Biostatistics & Epidemiological Data Analysis using R

1

Introduction to R & RStudio

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Learning objectives

Introduction to R, RStudio:

- Overview, what R as programming language can be used for.
- Get an overview how the graphical interface RStudio looks like and what it can be used for.
- Understand what kind of "R files" there are (.RData, .R, .Rmd).
- Be able to access the help pages for an R function and R package, and understand what these two mean.

But before we get started ...

... is everybody's installation of R and RStudio running?

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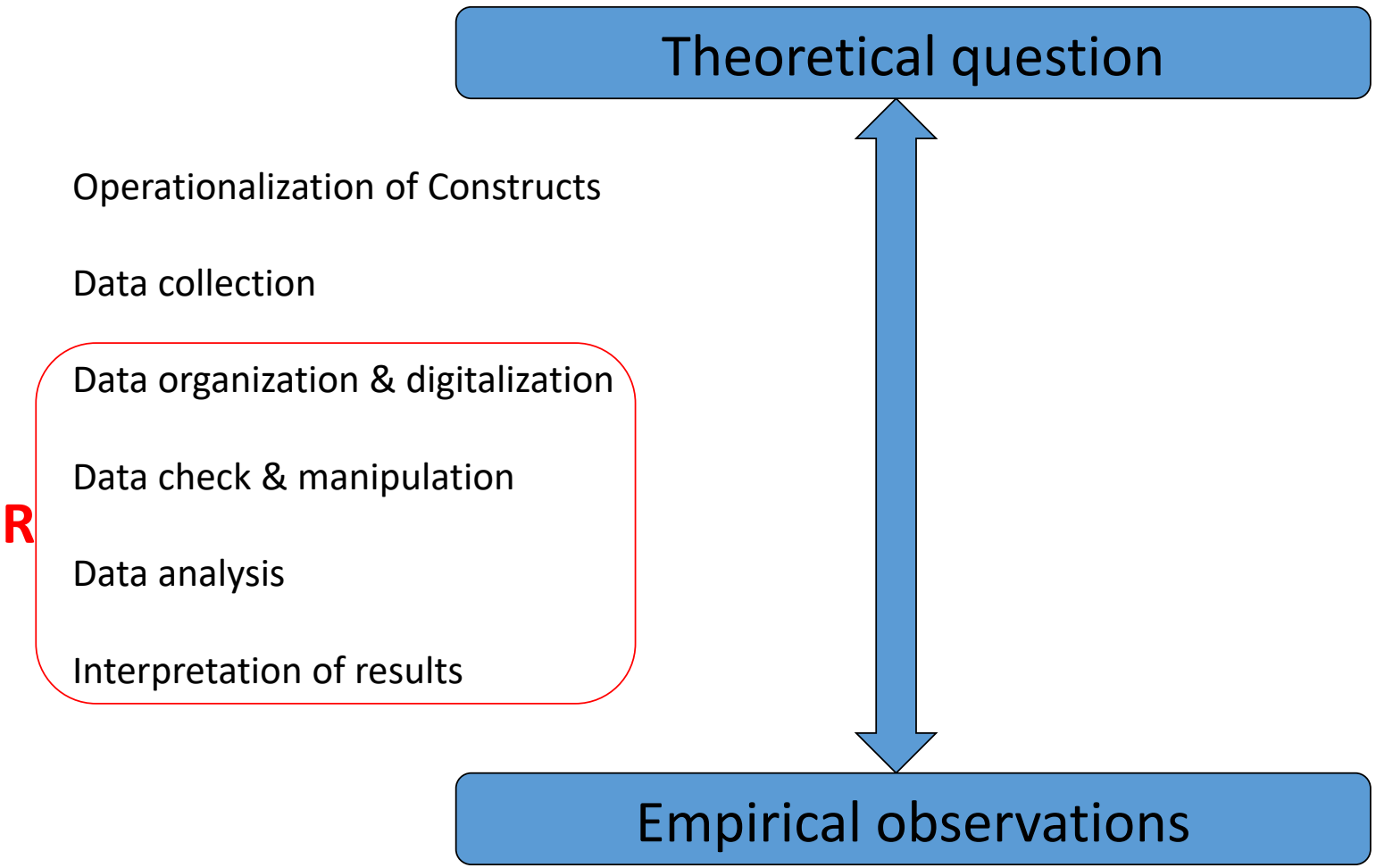
Who is working on Windows? Mac? Linux? Others?

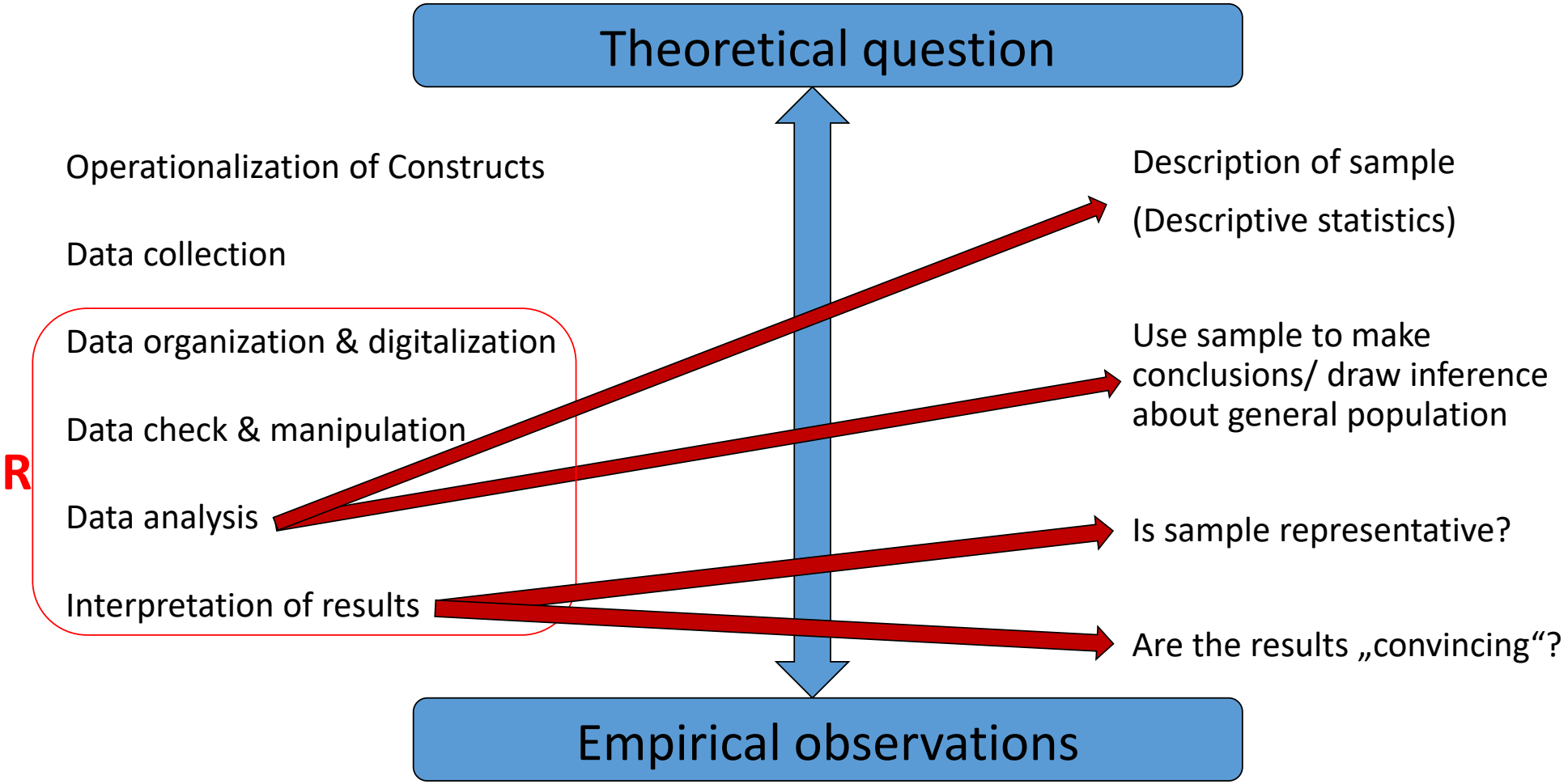
Who has a second screen?

Background

Empirical research process - overview



Empirical research process - analysis & interpretation



Empirical research process - steps in/around R

Theoretical question

Operationalization of Constructs

Specify study question, hypothesis, design, sample size, and statistical analysis plan before data collection and analysis!

Data collection

Collect data (best in digital format) otherwise input/format it so that it can be read into R

R

Data organization & digitalization

Data check & manipulation

Read in data, save as raw data, check, format, transform/extract variables, save as new dataset for the analysis

Data analysis

Interpretation of results

Calculate planned statistical analyses in R, extract/save results, create tables/plots, interpret results

Empirical observations

Empirical research process - example

International Journal of Epidemiology, 2019, 148–156 doi: 10.1093/ije/dyy118

Are birthweight and postnatal weight gain in childhood associated with blood pressure in early adolescence? Results from a Ugandan birth cohort

Background: In Africa, where low birthweight (LBW), malnutrition and high blood pressure (BP) are prevalent, the relationships between birthweight (BW), weight gain and BP later in life remain uncertain. We examined the effects of early life growth on BP among Ugandan adolescents.

Methods: Data were collected prenatally from women and their offspring were followed from birth, with BP measured following standard protocols in early adolescence. Weight-for-age Z-scores (WAZ) were computed using World Health Organization references. Linear regression was used to relate BW, and changes in WAZ between birth and 5 years, to adolescents' BP, adjusting for confounders.

Results: Among 2345 live offspring, BP was measured in 1119 (47.7%) adolescents, with mean systolic BP 105.9 mmHg and mean diastolic BP 65.2 mmHg. There was little evidence of association between BW and systolic [regression coefficient $\beta = 0.14$, 95% confidence interval (CI) (-1.00, 1.27)] or diastolic [$\beta = 0.43$, 95% CI (-0.57, 1.43)] BP. ...

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Which steps lie behind this description and these results?
(How) Can they be reproduced?

Statistical software

- R
- SPSS (PSPP)
- SAS (SAS Studio)
- Excel
- Stata
- Python
- Specialized software, e.g. Mplus, PLINK, ...
- ...

History of R

- 1980s: S, S-PLUS developed by Becker & Chambers.[1]
- Ross Ihaka & Robert Gentleman (University of Auckland): development of reduced version of S: R.[1]
- 1995: start of initiative to publish R under the GPL and Formation of core team with 19 members.[1]
- 2000: release of version 1.0.0.[1]
- Current version: 4.1.1 (1 year ago: 4.0.3)
- New version approx. every 2-3 months, mostly small updates that do not make any/a big difference in standard analyses.

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So what is R?

- Statistical computer program
- Complete programming language
- Environment to perform statistical analyses, produce graphics

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Why R?

- Free, open source (General Public License) - i.e. can see what is done in the analysis, adapt and contribute. Also, easy transport of files between programs/to other programs.
- Active methods development in/for R: if you find a paper with a new statistical method you want to apply, there is a very good chance it is implemented in R.
- Large active online community, tutorials, documentation, manuals, help forums etc. $\longrightarrow$ if you have problems in your analysis, almost always you can find an answer.

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- Large active online community, tutorials, documentation, manuals, help forums etc. $\longrightarrow$ if you have problems in your analysis, almost always you can find an answer.
- Increasing number of users in education, research, industry.
- Runs (to my experience) robustly on many operating systems, e.g. Windows, Mac, Linux, ...
- Can be run on servers, through bash scripts, and used for large multi-center studies (but has challenges for really large data).

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- Runs "on top of" R (e.g. you can also do all analyses and creation of plots and tables without RStudio).
- Very good people working on the development and adding new things (e.g. Hadley Wickham) – e.g. work in the cloud (`https://rstudio.cloud/`), write packages, create reports, apps, presentations, websites, CV ...

And why not others?

- SPSS: can do all analyses by "clicking" without programming (coding is also possible), with all upsides and downsides. Not free (free replica PSPP, with limited functionality), not open source, only restricted analyses possible, not running on all systems, cannot run on servers (at least very hard to).

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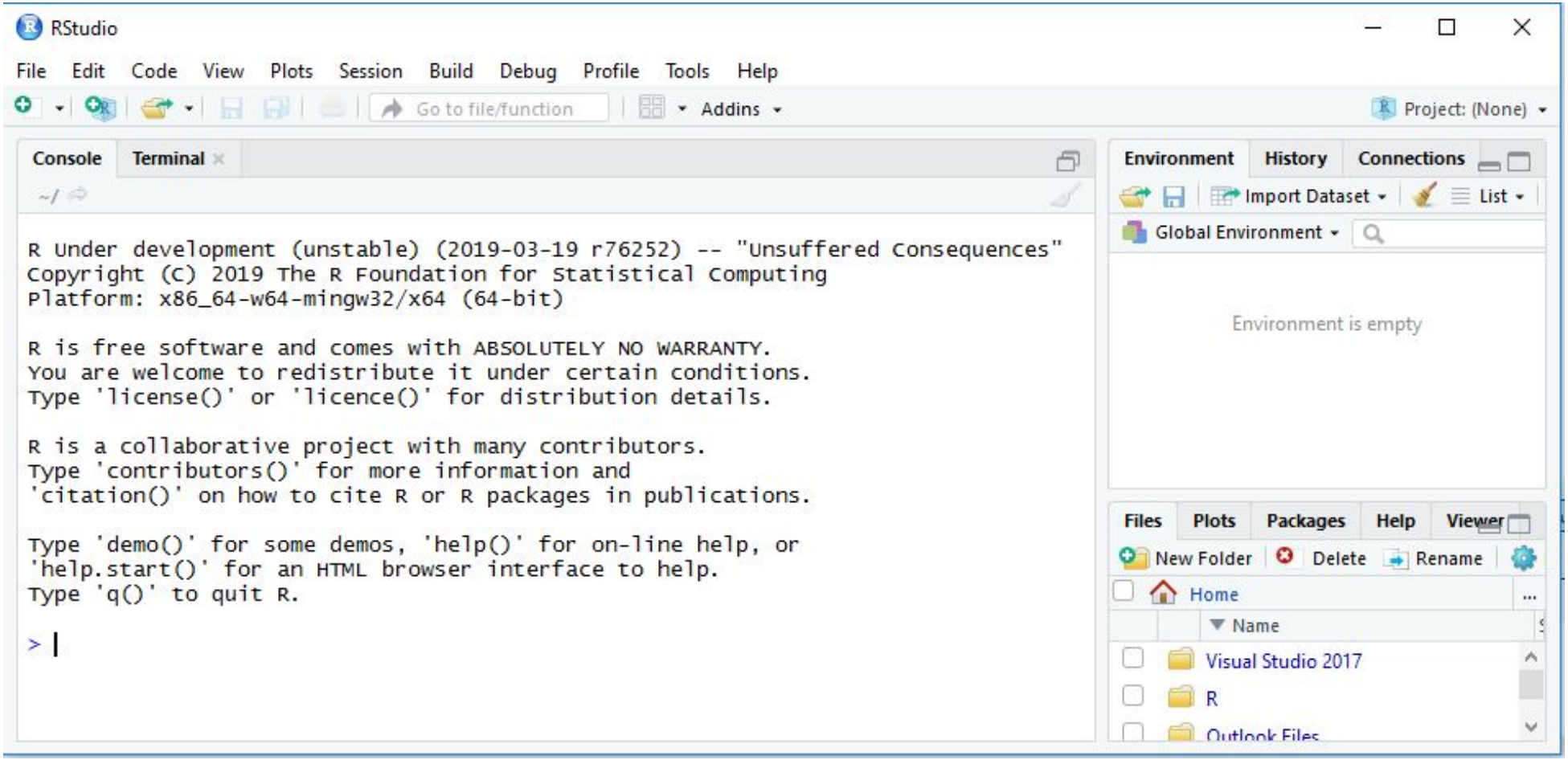
- SAS: Can do some analyses by clicking, generally made for programming. Very high costs (but since recent years free SAS Studio version available), only restricted analyses possible in base version, problems on different servers etc.
- Python: Similar to R: increasing user base and applications, especially in machine learning.

Installation of R and RStudio

- R: Download and install most recent, archived, and development versions from `https://cran.r-project.org/`.
- RStudio: Download and install from `www.rstudio.com/products/rstudio/download/`.
- Help for the installation can be found e.g. at `http://r-tutorial.nl/`.
- Update R e.g. using the functions in the `installr` package (`https://cran.r-project.org/web/packages/installr`).

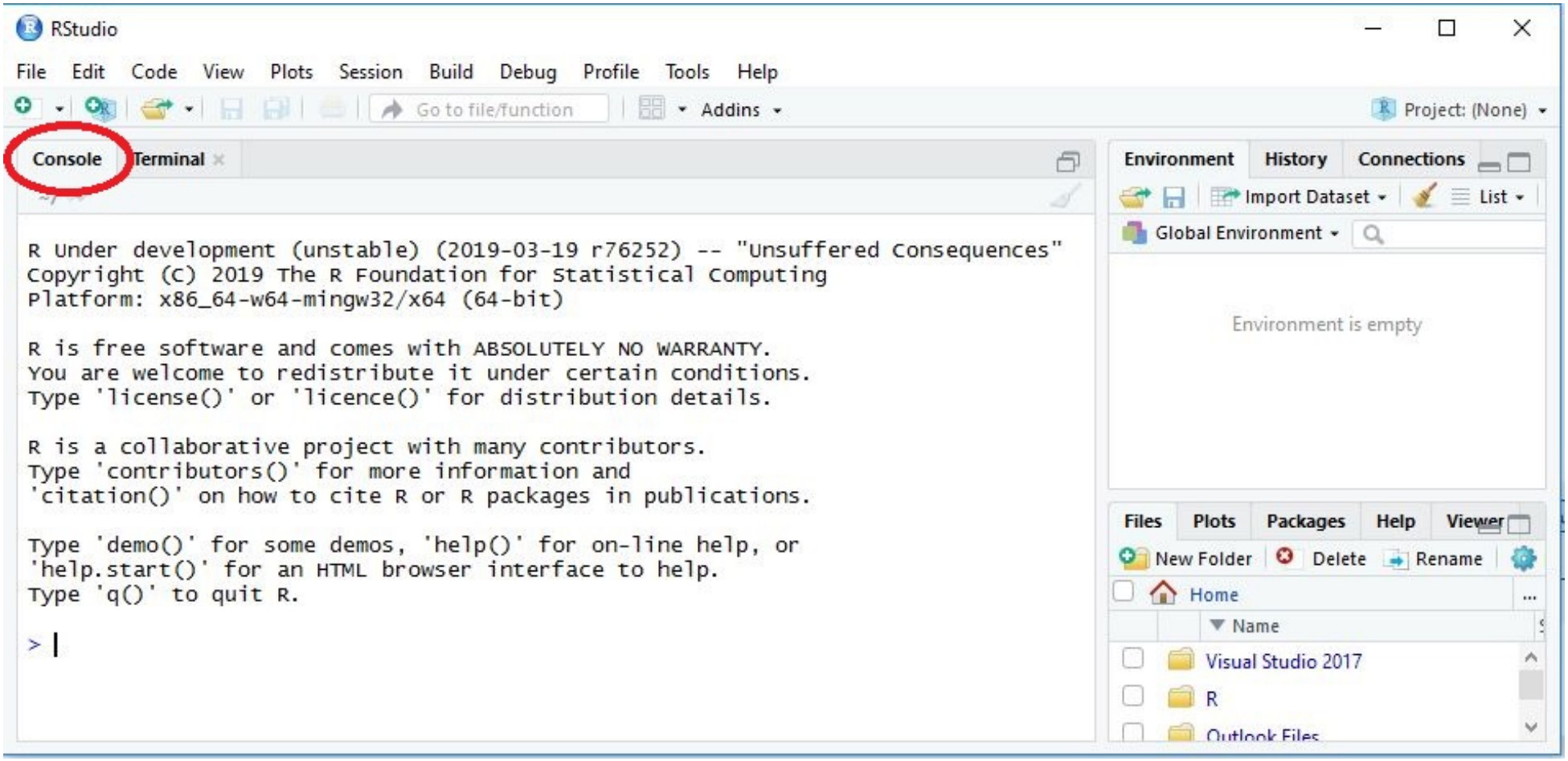
Overview of windows and functionalities in RStudio

First look at RStudio



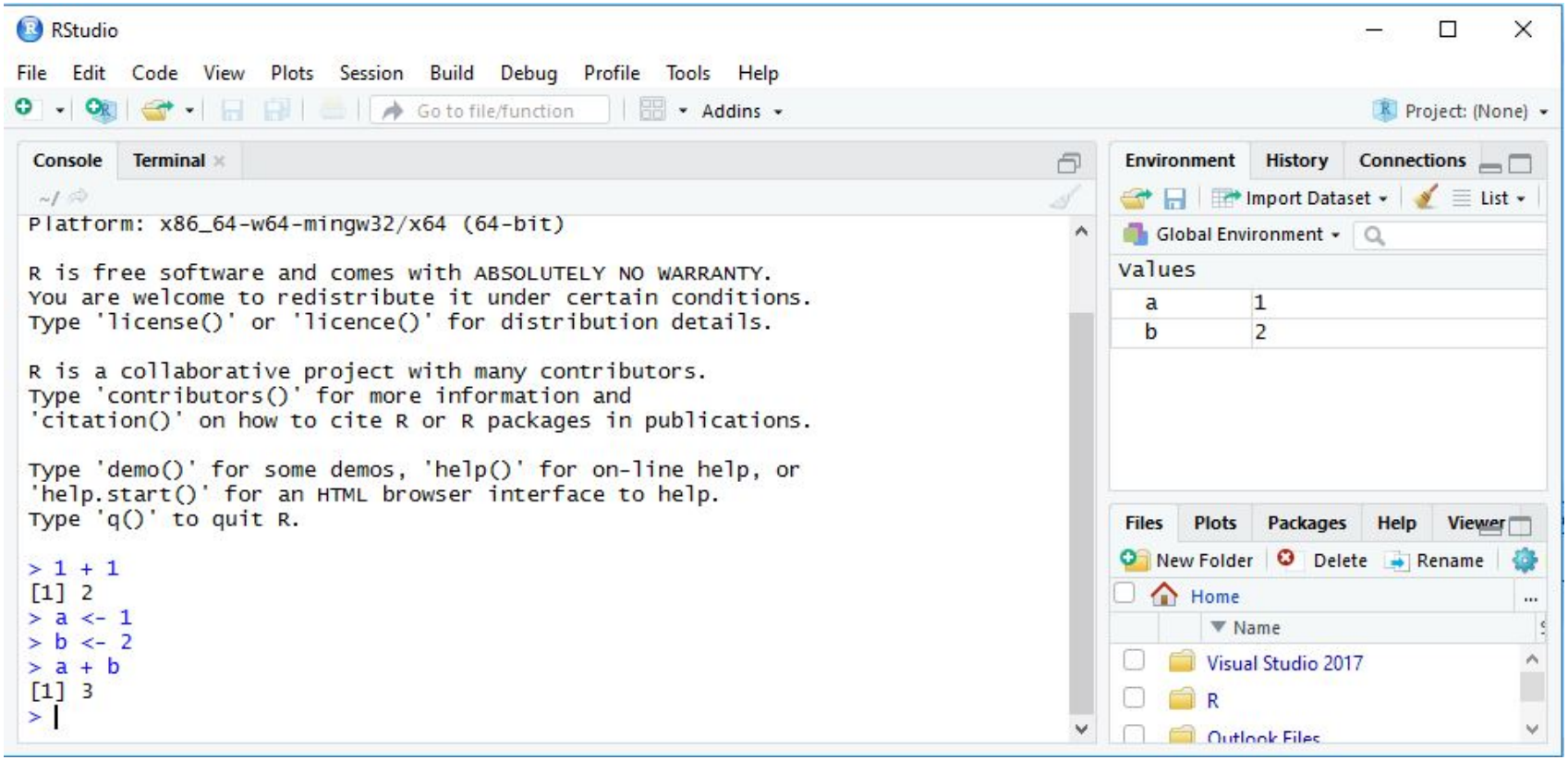
R Console

Here you can type in your R commands and execute them by pressing Enter:



R Console

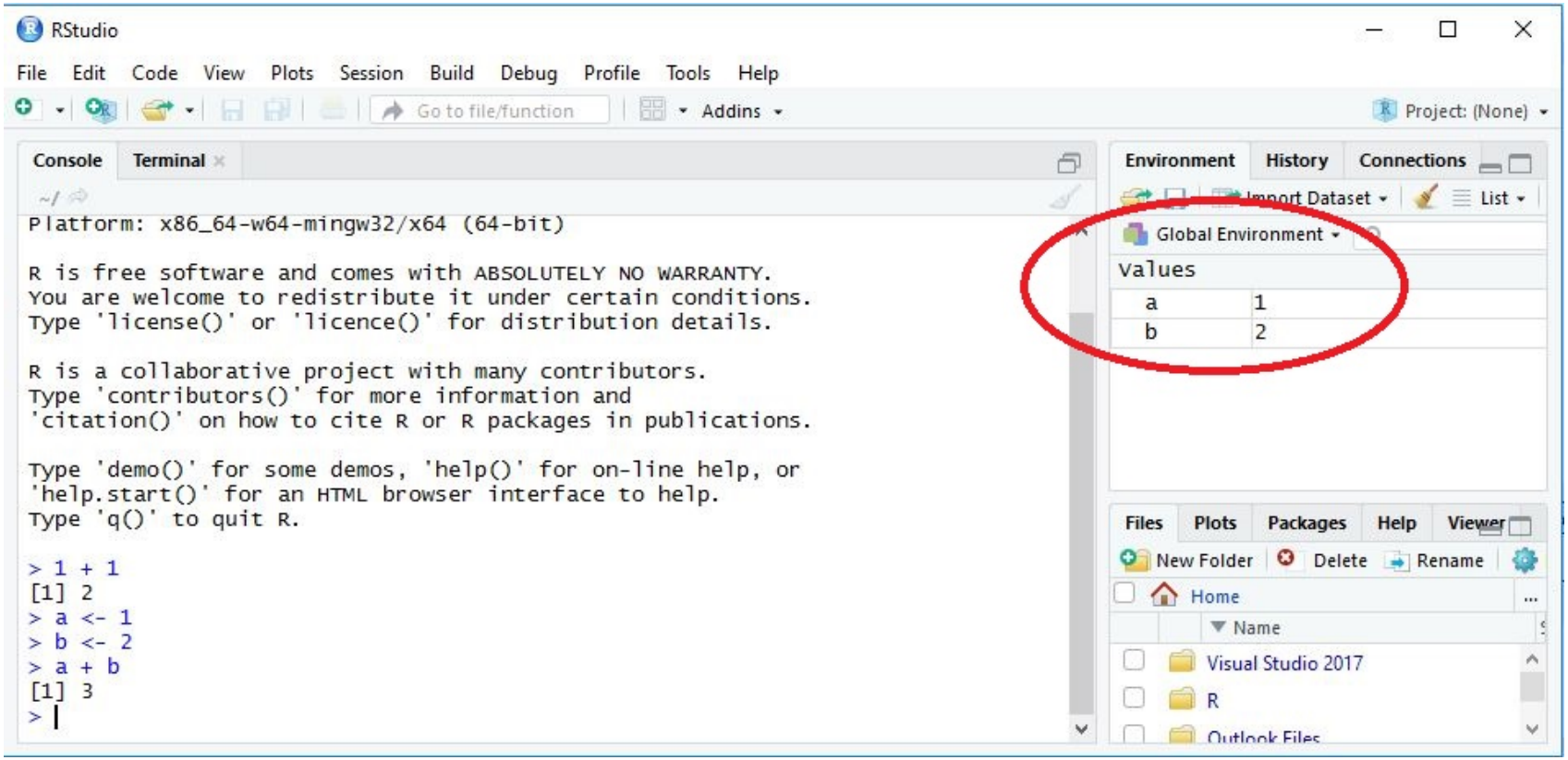
For example:



Many further options to use R as a calculator, e.g. `log`, `exp`, ...

R Console

After running these lines of R code, the objects a and b are created, and they are assigned the values 1 and 2:



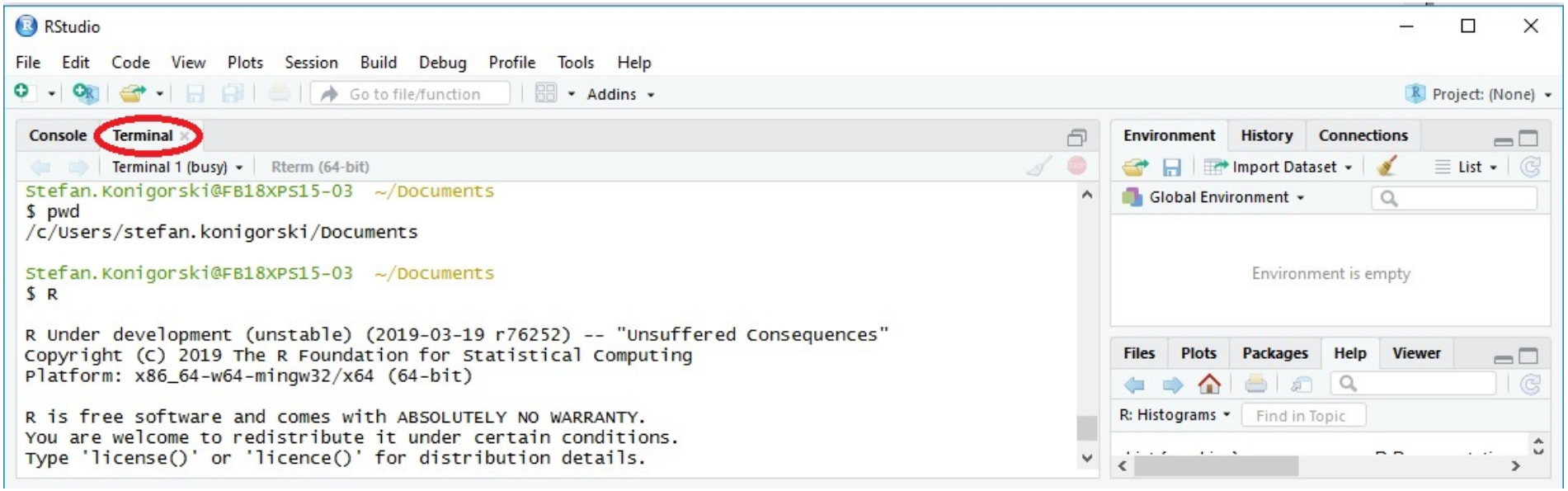
They are in the global environment, can be used in the analyses, and they can also be saved, for example.

Exercise 1

- Open the R script 'R_1_exercise_1.R' in RStudio by double clicking on the file, or open it with `File` ▶ `Open`.
- Go through points (1) - (7) and run the commands by copy-pasting them into the Console and pressing Enter.
- Look at the results and try to understand/take a guess what you have computed.

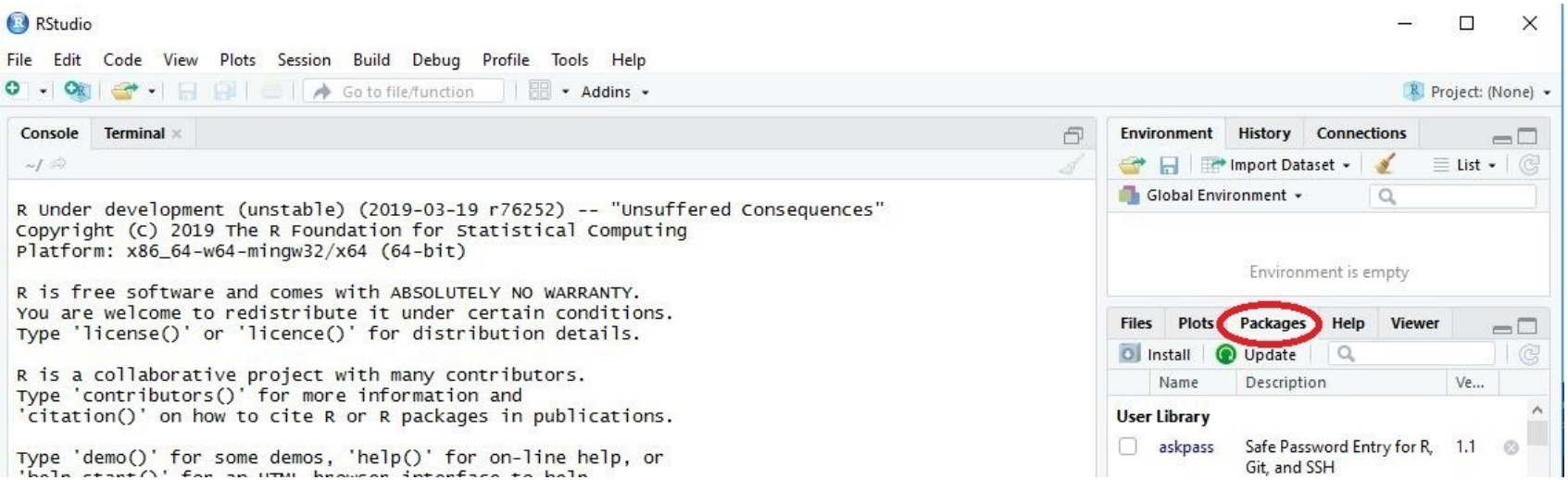
Terminal

"Linux-style command line" to do stuff:



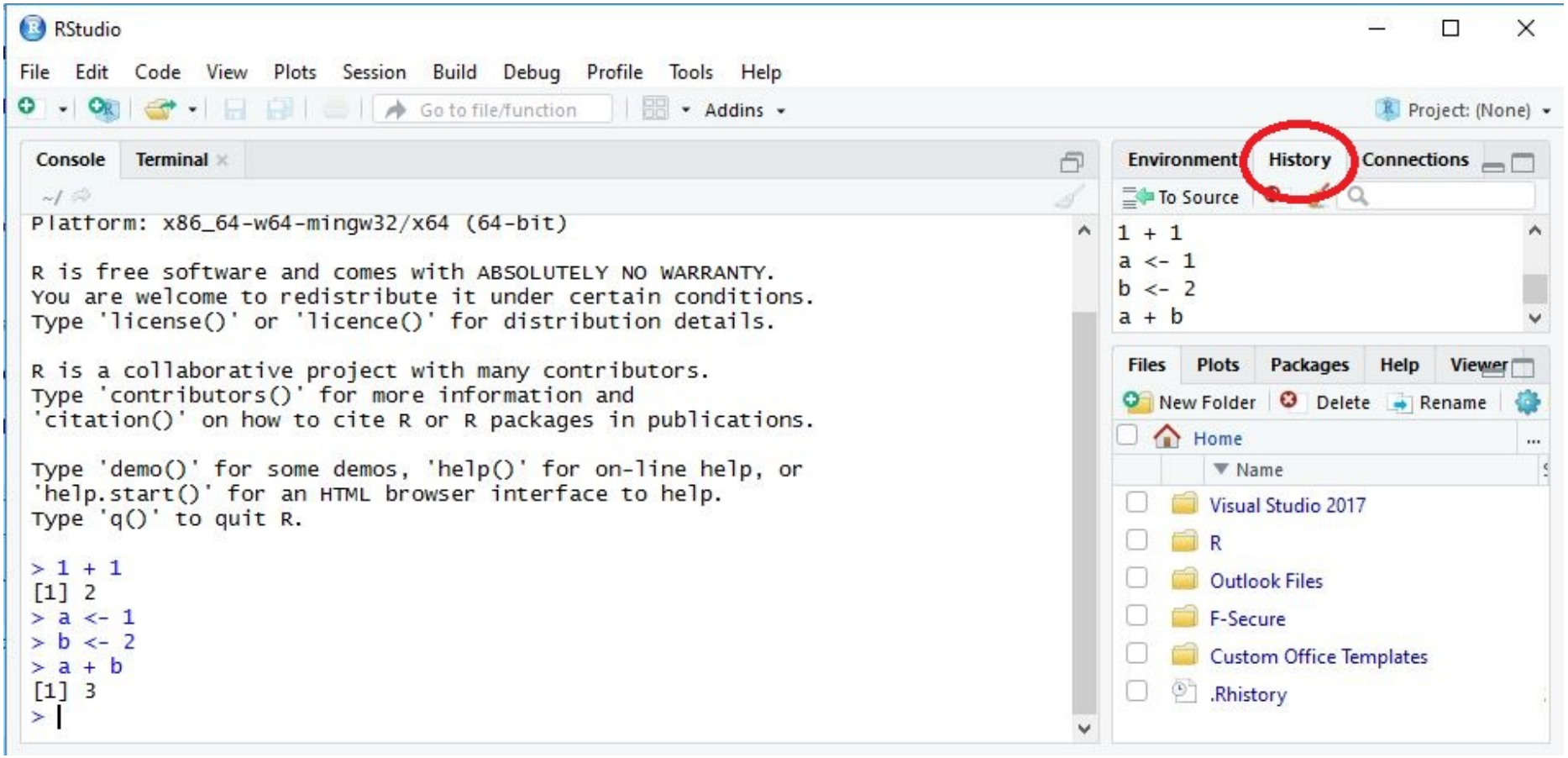
R packages

- Analyses in R are done using functions, e.g. `+` or `t.test`.
- Many are in the automatically loaded `base`, `stats` packages.
- Functions in other packages must be loaded, and the packages installed before use - either through the package tab, or through `install.packages("packagename")`
- More documentation for all packages is available in the manual and (for some packages) vignette at `https://cran.r-project.org/package=packagename`.



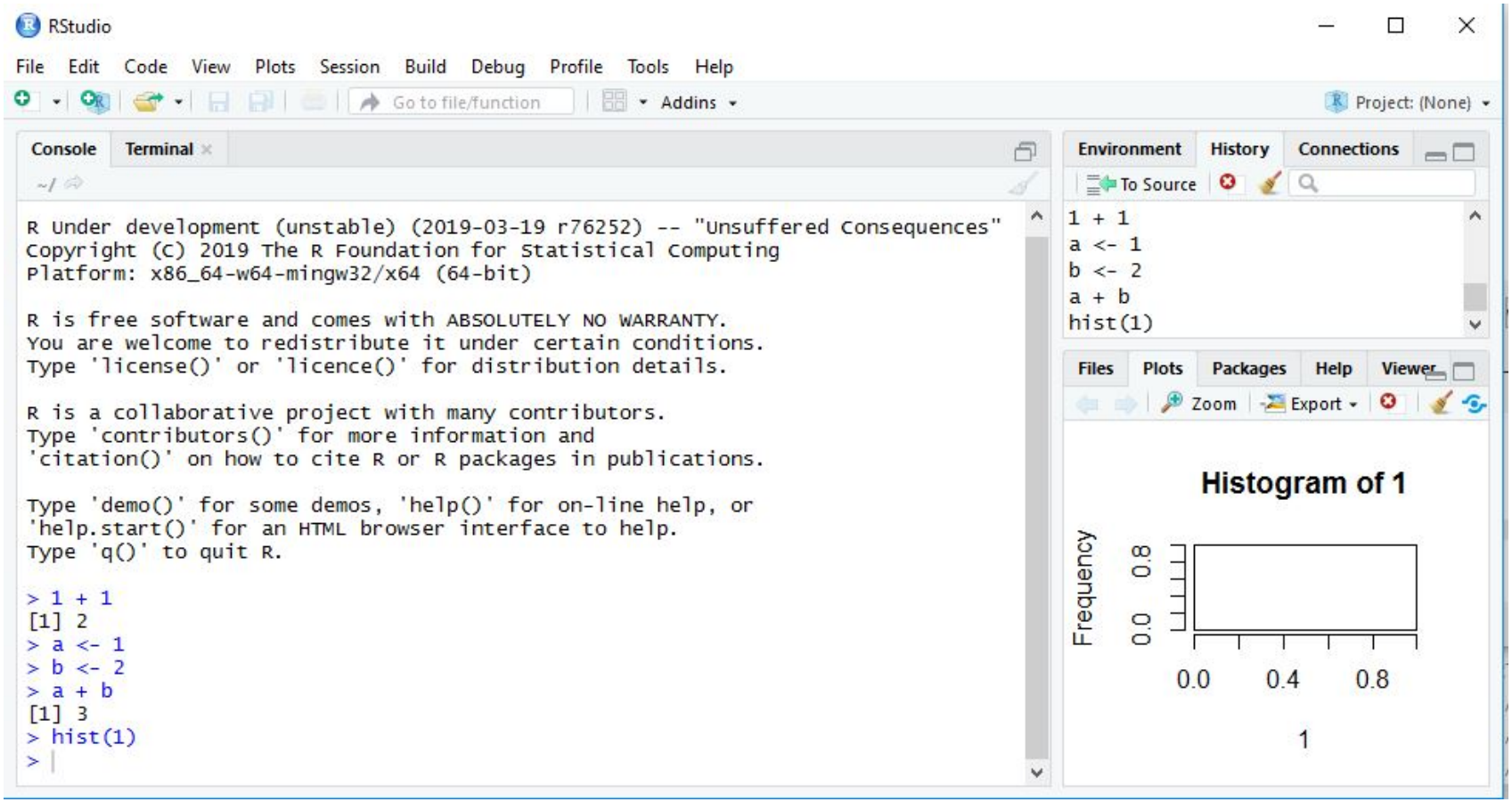
History

All code that has been run can be viewed in the History panel:



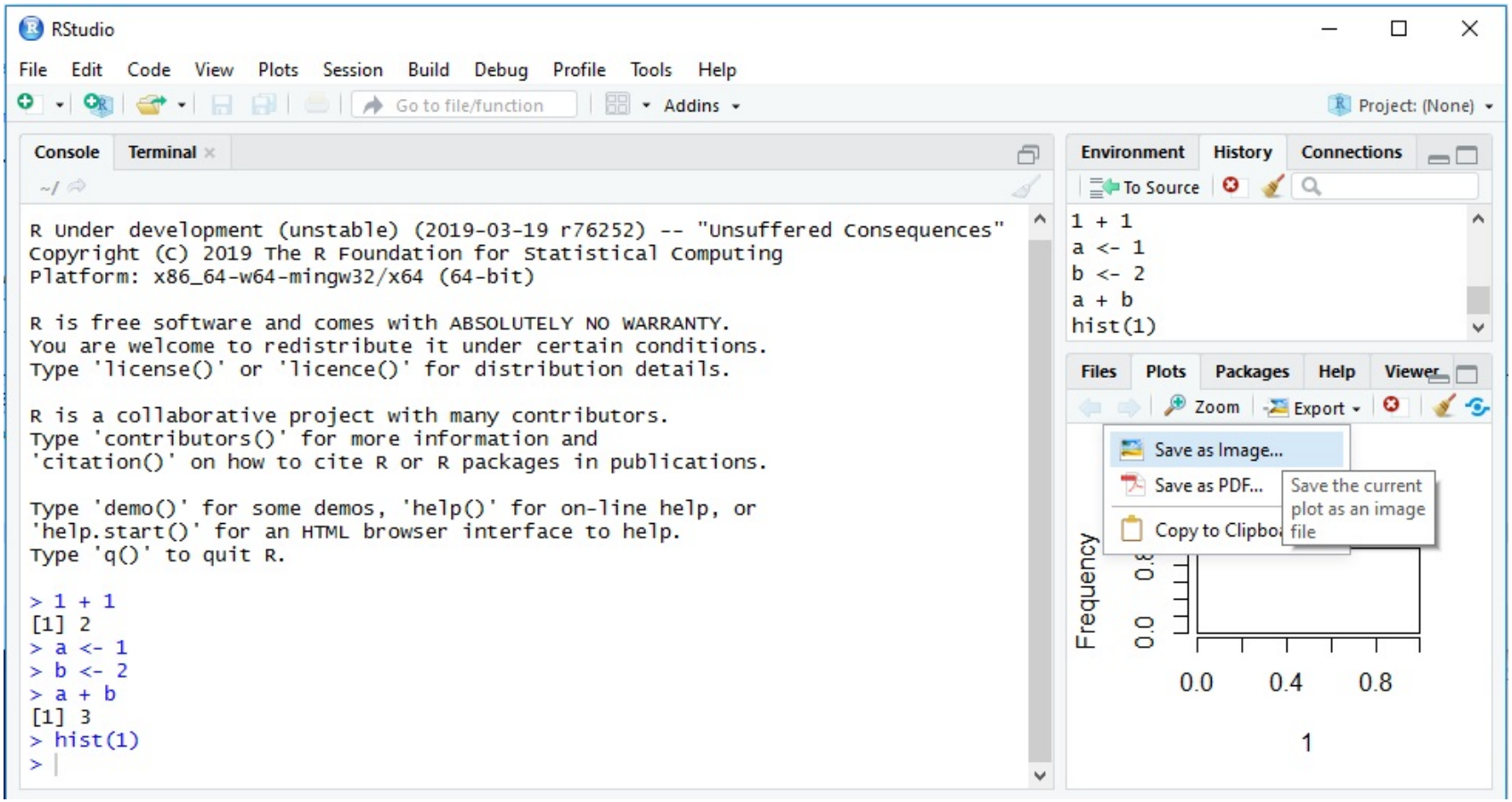
Graphics

Plots can be generated by typing commands in the console and pressing enter. The results are shown in the "Plots" Tab:



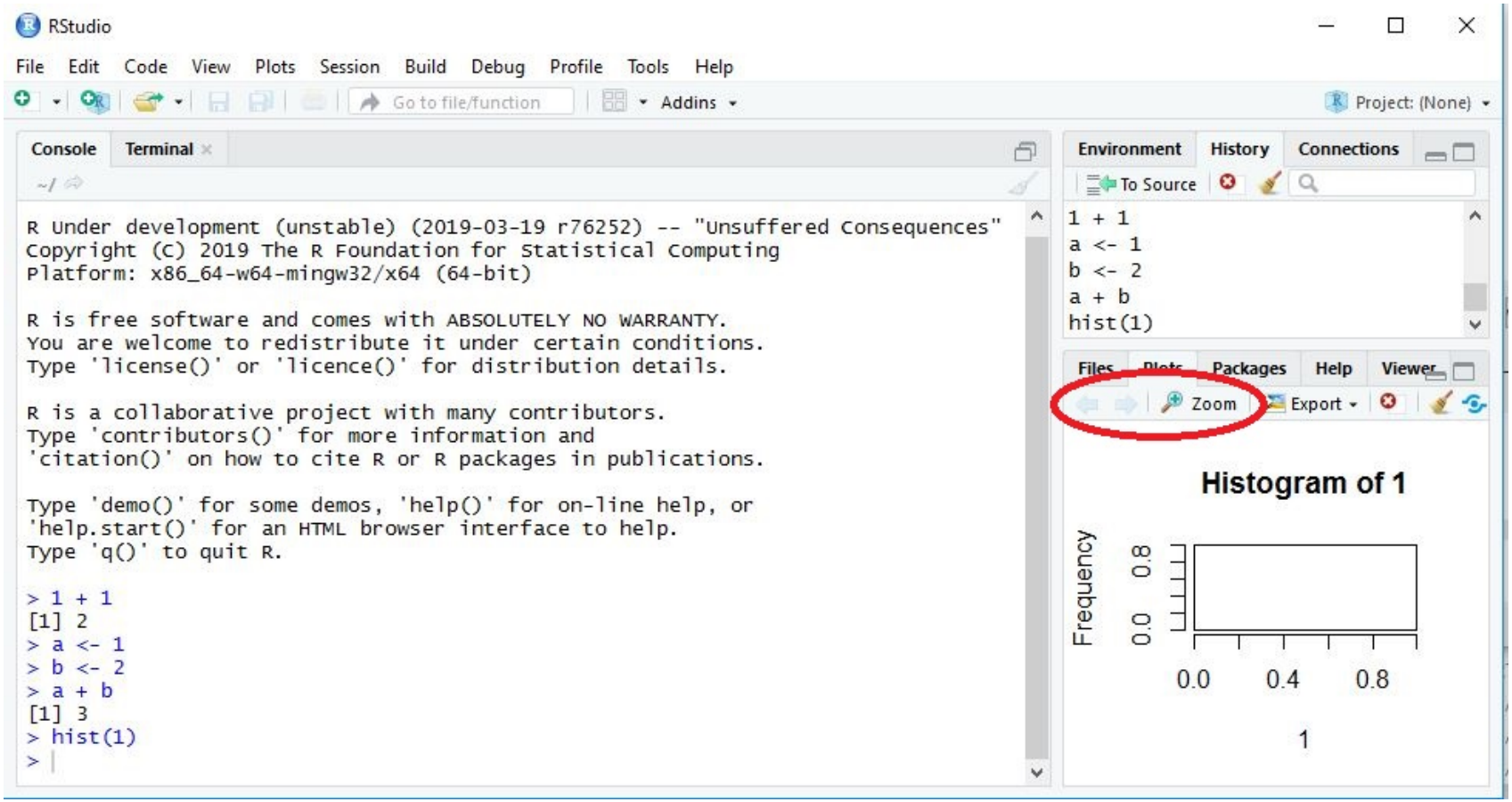
Save images

The image can be exported and saved:



Further handling of images

Images can be opened in a separate window to zoom in.
Also, buttons allow to go back and forth between created images.

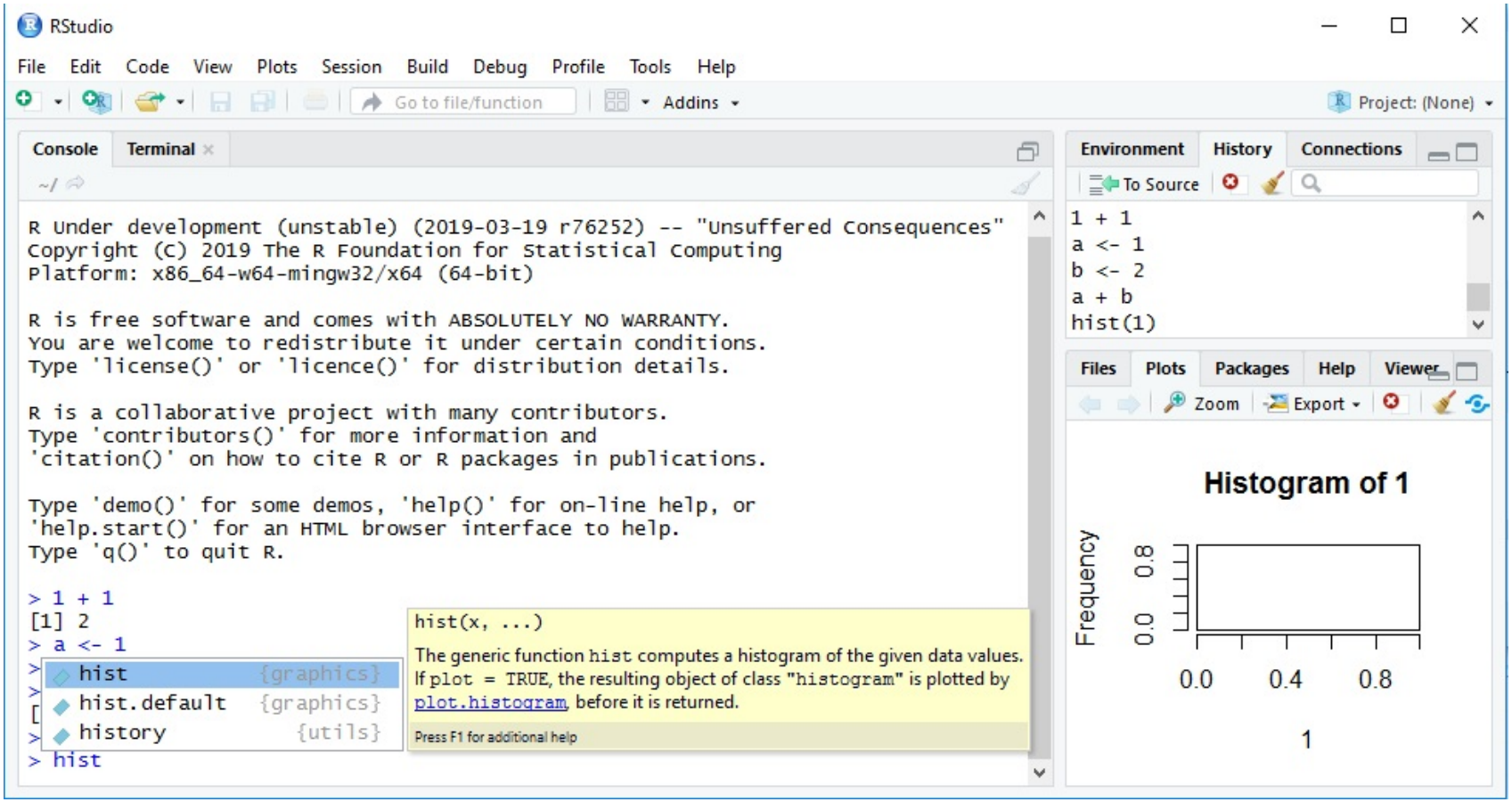


Exercise 2

- Generate a new histogram with the command `hist(c(1,1,1,2,4,2,5,2,6,7,8,9,101,100))`.
- Try to understand what information is shown in the plot that you have created.
- Save the graphic as a pdf file on your desktop.
- See 'R_1_exercise_2.R'.

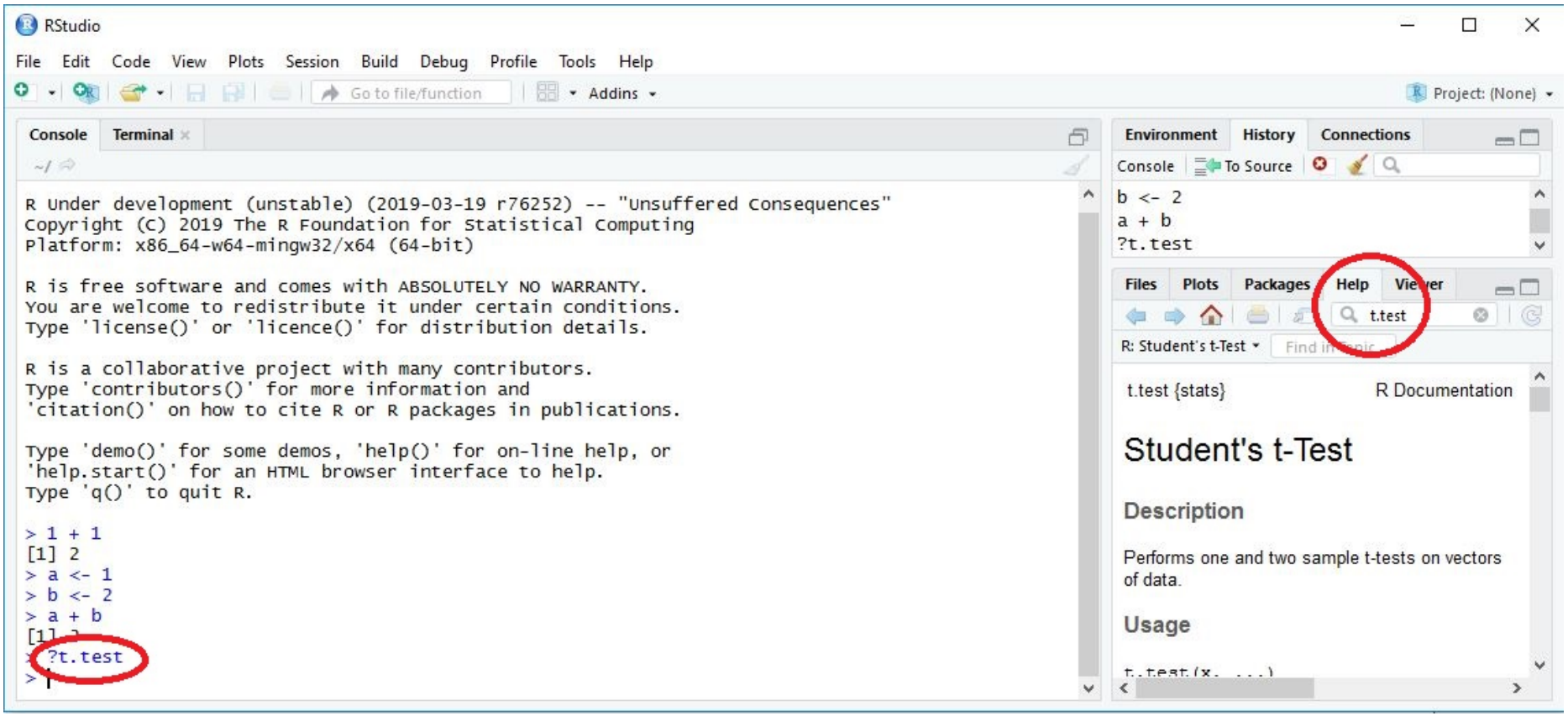
Help with typing and functions

Help for the functions can be seen while typing:



General help

The help sites for functions and packages can be reached by typing `?functionname` in the console (and pressing enter) or through the help panel:



First contact with data frames

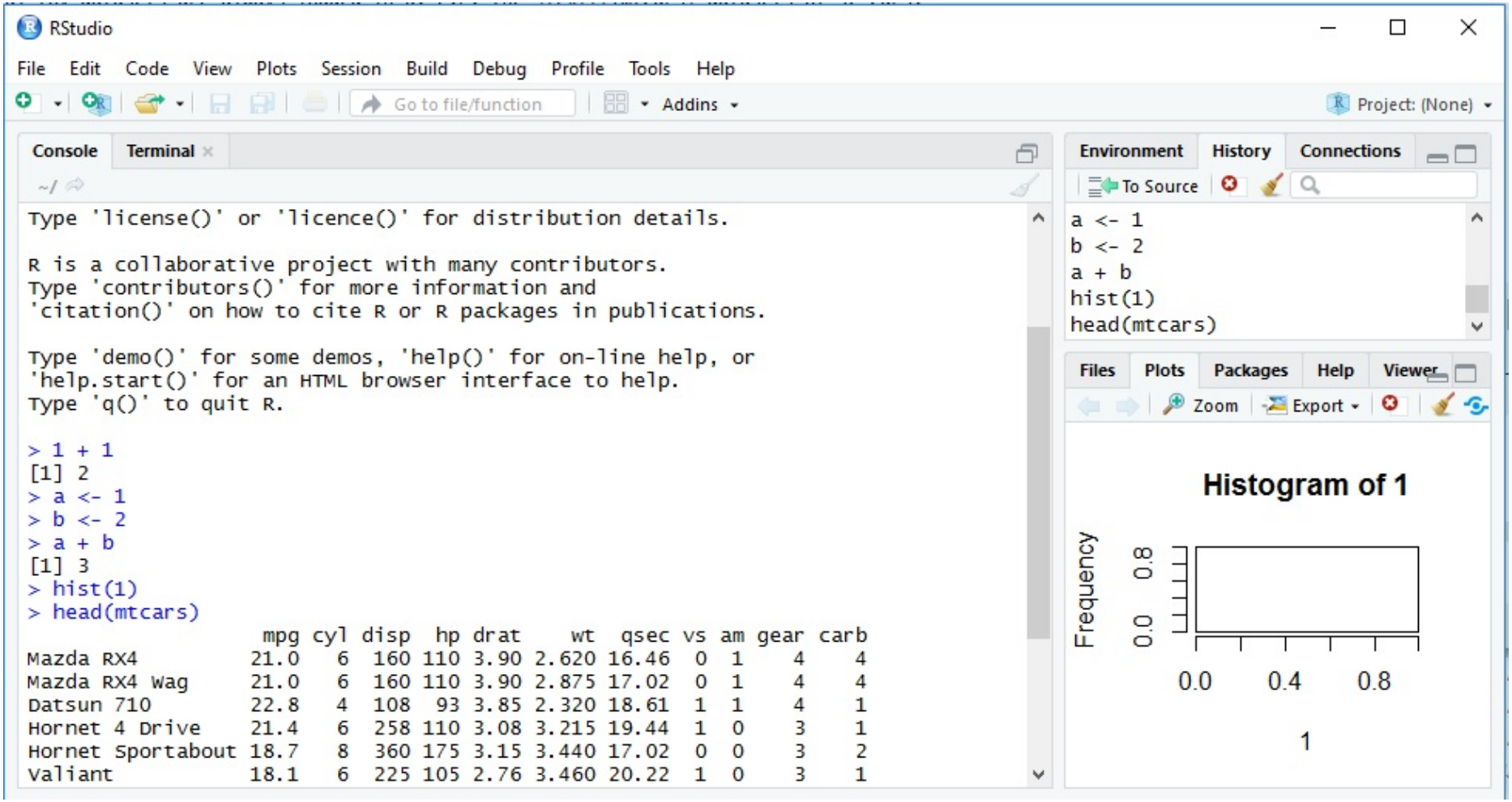
Load data

In order to work with data in R, the data can be:

- Imported from external files (e.g. xls, txt, ... files).
- Typed in directly into R (e.g. in the console).
- Loaded, if the data has already been saved in R format: .RData (or .rdata, .rda, .rds).

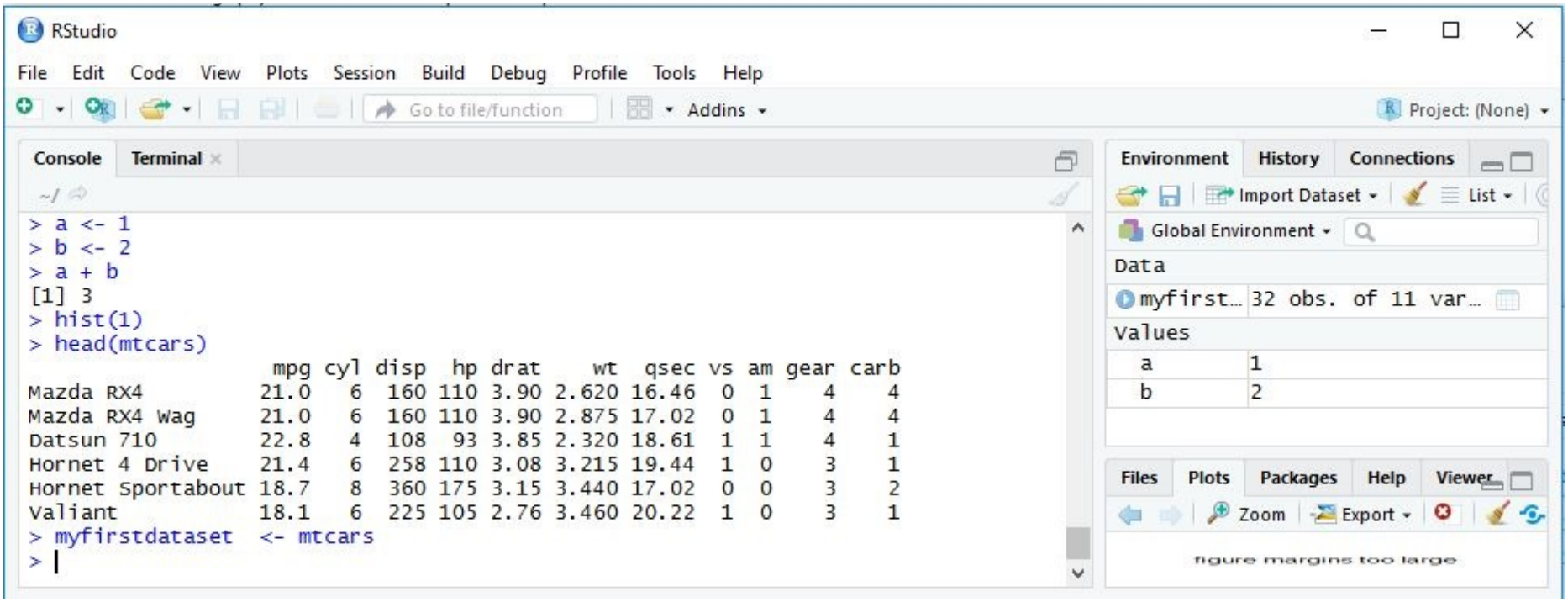
Existing datasets in R

Also, several toy datasets are always loaded in R, e.g. the `mtcars` datasets of 32 cars. Show the head (i.e. first 6 rows) of the data:



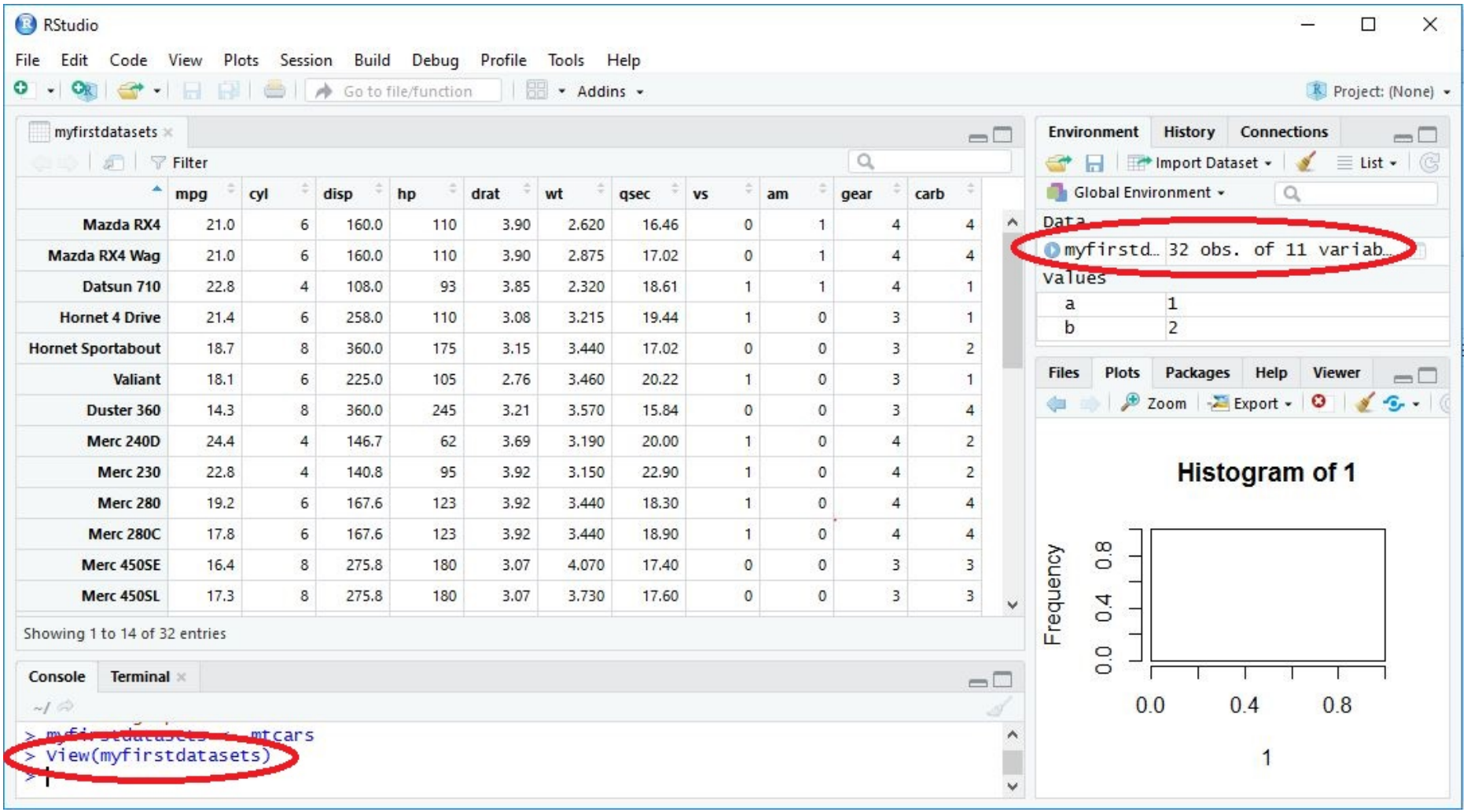
First contact with data frames

Copy mtcars data frame into new object `myfirstdataset`:



First contact with data frames

Show data frame with nicer formatting:



	mpg	cyl	disp	hp	drat	wt	qsec	vs	am	gear	carb
Mazda RX4	21.0	6	160.0	110	3.90	2.620	16.46	0	1	4	4
Mazda RX4 Wag	21.0	6	160.0	110	3.90	2.875	17.02	0	1	4	4
Datsun 710	22.8	4	108.0	93	3.85	2.320	18.61	1	1	4	1
Hornet 4 Drive	21.4	6	258.0	110	3.08	3.215	19.44	1	0	3	1
Hornet Sportabout	18.7	8	360.0	175	3.15	3.440	17.02	0	0	3	2
Valiant	18.1	6	225.0	105	2.76	3.460	20.22	1	0	3	1
Duster 360	14.3	8	360.0	245	3.21	3.570	15.84	0	0	3	4
Merc 240D	24.4	4	146.7	62	3.69	3.190	20.00	1	0	4	2
Merc 230	22.8	4	140.8	95	3.92	3.150	22.90	1	0	4	2
Merc 280	19.2	6	167.6	123	3.92	3.440	18.30	1	0	4	4
Merc 280C	17.8	6	167.6	123	3.92	3.440	18.90	1	0	4	4
Merc 450SE	16.4	8	275.8	180	3.07	4.070	17.40	0	0	3	3
Merc 450SL	17.3	8	275.8	180	3.07	3.730	17.60	0	0	3	3

Documentation with R

What is an R Script? Why use it?

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- Open new R script: `File` ▶ `New File` ▶ `R Script`.
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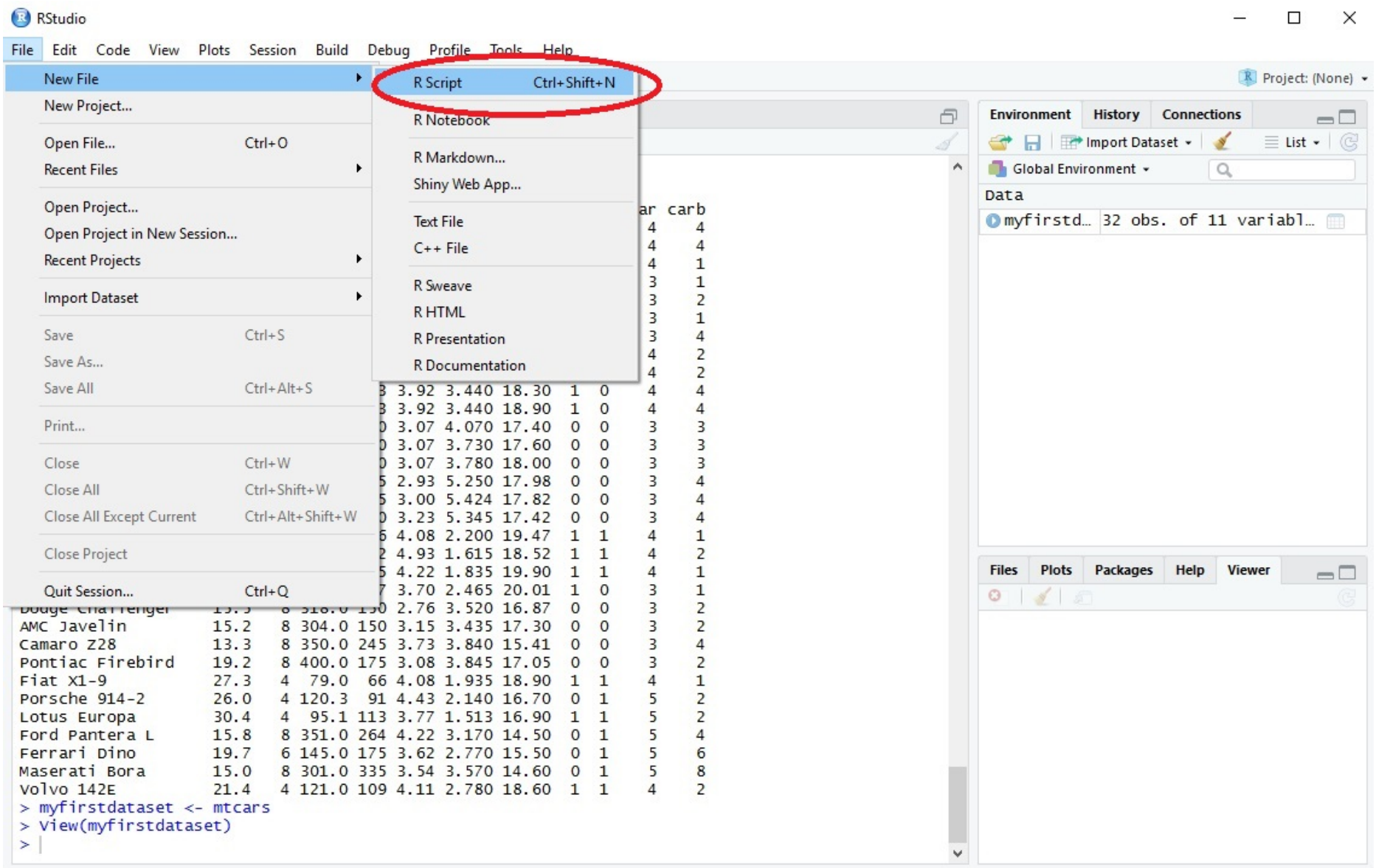
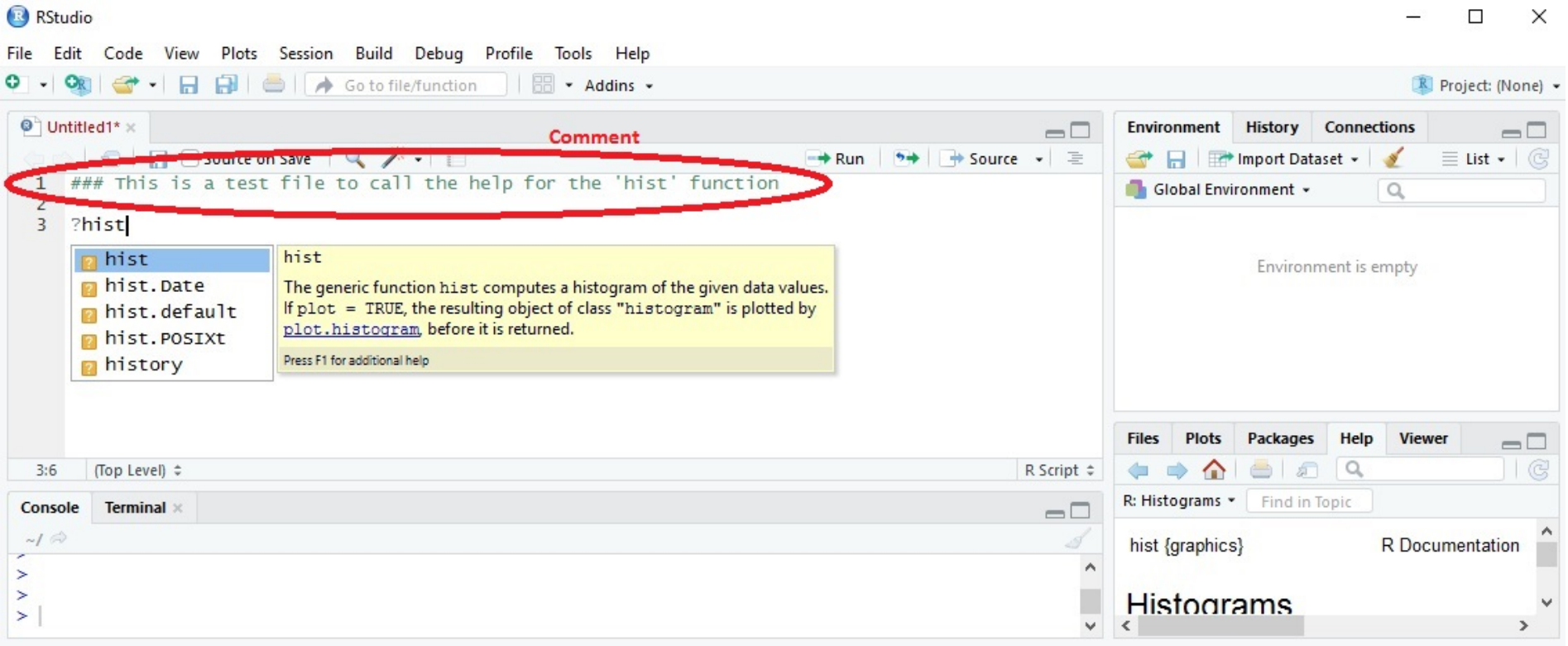
- Save as .R (or .r) file.

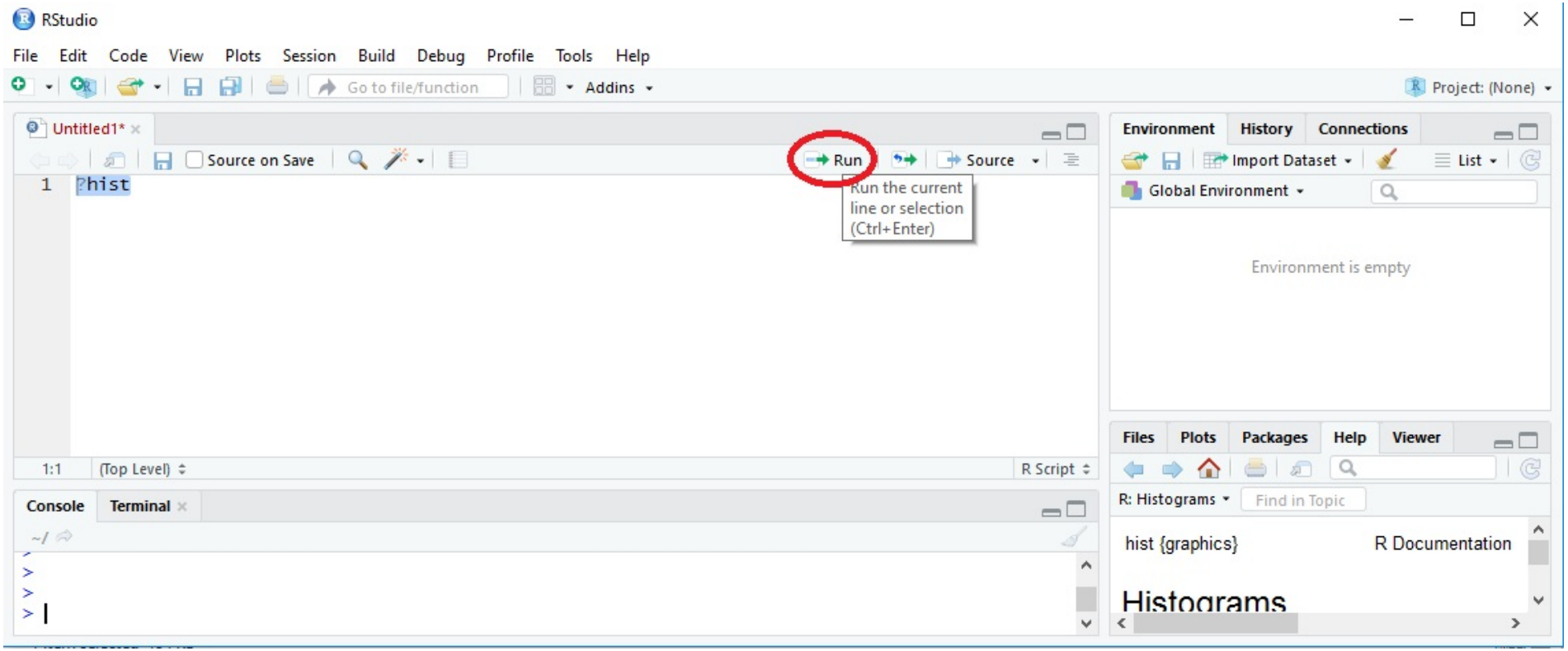
Create new R Script



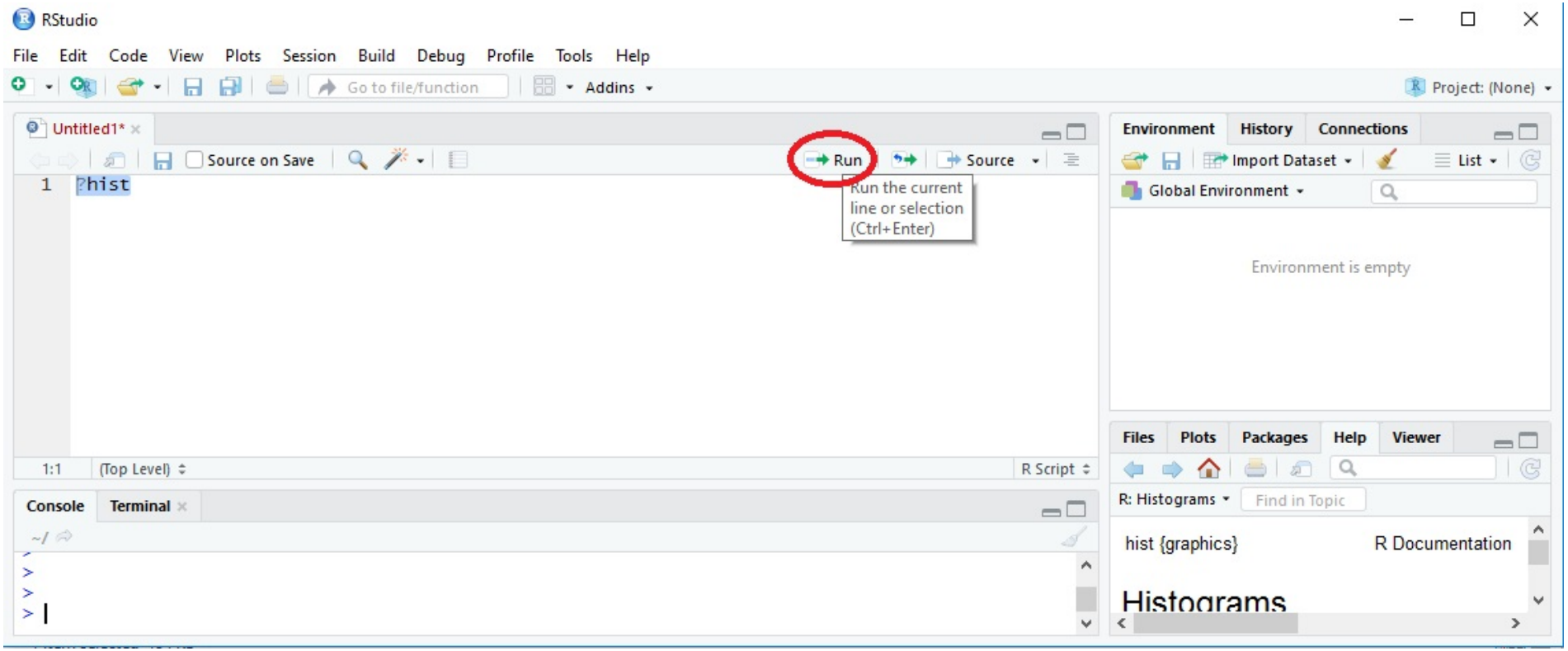
Example of a simple R Script



Run R Script


RStudio
File Edit Code View Plots Session Build Debug Profile Tools Help
Go to file/function
Addins
Project: (None)
Untitled1*
Source on Save
Run
Source
1 ?hist
Run the current line or selection (Ctrl+Enter)
1:1
(Top Level)
R Script
Console
Terminal
~/
Environment History Connections
Import Dataset
List
Global Environment
Environment is empty
Files Plots Packages Help Viewer
R: Histograms
Find in Topic
hist {graphics}
R Documentation
Histograms

Run R Script



Save R script at your desired location, then open it the next time you start RStudio.

R Markdown

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- Simple language for formatting text input and creating HTML, PDF, and MS Word documents.

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What is R Markdown?

- "Enhanced" R script.
- Interface of R with Markdown, to combine text with pieces of R code ("chunks") in one document.
- From this R Markdown file, a formatted pdf/html/word file can be generated by "knitting" the file through "knit", which contains the text, R code, and the results from these analyses.

$\longrightarrow$ more next week

Summary: general overview how to work with R

General steps

- Load (.Rdata) or import data.
- Load R packages and R scripts, or open R script (.R) / Markdown (.Rmd) file that includes functions for the analysis.
- Perform data analyses by running the R functions step-by-step: compute 1, use results from 1 in 2 to compute 3, ...
- Save edited R script/Markdown file, save results.

Run R code

- by writing code in "Console" and running it there (press enter)
- by writing code in R script, and run by clicking on "Run" (or pressing Ctrl+Enter)
- (by writing code in R Markdown file and running it)

Homework

Homework

See file `R_1_homework.R`

Questions?