

YasiR: Yet another short introduction to R

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Outline

- Introduction

 - Preamble

 - Five basic R concepts

- Installation, help, maintenance and interacting with R

- Loading a (SPSS) dataset

- Data cleaning and data preparation

- Descriptive statistics

 - Mean, median & Co

- Reproducible research (RR) and workflow

 - Some basics

 - L^AT_EX in 5 minutes

- Useful books and websites

Section overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Mean, median & Co

Reproducible research (RR) and workflow

Some basics

L^AT_EX in 5 minutes

Useful books and websites

Subsection overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Reproducible research (RR) and workflow

Useful books and websites

Acknowledgment, license and downloads

- ▶ My presentation was created using Emacs' *org-mode* and *Babel: active code in Org-mode*. *Babel* is developed and maintained by Eric Schulte and Dan Davison who were extremely helpful in answering my questions or fixing bugs.
- ▶ Licensed under a Creative Commons [Attribution-NonCommercial-ShareAlike 3.0 Germany](#) license.
- ▶ Slides, dataset and R code can be downloaded from my github page: https://github.com/berndweiss/ps2012-intro_R (see "Downloads" button on the right-hand side).

Objectives

- ▶ Introduce *some* basic concepts of R
- ▶ Show some common steps in data preparation and data analysis (esp. meta-analysis)
- ▶ Introduce my (R) data analysis workflow philosophy
- ▶ Present some showcases which cover advanced usage of R

What is R?

“R is a language and environment for statistical computing and graphics. [...] Many users think of R as a statistics system. We prefer to think of it of an environment within which statistical techniques are implemented. R can be extended (easily) via packages. There are about eight packages supplied with the R distribution and many more are available through the CRAN family of Internet sites covering a very wide range of modern statistics” (<http://www.r-project.org/about.html>).

Why use R?

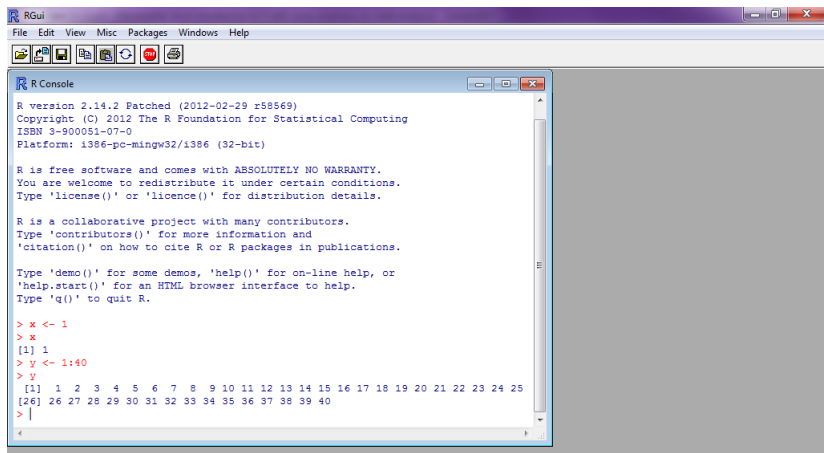
- ▶ It is free (GNU General Public Licence).
- ▶ Can be used on many platforms (MS Windows, Linux, Mac OS etc.).
- ▶ Includes cutting-edge statistical technologies and state-of-the-art graphics capabilities.
- ▶ Since R is a fully developed programming language, it is very (extremely) flexible.
- ▶ ...



Why not use R?

- ▶ Steep learning curve.
- ▶ R is a programming language.
- ▶ Sometimes R lacks consistency (packages).
- ▶ ...

R under MS Windows



```
RGui
File Edit View Misc Packages Windows Help

R Console
R version 2.14.2 Patched (2012-02-29 r58569)
Copyright (C) 2012 The R Foundation for Statistical Computing
ISBN 3-900051-07-0
Platform: i386-pc-mingw32/i386 (32-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> x <- 1
> x
[1] 1
> y <- 1:40
> y
[1] 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
[26] 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40
> |
```

Subsection overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Reproducible research (RR) and workflow

Useful books and websites

Five basic R concepts you need to know

1. Objects
2. Packages
3. Grammar (Syntax) of R functions
4. Important data types/data structures
5. Missing values

It's all about objects

- ▶ (Nearly) Everything in R is an object (some similarities to Stata's container concept)
- ▶ What are objects? “The entities that R creates and manipulates are known as objects” (AltR: 5), e.g.:
 - ▶ Data sets
 - ▶ Variables
 - ▶ Results of any statistical calculation
 - ▶ ...
- ▶ It is possible to access/manipulate pieces of more complex objects (e.g. datasets or regression results)

A first example of an R object

- ▶ “<-” means “assign”
- ▶ If you type in the object’s name, R prints out its value¹
- ▶ “[...]” denotes R output (here, 1, only one element is shown)
- ▶ “#” is used for comments

```
1 x <- 1 ## assign value 1 to symbol/variable "x"
2 x      ## or: print(x)
```

```
[1] 1
```

```
1 x + x
```

```
[1] 2
```

```
1 x * 100
```

```
[1] 100
```

¹Works in most but not all cases.

A second example of an R object

We also can create vectors (1×4) or matrices (2×3):

```
1 x.vector <- c(1,2,3,4) ## c() means "concatenate"  
2 x.vector
```

```
[1] 1 2 3 4
```

```
1 x.matrix <- matrix(c(1,2,3,4,5,6), ncol = 3)  
2 x.matrix
```

```
      [,1] [,2] [,3]  
[1,]    1    3    5  
[2,]    2    4    6
```

A third example of an R object

Conduct a t-test and save results in object oTtest.

```
1 oTtest <- t.test(rnorm(100) ~ sample(0:1, 100, replace = TRUE))
2 oTtest
```

Welch Two Sample t-test

```
data:  rnorm(100) by sample(0:1, 100, replace = TRUE)
t = -0.341, df = 97.99, p-value = 0.7339
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.4570725  0.3230416
sample estimates:
mean in group 0 mean in group 1
 -0.05497059      0.01204489
```

Get the test statistic...

```
1 oTtest$statistic
```

```
      t
-0.3409506
```

...or the p-value.

```
1 oTtest$p.value
```

```
[1] 0.7338707
```


Packages

- ▶ Most R functions are stored in packages.
- ▶ When you download R, it only comes with a very limited set of functions (e.g., it knows nothing about SPSS data files or meta-analysis).
- ▶ To load a particular package, use a command like `library(meta)`.
- ▶ However, before you can load a package, you have to install (download) it (only once). This can be done via `install.packages("meta")`.
- ▶ Whenever a new R session is started, the packages have to be loaded via `library(...)`.



[AltR on packages](#)

[Quick-R on packages](#)

[UCLA's ATS on How can I manage R packages?](#)

The basic syntax of an R function

- ▶ The general syntax is: `functionname(arglist)`
- ▶ `arglist`: A comma separated list of arguments which can be represented by
`symbol = expression`
- ▶ Often, a symbol called `x` is used; `x` represents an R object
- ▶ Some simple examples:
 - ▶ Average of an object `a` (a vector): `mean(x = a)`
 - ▶ Standard deviation of `a`: `sd(x = a)`
 - ▶ Correlation between two vectors `a` and `b`: `cor(x = a, y = b)`
- ▶ Type `?functionname` and see “Usage” and “Arguments” for more information.

Important data types/data structures

- ▶ When you are used to SPSS or Stata, you never (rarely) had to deal with data types or structures.
- ▶ The next few slides introduce some important data types or data structures. For R novices in the social sciences, the most important data structure you encounter is called “data frame”. A data frame can be used to store a typical rectangular social sciences data set with varying data modes (numeric, character)
- ▶ Typically, a data set is provided as text, csv, SPSS, Stata, SAS etc. file. When this file is loaded into R, (in most cases) it is available as data frame.

Important data types/data structures (cont'd)

► Scalar

```
1 x.scalar <- 1
2 x.scalar
```

```
[1] 1
```

► Vector

```
1 x.vector <- c(1,2,3)
2 x.vector
```

```
[1] 1 2 3
```

► Factor (nominal scale; sth like `mean(x.factor)` does not work!)

```
1 x.factor <- factor(c(1,2,3), labels = c("low", "middle", "high"))
2 x.factor
```

```
[1] low    middle high
Levels: low middle high
```

Important data types/data structures (cont'd)

- Data frame (each column can have a different data type)

```
1 x.df <- data.frame(ID = c(1,2,3), sex = factor(c("f", "f", "m")),  
2                   age = c(22, 45, 12))  
3 x.df
```

	ID	sex	age
1	1	f	22
2	2	f	45
3	3	m	12

- List (most complex data structure)

```
1 x.list <- list(a = c(1,2,3), b = x.df)  
2 x.list
```

```
$a  
[1] 1 2 3
```

```
$b  
  ID sex age  
1  1  f  22  
2  2  f  45  
3  3  m  12
```

Missing data

- ▶ The symbol NA (Not Available) represents missing values.
- ▶ Unlike SPSS, most R functions do not use a listwise deletion strategy, e.g.:

```
1 x.na <- c(1,2,3, NA, 5)
2 mean(x.na)
```

```
[1] NA
```

However, if you specify `na.rm = TRUE` then `mean()` will calculate the mean:

```
1 mean(x.na, na.rm = TRUE)
```

```
[1] 2.75
```

Section overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Mean, median & Co

Reproducible research (RR) and workflow

Some basics

\LaTeX in 5 minutes

Useful books and websites

Download and installation

- ▶ R can be downloaded from the Comprehensive R Archive Network (CRAN). The process is as follows:
 1. Go to <http://www.r-project.org/>, click on the link “CRAN”, can be found in the left navigation bar
 2. Choose a CRAN mirror (e.g., Wirtschaftsuniversitaet Wien: <http://cran.at.r-project.org/>).
 3. Choose a precompiled binary distribution (“Download and Install R”) (e.g., Windows).
 4. Choose binaries for base distribution and then “Download R 2.15.0 for Windows”. (I mostly choose the “patched” version, see “Other builds”)
- ▶ After downloading R-2.15.0-win.exe, execute the file and enjoy!

Getting help

- ▶ `help(functionname)` (or `?functionname`) opens the help pages (in rare cases you have to use quotation marks, e.g. `help("[")`).
- ▶ `help.search("keyword")` searches all installed packages for “keyword” (e.g., `help.search("meta-analysis")`).
- ▶ The package `sos` offers the function `findFn()` which is much more flexible than `help.search()`, (e.g., `findFn("meta-analysis")`).
- ▶ CRAN Task Views give an overview with respect to a certain topic (e.g.,

“CRAN Task View: Statistics for the Social Sciences” or “CRAN Task View: Psychometric Models and Methods”).



Keeping R up-to-date

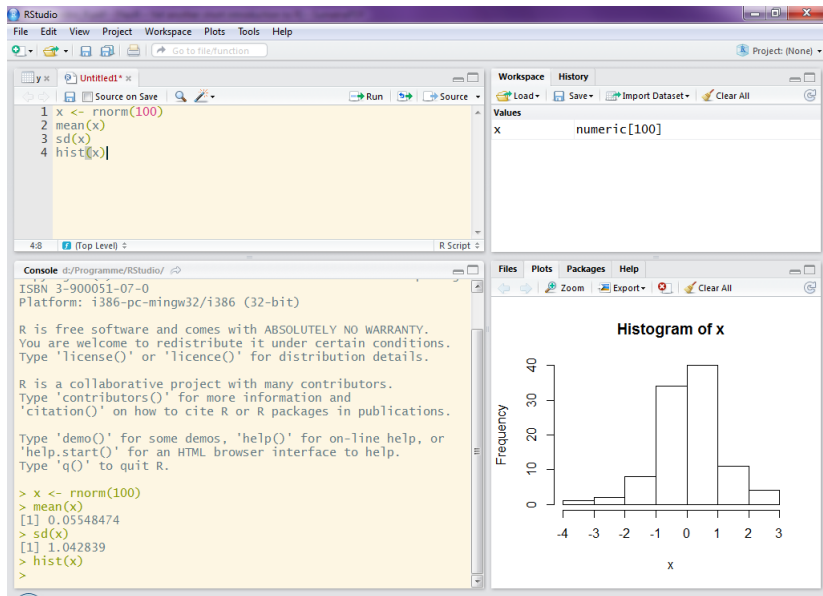
- ▶ Use the latest R version (updated twice a year).
- ▶ Updating packages is easy via `update.packages()`.

How to interact with R

(some statements refer to MS Windows only)

- ▶ Use the R console to type in R commands (REPL = read-eval-print loop).
- ▶ Use the built-in R script editor (see File - New script) to enter a (longer) sequence of R commands. Mark the lines which you want to run and press CTRL + r (STRG + r). This R script can be saved on you computer.
- ▶ An R script can also be “sourced”, i.e. you can run the command `source("myRscript.R")` (in Stata: use `myStataFile.do`).
- ▶ Use a text editor which (at least) offers syntax highlighting.
 - ▶ A recommended solution is RStudio (see next slide; can be downloaded from <http://rstudio.org/>)
 - ▶ My preferred solution is Emacs + ESS.
 - ▶ See also [The R GUI Projects website](#).

RStudio



Section overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Mean, median & Co

Reproducible research (RR) and workflow

Some basics

\LaTeX in 5 minutes

Useful books and websites

Overview

- ▶ R can handle many different data formats, e.g. SPSS, Stata, SAS, all sorts of text formats or DBMS.
- ▶ However, many data formats require you to load a certain package which then provides a function to load the data.
- ▶ Whenever you load a specific dataset, you need to assign it to an object via `<-`.
- ▶ The functions `fix()` and `edit()` open a MS-Excel-like datasheet (under MS-Windows).

Loading a dataset

- ▶ `setwd()`: set working directory
- ▶ `library(foreign)`: Enables R to load SPSS datasets
- ▶ `read.spss()`: Read SPSS dataset
- ▶ `names()`: show column ("variable") names of data object
- ▶ For a description see next slide

```
1 setwd("../data")
2 library(foreign)
3 dTeachExp <- read.spss(file = "dTeachExpRed.sav",
4                       to.data.frame = TRUE,
5                       use.value.labels = FALSE)
6 names(dTeachExp)
```

```
[1] "ID"      "T"      "V"      "weeks"  "weekcat"
```

The teacher-expectancy data set

XXX

Inspect your data I

```
1 head(dTeachExp) # prints first 6 cases
```

		ID	T	V weeks	weekcat
1	1	0.03	0.015625	2	2
2	2	0.12	0.021609	21	3
3	3	-0.14	0.027889	19	3
4	4	1.18	0.139129	0	0
5	5	0.26	0.136161	0	0
6	6	-0.06	0.010609	3	3

Another way to inspect your data is `edit()` or `fix()` (be careful not to modify your data unintentionally).

Inspect your data II

Here is a list of useful R functions to learn more about your data (object):

- ▶ `names()`: show column (“variable”) names of data object
- ▶ `dim()`: Retrieve (or set) the dimension of an R object, i.e. for an object of type `data.frame` it returns the number of rows and columns.
- ▶ `head()`: show first `n` cases (default is `n=6`)

Accessing elements of a data frame

- ▶ Since R can handle many data objects, you first have to refer to a particular data object. Second, specify which element(s) you are interested in.
- ▶ There is a more general and a more specific method of accessing elements of a data frame: the `[-` and the `$`-operator.

```
1 dTeachExp[, "T"] # access variable T
```

```
      [1]  0.03  0.12 -0.14  1.18  0.26 -0.06 -0.02 -0.32  0.27  0.80  0.54  0.18  
     [13] -0.02  0.23 -0.18 -0.06  0.30  0.07 -0.07
```

```
1 dTeachExp$T # access variable T, shortcut for dTeachExp[, "T"]
```

```
      [1]  0.03  0.12 -0.14  1.18  0.26 -0.06 -0.02 -0.32  0.27  0.80  0.54  0.18  
     [13] -0.02  0.23 -0.18 -0.06  0.30  0.07 -0.07
```

```
1 dTeachExp[1:4, c("T", "weeks")] # access first 4 obs of T and weeks
```

	T	weeks
1	0.03	2
2	0.12	21
3	-0.14	19
4	1.18	0

Saving a dataset

- ▶ `save(object, file = "filename")` saves a particular data (or a list of objects) object to the specified file.
- ▶ `save.image(file = "filename")` saves the current workspace (i.e., all objects shown by `ls()` or `objects()`).
- ▶ `dump()` or `write.table()` saves data objects in plain text files.
- ▶ The `foreign` package has functions to save data objects as SPSS, Stata, SAS files.

Section overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Mean, median & Co

Reproducible research (RR) and workflow

Some basics

\LaTeX in 5 minutes

Useful books and websites

Overview

- ▶ Generate new variables
- ▶ Select cases (subsetting/indexing) and variables
- ▶ Missing values

Creating new variables

```
1 dTeachExp$SE <- sqrt(dTeachExp$V)
2 head(round(dTeachExp, digits = 2))
```

	ID	T	V	weeks	weekcat	SE
1	1	0.03	0.02	2	2	0.12
2	2	0.12	0.02	21	3	0.15
3	3	-0.14	0.03	19	3	0.17
4	4	1.18	0.14	0	0	0.37
5	5	0.26	0.14	0	0	0.37
6	6	-0.06	0.01	3	3	0.10

Removing cases I (subsetting/indexing)

Relational (<, >, <=, >=, ==, !=) and logical operators (&, |, !)
can be used to remove certain cases.

```
1 subset(dTeachExp, weekcat == 0)
```

	ID	T	V	weeks	weekcat	SE
4	4	1.18	0.139129	0	0	0.373
5	5	0.26	0.136161	0	0	0.369
9	9	0.27	0.026896	0	0	0.164
11	11	0.54	0.091204	0	0	0.302
12	12	0.18	0.049729	0	0	0.223

```
1 subset(dTeachExp, weekcat == 0 & T > 1)
```

	ID	T	V	weeks	weekcat	SE
4	4	1.18	0.139129	0	0	0.373

Removing cases II

`subset()` is one way to create subsets. Another possibility is using the `[]`-operator.

```
1 dTeachExp[dTeachExp$weekcat == 0, ]
```

	ID	T	V	weeks	weekcat	SE
4	4	1.18	0.139129	0	0	0.373
5	5	0.26	0.136161	0	0	0.369
9	9	0.27	0.026896	0	0	0.164
11	11	0.54	0.091204	0	0	0.302
12	12	0.18	0.049729	0	0	0.223

```
1 dTeachExp[dTeachExp$weekcat == 0 & dTeachExp$T > 1,
```

	ID	T	V	weeks	weekcat	SE
4	4	1.18	0.139129	0	0	0.373

Removing (or keeping) cases III

Say, you want to remove cases based on a list of person IDs.
In that case, you can use the `%in%` function.

```
1 keep.ids <- c(1, 4, 6, 8)
2 dTeachExp.new <- dTeachExp[dTeachExp$ID %in% keep.i
3 dTeachExp.new
```

	ID	T	V	weeks	weekcat	SE
1	1	0.03	0.015625	2	2	0.125
4	4	1.18	0.139129	0	0	0.373
6	6	-0.06	0.010609	3	3	0.103
8	8	-0.32	0.048400	24	3	0.220

Removing missing values

```
1 dTeachExp.missing <- dTeachExp
2 dTeachExp.missing$T[c(1, 3, 6)] <- NA
3 dTeachExp.missing$weekcat[c(2, 3)] <- NA
4 head(dTeachExp.missing)
```

	ID	T	V	weeks	weekcat	SE
1	1	NA	0.015625	2	2	0.125
2	2	0.12	0.021609	21	NA	0.147
3	3	NA	0.027889	19	NA	0.167
4	4	1.18	0.139129	0	0	0.373
5	5	0.26	0.136161	0	0	0.369
6	6	NA	0.010609	3	3	0.103

Removing missing values (cont'd)

```
1 dTeachExp.missing[!is.na(dTeachExp.missing$T), ][1:6,]
```

	ID	T	V	weeks	weekcat	SE
2	2	0.12	0.021609	21	NA	0.147
4	4	1.18	0.139129	0	0	0.373
5	5	0.26	0.136161	0	0	0.369
7	7	-0.02	0.010609	17	3	0.103
8	8	-0.32	0.048400	24	3	0.220
9	9	0.27	0.026896	0	0	0.164

```
1 na.omit(dTeachExp.missing)[1:6,]
```

	ID	T	V	weeks	weekcat	SE
4	4	1.18	0.139129	0	0	0.373
5	5	0.26	0.136161	0	0	0.369
7	7	-0.02	0.010609	17	3	0.103
8	8	-0.32	0.048400	24	3	0.220
9	9	0.27	0.026896	0	0	0.164
10	10	0.80	0.063001	1	1	0.251

Removing variables

```
1 (dTeachExp.names <- names(dTeachExp))
```

```
[1] "ID"      "T"      "V"      "weeks"   "weekcat" "SE"
```

Remove the 1. and 3. variable

```
1 dTeachExp[1:2, c(dTeachExp.names)[-c(1,3)]]
```

	T	weeks	weekcat	SE
1	0.03	2	2	0.125
2	0.12	21	3	0.147

Remove weeks and weekcat.

```
1 !(dTeachExp.names %in% c("weeks", "weekcat"))
```

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

```
1 dTeachExp[1:2,!(dTeachExp.names %in% c("weeks", "weekcat"))]
```

	ID	T	V	SE
1	1	0.03	0.015625	0.125
2	2	0.12	0.021609	0.147

Section overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Mean, median & Co

Reproducible research (RR) and workflow

Some basics

\LaTeX in 5 minutes

Useful books and websites

Make up some data

The next few slides will rely on some fake data.

```
1 df.fake <- data.frame(  
2     x = rnorm(10), # standard normal distr.  
3     y = rnorm(10, mean = 10, sd = 5),  
4     sex = factor(rep(c("f", "m"), 5))  
5 )  
6 df.fake[1:4, ] # show rows 1 to 4
```

	x	y	sex
1	0.2434808	16.860472	f
2	-0.8632959	7.169341	m
3	-0.2107243	4.684020	f
4	-0.6146973	10.721603	m

Subsection overview

Introduction

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Mean, median & Co

Reproducible research (RR) and workflow

Useful books and websites

The summary() function

```
1 summary(df.fake)
```

	x	y	sex
Min.	:-1.58721	Min. : 3.905	f:5
1st Qu.:	-0.75659	1st Qu.: 6.875	m:5
Median :	-0.05943	Median : 9.371	
Mean :	-0.07091	Mean : 9.929	
3rd Qu.:	0.21711	3rd Qu.:11.043	
Max.	: 2.21622	Max. :19.279	

```
1 summary(df.fake$x)
```

	Min.	1st Qu.	Median	Mean	3rd Qu.	
	-1.58700	-0.75660	-0.05943	-0.07091	0.21710	2.21600

The `mean()` and `median()` functions

```
1 mean(df.fake$x)
2 mean(df.fake$y)
```

```
      [1] -0.07091068
[1] 9.928677
```

Section overview

Introduction

Preamble

Five basic R concepts

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Mean, median & Co

Reproducible research (RR) and workflow

Some basics

L^AT_EX in 5 minutes

Useful books and websites

Subsection overview

Introduction

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Reproducible research (RR) and workflow

Some basics

\LaTeX in 5 minutes

Useful books and websites

What is reproducible research?

“By reproducible research, we mean research papers with accompanying software tools that allow the reader to directly reproduce the results and employ the methods that are presented in the research paper” (Gentleman/Lang 2004: 1).

Requirements for the workflow: TREMMP

- ▶ Transparency (e.g., by using dynamic documents, “The source code is real”)
- ▶ Reproducibility (e.g., by using dynamic documents, “The source code is real”)
- ▶ Efficiency (a good workflow saves you time, by automating as much of the process as possible)
- ▶ Maintainability (standardized script names, good commenting practices, README files)
- ▶ Modularity (discrete tasks into separate components (e.g. scripts))
- ▶ Portability (e.g., by using relative (not absolute) pathnames)

(Source: David Smith on “A workflow for R”: <http://blog.revolutionanalytics.com/2010/10/a-workflow-for-r.html>)

The source code is real

“The source code is real. The objects are realizations of the source code. Source for EVERY user modified object is placed in a particular directory or directories, for later editing and retrieval” (Rossini et al. 2011:[ESS - Emacs Speaks Statistics - Manual](#))

Use `source()` to read R code from a file

The R console can be used for short and temporary tests. In order to establish a TREMMP workflow, however, it is required to write R programs and to source them. So, use `source(file = "myfile.R")` to run an external R program. In SPSS, you would create an `.sps`-file, in Stata a `.do`-file.

More on reproducible research

- ▶ Kieran Healy: “Choosing Your Workow Applications”
<http://www.kieranhealy.org/files/misc/workflow-apps.pdf>
- ▶ ... to be continued ...

Subsection overview

Introduction

Installation, help, maintenance and interacting with R

Loading a (SPSS) dataset

Data cleaning and data preparation

Descriptive statistics

Reproducible research (RR) and workflow

Some basics

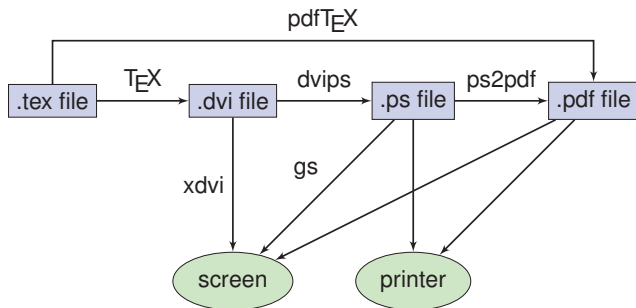
\LaTeX in 5 minutes

Useful books and websites

What is \LaTeX

- ▶ \LaTeX is a markup language. Another markup language you might know is HTML.
- ▶ \LaTeX provides high-quality typesetting features.
- ▶ The typical workflow is as follows:
 1. Create \LaTeX source code file (`.tex`)
 2. Compile it via \LaTeX or `pdf\text{\LaTeX}`
 3. Use a viewer (PDF, DVI or via `dvips` PS) to view the compiled file
- ▶ In order to run \LaTeX on your computer, you will need to install a \LaTeX -distribution (e.g., `MikTeX` for MS-Windows).

The T_EX work flow



Navigation icons: back, forward, search, etc.

Source:

<http://media.texample.net/tikz/examples/PDF/tex-workflow.pdf>

Navigation icons: back, forward, search, etc.

What a \LaTeX file looks like

```
1  %% Part 1: Preamble
2  \documentclass{article}
3
4  \usepackage[utf8]{inputenc}
5  \usepackage[T1]{fontenc}
6  \usepackage[english]{babel}
7
8  %% Part 2: Body
9  \begin{document}
10
11  \section{Heading}
12
13  Hello world!
14
15  \begin{equation}
16  \overline{T} = \frac{\sum\limits^{k}_{i = 1} \%
17    T_{i}\cdot w_{i}}{\sum\limits^{k}_{i = 1}w_{i}}
18  \end{equation}
19
20  \end{document}
```

The compiled 'Hello world'-example

1 Heading

Hello world!

$$\overline{T} = \frac{\sum_{i=1}^N T_i \cdot w_i}{\sum_{i=1}^N w_i} \quad (1)$$

Section overview

Introduction

Preamble

Five basic R concepts

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Mean, median & Co

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Useful books and websites

Useful books or websites

► Websites

- [The R Manuals](#) (esp. An Introduction to R)
- [Quick-R](#)
- [Using R for psychological research: A simple guide to an elegant package](#)
- [R for SAS and SPSS users](#) (see “Free Version”)
- See also the [R Wiki](#)
- ...

► Books

- [R for SAS and SPSS users](#) by RA Muenchen
- [Introductory Statistics with R](#) by P Dalgaard
- See also [Books related to R](#)
- ...