Introduction to R, Rstudio & Project Management

ENCOURAGED

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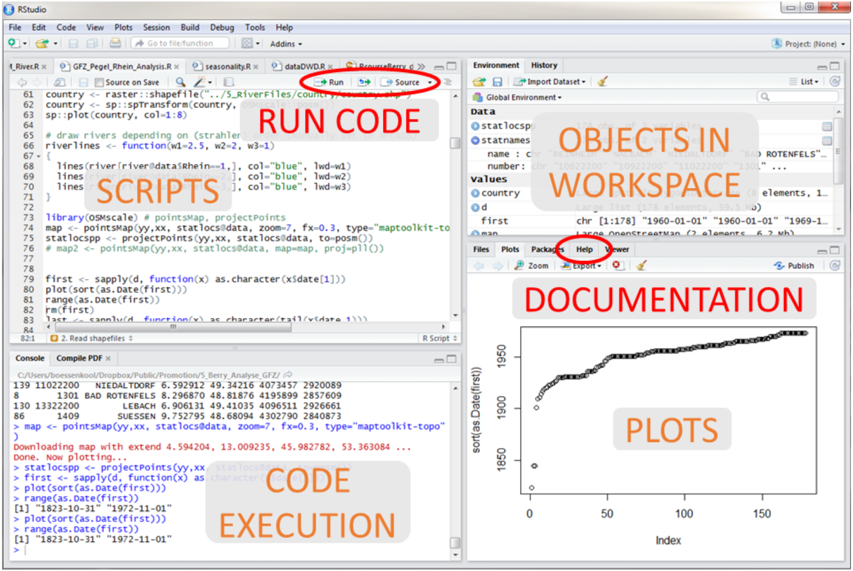
Presentation template generated with `berryFunctions::createPres`

Survey

knowledge survey to determine focus for this session

bit.ly/knowR

RStudio



```r
country <- raster::shapefile("../5_RiverFiles/country/country.shp")
country <- sp::spTransform(country, OSMscale::posm())
sp::plot(country, col=1:8)

# draw rivers depending on (strahler) order (manually set in ArcGIS)
riverlines <- function(w1=2.5, w2=2, w3=1)
{
  lines(river[river@data$Rhein==1,], col="blue", lwd=w1)
  lines(river[river@data$Rhein==2,], col="blue", lwd=w2)
  lines(river[river@data$Rhein==3,], col="blue", lwd=w3)
}

library(OSMscale) # pointsMap, projectPoints
map <- pointsMap(yy,xx, statlocs@data, zoom=7, fx=0.3, type="maptoolkit-to
statlocspp <- projectPoints(yy,xx, statlocs@data, to=posm())
# map2 <- pointsMap(yy,xx, statlocs@data, map=map, proj=pll())


first <- sapply(d, function(x) as.character(x$date[1]))
plot(sort(as.Date(first)))
range(as.Date(first))
rm(first)
last <- sapply(d, function(x) as.character(tail(x$date,1)))
```

```
Data
statlocspp     178 obs. of 2 variables
statnames      178 obs. of 2 variables
  name : chr "REINHEIM" "NALBACH" "NIEDALTDORF" "BAD ROTENFELS"...
  number: chr "10622200" "10922200" "11022200" "1301" ...
Values
country        Large SpatialPolygonsDataFrame (8 elements, 1...
d              Large list (178 elements, 59.5 Mb)
first          chr [1:178] "1960-01-01" "1960-01-01" "1969-1...
map            Large OpenStreetMap (2 elements, 6.2 Mb)
```

```
C:/Users/boessenkool/Dropbox/Public/Promotion/5_Berry_Analyse_GFZ/
139 11022200   NIEDALTDORF 6.592912 49.34216 4073457 2920089
8       1301 BAD ROTENFELS 8.296870 48.81876 4195899 2857609
130 13322200        LEBACH 6.906131 49.41035 4096511 2926661
86      1409       SUESSEN 9.752795 48.68094 4302790 2840873
> map <- pointsMap(yy,xx, statlocs@data, zoom=7, fx=0.3, type="maptoolkit-topo"
)
Downloading map with extend 4.594204, 13.009235, 45.982782, 53.363084 ...
Done. Now plotting...
> statlocspp <- projectPoints(yy,xx, statlocs@data, to=posm())
> first <- sapply(d, function(x) as.character(x$date[1]))
> plot(sort(as.Date(first)))
> range(as.Date(first))
[1] "1823-10-31" "1972-11-01"
> plot(sort(as.Date(first)))
> range(as.Date(first))
[1] "1823-10-31" "1972-11-01"
> 
```

RStudio configuration

keyboard shortcuts (`ALT+SHIFT+K`)

Recommended settings for reproducible research under
Tools - Global Options - General
ON: Restore previously open source documents at startup
OFF: Restore .Rdata into workspace at startup
Save workspace to .RData on exit: **NEVER**

Instead use `save(object, file="object.Rdata")` after long computations. You can load them later with `load("object.Rdata")`.

Tools - Global Options - Code - Display
ON: Show margin (Margin column:80) *People hate horizontal scrolling!*

Tools - Global Options - Code - Saving
Line ending conversion: **Windows (CR/LF)**

Assignments

- objects: assignment with $<-$

  ```
  nstudents <- 15
  nstudents
  nstudents > 12
  ```
- Rstudio Keyboard shortcut: `ALT` + `-`
- What's a good object name? → short, but explanatory, lowerCamelStandard.or.dot_or_underscore are good naming conventions
- comments: `# everything after a hashtag is not executed.`

Exercise 1: Basic R syntax

- Open Rstudio, start new script. Write comments about what you do, save the file in a useful place.
- Calculate 21+21 , 7*6 and $\frac{0{,}3}{4} * \sqrt{313600}$
- Is `0.5 - 0.2` equal to `0.3`? Is `0.4 - 0.1` equal to `0.3`?
- With the `c` command, create a vector with body sizes of people around you. You can also use the values 1.75, 1.76, 1.83, 1.84, 1.77, 1.76, 1.77, 1.66, 1.86, 1.76
- What does `3:6` create? What does `YourObject[3:6]` do?
- What does `YourObject[-4]` do?
- BONUS (for fast people): Analyze the descriptive statistics: `mean(YourObject), median, min, max, range, quantile`
- BONUS 2: Generate 150 random numbers from a normal distribution with $\mu = 170cm$ and $\sigma = 8cm$. Perform a Kolmogorov-Smirnov test for normality of that sample.

Solutions to Exercise 1: Basic R syntax

```
# simple introductionary tasks
21+21   ;   7*6   ;   0.3/4*sqrt(313600)
0.5-0.2 == 0.3 # TRUE
0.4-0.1 == 0.3 # FALSE
print(0.4-0.1, digits=22) # Numerical accuracy limits
all.equal(0.4-0.1, 0.3) # TRUE

size <- c(1.75, 1.76, 1.83, 1.84, 1.77, 1.76, 1.77,
          1.66, 1.86, 1.76)
3:6 # A vector with consecutive integers
size[3:6] # Select the corresponding elements of a vector
size[-4] # Select all but the fourth value
mean(size); median(size); min(size); max(size)
range(size); quantile(size)
x <- rnorm(n=150, m=170, s=8)
ks.test(x, "pnorm", mean(x), sd(x) )
```

Exercise 2: Reading files

- Copy the file `treesize.txt` (from bit.ly/swc_tree)
- Tell R where to look for it with: `setwd("C:/path/to/input")`
  `# change back- to forwardslashes`
- Read the file into R with the command `read.table`.
- If R tells you ”no such file” exists, check the output of `dir()`.
- Use the documentation to find out the correct settings of the arguments: `help(read.table)`, `?read.table`, or press F1.
- `str(YourObject)` must yield the column data types: `num`, `num`, `factor`.
- BONUS: What arguments for `read.table` seem useful?
- BONUS 2: What commands are useful to read csv files, excel sheets or dataset with fix column widths?

Solution to Exercise 2: Reading files

```r
treesize <- read.table(file="treesize.txt", header=TRUE)
```

header = TRUE	read first line as column names
dec = ","	comma as decimal mark
sep = "_"	underscore as column separator ("\t" for tabstop)
fill = T	fill incomplete rows with NAs at the end
skip = 12	ignore the first 12 lines (eg with meta data)
comment.char = "%"	omit (rest of) lines that start with % (like R's #)
na.strings = c(-999, "NN")	identify NA entries (missing values)
stringsAsFactors=FALSE	do not convert characters to factors
as.is=TRUE	the same, but less typing, and potentially columnwise

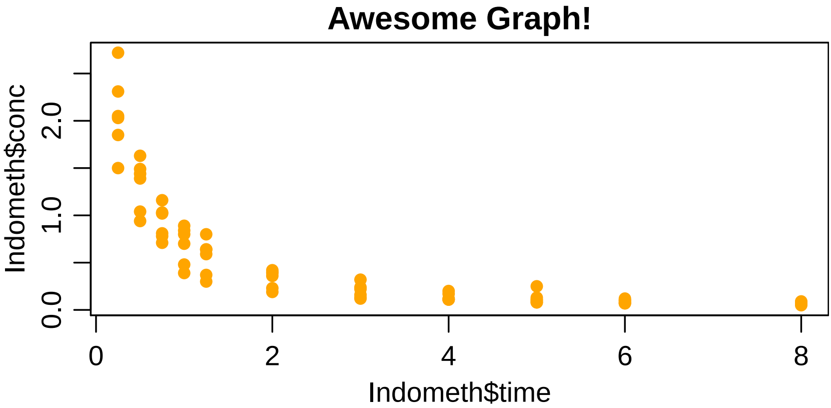
Alternatives to read.table:

scan	At the core of read.table - for complicated things
read.csv	comma separated values (different defaults than read.table)
read.fwf	fixed width formatted data
read_excel	Excel files (install package, see github.com/hadley/readxl)

Plotting I

General code for scatterplots: `plot(x, y, ...)`

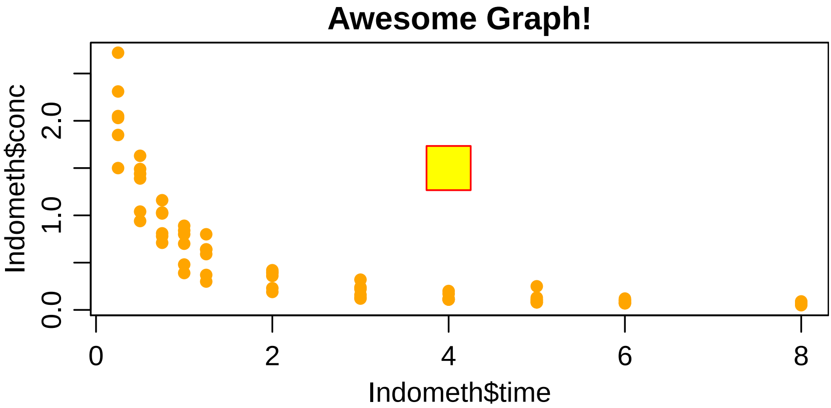
```
plot(x=Indometh$time, y=Indometh$conc,
    col="orange", pch=16, main="Awesome Graph!")
```



Plotting II

General code for scatterplots: `plot(x, y, ...)`

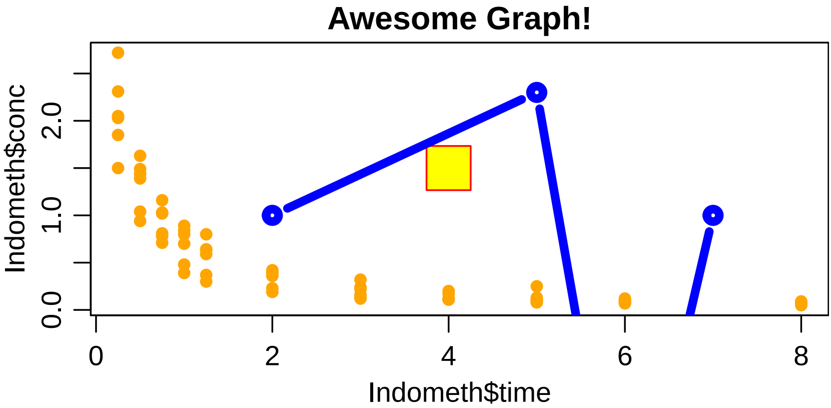
```
points(4, 1.5, pch=22, bg="yellow", cex=4, col="red")
# PointCHaracter, BackGround, Character EXpansion
```



Plotting III

General code for scatterplots: `plot(x, y, ...)`

```
lines(x=c(2,5,6,7), y=c(1,2.3,-3,1),
      col=4, type="b", lwd=5)
```



Exercise 3: Plotting the treesize dataset

```r
treesize <- read.table(file="treesize.txt", header=TRUE)
```

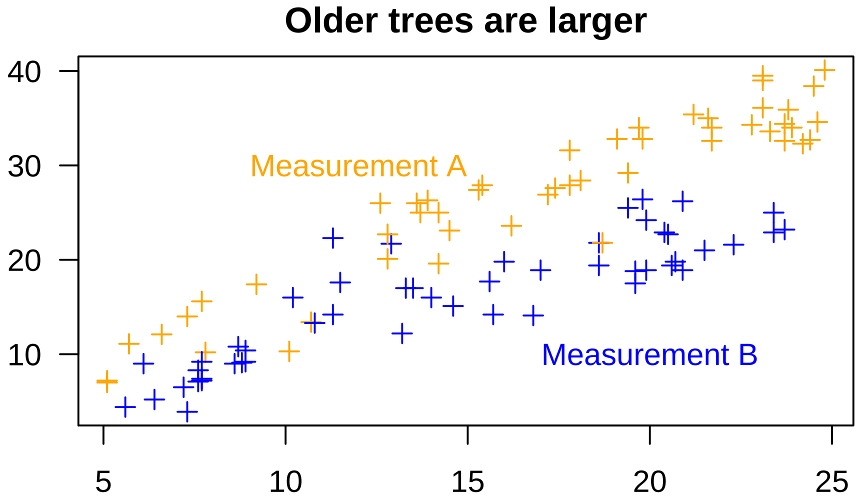
```r
plot(x=xvalues, y=y_values, xlab="nice axis label",
     main="graph title", las=1)
```

- Plot tree height over age.
- Add labels to the plot.
- Change the point character (`pch`) and color (`col`).
- BONUS 1: Use a vector for colors, e.g. subset by tree measurement
- BONUS 2: Compare the histogram (`hist`) of the heights with the `boxplot` and `quantile(x, probs=c(0.1, 0.8))`.

Solution to Exercise 3: Plotting the treesize dataset I

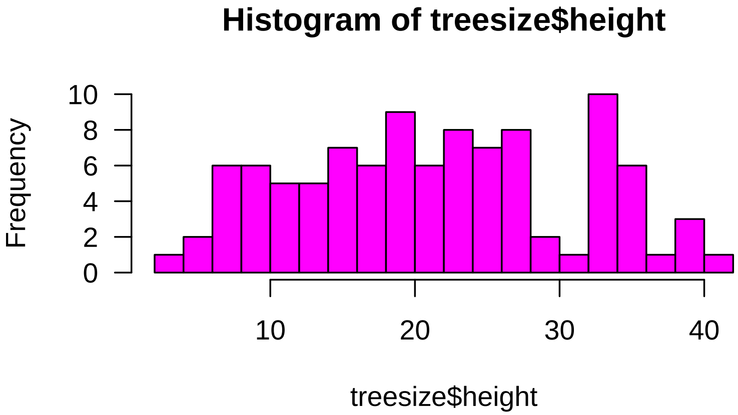
```
treesize <- read.table(file="treesize.txt", header=TRUE)

plot(treesize$age, treesize$height)
cols <- c("orange", "blue")
plot(treesize$age, treesize$height, las=1, ylab="Tree height [m]",
     xlab="Tree age [years]", col=cols[treesize$measurement],
     main="Older trees are larger", pch=3)
text(x=c(12,20), y=c(30,10),
     labels=paste("Measurement", levels(treesize$measurement)), col=cols)
quantile(treesize$height, probs=c(0.1, 0.8))

##   10%   80%
##  8.93 32.36
```

Solution to Exercise 3: Plotting the treesize dataset II



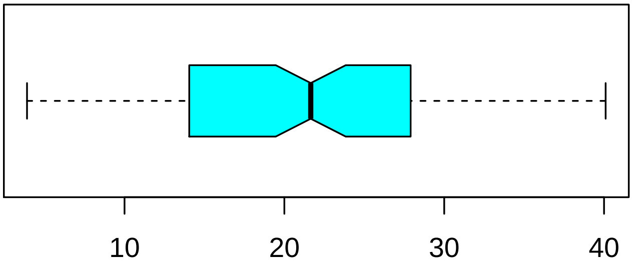
Solution to Exercise 3: Plotting the treesize dataset III

```
hist(treesize$height, col=6, breaks=20, las=1)
```



Solution to Exercise 3: Plotting the treesize dataset IV

```
boxplot(treesize$height, col=5, horizontal=TRUE, notch=TRUE)
```



Commonly needed plot arguments

```
plot(x, y, # point coordinates
col="lightblue", # point color
pch=0, # point character (symbol)
xlab="My label  [km]", ylab="", # axis labels
main="Graph title", # title
cex=1.8, # character expansion (symbol size)
type="l", # draw lines instead of points
lwd=3, # line width (thickness of lines)
las=1, # label axis type (axis numbers upright)
xaxt="n" # axis type (none to suppress axis)
)
```

Objects

- Check the objects in your workspace with `ls()`.
- Remove objects with `rm(YourObject, AnotherOne)`
- Remove all objects with `rm(list=ls() )`
- Or just the Rstudio button
- To make sure your script is reproducible (you may rename objects, for example, and miss one occurrence):
  restart R (`CTRL` + `SHIFT` + `F10`) every once in a while (Make sure Rstudio settings are reproducible as shown on slide 4).

Overview: data types

In order of coercion (if mixed, TRUE is converted to 1, 3.14 to ”3.14” etc)

Description	example	`typeof`	`class`
empty set	NULL	NULL	NULL
not available	NA	logical	logical
logical	c(T, F, FALSE, TRUE)	logical	logical
category	factor(”left”)	integer	**factor**
integer number	4:6	integer	integer
decimal	8.7	double	**numeric**
complex	5+3i	complex	complex
character string	”homer rocks”	character	character
time	Sys.time()	double	**POSIXct**
date	as.Date(”2017-05-02”)	double	**Date**
function	ncol	closure	**function**

adv-r.had.co.nz/Data-structures. `as.character(3.14)` converts a data type; `is.integer(4:6)` checks. `str` shows an abbreviation of `class`. `mode` (for users) is like `typeof` (R internal), but combines integer and double to numeric (& closure, special and builtin to function). When mixing date/time with others, the order of appearance determines the output class.

Overview: Object types

Object	example	`typeof`	`class`
vector	*see data types*	...	...
matrix	matrix(9:15, ncol=2)	...	matrix
array	array(letters[1:24], dim=c(2,6,4))	...	array
data.frame	data.frame(C1=4:5, C2=c(”a”,”b”))	list	data.frame
list	list(el1=7:15, el2=”big”)	list	list
function	function(x) 12+0.5*x	closure	function
...	lm(b ∼ a)	list	lm

A `matrix` consists of only one data type. If you accidentally change one element to a character, all are converted and calculations are not possible any more (See coercion order in previous slide).

`data.frame`s can have multiple data types, but a column in itself also has only one type.

`list`s can combine anything, even other lists.

`is.atomic(Object)` returns TRUE (vector, matrix, array) or FALSE

`as.matrix(Object)` converts the class of an object by force.

R Packages

- Many people write code for specific tasks and publish it on CRAN, the Comprehensive R Archive Network
- Packages for a range of topics: cran.r-project.org/web/views
- All >10'500 available packages: cran.r-project.org/web/packages
- `install.packages("ggplot2")` to download and install.
  (only needs to be executed once, works on user level, no admin rights required)
  You can do this in Rstudio
- `library("ggplot2")` to load it
  (needed in every new R session) Put this in the script for reproducibility
- Better to use the `package::function` syntax
- Regularly run `update.packages()` or use the Rstudio button
- Rarely needed: `remove.packages("packagename")`

Exercise 4: Linear regression

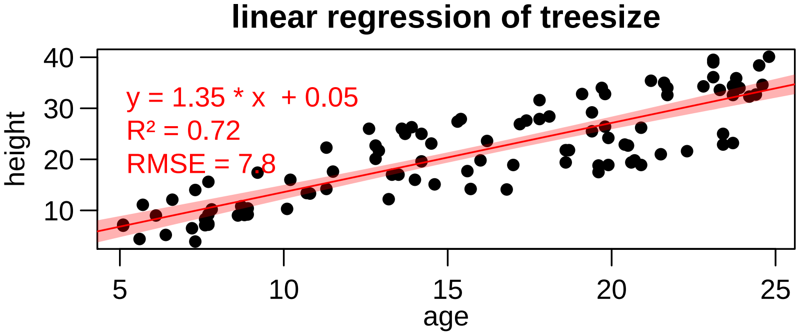
- Install and load the package `berryFunctions`
- How can we pass the treesize data to `?linReg` with a formula?
- Describe the resulting graph (height vs age).
- Look into the source code of `linReg`. What is actually the backbone for the calculation of the function?
- Feed the data into `lm`, assign the output to an object (useful name!).
- Briefly explain the `summary` of the linear model.

Solution to Exercise 4: Linear regression

```
library("berryFunctions")
linReg(height~age, data=treesize)
linReg # nicer:  berryFunctions::funSource(linReg)
browseURL("https://github.com/brry/berryFunctions") #  R/linReg.R  -> lm
linear_model <- lm(height~age, data=treesize)
summary(linear_model)
```

blog.yhathq.com/posts/r-lm-summary.html

stats.stackexchange.com/questions/5135/interpretation-of-rs-lm-output



More things

- Connect Rstudio to github
- Data.frames

Objects: data.frames

- For tables with different data types (numbers, characters, categories, integers), R has the object type data.frame: `data.frame(count=c(2,6,5), type=c("a","k","k"))`
- `read.table` also returns a data.frame
- If we have the object `df`, we can subset with `df[rows,columns]`
- `df[1,2:4]; df[2, ]; df[ ,"name"]; df$name`
- Logical values: `vect[c(TRUE,TRUE,FALSE,FALSE,TRUE,FALSE)]`

From the dataset `treesize` from the previous exercise, obtain:

- The first 5 values in column 2
- The maximum "Height" (the maximum of the values in that column)
- For each entry: is the measurement equal to (`==`) A?
- BONUS 1: The height entries for trees older than 23.5 years
- BONUS 2: All rows, excluding rows 3, 7,8,9,...,20