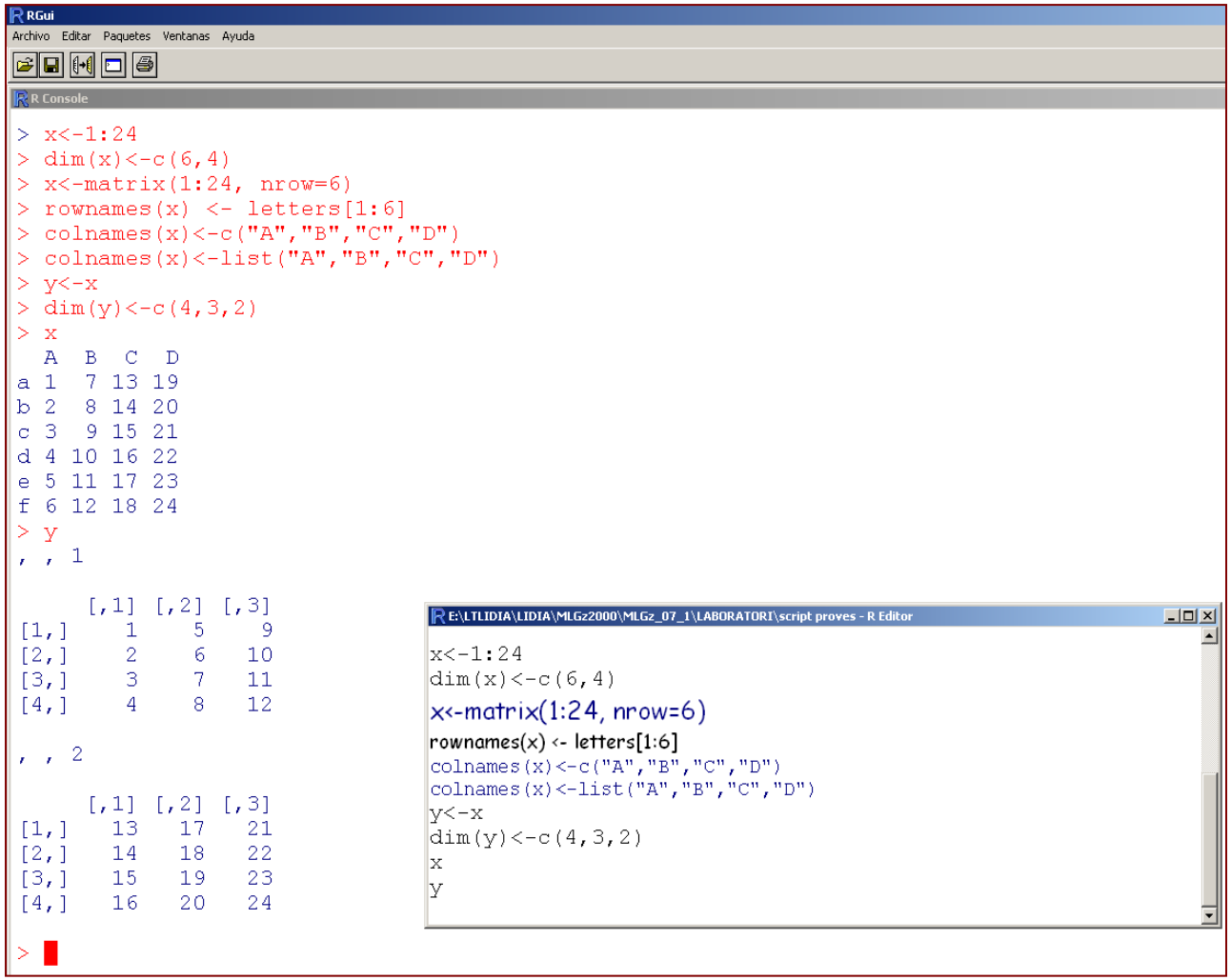
Sequence: `seq(.)`

Replication: `rep(.)`



INTRODUCTION TO R - BASIC OBJECTS:

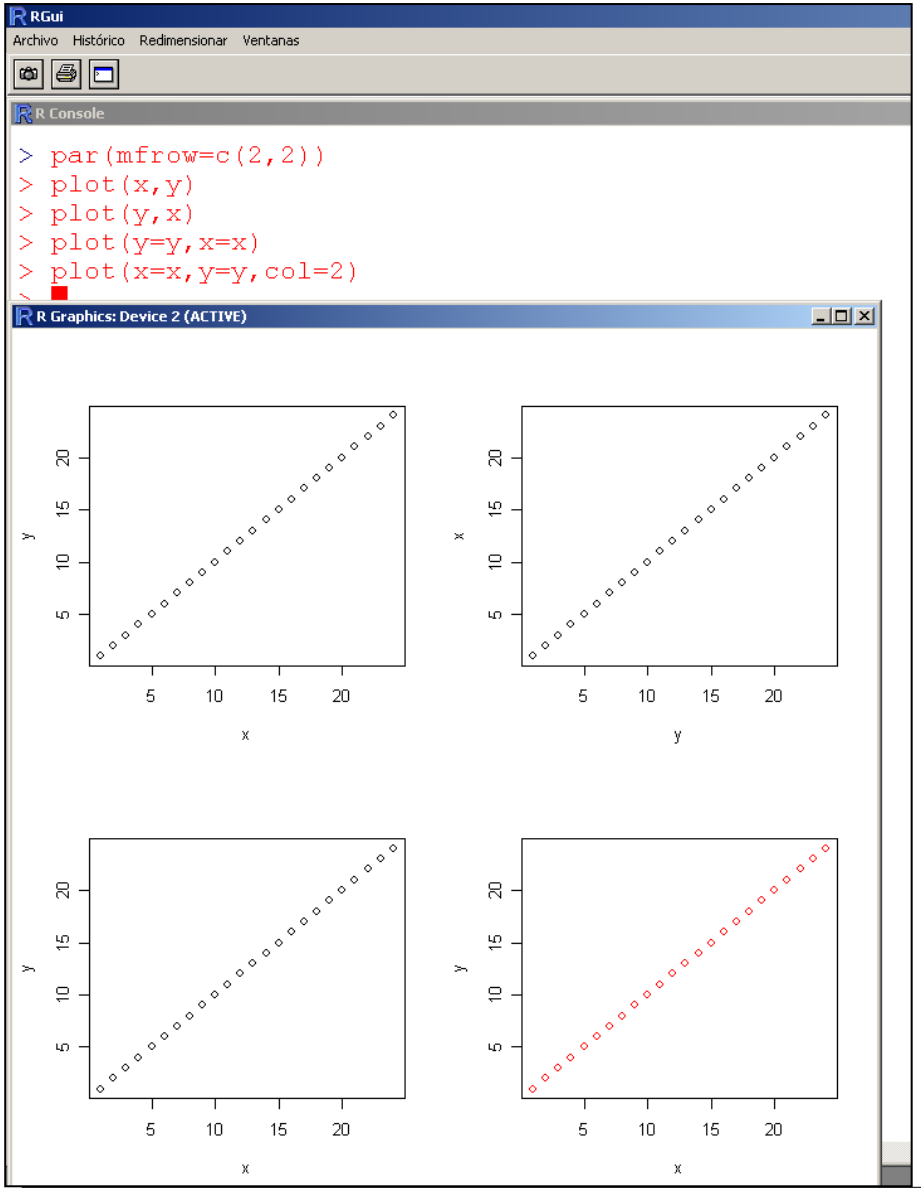
Important Objects: lists, vectors, matrices and arrays



- Matrices are arrays of 2 dimensions.
- Matrices and arrays of dimension greater than a 2 are allowed.
- Related commands: rownames(), colnames(), dim() to check dimensions.
- To create matrices:

```
> x<-matrix(1:24, nrow=6)
> rownames(x) <- letters
[1:6]
> colnames(x)<-
c("A","B","C","D")
> colnames(x)<-
list("A","B","C","D")
```

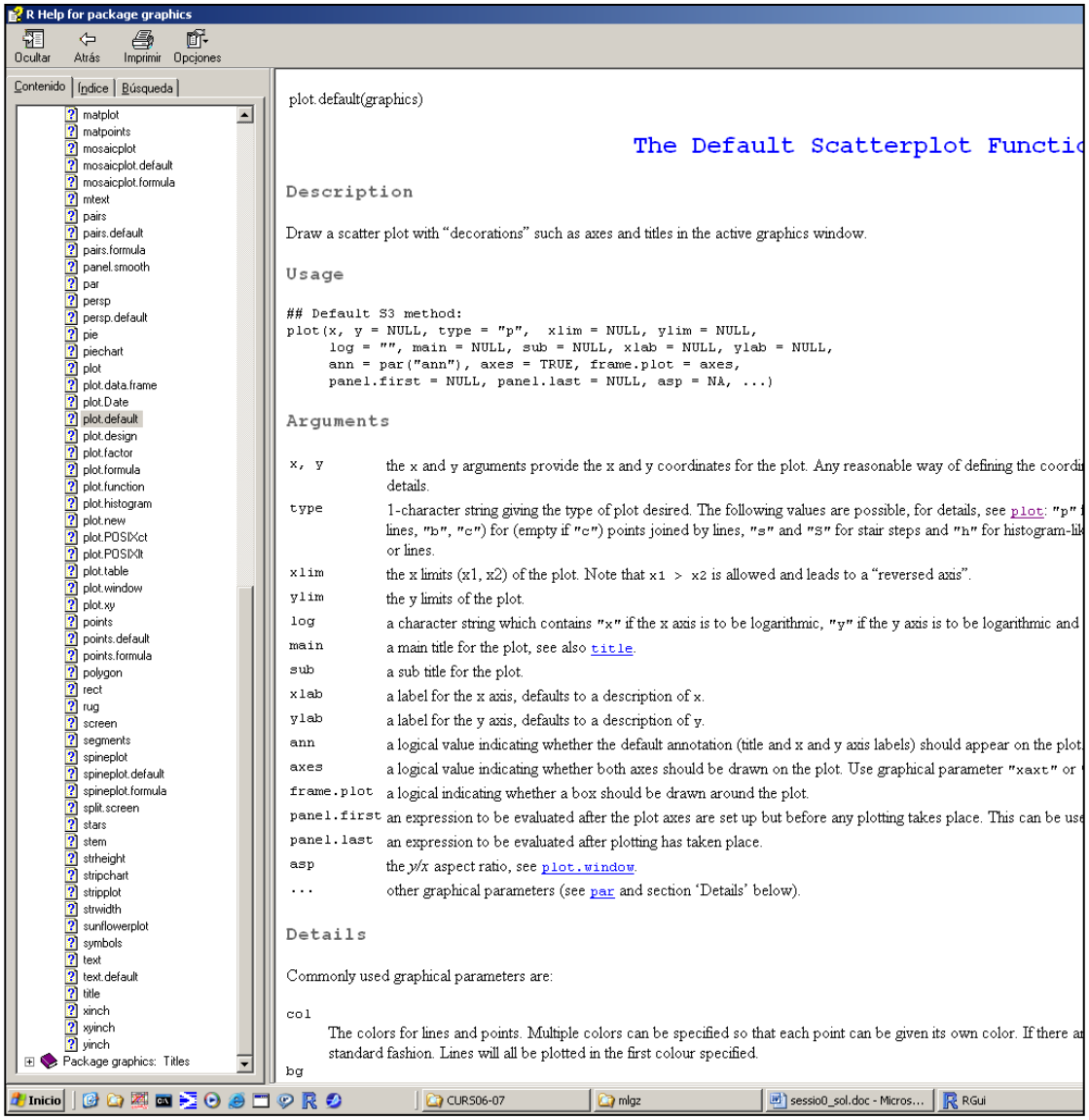
INTRODUCTION TO R - FUNCTIONS AND ARGUMENTS



Functions and *arguments*:

- An R function might be a mathematic or statistical function, as `log(x)`, but there are additional functions as `plot( height, weight )`.
- Functions have actual parameters (**actual arguments**) and formal parameters (*formal arguments*).
- Most arguments have default values and can be omitted.
- R functions *arguments* can be positionally *matched* (*positional matching*) or by name (*keyword matching*). You can mix *positional matching* with *matching* by name.

INTRODUCTION TO R - FUNCTIONS AND ARGUMENTS

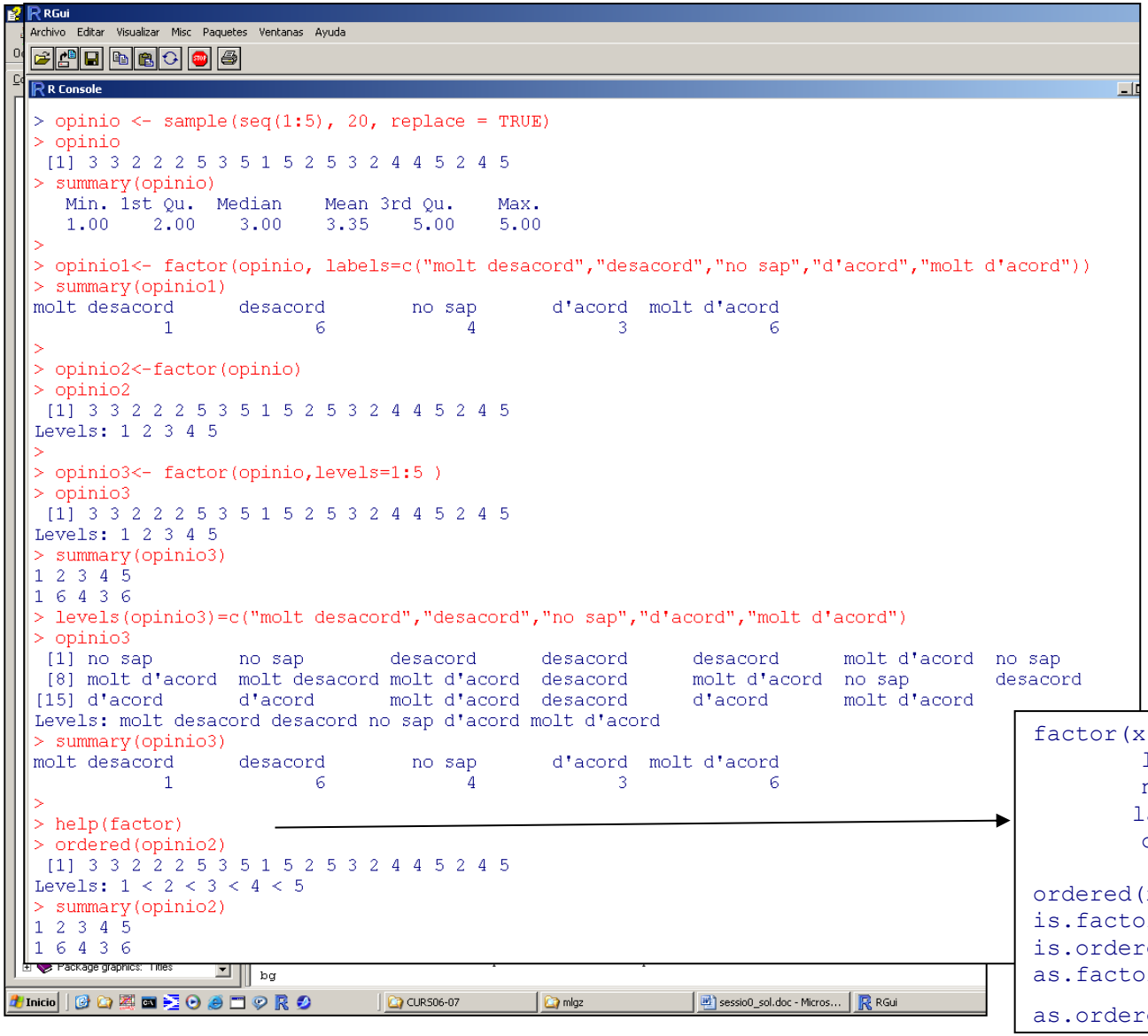


For example:

- plot(height, weight) is a *positional matching call.*
- plot(height,weight, col=2) adds a *keyword matching* argument.
- plot(y=weight, x=height, col=2) allows arguments in any order (all arguments by *keyword matching*).

- Check parameters in:
  help(plot)
  args(plot.default)

INTRODUCTION TO R - FACTORS



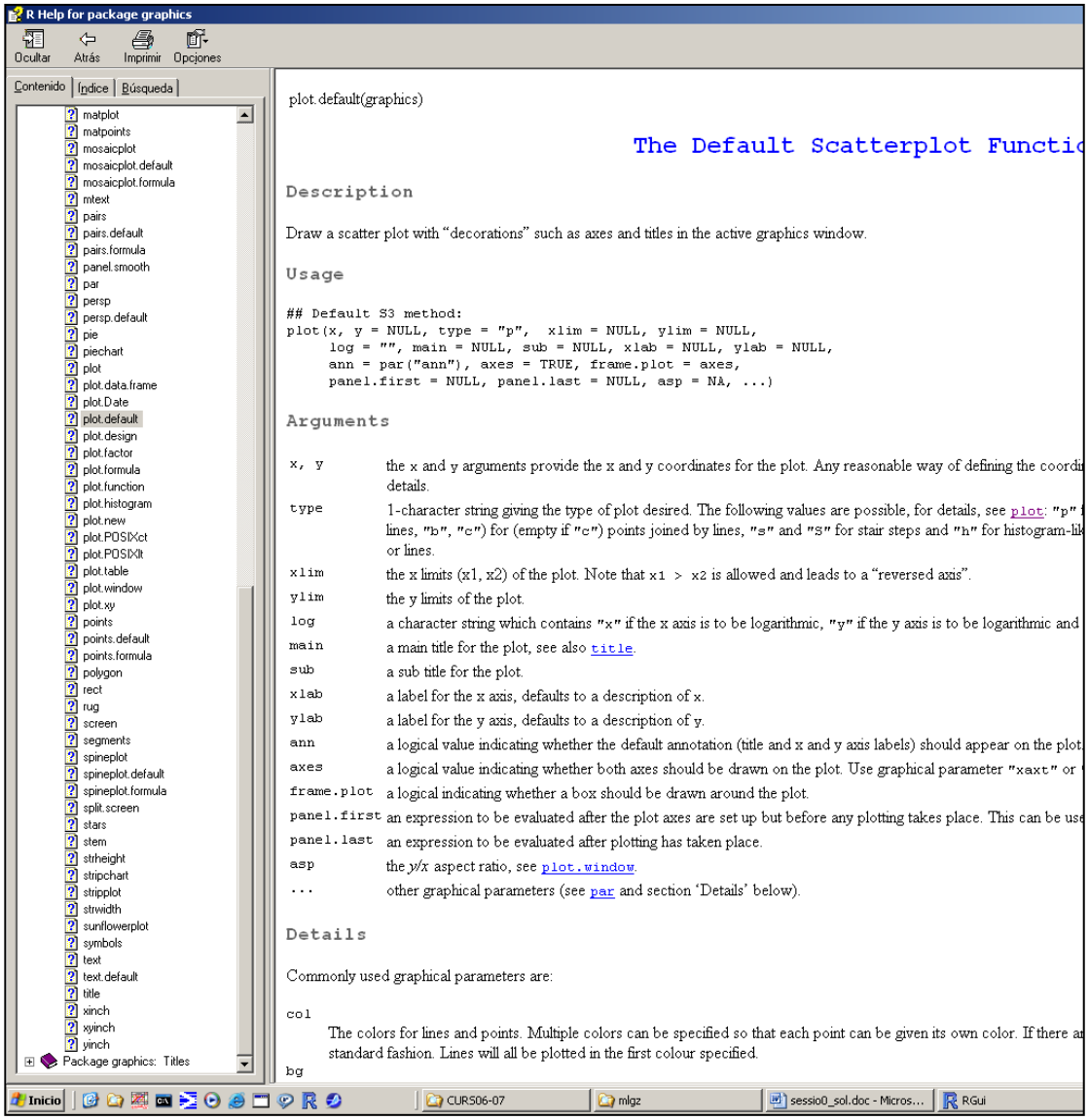

```
> opinio <- sample(seq(1:5), 20, replace = TRUE)
> opinio
 [1] 3 3 2 2 2 5 3 5 1 5 2 5 3 2 4 4 5 2 4 5
> summary(opinio)
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   1.00    2.00    3.00    3.35    5.00    5.00
>
> opinio1<- factor(opinio, labels=c("molt desacord","desacord","no sap","d'acord","molt d'acord"))
> summary(opinio1)
molt desacord      desacord        no sap       d'acord  molt d'acord
            1             6             4             3             6
>
> opinio2<-factor(opinio)
> opinio2
 [1] 3 3 2 2 2 5 3 5 1 5 2 5 3 2 4 4 5 2 4 5
Levels: 1 2 3 4 5
>
> opinio3<- factor(opinio,levels=1:5 )
> opinio3
 [1] 3 3 2 2 2 5 3 5 1 5 2 5 3 2 4 4 5 2 4 5
Levels: 1 2 3 4 5
> summary(opinio3)
1 2 3 4 5
1 6 4 3 6
> levels(opinio3)=c("molt desacord","desacord","no sap","d'acord","molt d'acord")
> opinio3
 [1] no sap        no sap        desacord      desacord      desacord      molt d'acord  no sap
 [8] molt d'acord  molt desacord molt d'acord  desacord      molt d'acord  no sap        desacord
[15] d'acord       d'acord       molt d'acord  desacord      d'acord       molt d'acord
Levels: molt desacord desacord no sap d'acord molt d'acord
> summary(opinio3)
molt desacord      desacord        no sap       d'acord  molt d'acord
            1             6             4             3             6
>
> help(factor)
> ordered(opinio2)
 [1] 3 3 2 2 2 5 3 5 1 5 2 5 3 2 4 4 5 2 4 5
Levels: 1 < 2 < 3 < 4 < 5
> summary(opinio2)
1 2 3 4 5
1 6 4 3 6
```

Factors:

- Vectors to represent qualitative variables.
- Ordered or not.
- Consider values as *levels* o *labels*.
- To convert labels into numeric values: as.numeric(*factor*)

```
factor(x = character(),
        levels = sort(unique.default(x),
        na.last = TRUE),
       labels = levels, exclude = NA,
        ordered = is.ordered(x))

ordered(x, ...)
is.factor(x)
is.ordered(x)
as.factor(x)

as.ordered(x)
```

INTRODUCTION TO R – NEW VARIABLES

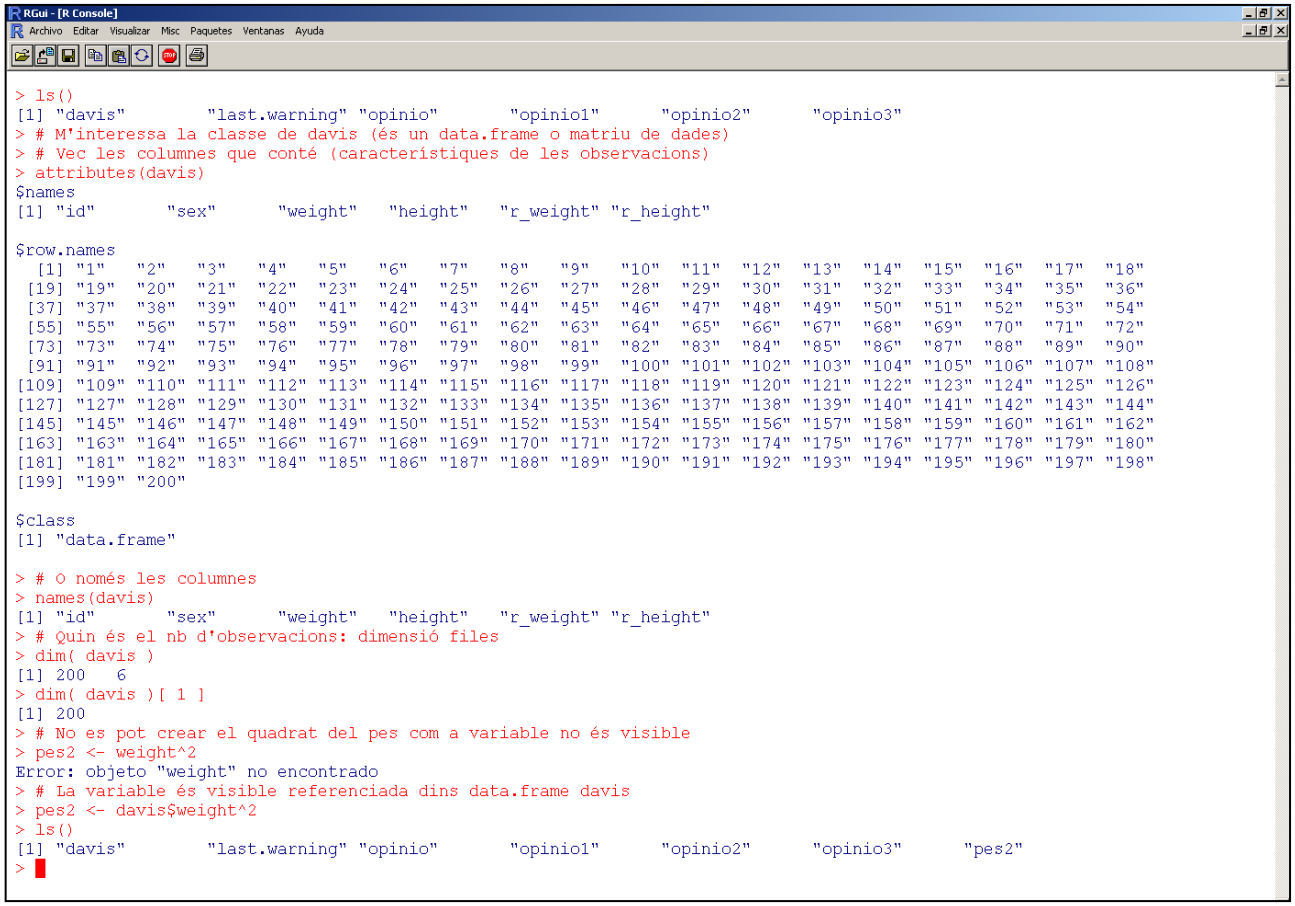


Manipulation of data matrices (data.frame) :

- Create a new variable from existent variables in the current workspace using mathematic functions:
  - For example, y<- log(x)+z+4.5 (x and z existent vectors.
  - In a *data.frame*: attach(Davis)
  - weight2 <- weight^2 new variable not included in Davis *data.frame*.
  - Davis$weight2 <- weight^2 new variable included in Davis *data.frame*, but a detach(Davis) and new attach(Davis).
- Remove an object: rm(object-name).

INTRODUCTION TO R - NEW VARIABLES

- To remove a variable included in a data.frame: Davis$weight2<-NULL.
- Remove all objects in the current workspace: rm(list=ls()).
- Remove all objects in the current workspace beginning with 'la': rm(list=ls(pattern="la")).
- R can deal with multiple datasets at the same time.
  - You just need to specify the name of the dataset and a "$" symbol before each variable name.
  - If you don't want to write again and again the name of the dataset as a prefix for each variable, you can use attach()



INTRODUCTION TO R - SCOPE OF VISIBILITY: ATTACH COMMAND

RGui - [R Console]

Archivo Editar Visualizar Misc Paquetes Ventanas Ayuda

```
> # Podem fer visibles totes les variables d'un data.frame
> attach(davis)
> # Ara es pot crear una nova variable fora del data.frame
> pes2 <- weight^2
> ls()
[1] "davis"        "last.warning" "opinio"       "opinio1"      "opinio2"      "opinio3"      "pes2"
> detach(davis)
> # Si es vol crear dins del data.frame davis
> davis<-transform( davis, pes2=weight^2 )
> summary(davis)
       id         sex         weight          height         r_weight         r_height          pes2
 Min.   :  1.00   F:112   Min.   : 39.0   Min.   : 57.0   Min.   : 41.00   Min.   :148.0   Min.   : 1521
 1st Qu.: 50.75   M: 88   1st Qu.: 55.0   1st Qu.:164.0   1st Qu.: 55.00   1st Qu.:160.5   1st Qu.: 3025
 Median :100.50           Median : 63.0   Median :169.5   Median : 63.00   Median :168.0   Median : 3969
 Mean   :100.50           Mean   : 65.8   Mean   :170.0   Mean   : 65.62   Mean   :168.5   Mean   : 4556
 3rd Qu.:150.25           3rd Qu.: 74.0   3rd Qu.:177.2   3rd Qu.: 73.50   3rd Qu.:175.0   3rd Qu.: 5476
 Max.   :200.00           Max.   :166.0   Max.   :197.0   Max.   :124.00   Max.   :200.0   Max.   :27556
                                                          NA's   : 17.00   NA's   : 17.0
> # O bé:
> davis$pes2<- davis$weight
> # Esborrar objecte de l'espai de treball: rm()
> rm( pes2 )
> # Esborrar una columna d'un data.frame
> davis$pes2<- NULL
> # Noms de les característiques (variables) d'un data.frame
> names( davis )
[1] "id"     "sex"    "weight" "height" "r_weight" "r_height"
>
```

- attach() command can be dangerous. Use detach() as soon as possible.
- Suggested command: Evaluate an R expression in an environment constructed from data, possibly modifying the original data:

```
with(Davis,{boxplot(height);summary(height)})
```

INTRODUCTION TO R - NEW VARIABLES

RGui - [R Console]

Archivo Editar Visualizar Misc Paquetes Ventanas Ayuda

```
> names( davis )
[1] "id"       "sex"      "weight"   "height"   "r_weight" "r_height"
> # Vull un data.frame reduit sense pes i alçada reportat
> davis1 <- davis[,1:4]
> attributes( davis1 )
$names
[1] "id"     "sex"    "weight" "height"

$class
[1] "data.frame"

$row.names
  [1] "1"   "2"   "3"   "4"   "5"   "6"   "7"   "8"   "9"   "10"  "11"  "12"  "13"  "14"  "15"  "16"  "17"  "18"
 [19] "19"  "20"  "21"  "22"  "23"  "24"  "25"  "26"  "27"  "28"  "29"  "30"  "31"  "32"  "33"  "34"  "35"  "36"
 [37] "37"  "38"  "39"  "40"  "41"  "42"  "43"  "44"  "45"  "46"  "47"  "48"  "49"  "50"  "51"  "52"  "53"  "54"
 [55] "55"  "56"  "57"  "58"  "59"  "60"  "61"  "62"  "63"  "64"  "65"  "66"  "67"  "68"  "69"  "70"  "71"  "72"
 [73] "73"  "74"  "75"  "76"  "77"  "78"  "79"  "80"  "81"  "82"  "83"  "84"  "85"  "86"  "87"  "88"  "89"  "90"
 [91] "91"  "92"  "93"  "94"  "95"  "96"  "97"  "98"  "99"  "100" "101" "102" "103" "104" "105" "106" "107" "108"
[109] "109" "110" "111" "112" "113" "114" "115" "116" "117" "118" "119" "120" "121" "122" "123" "124" "125" "126"
[127] "127" "128" "129" "130" "131" "132" "133" "134" "135" "136" "137" "138" "139" "140" "141" "142" "143" "144"
[145] "145" "146" "147" "148" "149" "150" "151" "152" "153" "154" "155" "156" "157" "158" "159" "160" "161" "162"
[163] "163" "164" "165" "166" "167" "168" "169" "170" "171" "172" "173" "174" "175" "176" "177" "178" "179" "180"
[181] "181" "182" "183" "184" "185" "186" "187" "188" "189" "190" "191" "192" "193" "194" "195" "196" "197" "198"
[199] "199" "200"

> names( davis1 )
[1] "id"     "sex"    "weight" "height"
> # Vull un data.frame pels homes sex == M i un altre per dones amb totes les característiques
>
> homes <- (davis$sex=='M')
> davisM <- davis[ homes, ]
> #davisM
> davisF <- davis[ davis$sex=='F', ]
>
> dim( davisM )
[1] 88  6
> dim( davisF )
[1] 112   6
> # Per quedar-me amb les observacions 20 a 110 més 119 i les 4 columnes:
> davis2<- davis[ c(20:110,119), 1:4]
> dim( davis2 )
[1] 92  4
```

Access to columns in a *data.frame* as if there were matric

INTRODUCTION TO R - INDEXING VARIABLES

- Indexing vectors?: weight2[29] position 29 in weight2 vector.
- Indexing matrices?: Davis[2,4] observation 2 and variable in 4th column.
- Row number 2 in a data.frame: Davis[2,].
- Column number 4 in a *data.frame* : Davis[, 4] (*height* is a vector with 200 observations).
- A set of columns: Davis[, c(1,3:4)].
- A set of rows (observations):
  - Davis[1:100,] observations 1, 2, 3 … 100
  - Davis[seq(1,100,2),] … observations 1, 3, 5, 7 …
  - Davis[sample(100:200,50,rep=T),] 50 random rows contained in row numbers 1 tp 100.
  - Davis[rep(c(1,2),10) ,] observations (repeated)

1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2 1 2

```
> davis3<- Davis[ sample(100:200,10,rep=T), ]
> table(Davis3$id)
104 105 141 173 174 175 177 180 194
  1   1   1   1   1   1   2   1   1
```

INTRODUCTION TO R - RECODIFICATION OF VARIABLES

R Console

```
> summary( davis$weight )
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
   39.0    55.0    63.0    65.8    74.0   166.0
> davis$tipus <- factor(cut(davis$weight, 4))   # Discretització en 4 intervals
> table(davis$tipus)

(38.9,70.7]  (70.7,102]   (102,134]   (134,166]
        142          55           2           1
> summary( davis$tipus )
(38.9,70.7]  (70.7,102]   (102,134]   (134,166]
        142          55           2           1
> tapply( davis$weight, davis$tipus, median)
(38.9,70.7]  (70.7,102]   (102,134]   (134,166]
         58          80         111         166
> # Discretització per 4 quartils
> davis$tipus <-  factor(cut(davis$weight, quantile(davis$weight,c(0,1/4,2/4,3/4,1))))
> table(davis$tipus)

 (39,55]  (55,63]  (63,74] (74,166]
      52       50       48       49
> tapply( davis$weight, davis$tipus, median)
 (39,55]  (55,63]  (63,74] (74,166]
      52       59       68       82
> # Discretització en 4 intervals triats per l'usuari
> davis$tipus <-  factor(cut(davis$weight, breaks=c(-1,55,65,75,200)))
> table(davis$tipus)

 (-1,55]  (55,65]  (65,75] (75,200]
      53       64       38       45
> tapply( davis$weight, davis$tipus, median)
 (-1,55]  (55,65]  (65,75] (75,200]
      52       61       69       83
> levels(davis$tipus)<-paste("TYPE",levels(davis$tipus), sep=":")
> summary(davis$tipus)
 TYPE:(-1,55]  TYPE:(55,65]  TYPE:(65,75] TYPE:(75,200]
           53            64           38           45
> levels(davis$tipus) <- c("prim","normal","sobrepes","obes")
> summary(davis$tipus)
    prim   normal sobrepes     obes
      53       64       38       45
>
```

Recodification: Create a new variable from an existent numerical one.

- Discretization of a numeric variable:
  - Equal length intervals.
  - Intervals selected by the users.
  - Intervals defined by quantiles.

INTRODUCTION TO R - DEFINING FACTORS

Recoding: Creating a new variable by working with ranges.

- Grouping categories: create a new variable using ifelse() sentence.

```
> as.numeric( davis$tipus )
  [1] 4 2 1 3 2 4 4 3 3 2 3 4 1 2 1 2 4 2 4 2 4 2 2 3 1 1 2 2 1 4 3 3 4 1 3 2 2 3 4 2 1 4 2 4 4 1 3 1 1
 [50] 3 4 2 3 4 2 2 3 3 3 2 3 3 3 4 4 2 2 2 1 4 2 3 1 2 1 1 1 2 3 3 2 1 1 2 2 2 2 1 2 2 3 2 4 3 4 2 4 1
 [99] 1 1 1 2 1 1 2 1 1 2 2 2 4 4 1 3 4 2 4 4 3 2 4 3 3 1 3 1 1 1 3 1 2 4 2 1 4 1 2 2 4 4 3 1 1 1 2 1 1
[148] 2 3 4 2 1 1 1 1 1 3 2 2 2 1 1 1 2 2 2 2 3 4 1 4 1 2 4 2 3 2 3 4 3 4 1 4 2 3 2 2 2 4 1 4 4 2 1 2 3
[197] 4 4 4 4
> grup <- rep( 0, dim( davis )[1] )
> grup <- factor(ifelse( as.numeric(davis$tipus)>2,1,0))
> levels(grup) <- c("correcte","controlar")
> summary(grup)
 correcte controlar
      117        83
>
```

INTRODUCTION TO R – EDA – BIVARIATE: NUMERIC VS FACTOR

TWO VARIABLES ARE INVOLVED:

RESPONSE VARIABLE IS NUMERIC, as Davis$height
EXPLANATORY VARIABLE IS A FACTOR, as Davis$sex (max 5-6 levels)

Goal: Do groups defined by levels of the factor determine a difference profile in the numeric response.

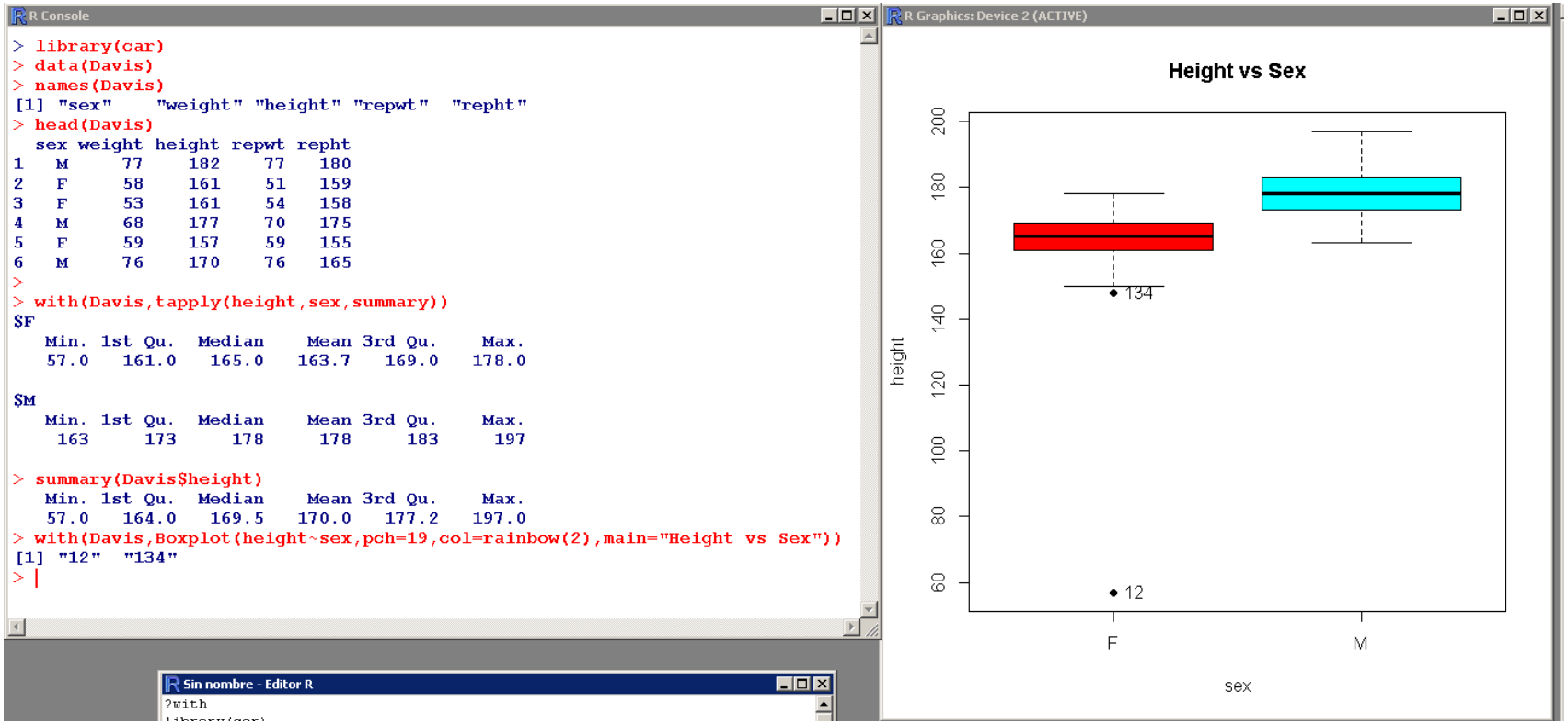
- Do height and sex show an independent behavior/profile? Statistical question: Is the profile of height the same for both levels of factor sex?

- If height and sex don't show any relationship- Statistical statement: The profile of height is the same for both levels in sex factor ?

EDA for a numeric variable according to groups defined by factor. Particular analysis: ANOVA – Analysis of Variance

INTRODUCTION TO R - EDA - BIVARIATE: NUMERIC VS FACTOR

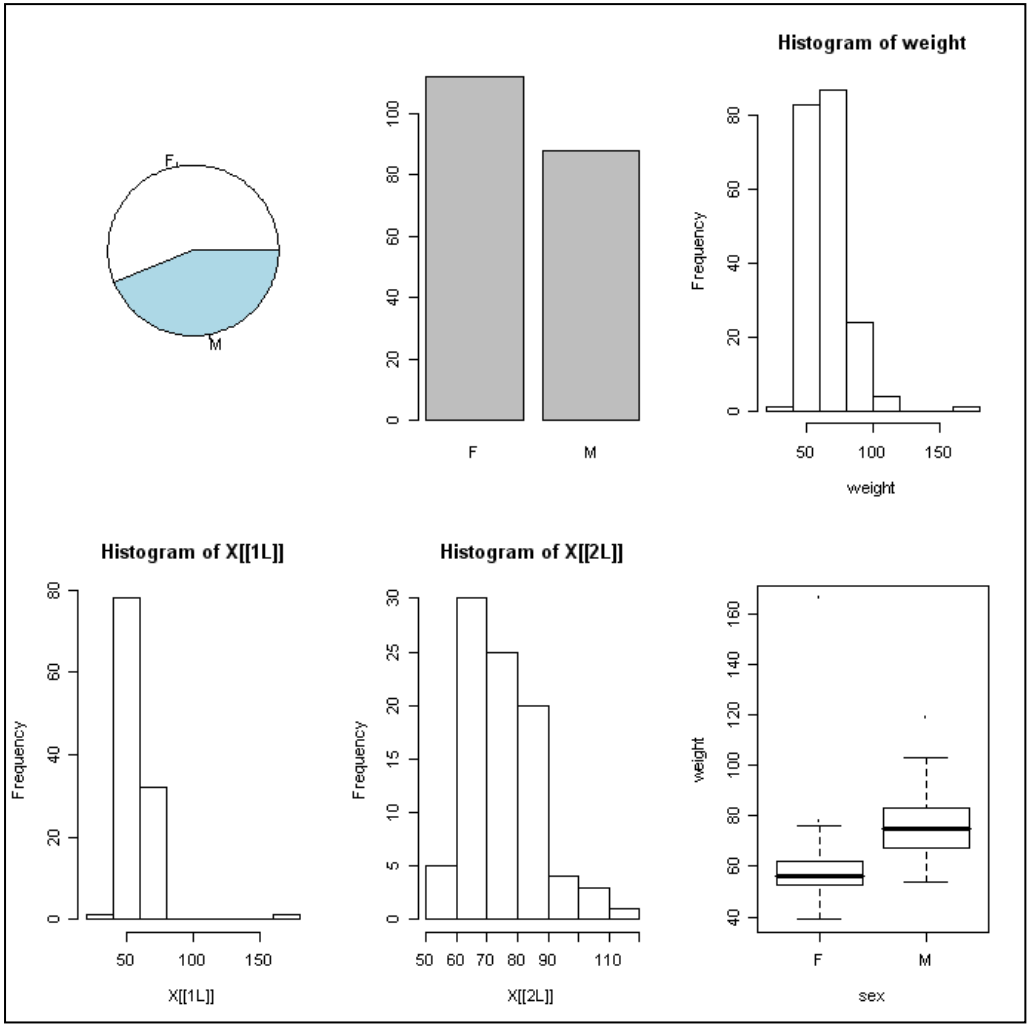
For example: Height (Y) vs Sex (A) - Formula expression in R: Y ~ A




```
library(car)
data(Davis)
names(Davis)
head(Davis)
```

```
with(Davis,tapply(height,sex,summary))
summary(Davis$height)
with(Davis,Boxplot(height~sex,pch=19,
    col=rainbow(2),main="Height vs Sex"))
```

4. INTRODUCTION TO R – EDA – BIVARIATE: NUMERIC VS FACTOR




```
par(mfrow=c(2,3))
attach(Davis)
pie( table( sex ))
barplot( table(sex) )
hist( weight )
```

```
tapply( weight, sex, hist )# Not nice
plot( weight ~ sex ) # Boxplot is default plot
```

5. EDA – BIVARIATE: 2 NUMERICS Y VS X

5.1 Numeric statistics to assess linear relationship between Y and X

Covariance, COV(y,x)=COV(x,y), defined as E(YX) – E(X)E(Y)

- Disadvantage: Depends on units, so not direct interpretation

Pearson's coefficient of correlation, suitable for assessment in normal data

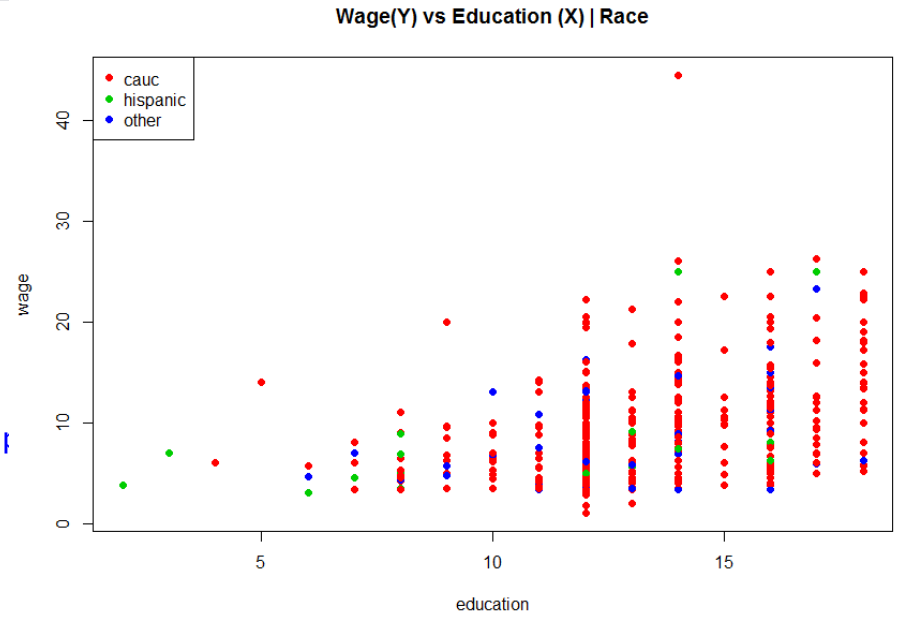
$$\rho(X,Y)=\frac{Cov(X,Y)}{\sigma_X\,\sigma_Y} \quad \text{and} \quad \sigma_X=\sqrt{Var(X)}\ \sigma_Y=\sqrt{Var(Y)}$$

- Advantage: Adimensional, no affected by units
  - $\rho(X, Y)$ **range is** $[-1,1]$.
    - $\rho(X, Y)$ > 0 means positive relationship X and Y.
    - $\rho(X, Y)$ < 0 means negative relationship X and Y,.
    - $\rho(X, Y)$ = 0 indicates uncorrelated variables, not equivalent to independence.
  - If Y = aX + b then $|\rho(X, Y)|=1$.
- **Spearman's coefficient of correlation**, is a nonparametric measure of statistical dependence.

EDA - BIVARIATE: 2 NUMERICS Y VS X

In R, use var(Davis[,2:3]) or try with Census Data data("CPS1985") in library AER.

```
> library(AER)
> data("CPS1985")
> df<-CPS1985
> ls()
[1] "CPS1985" "df"
> dim( df )  # dimensions: rows and columns
[1] 534  11
> summary( df )
      wage          education       experience         age              ethnicity     region       gender          occupation
 Min.   : 1.000   Min.   : 2.00   Min.   : 0.00   Min.   :18.00   cauc    :440   south:156   male  :289   worker    :156
 1st Qu.: 5.250   1st Qu.:12.00   1st Qu.: 8.00   1st Qu.:28.00   hispanic: 27   other:378   female:245   technical :105
 Median : 7.780   Median :12.00   Median :15.00   Median :35.00   other   : 67                            services  : 83
 Mean   : 9.024   Mean   :13.02   Mean   :17.82   Mean   :36.83                                           office    : 97
 3rd Qu.:11.250   3rd Qu.:15.00   3rd Qu.:26.00   3rd Qu.:44.00                                           sales     : 38
Max.   :44.500   Max.   :18.00   Max.   :55.00   Max.   :64.00
          sector    union     married
 manufacturing: 99   no :438   no :184
 construction : 24   yes: 96   yes:350
 other        :411


> attach( df )
> # Bivariate analysis: 2 numeric variables
> plot(education,wage,col=as.numeric(ethnicity)+1,
       main="Wage(Y) vs Education (X) | Race",pch=19)

> legend("topleft",legend=levels(ethnicity),col=2:4,
       pch=19)
> cor(wage,education,method="spearman")
[1] 0.3813425
> cor(wage,education,method="pearson")  # The one defined
[1] 0.3819221


Nicer option: scatterplot, try in lab session

> library(car)
> scatterplot(wage~education|ethnicity,main="Wage(Y) vs Education (X) | Race",smooth=FALSE)
```

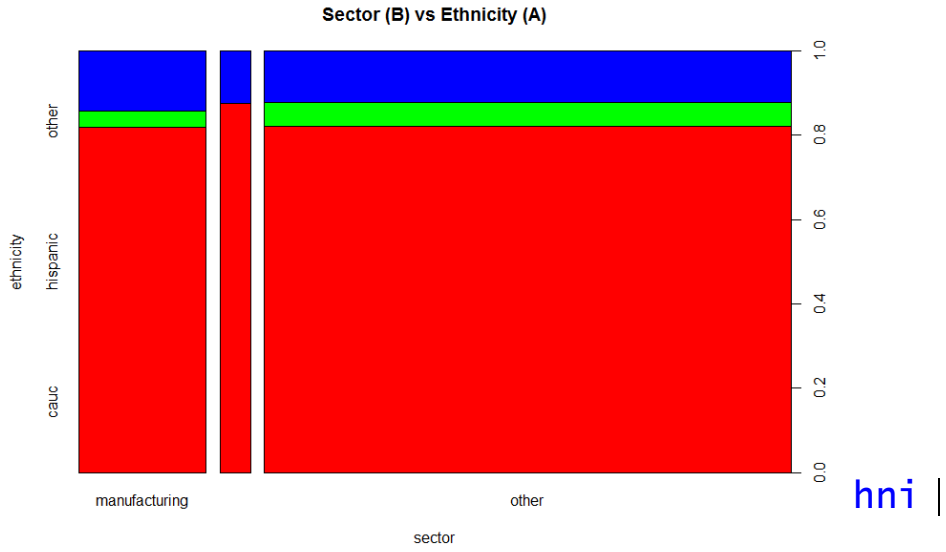


6. EDA – BIVARIATE: 2 FACTORS, A AND B

6.1 Numeric statistics to assess linear relationship A and B

Non-existent. Analysis of Contingency Tables and classical inference test to assess Independence of both factors using Chi-Squared Test: chisq.test() in R, arguments a contingency table.

```
> ta<-table(ethnicity,sector)
> ta
          sector
ethnicity  manufacturing construction other
  cauc               81           21   338
  hispanic            4            0    23
  other              14            3    50
> round(prop.table(ta,2),2)
          sector
ethnicity  manufacturing construction other
  cauc              0.82         0.88  0.82
  hispanic          0.04         0.00  0.06
  other             0.14         0.12  0.12

> plot(ethnicity~sector,main="Sector (B) vs Et
city (A)",col=rainbow(3))
> chisq.test(ta)

        Pearson's Chi-squared test data:  ta
X-squared = 1.9819, df = 4, p-value = 0.7391
Warning message:In chisq.test(ta) : Chi-squared approximation may be incorrect
```



hni

EDA - BIVARIATE: 2 FACTORS, A AND B

Graphic display (default in R): mosaic plot

More than 2 dimensions: use xtabs() command in R

```
> xtabs(~gender+ethnicity+sector)
, , sector = manufacturing

        ethnicity
gender   cauc hispanic other
  male     48        2    10
  female   33        2     4

, , sector = construction

        ethnicity
gender   cauc hispanic other
  male     19        0     3
  female    2        0     0

, , sector = other

        ethnicity
gender   cauc hispanic other
  male    169       12    26
  female  169       11    24

> ta<-xtabs(~gender+ethnicity+sector)
> chisq.test(ta)

      Chi-squared test for given probabilities

data:  ta
X-squared = 1573.753, df = 17, p-value < 2.2e-16
```