Introduction to R Programming

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بسم الله الرحمن الرحيم

R

- A language and environment for statistical computing and graphics
- Similar to the **S** language and environment: some important differences, but much code written for **S** runs unaltered under **R**
- Available as Free Software under the terms of the Free Software Foundation's GNU
- It compiles and runs on a wide variety of UNIX platforms and similar systems (including FreeBSD and Linux), Windows and MacOS.

(https://www.r-project.org/)

R

- A wide variety of statistical (linear and nonlinear modelling, classical statistical tests, time-series analysis, classification, clustering, …) and graphical techniques
- Highly extensible
- The ease with well-designed publication-quality

(https://www.r-project.org/)

R Environment

R is an integrated suite of software facilities for data manipulation, calculation and graphical display. It includes:

- an effective data handling and storage facility,
- a suite of operators for calculations on arrays, in particular matrices,
- a large, coherent, integrated collection of intermediate tools for data analysis,

(https://www.r-project.org/)

R Environment

- graphical facilities for data analysis and display either on-screen or on hardcopy, and
- a well-developed, simple and effective programming language which includes conditionals, loops, user-defined recursive functions and input and output facilities.

The term "environment is intended to characterize it as a fully planned and coherent system, rather than an incremental accretion of very specific and inflexible tools.

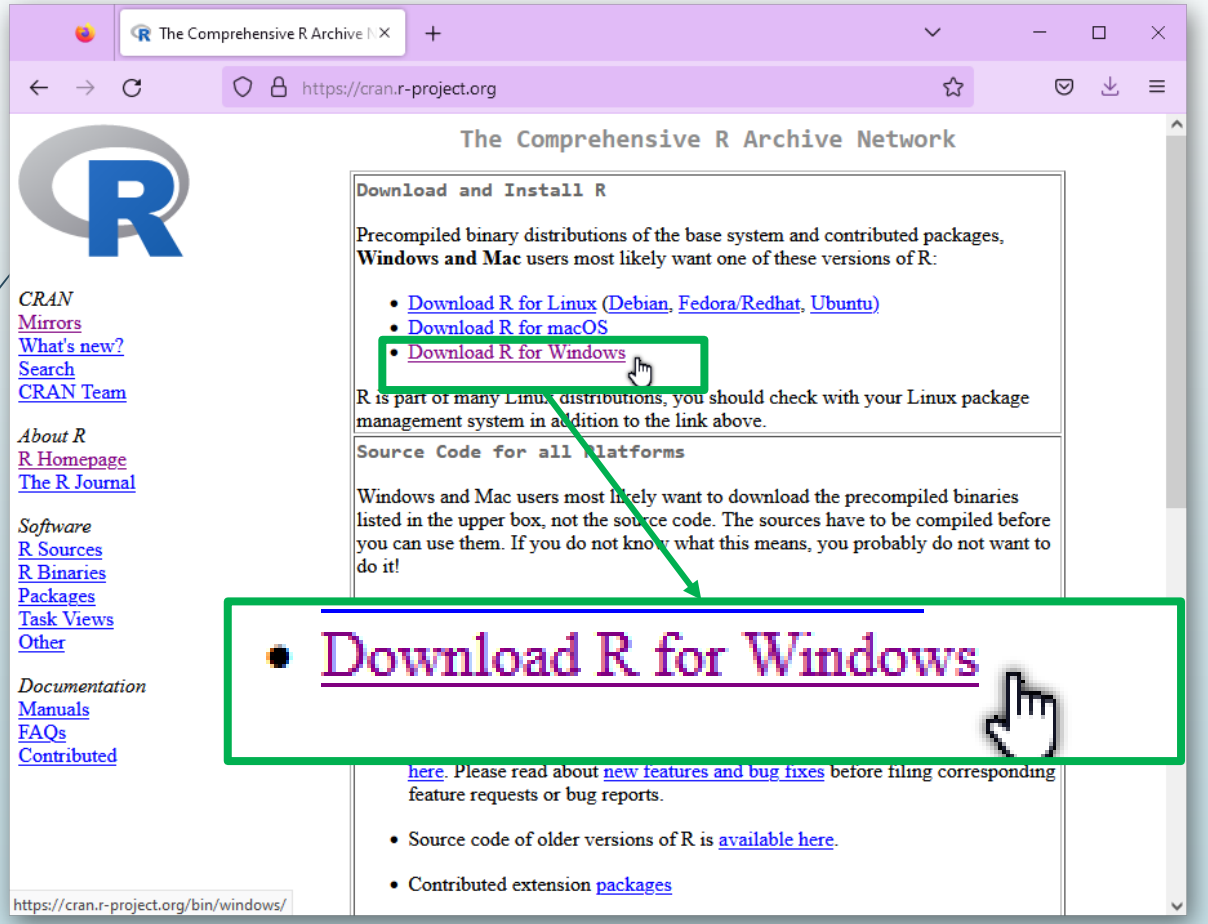
(https://www.r-project.org/)

R Contributors

- The current **R** is the result of a collaborative effort with contributions from all over the world. **R** was initially written by Robert Gentleman and Ross Ihaka also known as "R & R" of the Statistics Department of the University of Auckland. Since mid-1997 there has been a core group, the **R** Core Team, with write access to the **R** source. (https://www.r-project.org/)

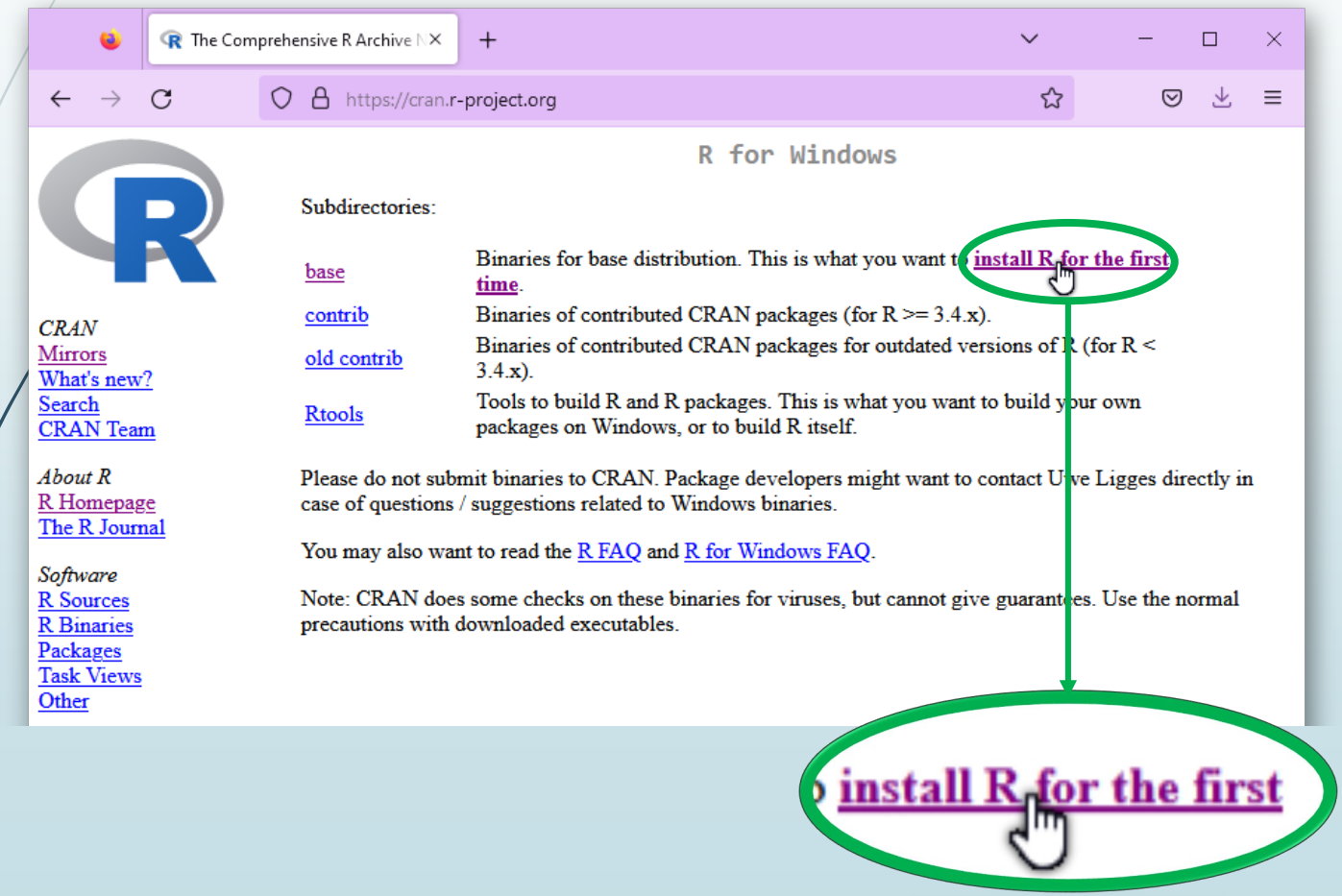
Downloading the Installation File

- https://cran.r-project.org/



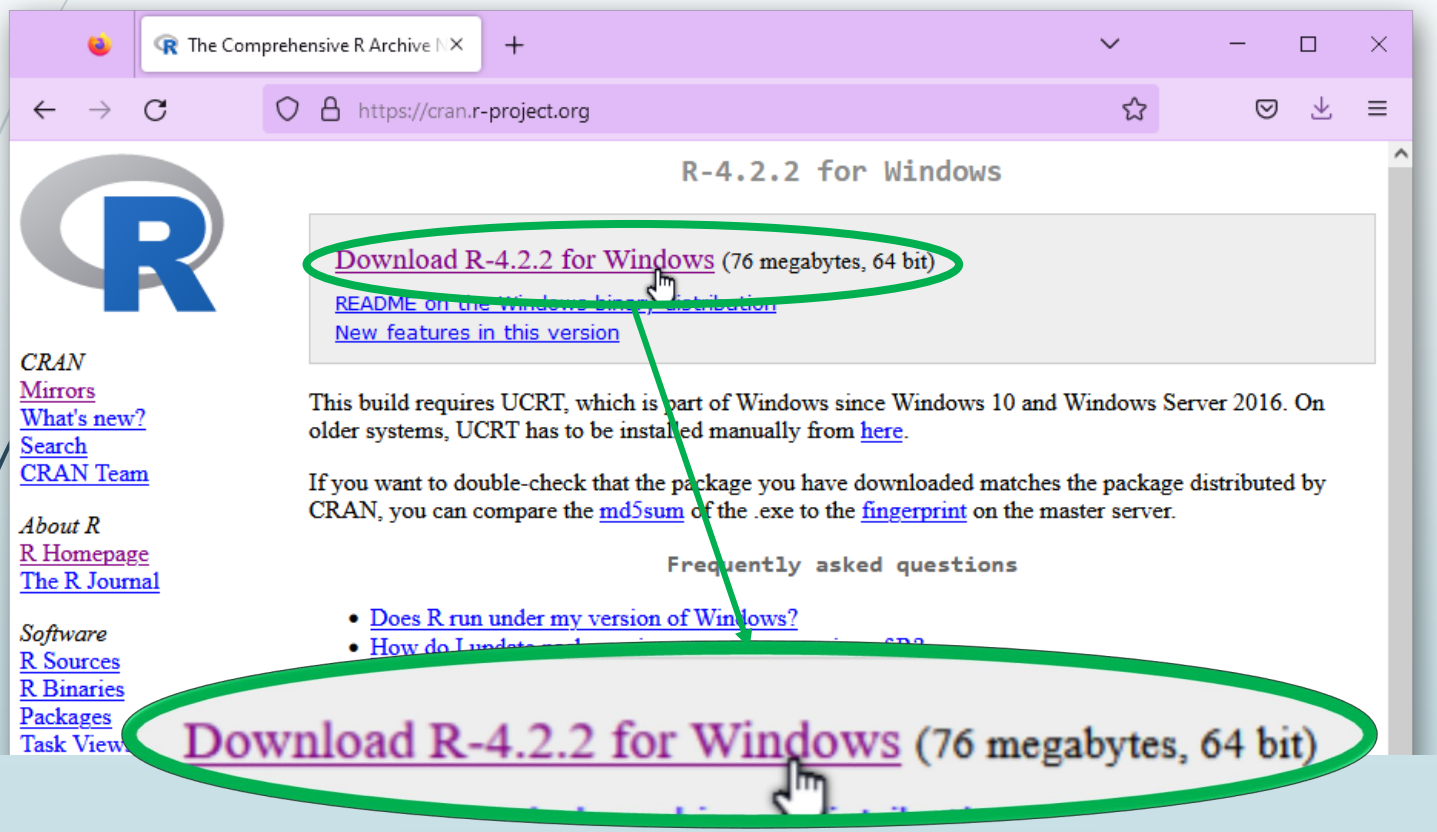
Downloading the Installation File

- https://cran.r-project.org/



Downloading the Installation File

- https://cran.r-project.org/



Downloading the Installation File

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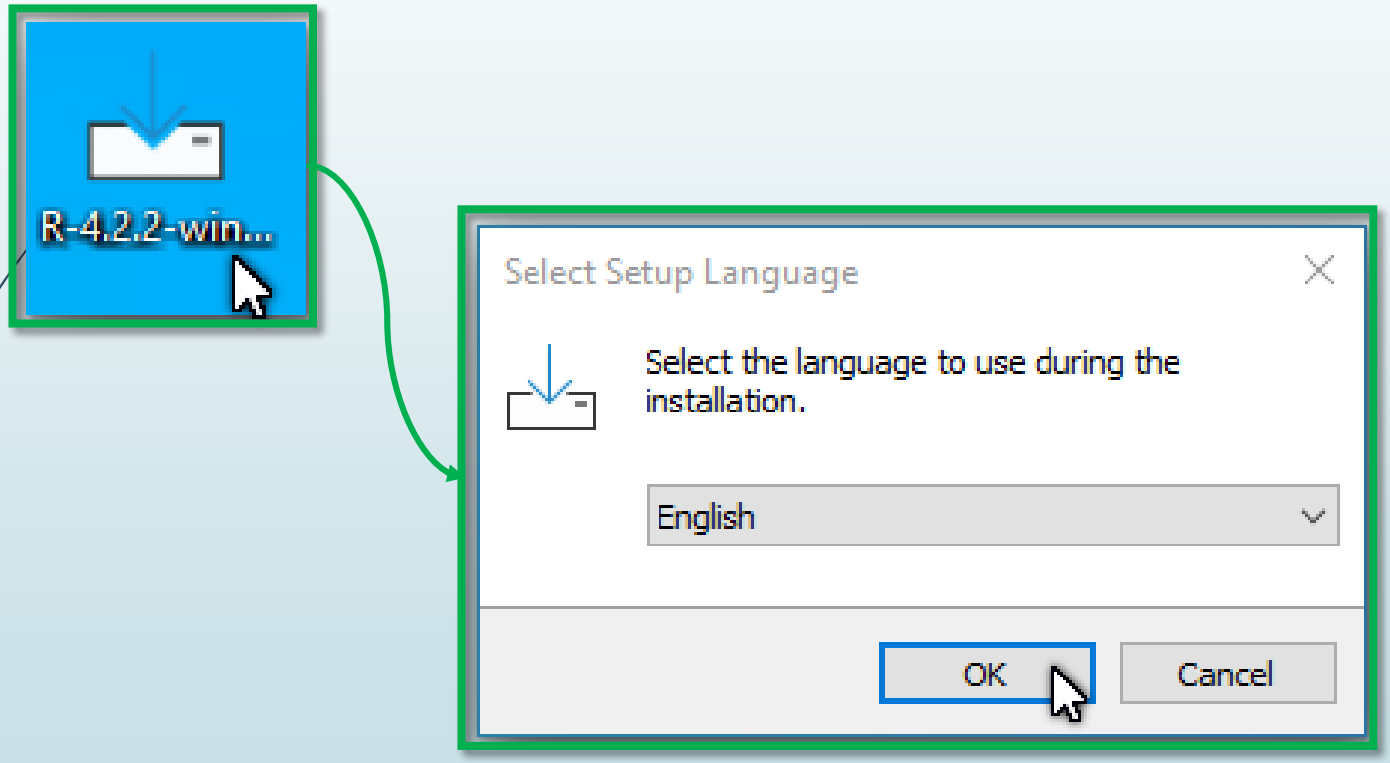

Downloading the Installation File

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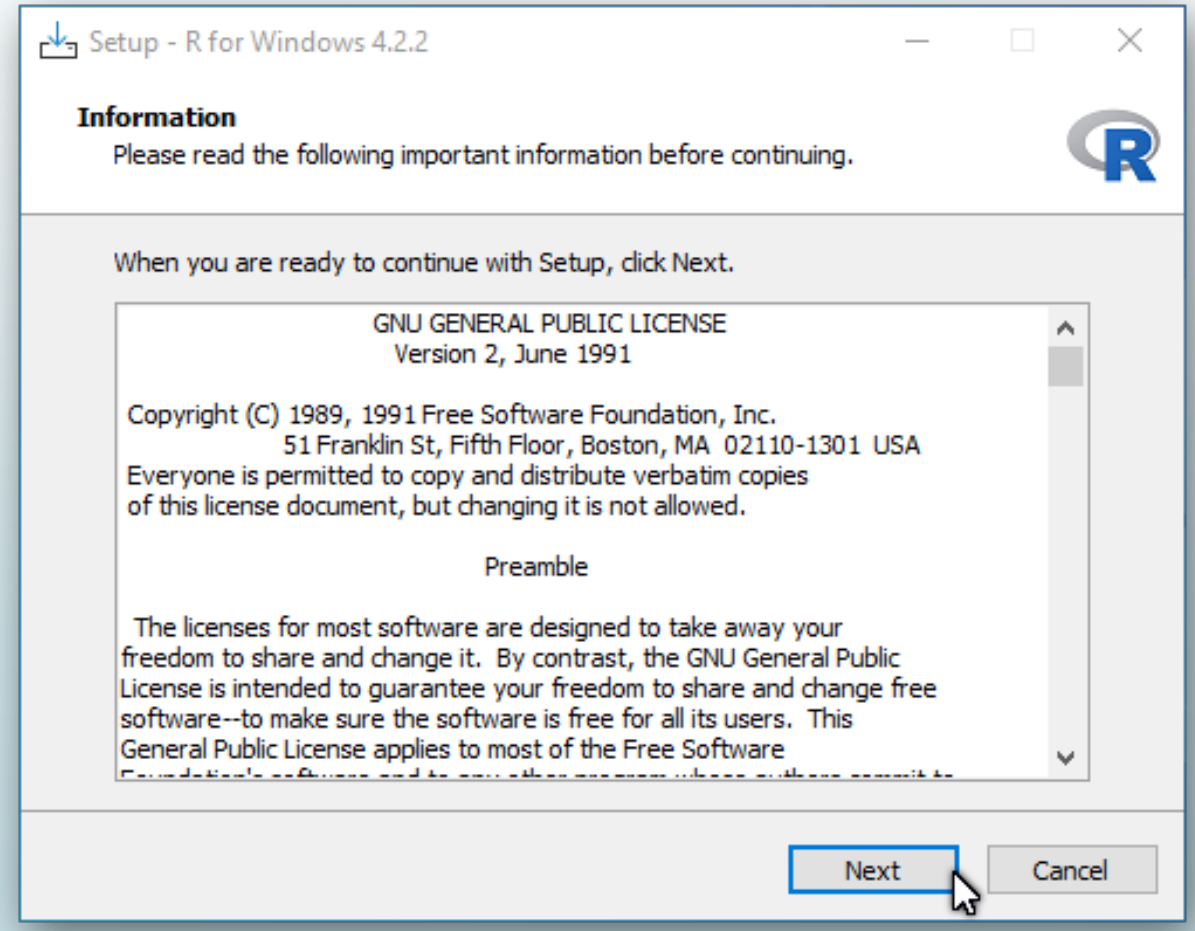

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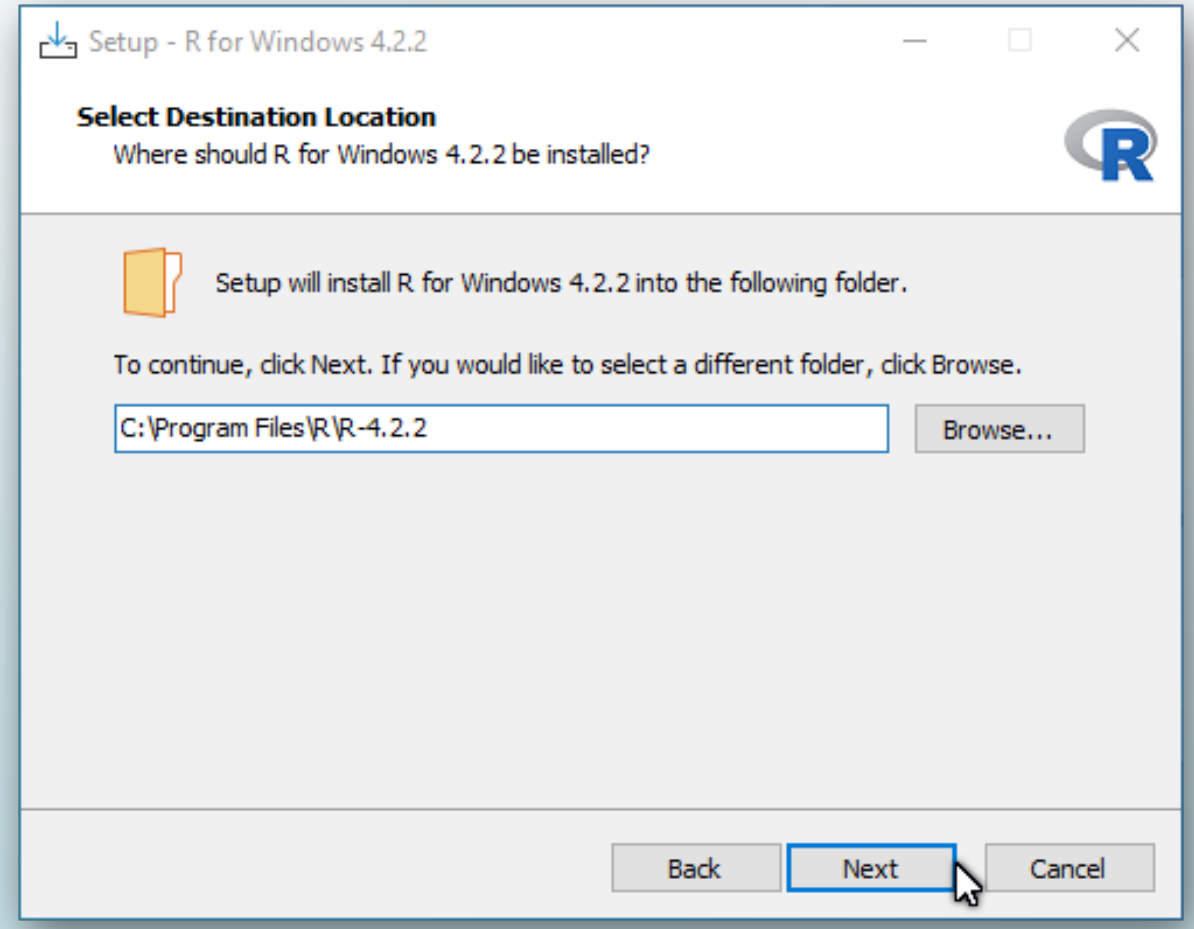

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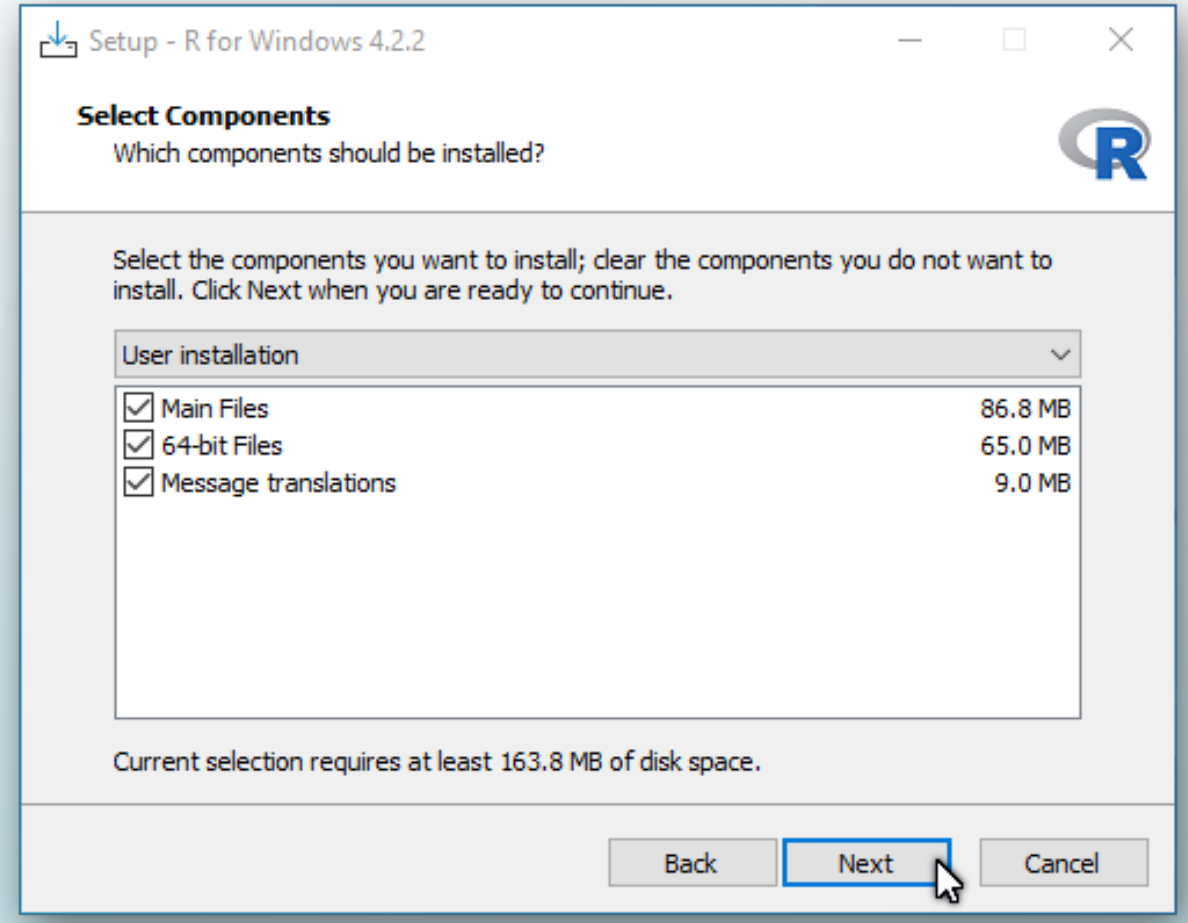

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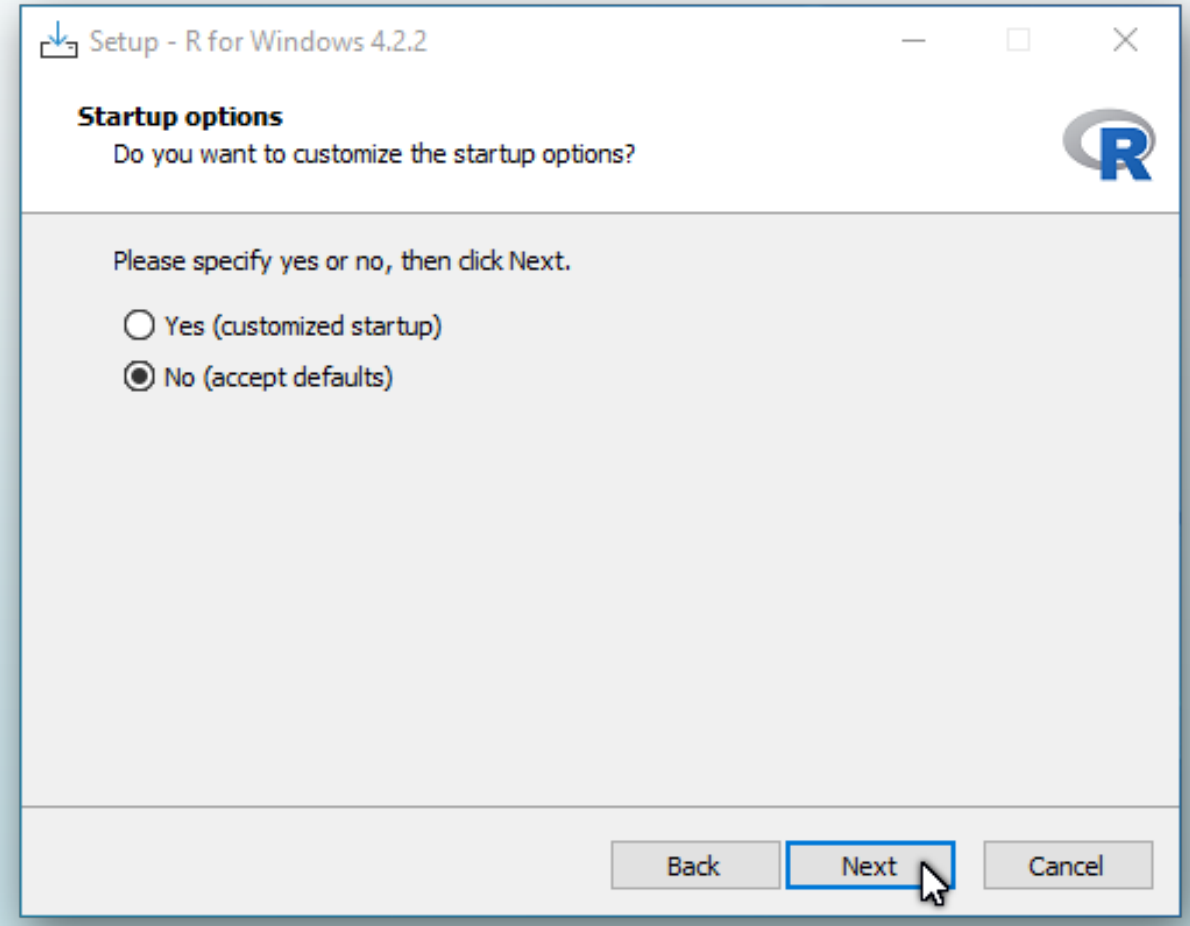
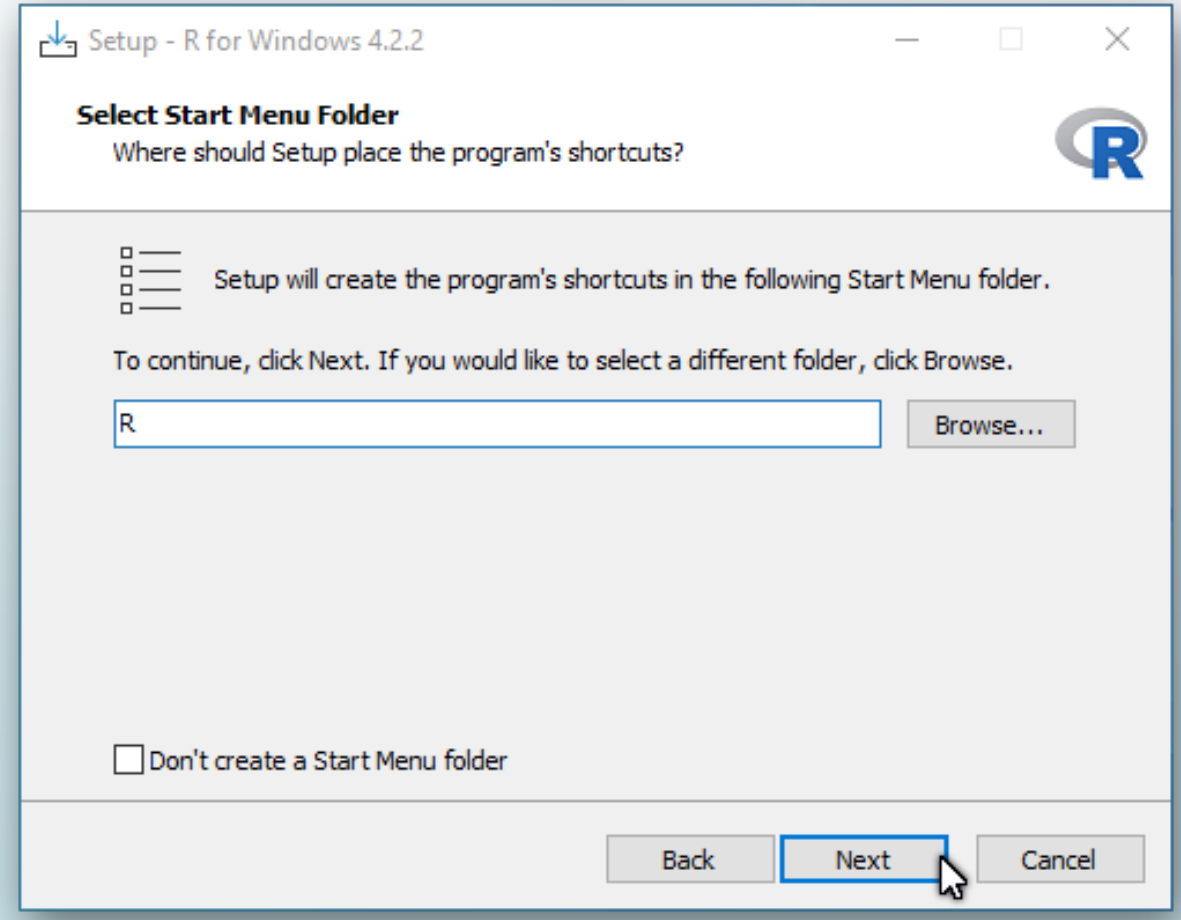


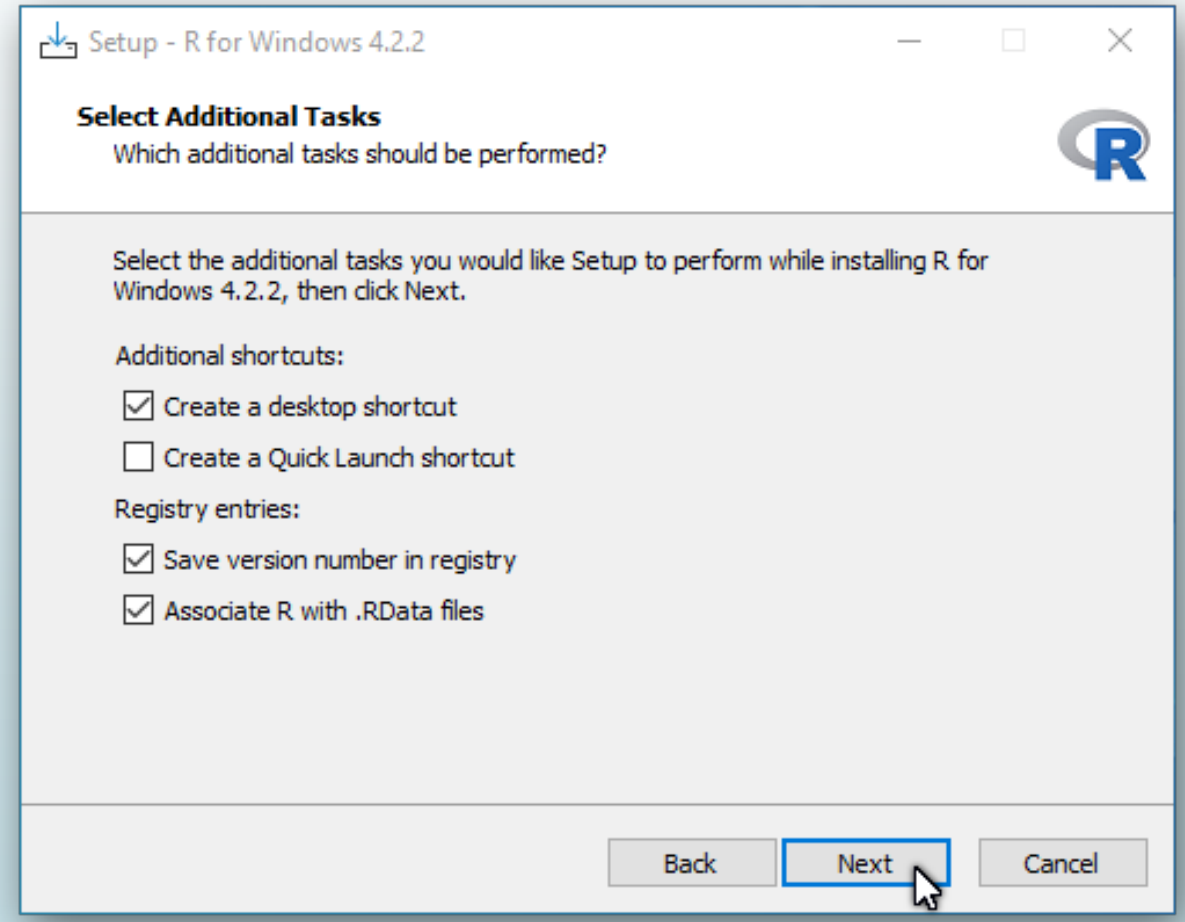
Downloading the Installation File

- https://cran.r-project.org/



Downloading the Installation File

- https://cran.r-project.org/



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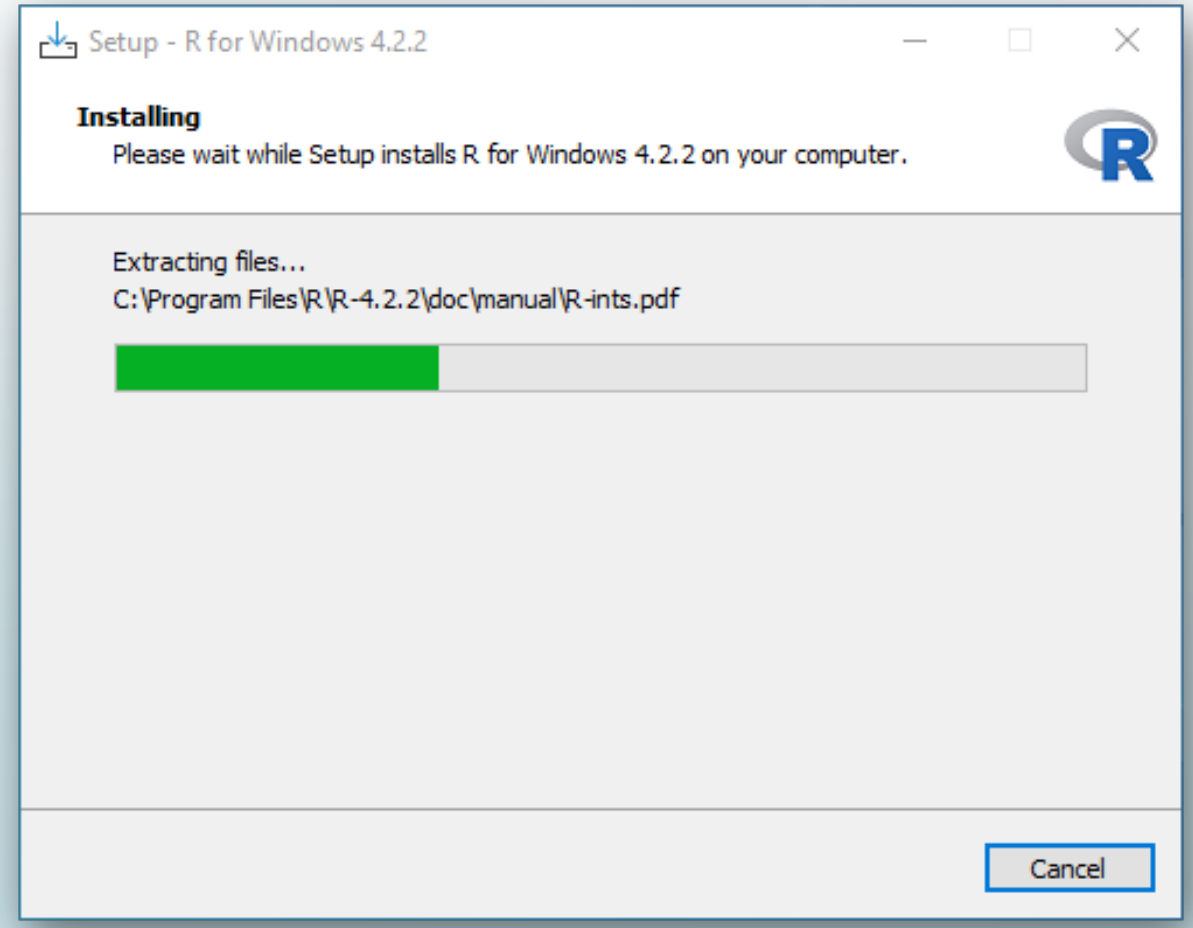

Downloading the Installation File

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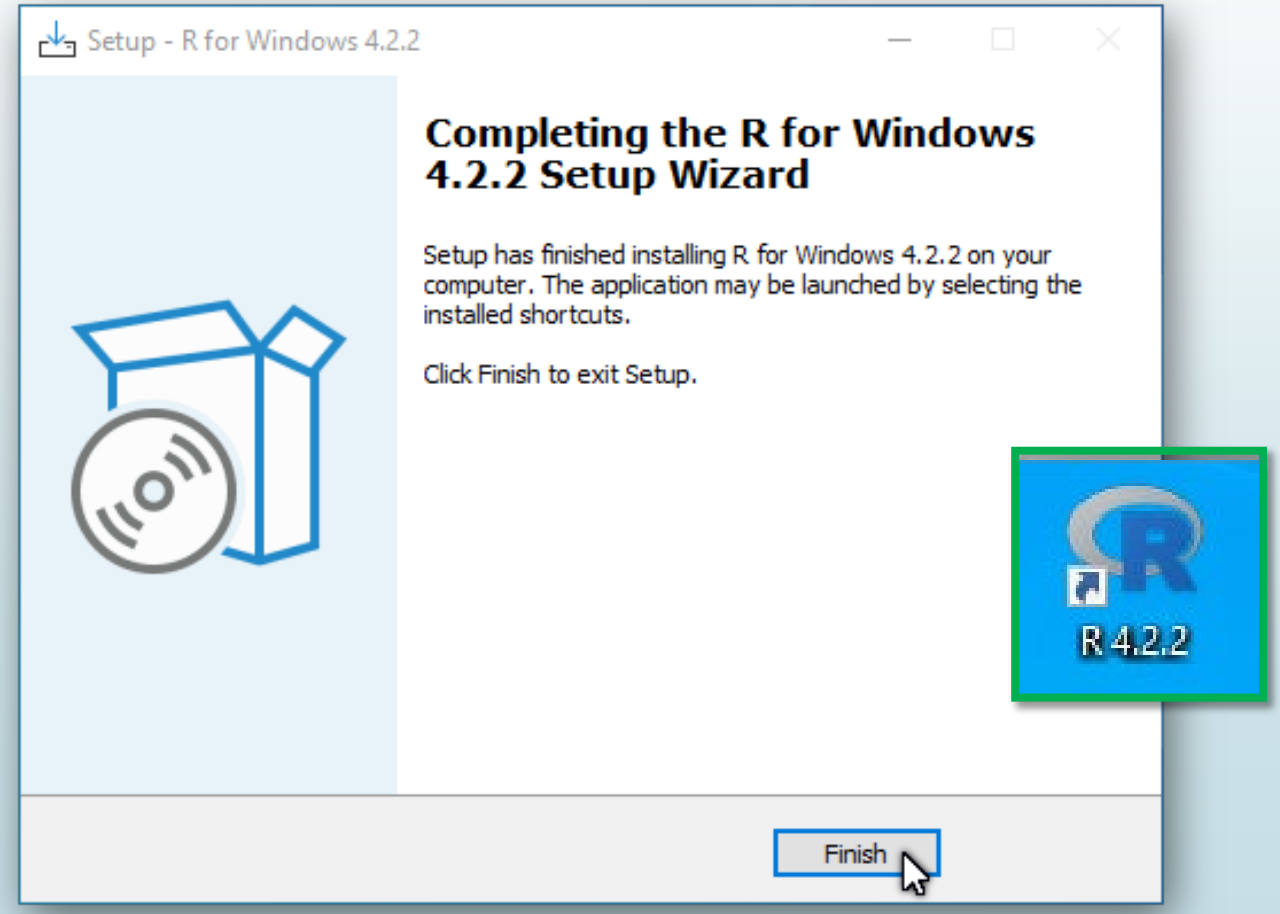
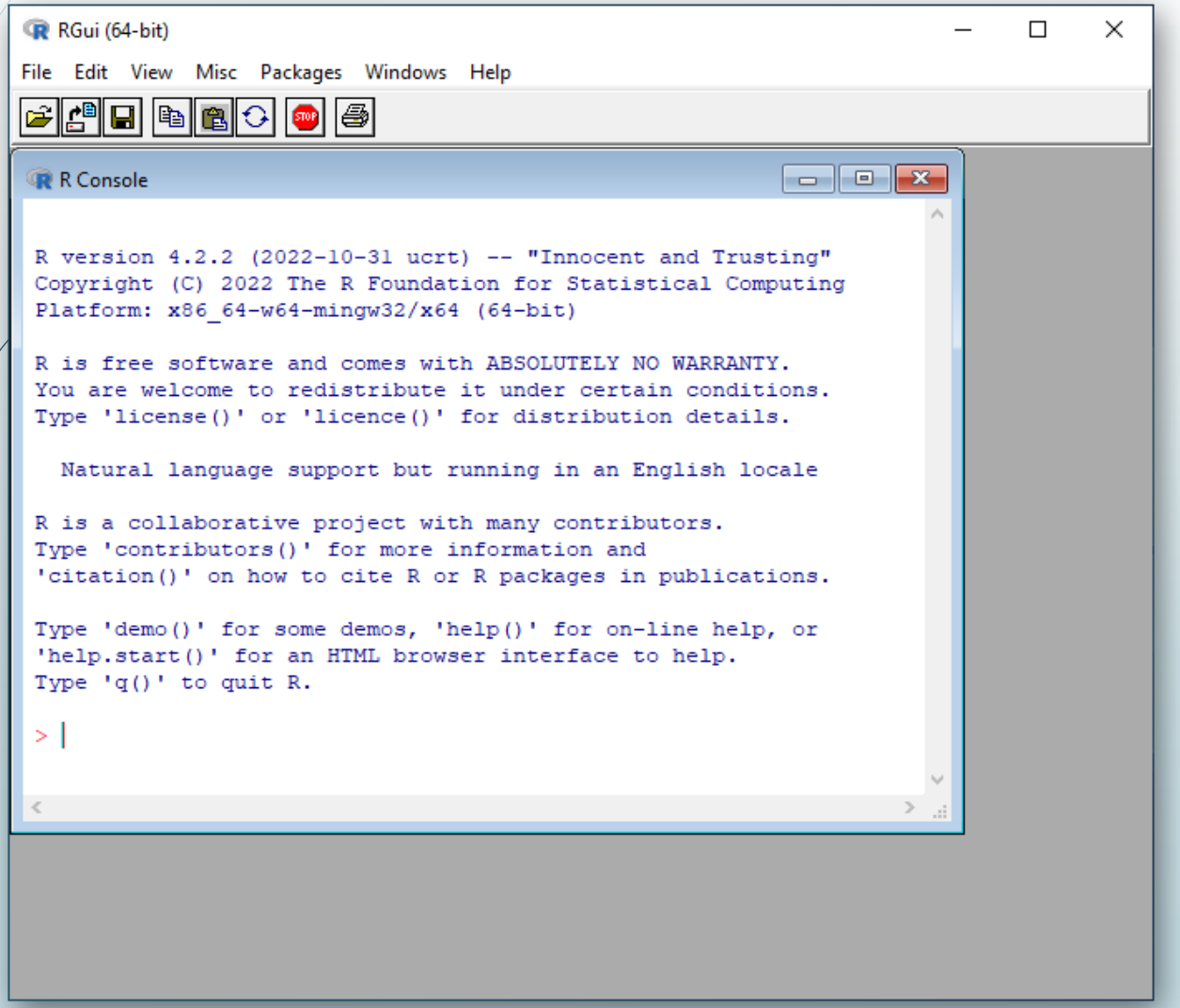
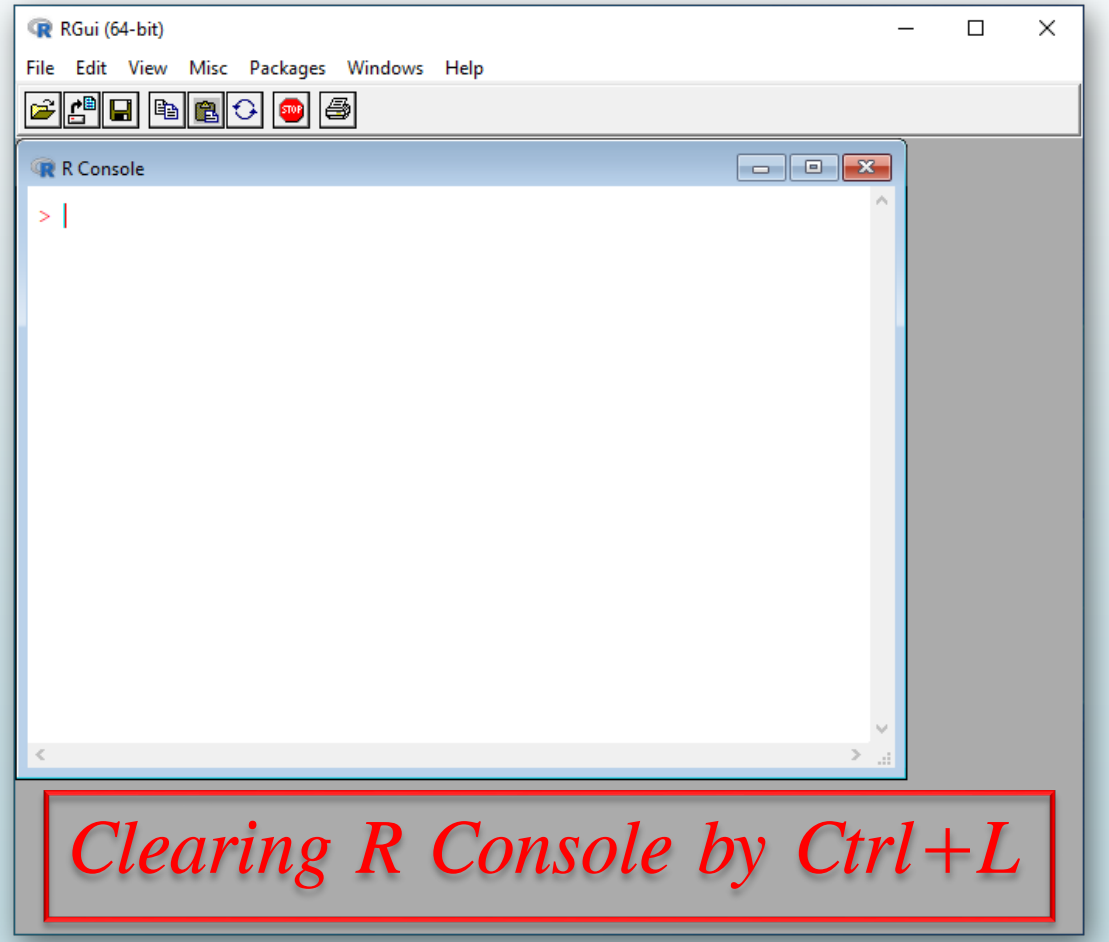


R GUI


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
R version 4.2.2 (2022-10-31 ucrt) -- "Innocent and Trusting"
Copyright (C) 2022 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-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.
Natural language support but running in an English locale
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.
>

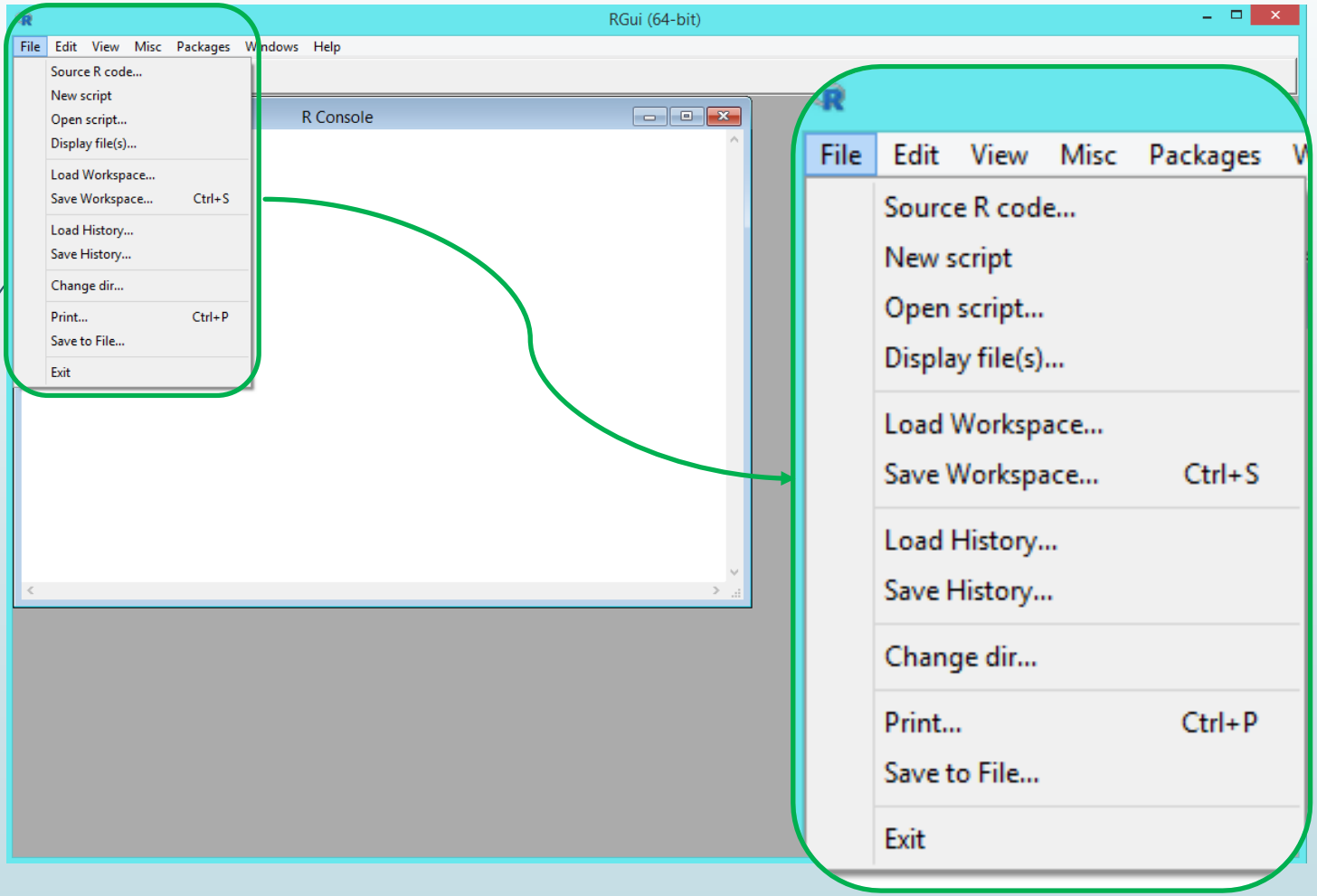
R GUI

- R Console



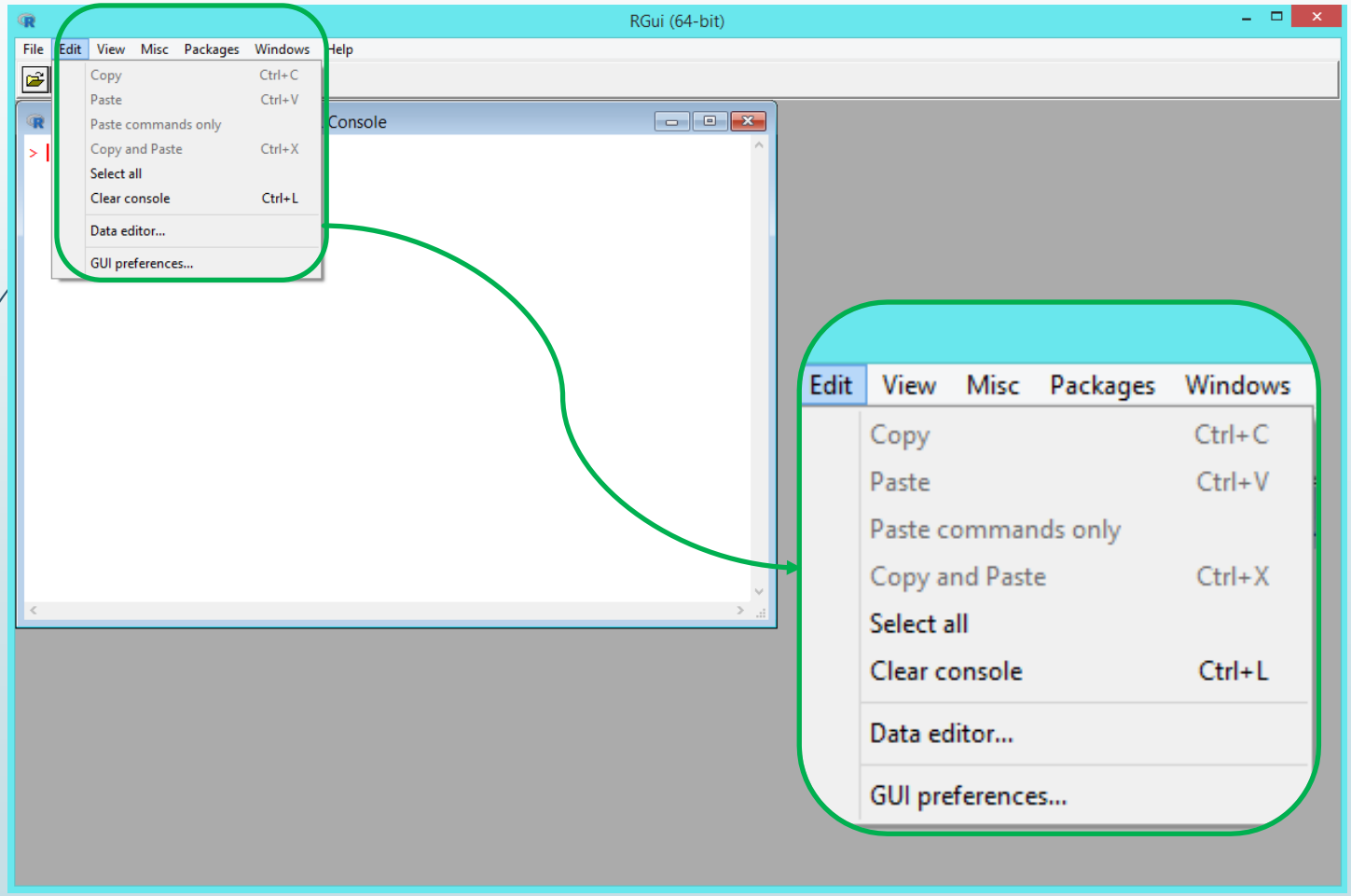
R GUI

- Menu: File



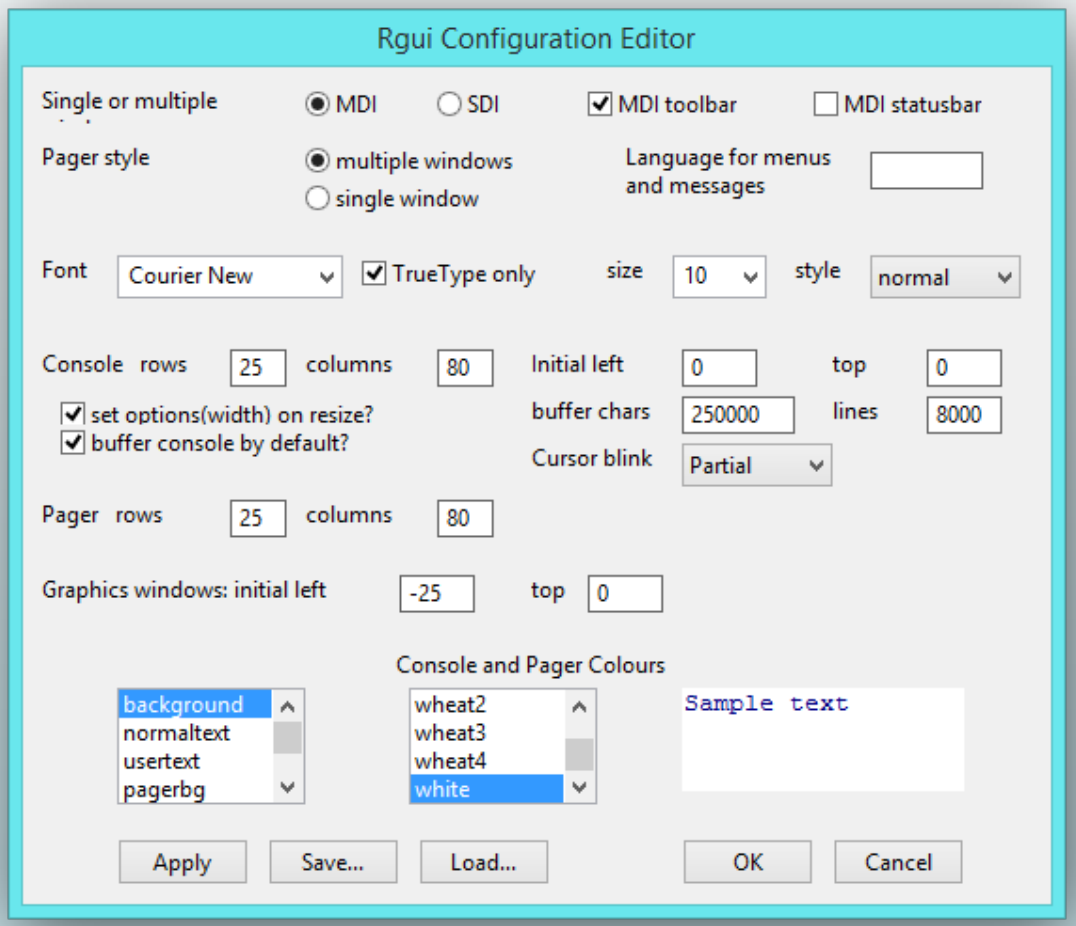
R GUI

- Menu: Edit



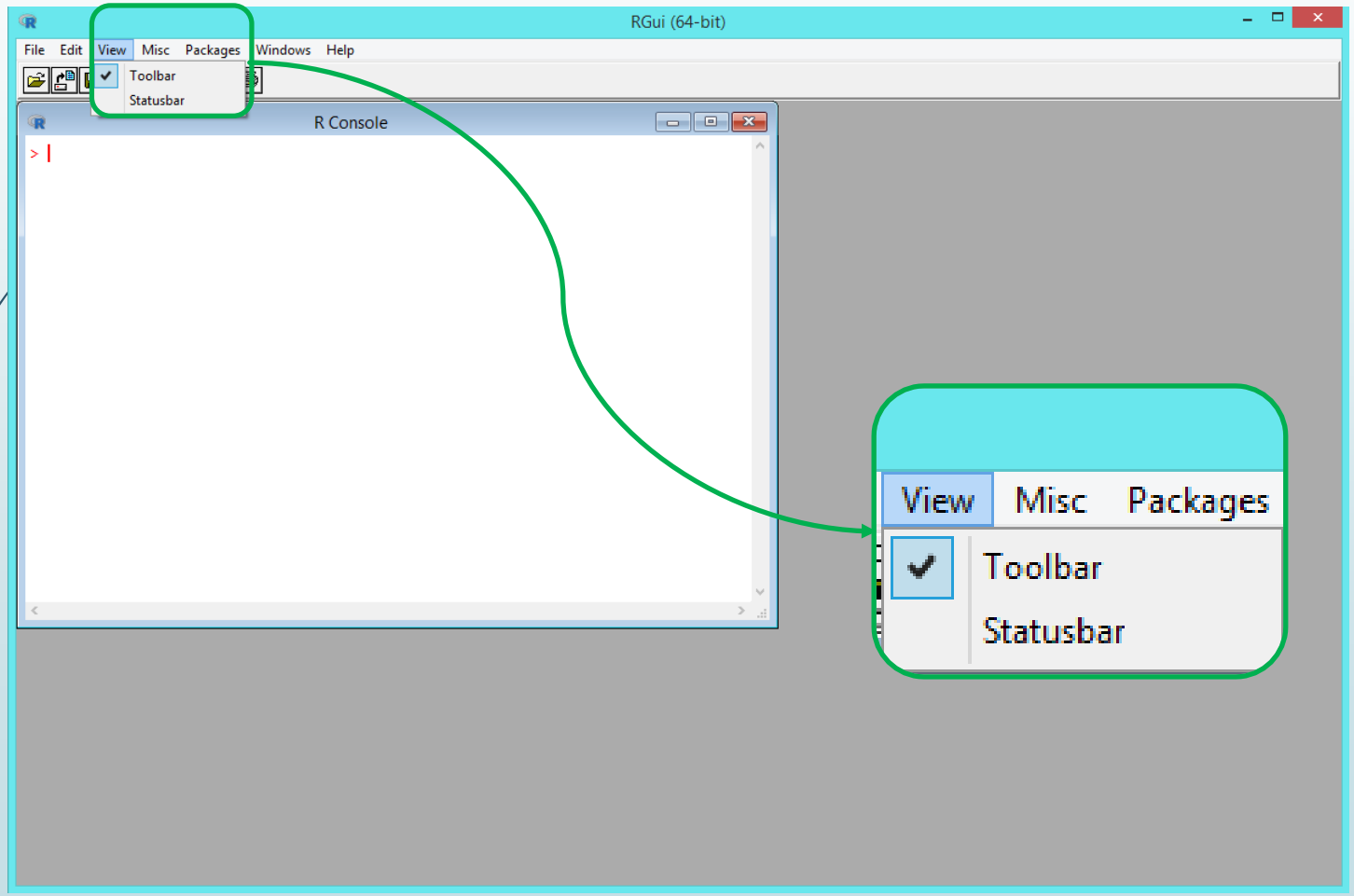
R GUI

- Menu: Edit → GUI preferences …



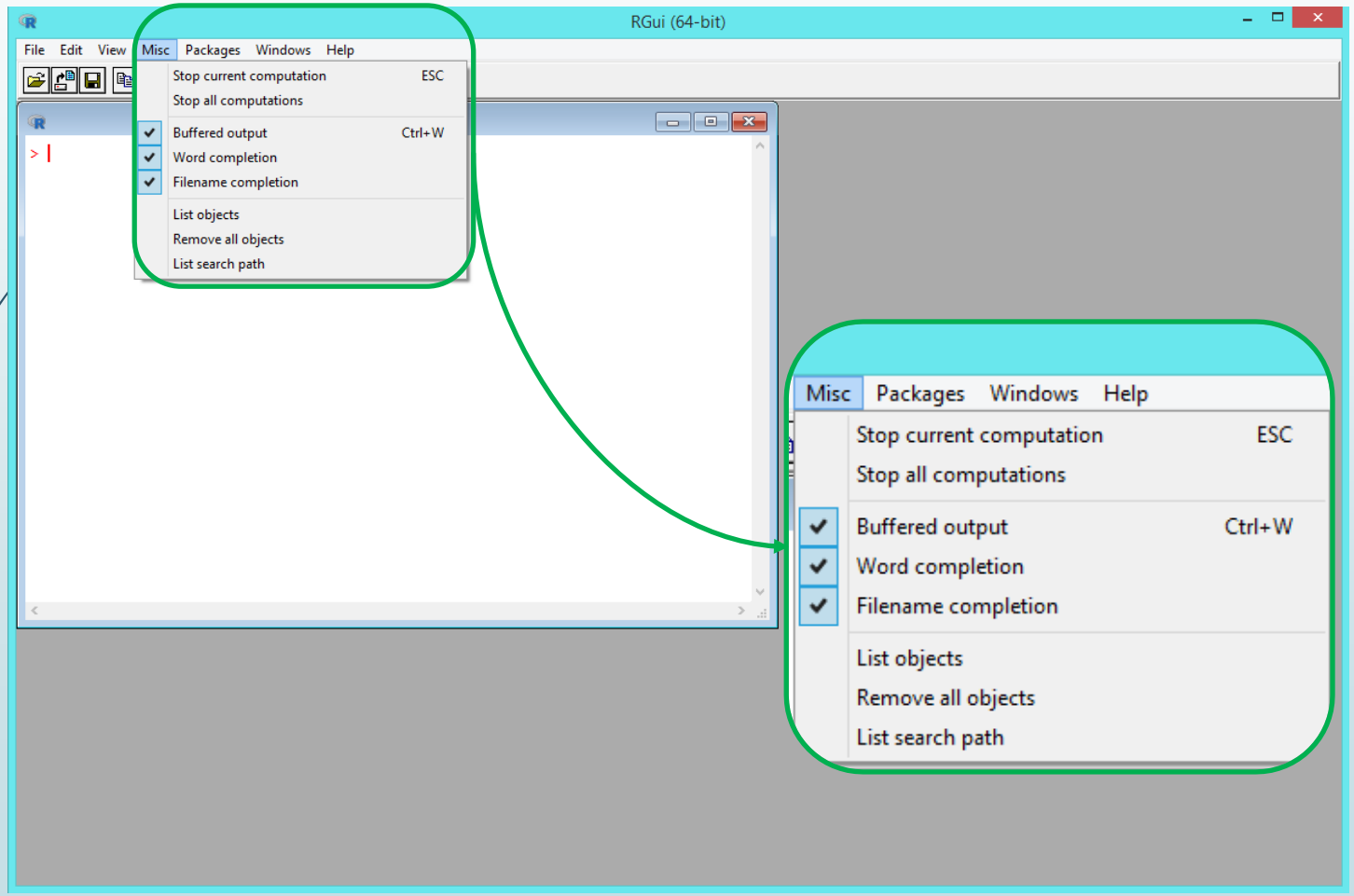
R GUI

- Menu: View



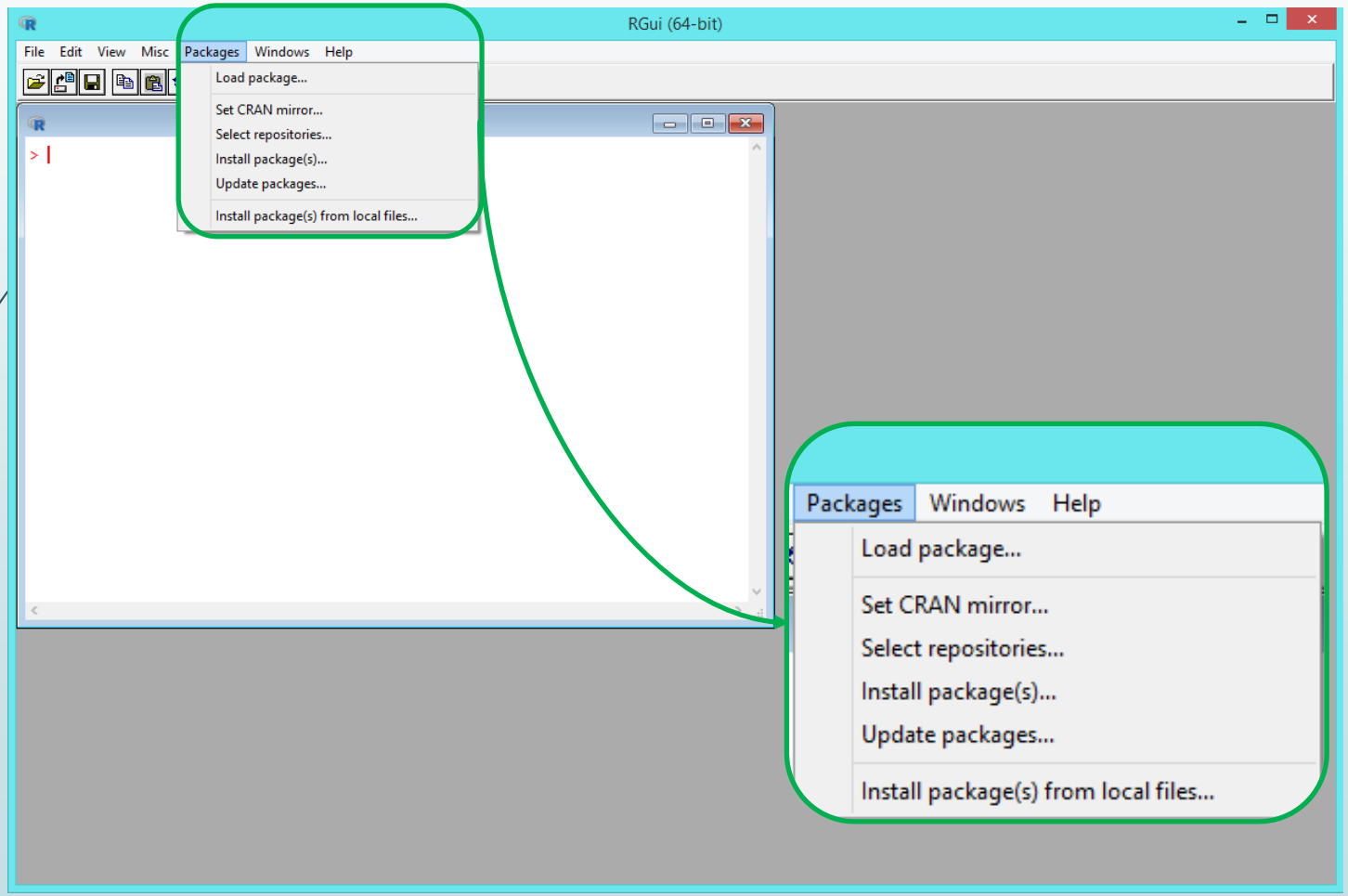
R GUI

- Menu: Misc



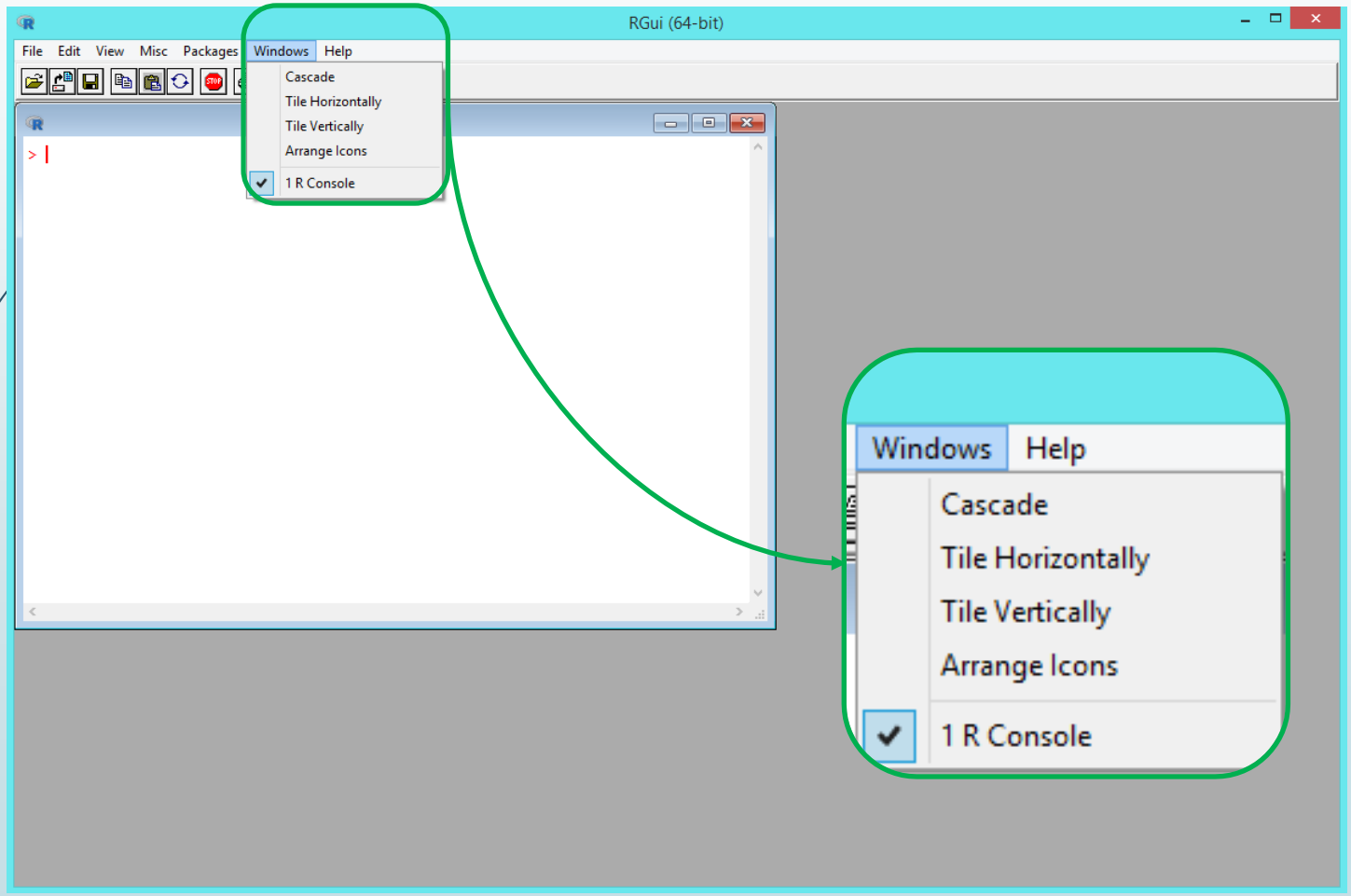
R GUI

- Menu: Packages



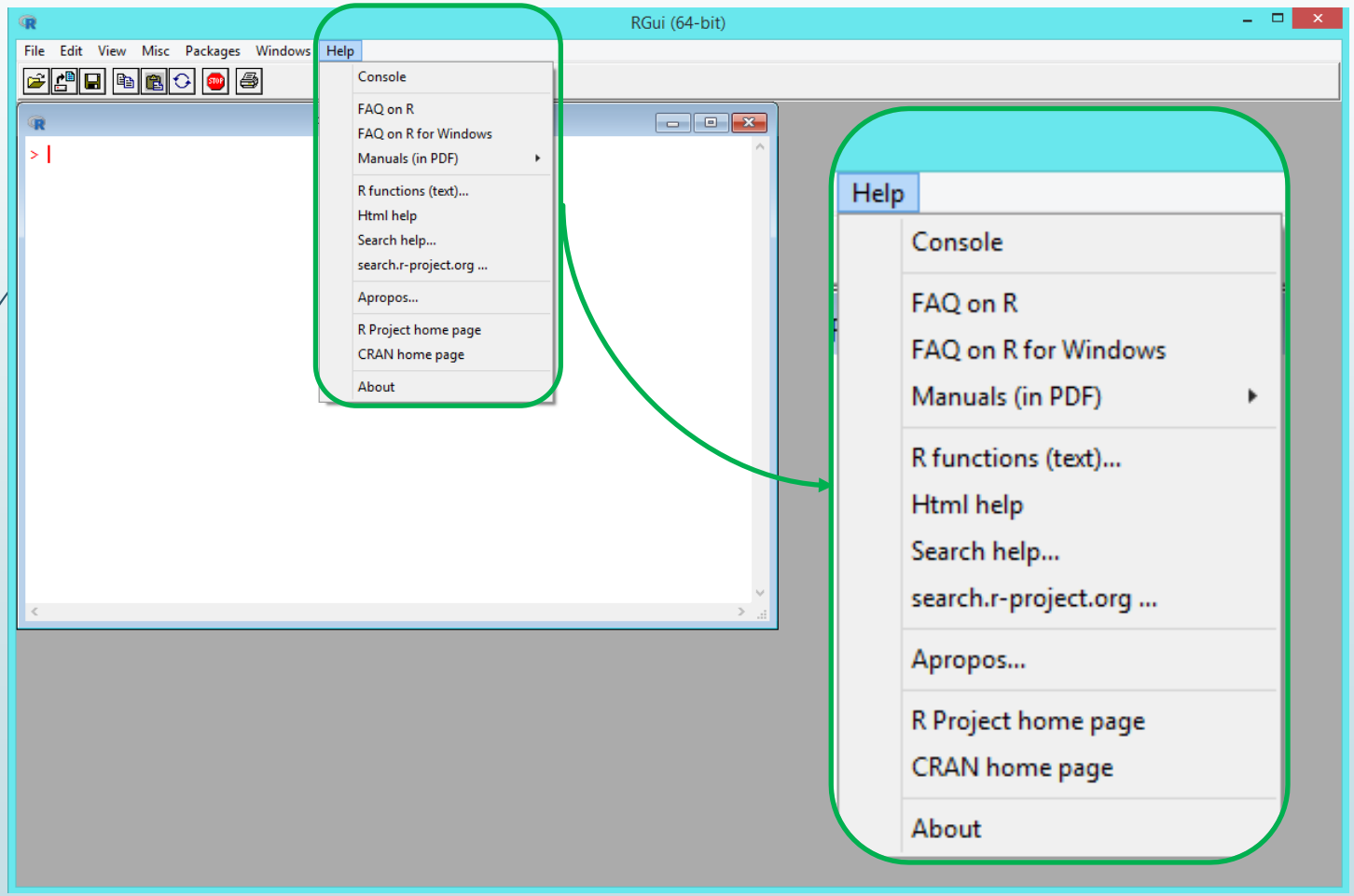
R GUI

- Menu: Windows



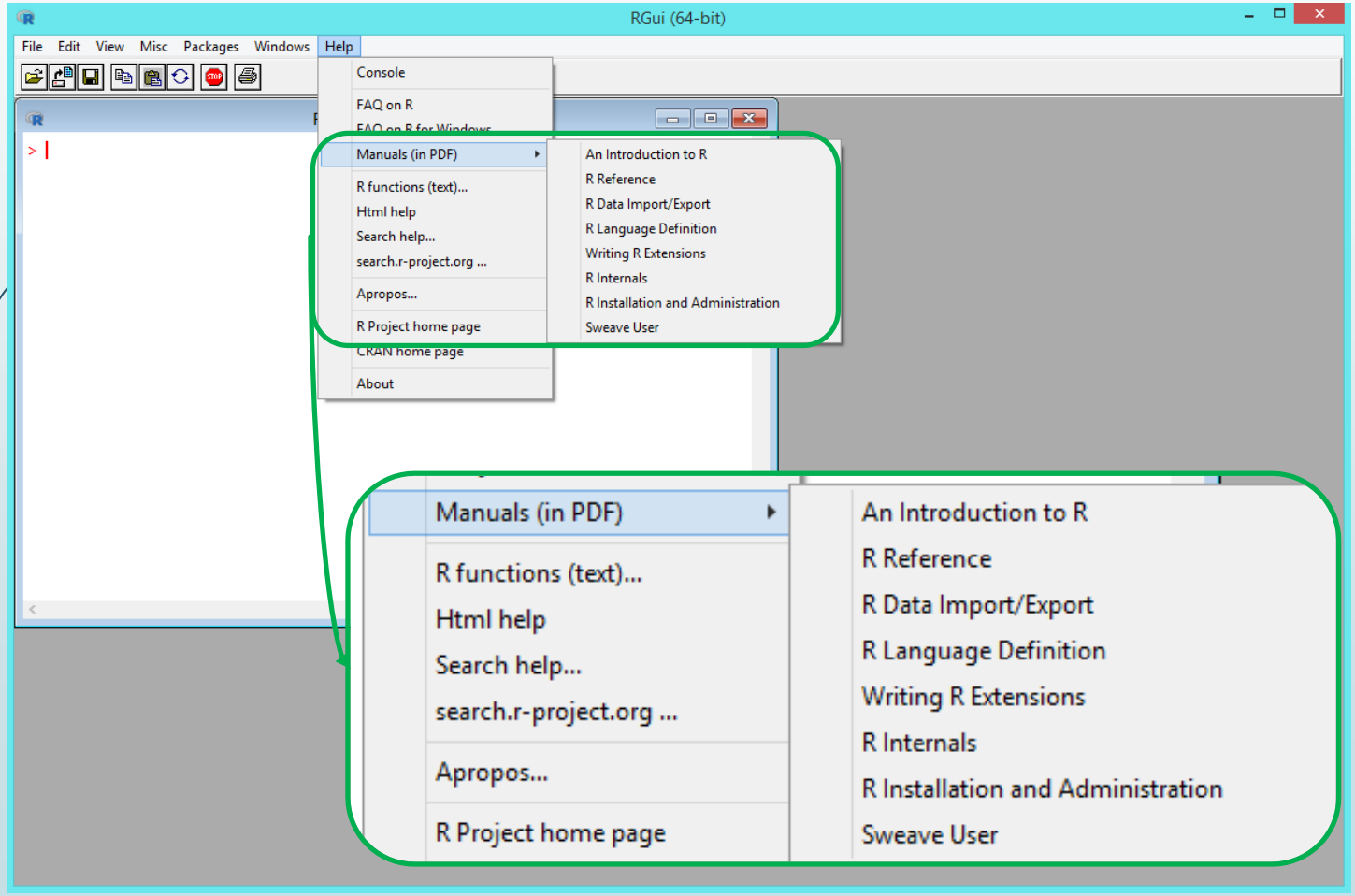
R GUI

- Menu: Help



R GUI

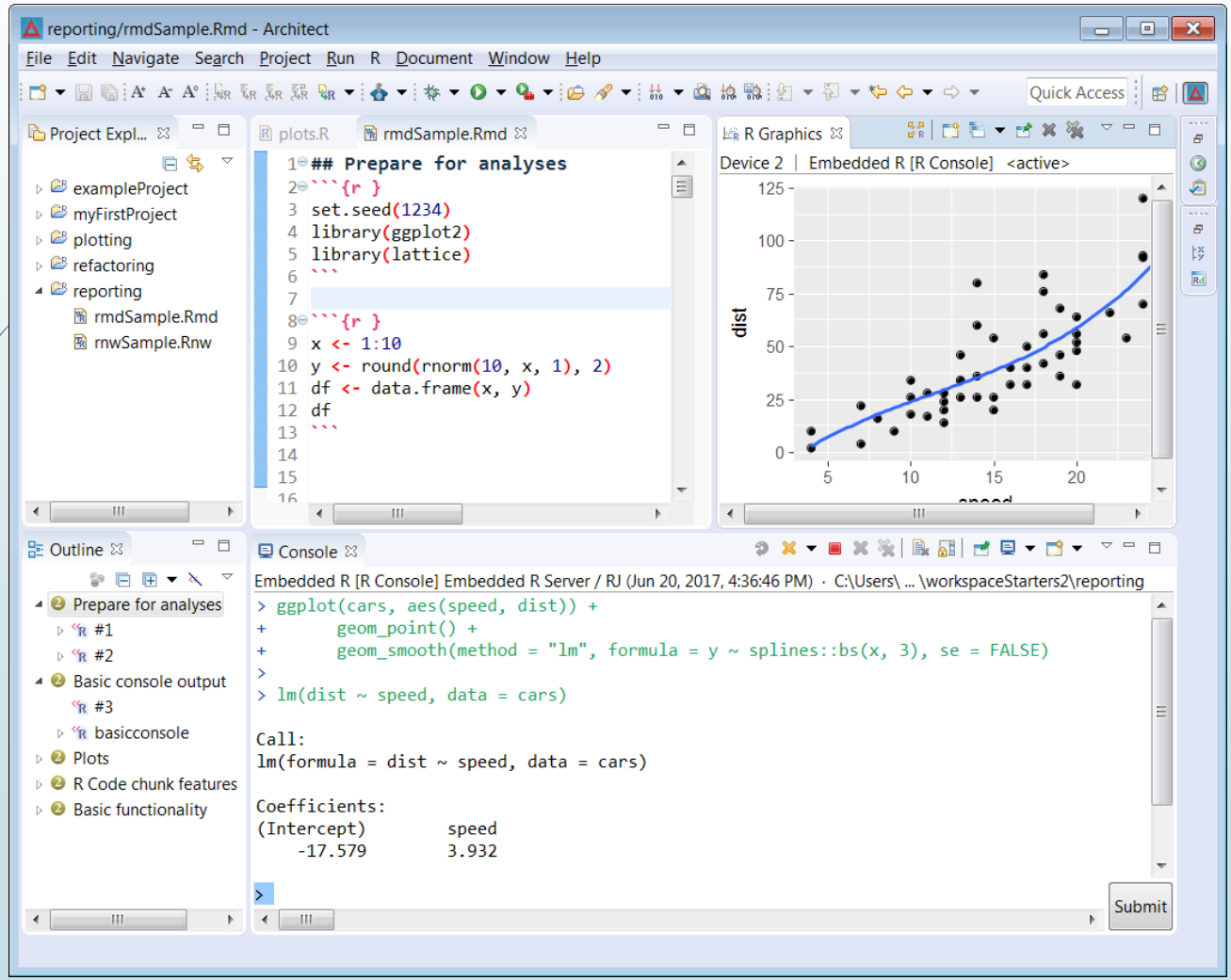
- Menu: Help → Manuals (in PDF)



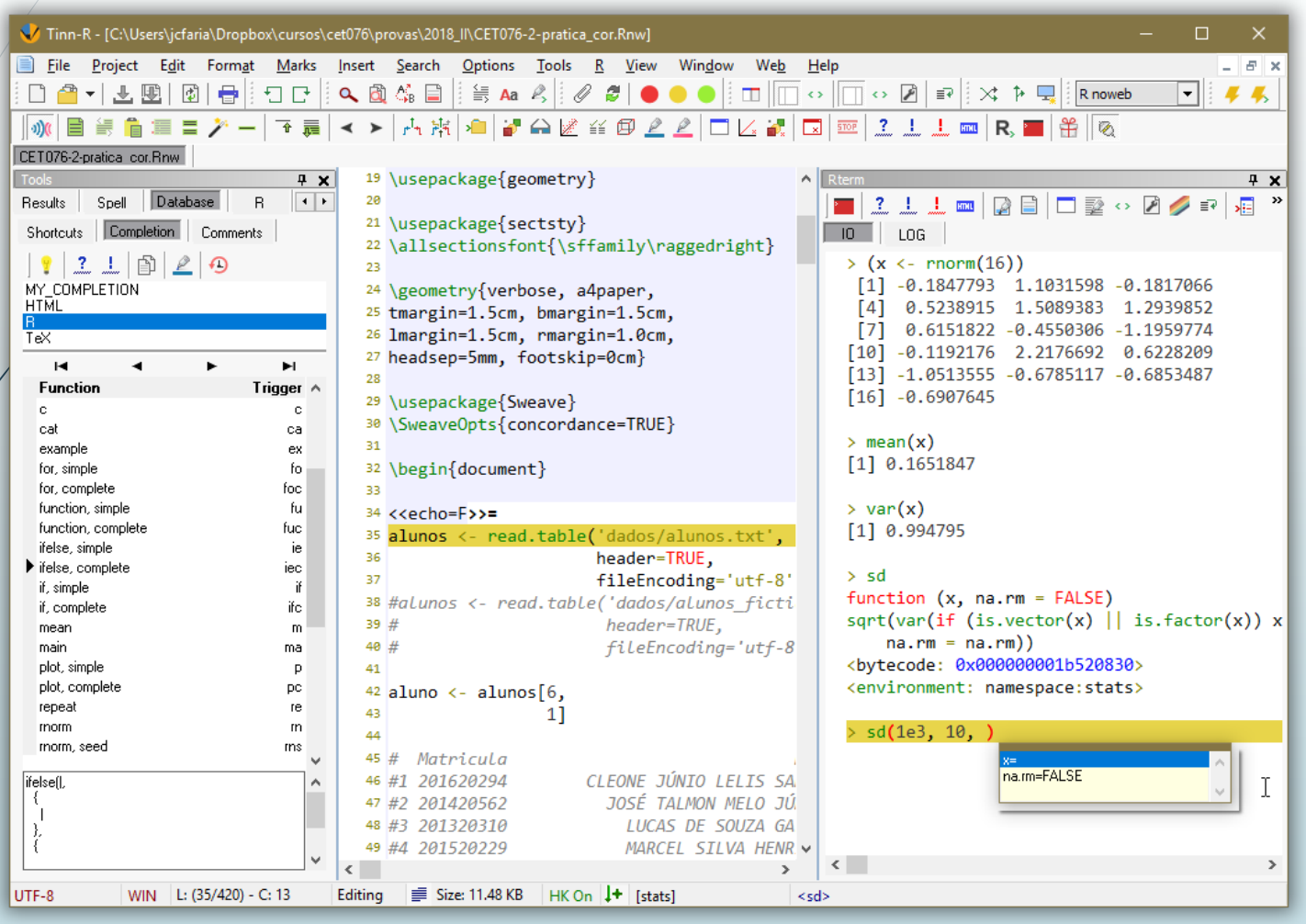
R IDEs

- Integrated Development Environments
  - Rstudio
  - JupyterLab
  - Rattle
  - RTVS (R Tools for Visual Studio)
  - displayr
  - Architect
  - RKWard
  - Tinn-R
  - R AnalyticFlow
  - …

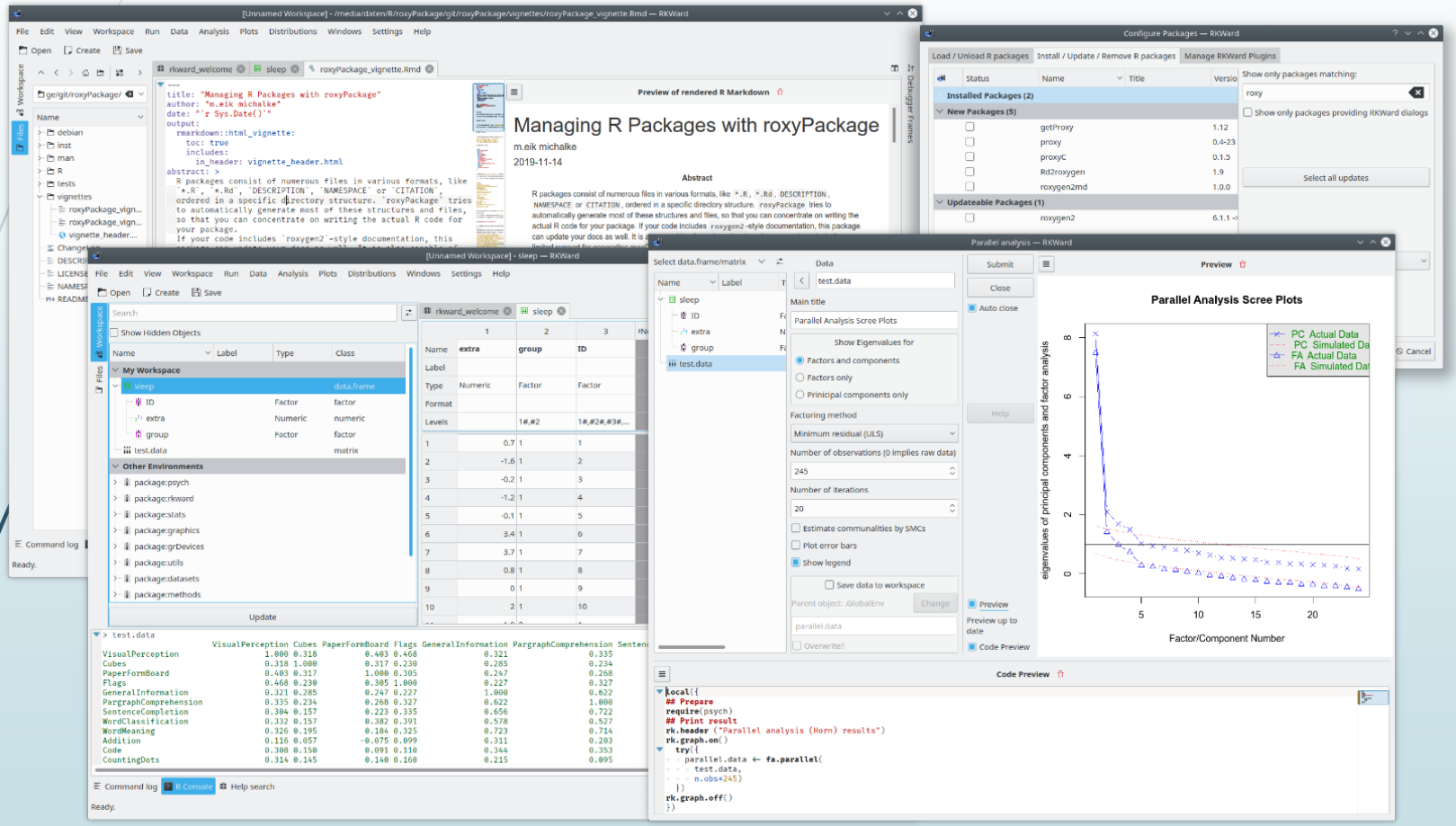
R IDEs


reporting/rmdSample.Rmd - Architect
File Edit Navigate Search Project Run R Document Window Help
Quick Access
Project Expl...
exampleProject
myFirstProject
plotting
refactoring
reporting
rmdSample.Rmd
rnwSample.Rnw
plots.R
rmdSample.Rmd
Prepare for analyses
```{r }
set.seed(1234)
library(ggplot2)
library(lattice)
```
```{r }
x <- 1:10
y <- round(rnorm(10, x, 1), 2)
df <- data.frame(x, y)
df
```
R Graphics
Device 2 | Embedded R [R Console] <active>
dist
speed
Outline
Prepare for analyses
#1
#2
Basic console output
#3
basicconsole
Plots
R Code chunk features
Basic functionality
Console
Embedded R [R Console] Embedded R Server / RJ (Jun 20, 2017, 4:36:46 PM) · C:\Users\ ... \workspaceStarters2\reporting
> ggplot(cars, aes(speed, dist)) +
+ geom_point() +
+ geom_smooth(method = "lm", formula = y ~ splines::bs(x, 3), se = FALSE)
>
> lm(dist ~ speed, data = cars)
Call:
lm(formula = dist ~ speed, data = cars)
Coefficients:
(Intercept) speed
-17.579 3.932
Submit

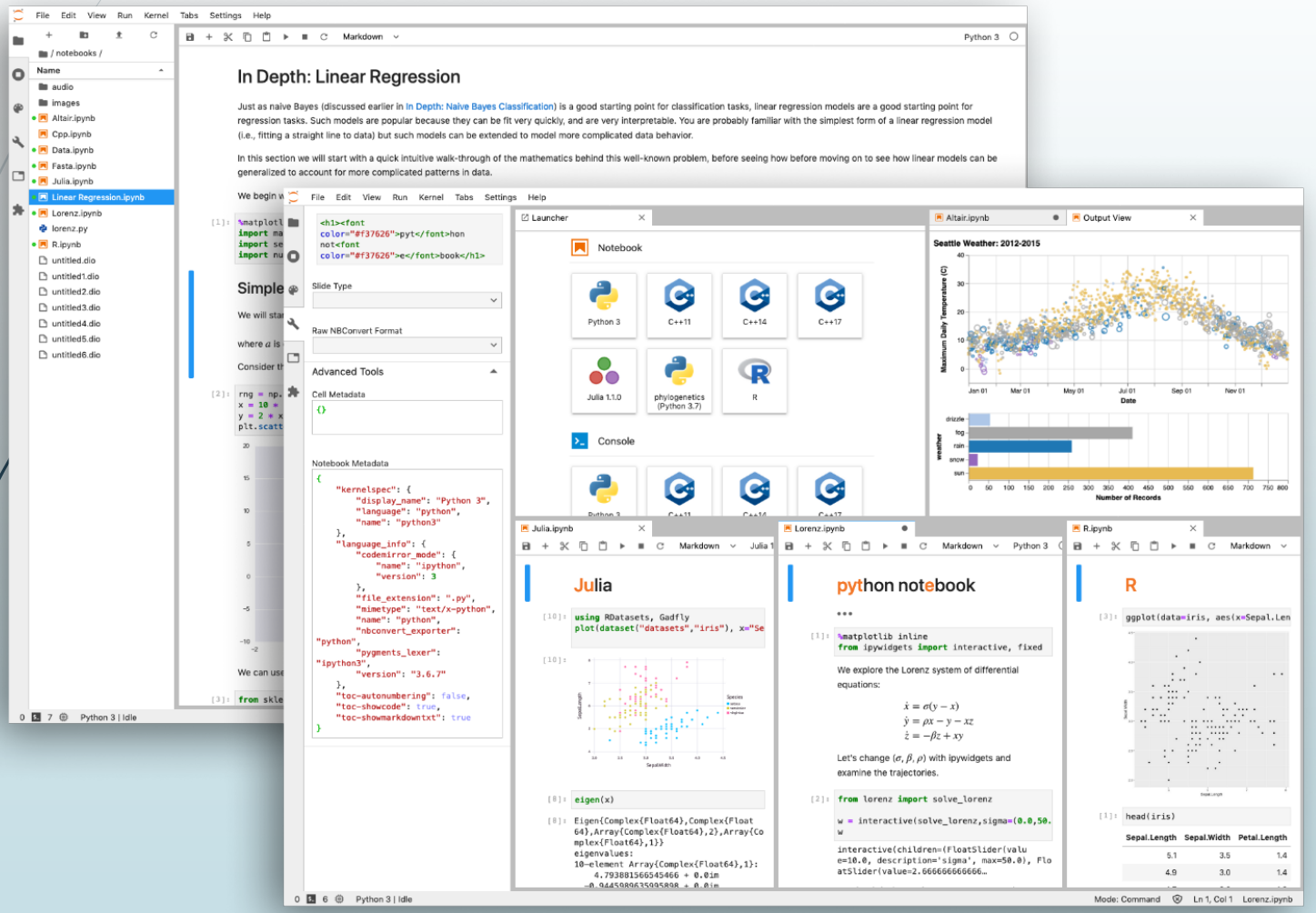
R IDEs


Tinn-R - [C:\Users\jcfaria\Dropbox\cursos\cet076\provas\2018_II\CET076-2-pratica_cor.Rnw]
File Project Edit Format Marks Insert Search Options Tools R View Window Web Help
CET076-2-pratica_cor.Rnw
Tools
Results Spell Database R
Shortcuts Completion Comments
MY_COMPLETION
HTML
R
TeX
Function Trigger
c c
cat ca
example ex
for, simple fo
for, complete foc
function, simple fu
function, complete fuc
ifelse, simple ie
ifelse, complete iec
if, simple if
if, complete ifc
mean m
main ma
plot, simple p
plot, complete pc
repeat re
rnorm rn
rnorm, seed rns
ifelse(|,
{
|
},
{
\usepackage{geometry}
\usepackage{sectsty}
\allsectionsfont{\sffamily\raggedright}
\geometry{verbose, a4paper,
tmargin=1.5cm, bmargin=1.5cm,
lmargin=1.5cm, rmargin=1.0cm,
headsep=5mm, footskip=0cm}
\usepackage{Sweave}
\SweaveOpts{concordance=TRUE}
\begin{document}
<<echo=F>>=
alunos <- read.table('dados/alunos.txt',
header=TRUE,
fileEncoding='utf-8'
#alunos <- read.table('dados/alunos_ficti
# header=TRUE,
# fileEncoding='utf-8
aluno <- alunos[6,
1]
Matricula
#1 201620294 CLEONE JÚNIO LELIS SA
#2 201420562 JOSÉ TALMON MELO JÚ
#3 201320310 LUCAS DE SOUZA GA
#4 201520229 MARCEL SILVA HENR
Rterm
IO LOG
> (x <- rnorm(16))
[1] -0.1847793 1.1031598 -0.1817066
[4] 0.5238915 1.5089383 1.2939852
[7] 0.6151822 -0.4550306 -1.1959774
[10] -0.1192176 2.2176692 0.6228209
[13] -1.0513555 -0.6785117 -0.6853487
[16] -0.6907645
> mean(x)
[1] 0.1651847
> var(x)
[1] 0.994795
> sd
function (x, na.rm = FALSE)
sqrt(var(if (is.vector(x) || is.factor(x)) x
na.rm = na.rm))
<bytecode: 0x000000001b520830>
<environment: namespace:stats>
> sd(1e3, 10,)
x=
na.rm=FALSE
UTF-8 WIN L: (35/420) - C: 13 Editing Size: 11.48 KB HK On [stats] <sd>

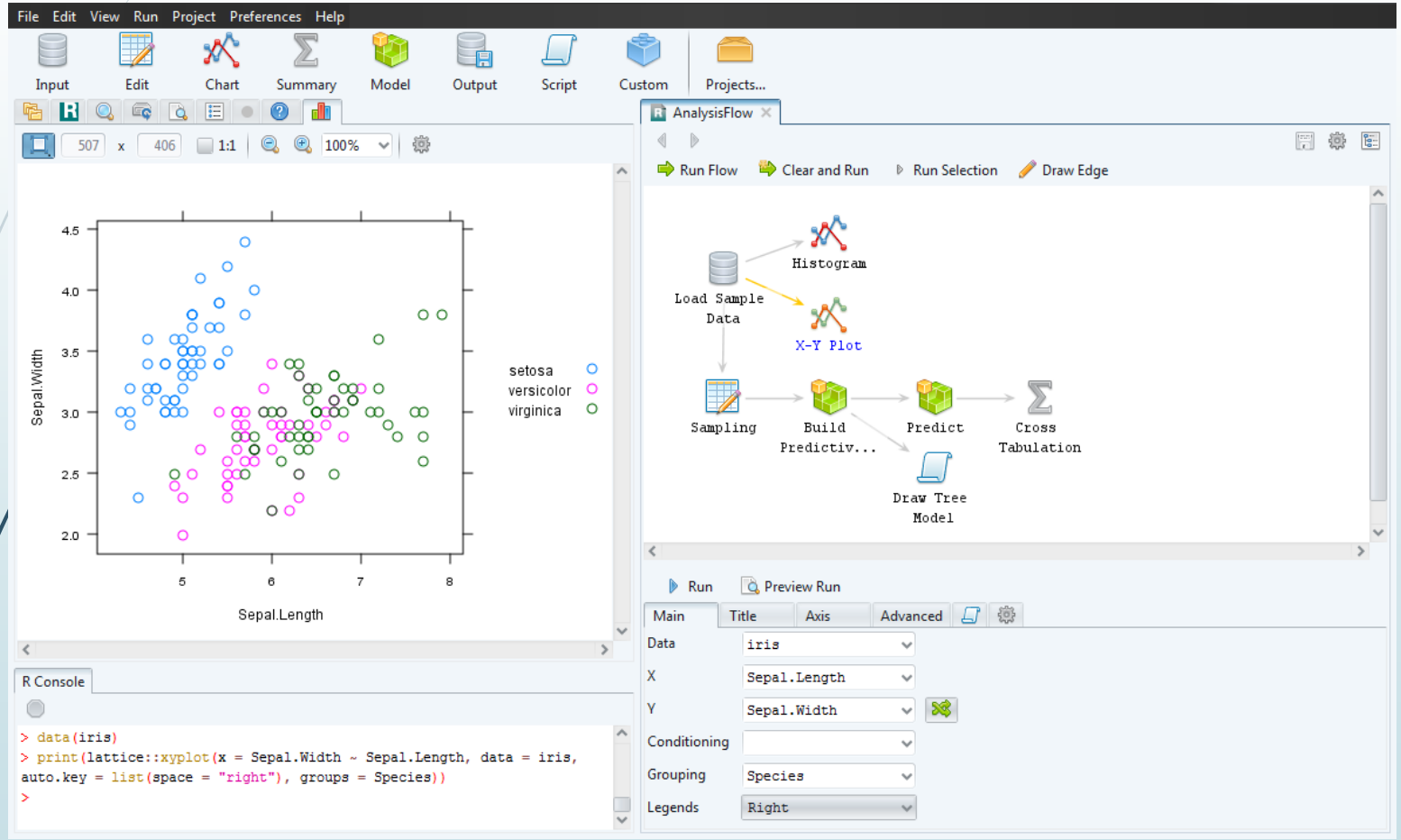
R IDEs


[Unnamed Workspace] - /media/daten/R/roxyPackage/git/roxyPackage/vignettes/roxyPackage_vignette.Rmd — RKWard
Managing R Packages with roxyPackage
m.eik michalke
2019-11-14
Abstract
Configure Packages — RKWard
Load / Unload R packages
Install / Update / Remove R packages
Manage RKWard Plugins
[Unnamed Workspace] - sleep — RKWard
Parallel analysis — RKWard
Parallel Analysis Scree Plots
PC Actual Data
PC Simulated Data
FA Actual Data
FA Simulated Data
eigenvalues of principal components and factor analysis
Factor/Component Number
Code Preview

R IDEs

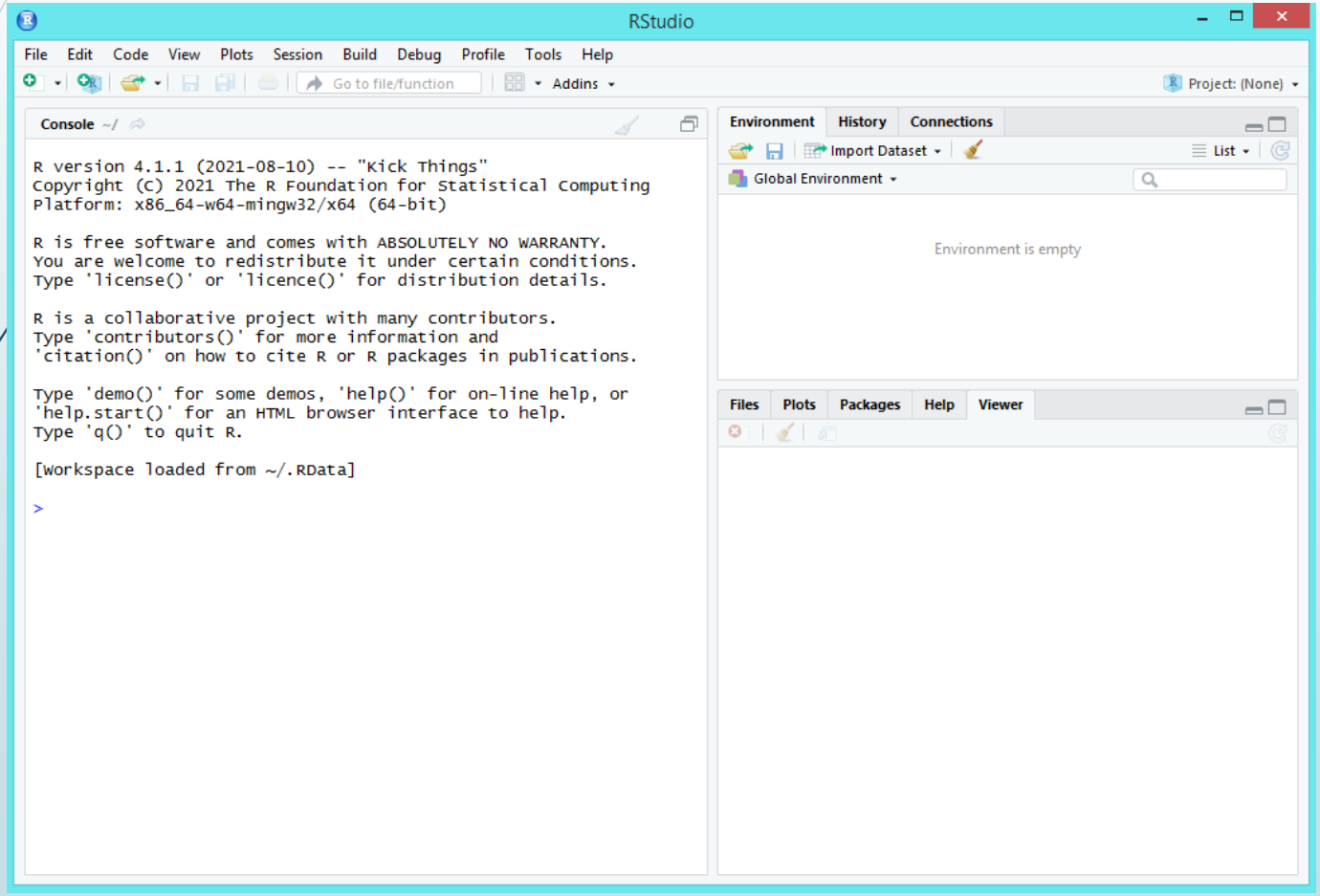

In Depth: Linear Regression
Launcher
Notebook
Console
Python 3
C++11
C++14
C++17
Julia 1.1.0
phylogenetics (Python 3.7)
R
Altair.ipynb
Output View
Seattle Weather: 2012-2015
Julia.ipynb
Julia
Lorenz.ipynb
python notebook
R.ipynb
R

R IDEs

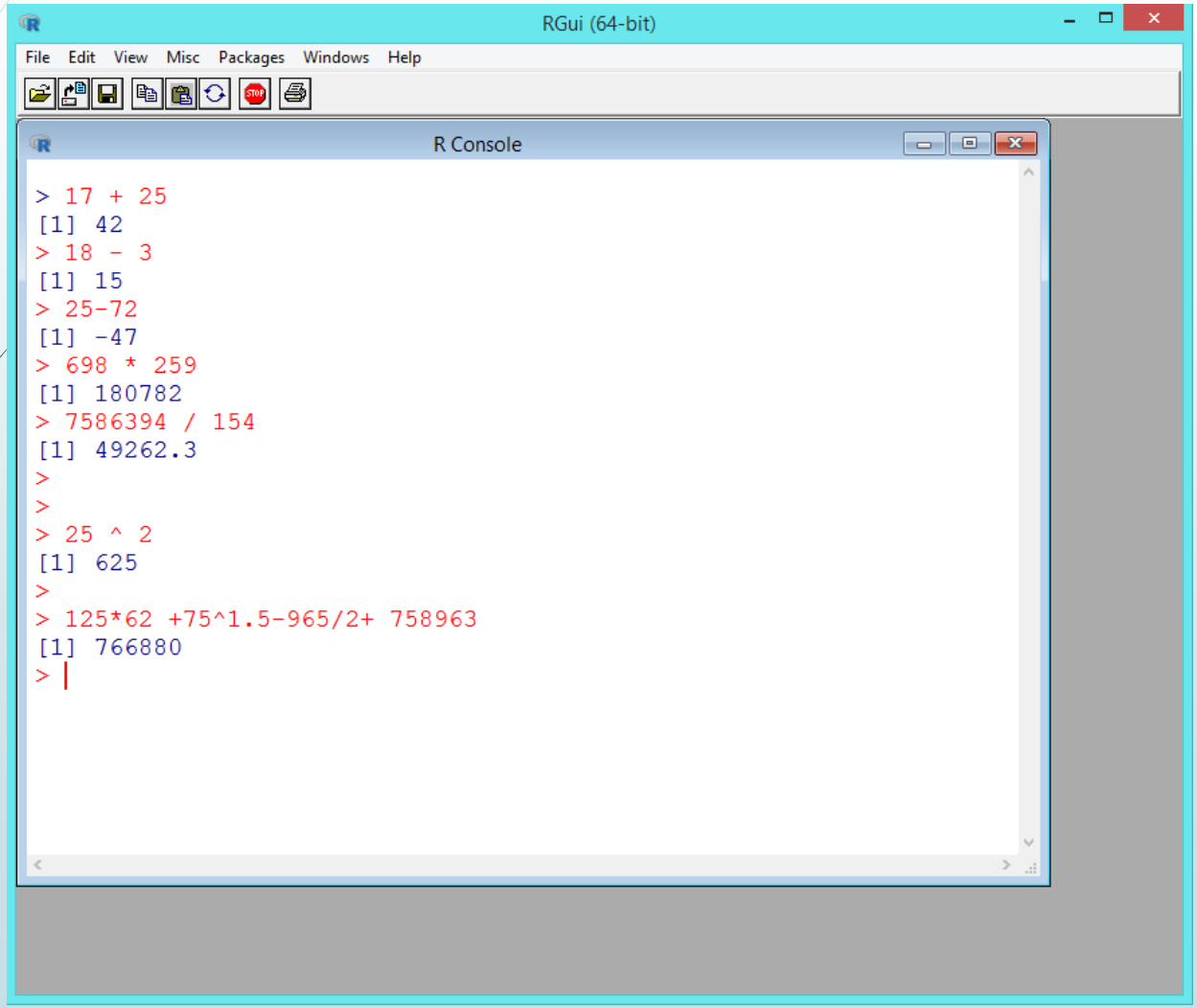

File Edit View Run Project Preferences Help
Input
Edit
Chart
Summary
Model
Output
Script
Custom
Projects...
AnalysisFlow
Run Flow
Clear and Run
Run Selection
Draw Edge
Histogram
Load Sample Data
X-Y Plot
Sampling
Build Predictiv...
Predict
Cross Tabulation
Draw Tree Model
Run
Preview Run
Main
Title
Axis
Advanced
Data
iris
X
Sepal.Length
Y
Sepal.Width
Conditioning
Grouping
Species
Legends
Right
Sepal.Width
Sepal.Length
setosa
versicolor
virginica
R Console
> data(iris)
> print(lattice::xyplot(x = Sepal.Width ~ Sepal.Length, data = iris,
auto.key = list(space = "right"), groups = Species))
>

RStudio

- Popular **R** IDE



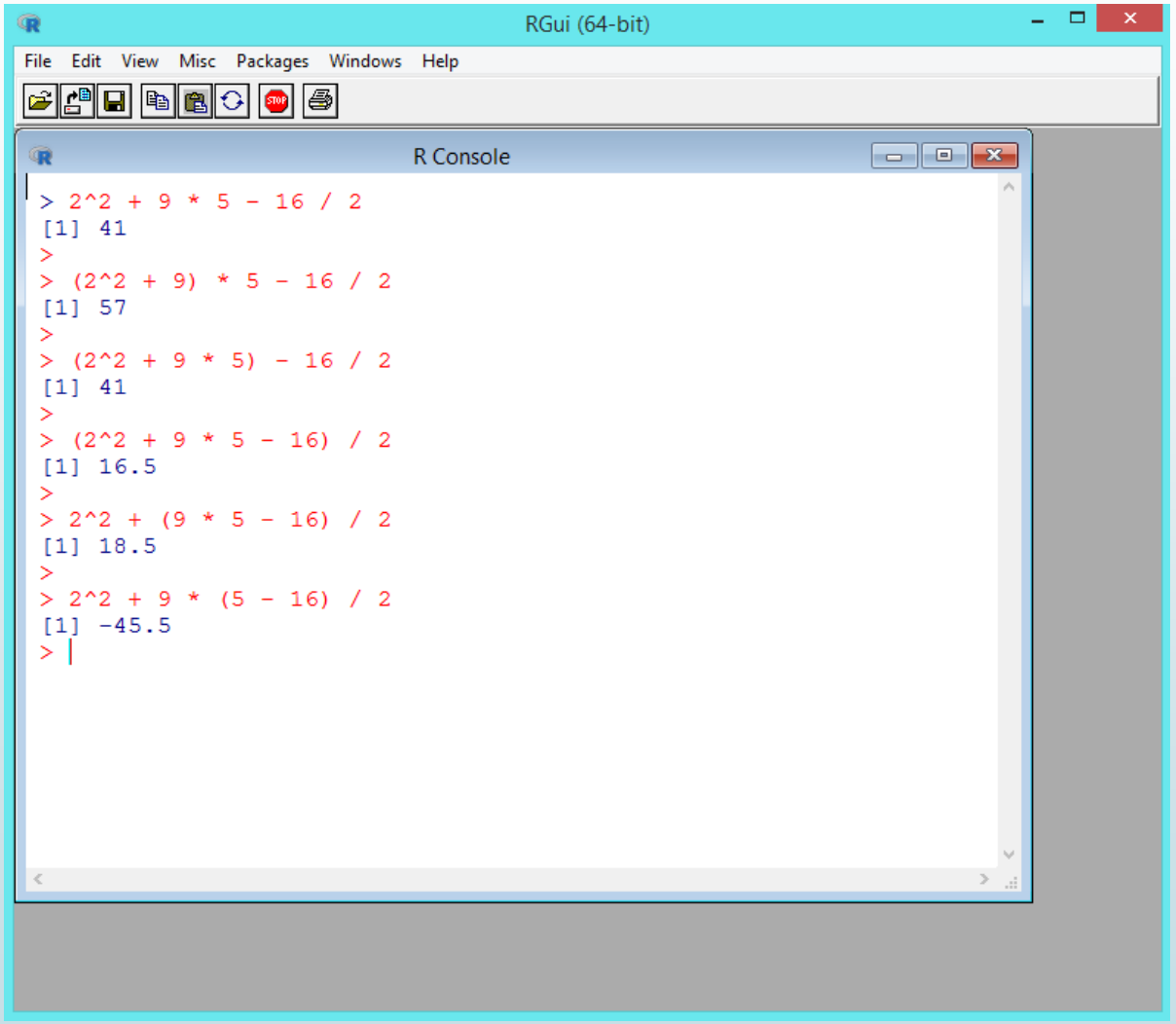
R Console as a Calculator



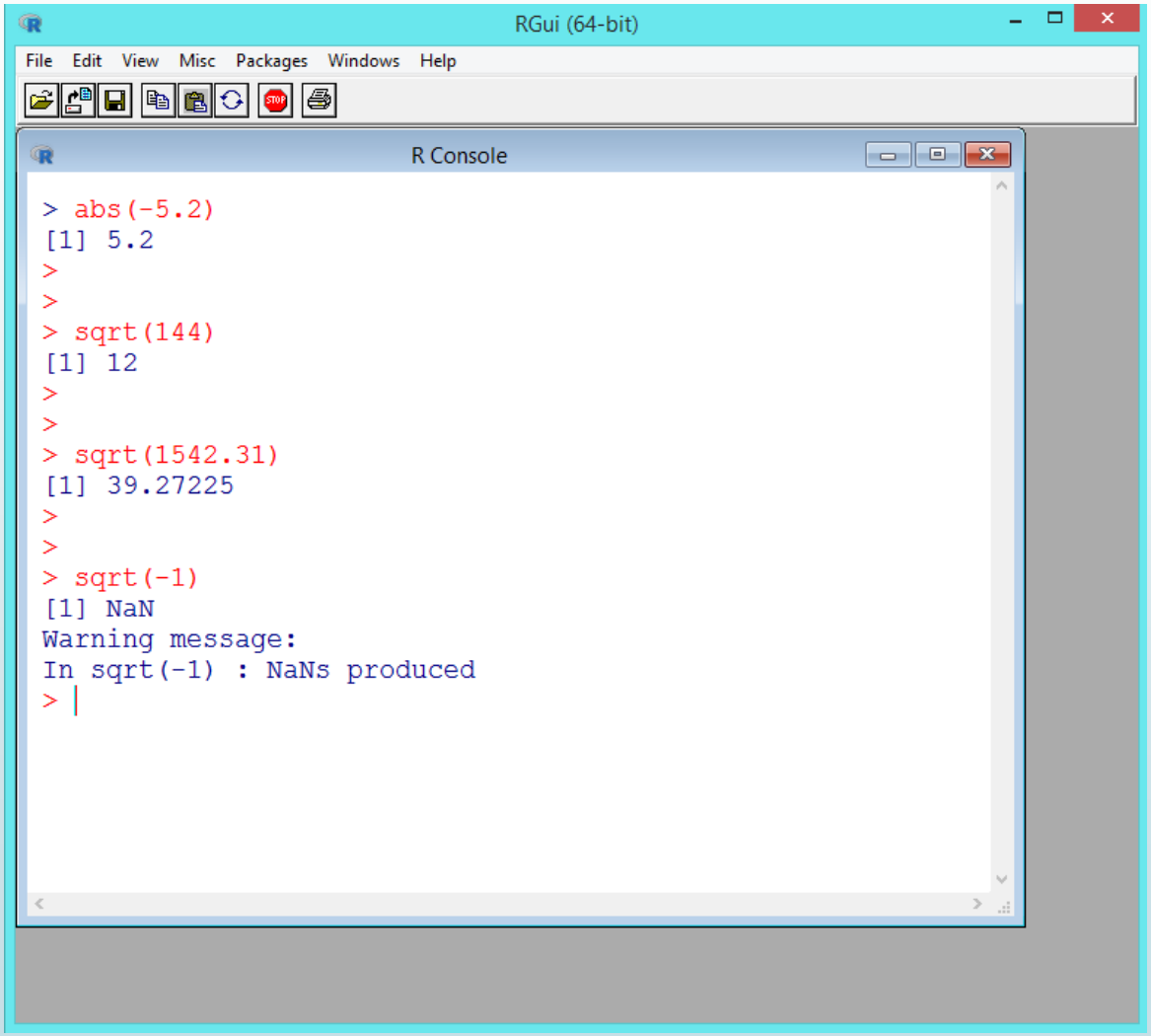
Order of Precedence

Order	Symbol
1	Parentheses. For nested parentheses, the innermost are executed first.
2	Exponentiation.
3	Multiplication, division (equal precedence).
4	Addition and subtraction.

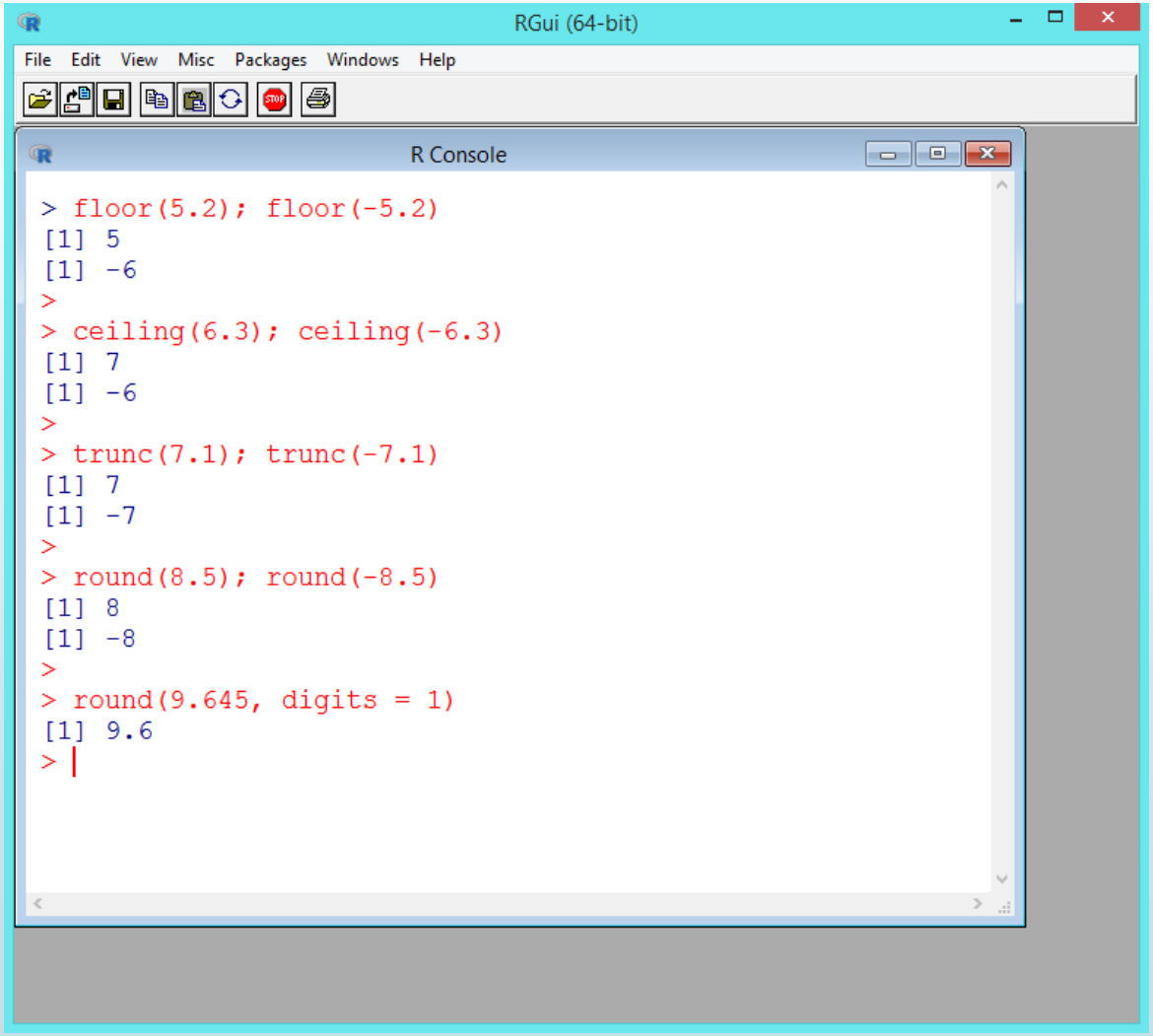
Order of Precedence



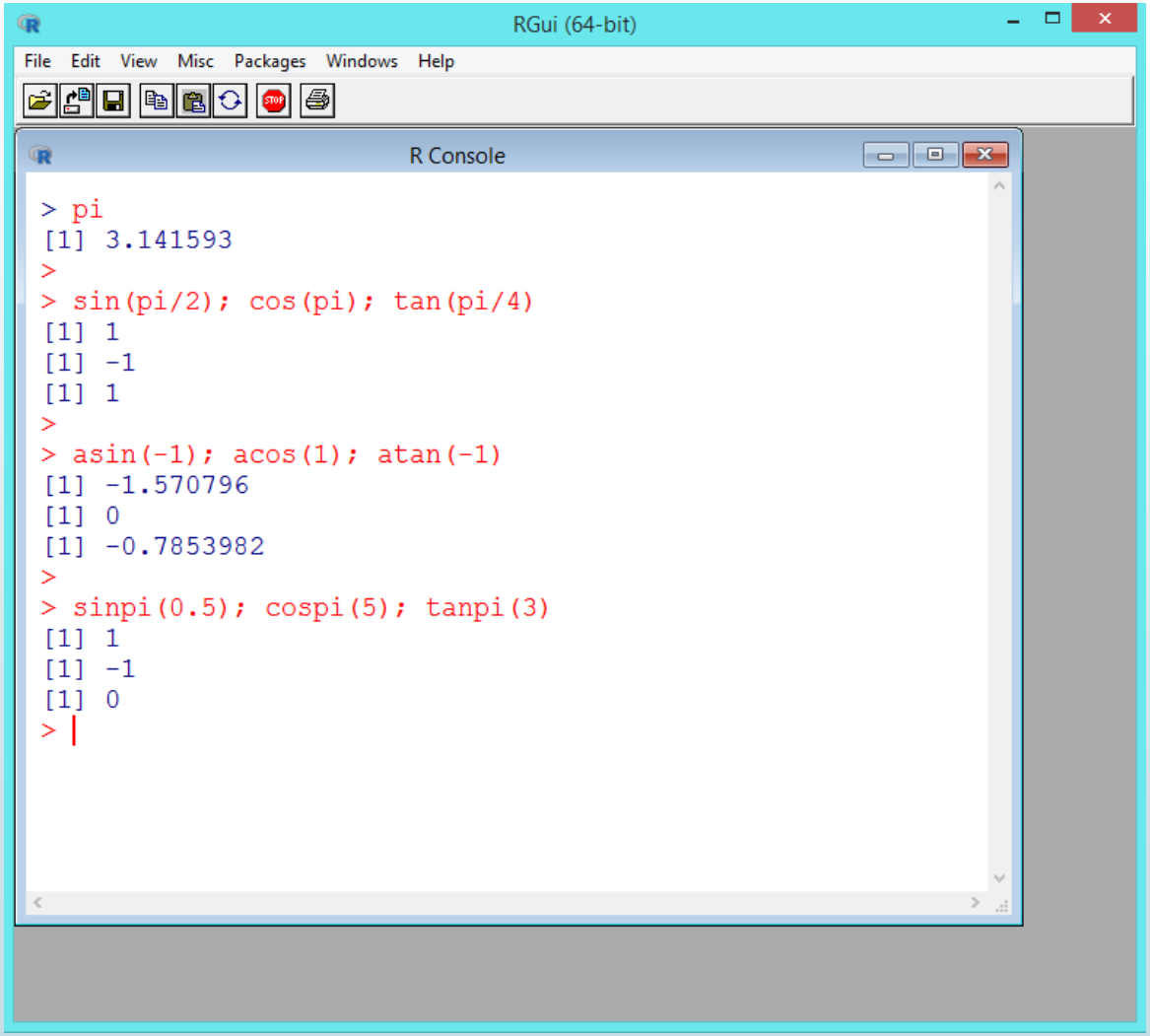
Some Base Functions



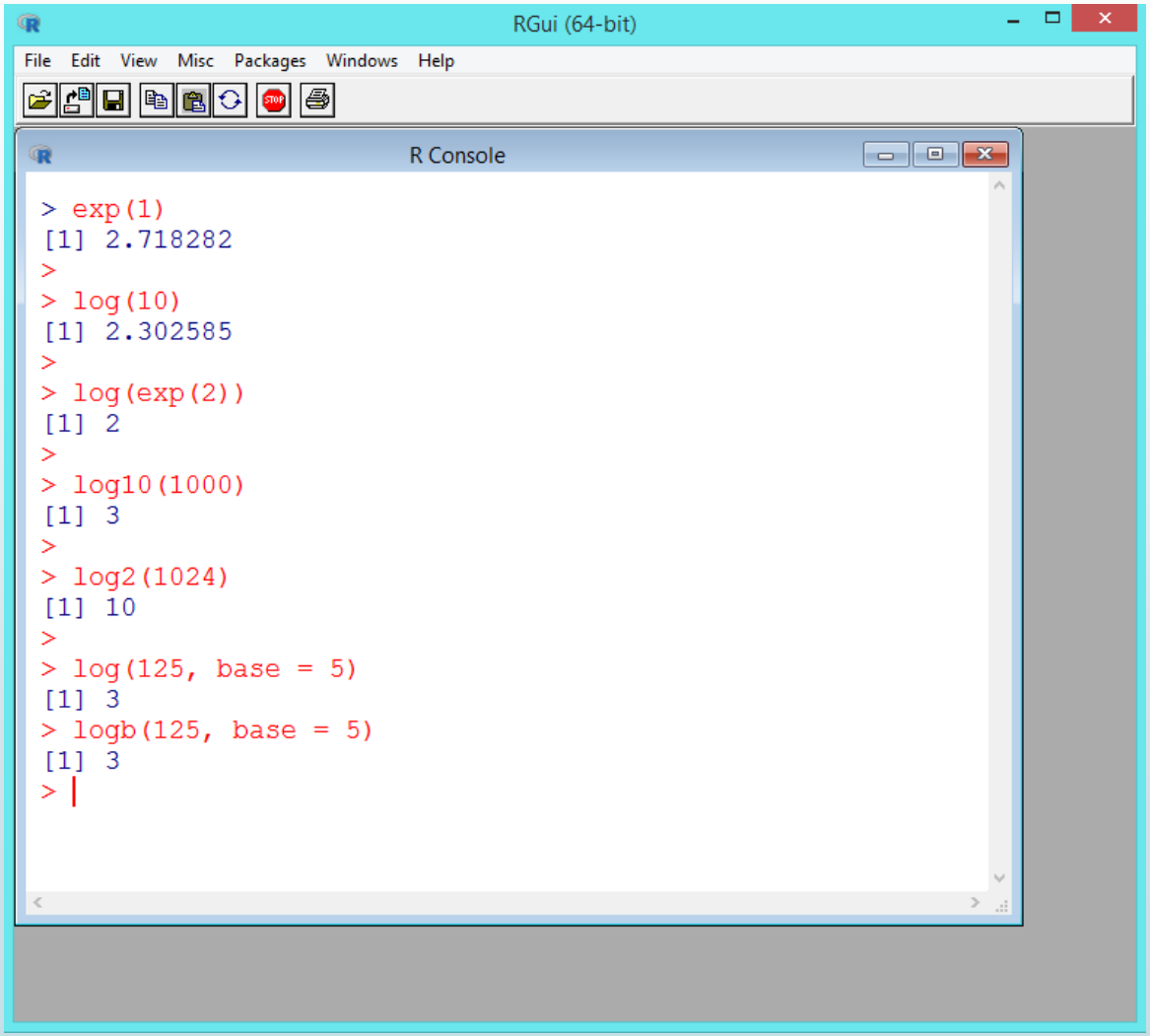
Rounding Functions



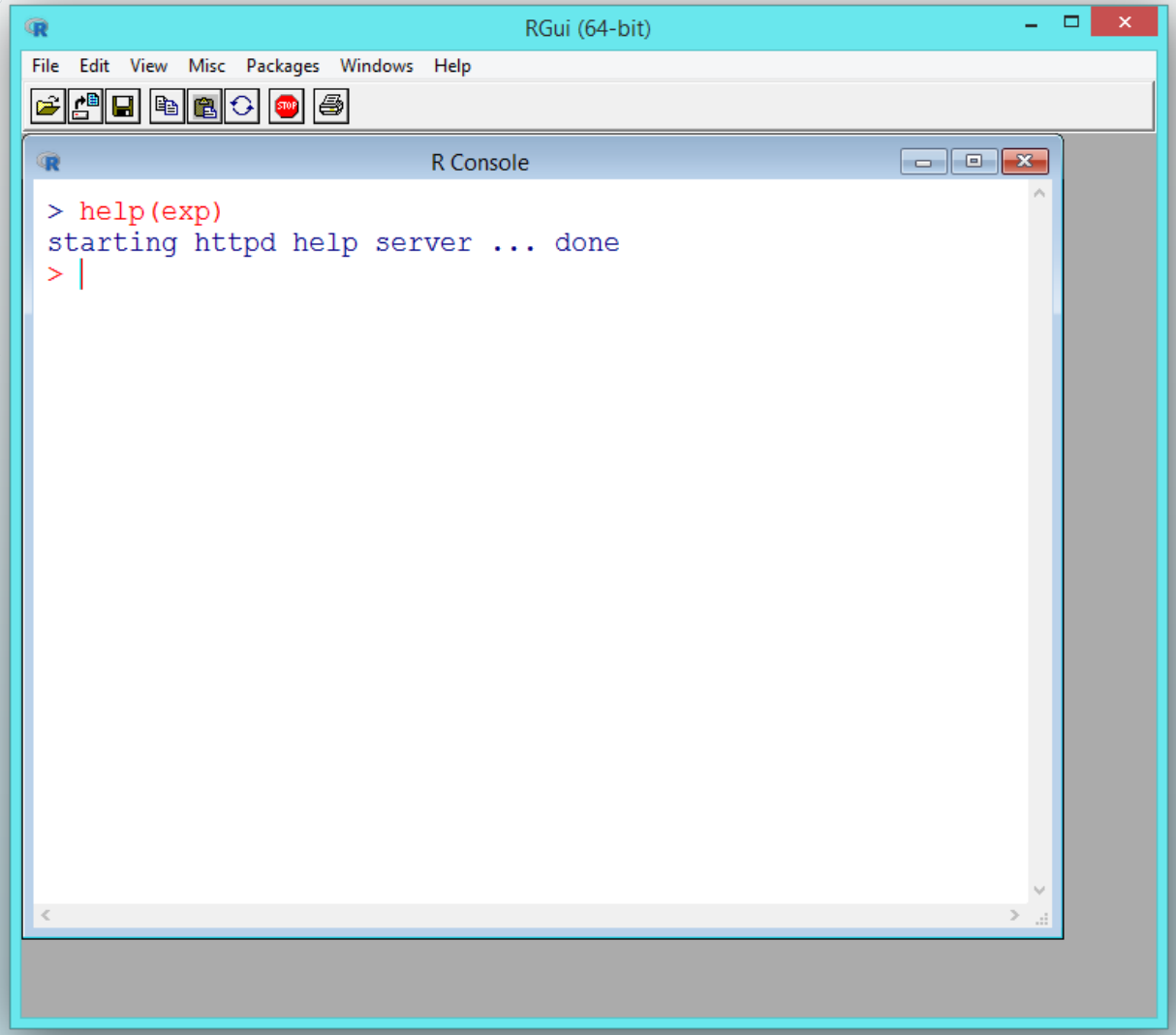
Trigonometric Functions



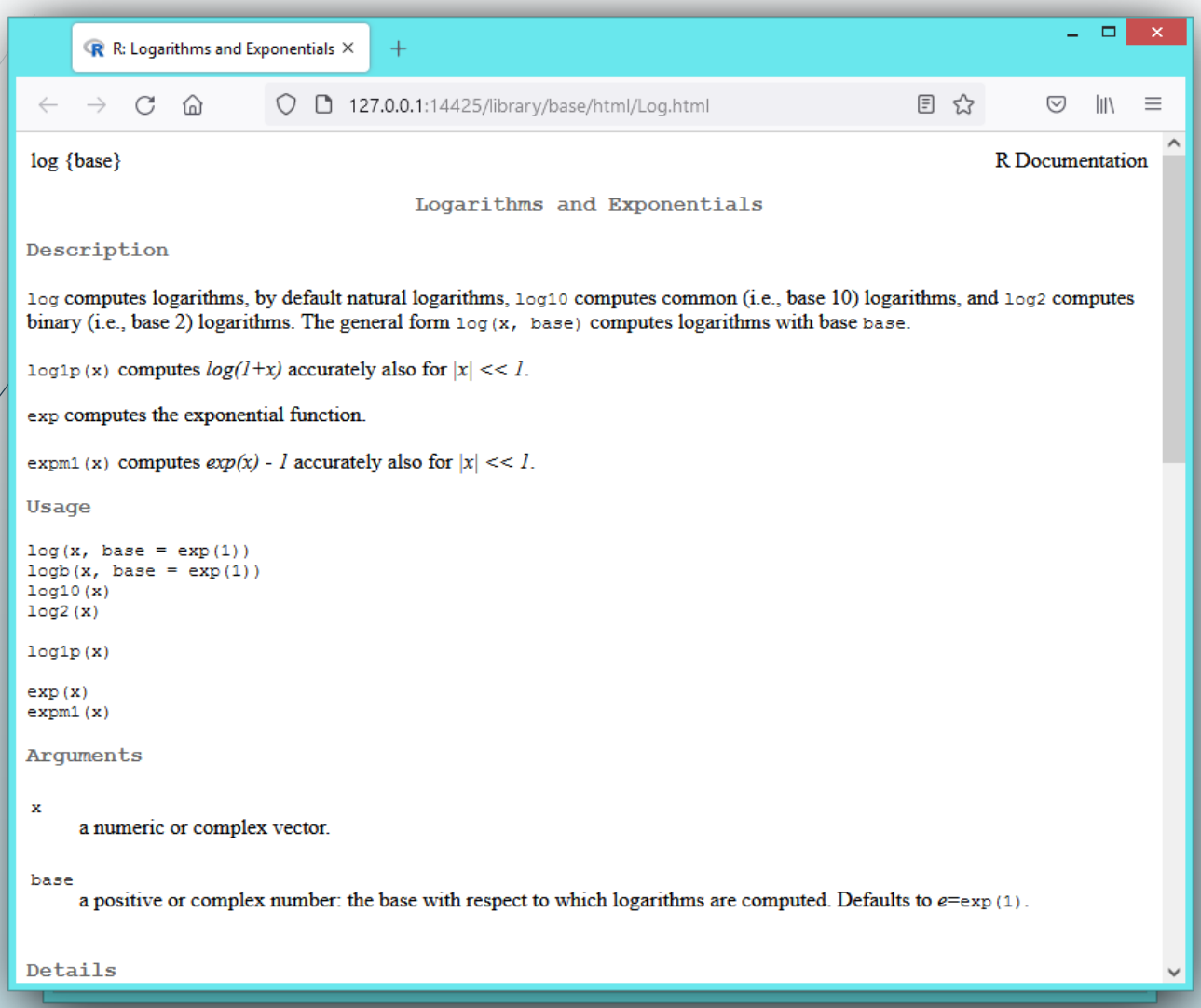
Exponential and Logarithmic Functions



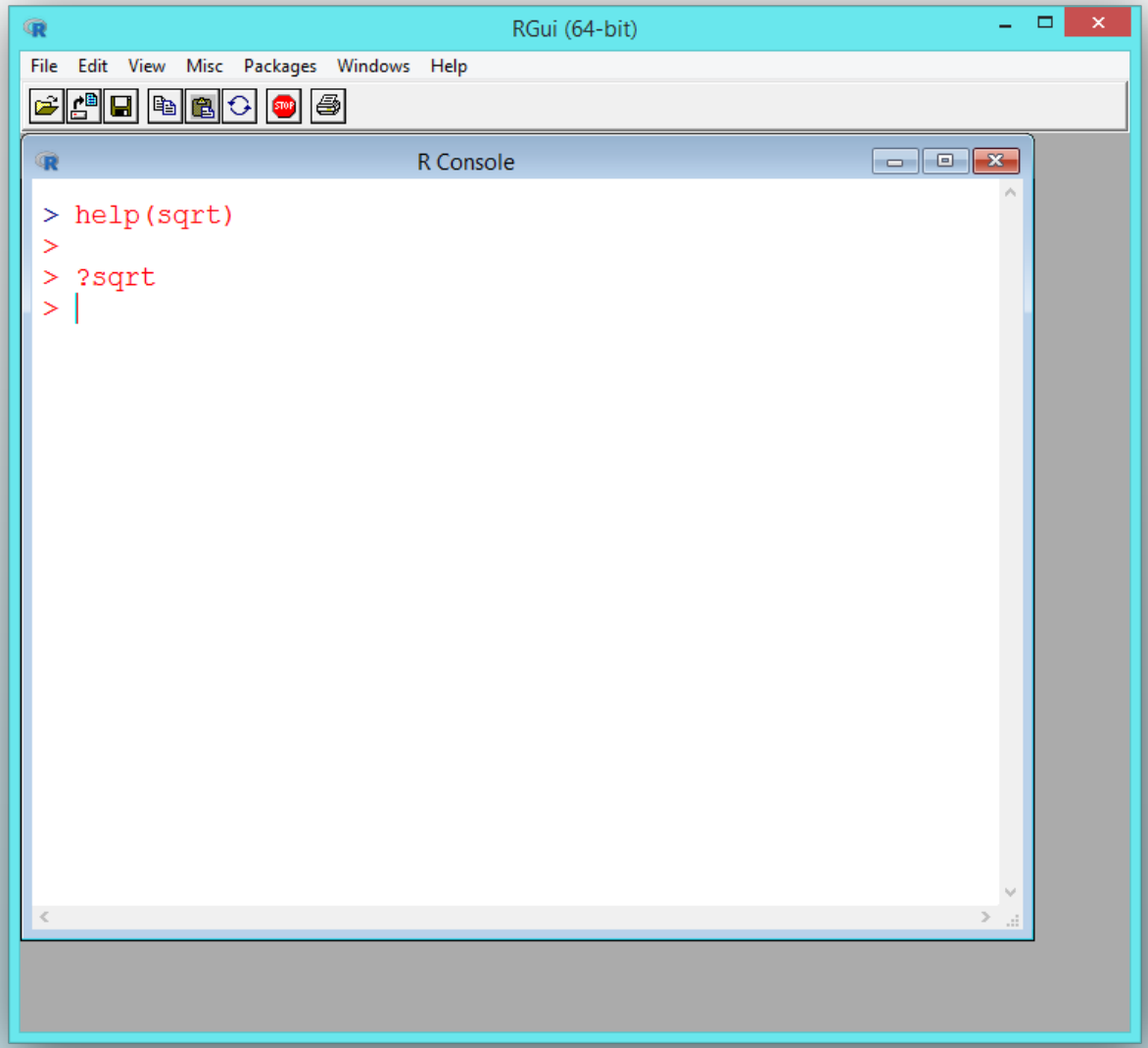
help()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> help(exp)
starting httpd help server ... done
>

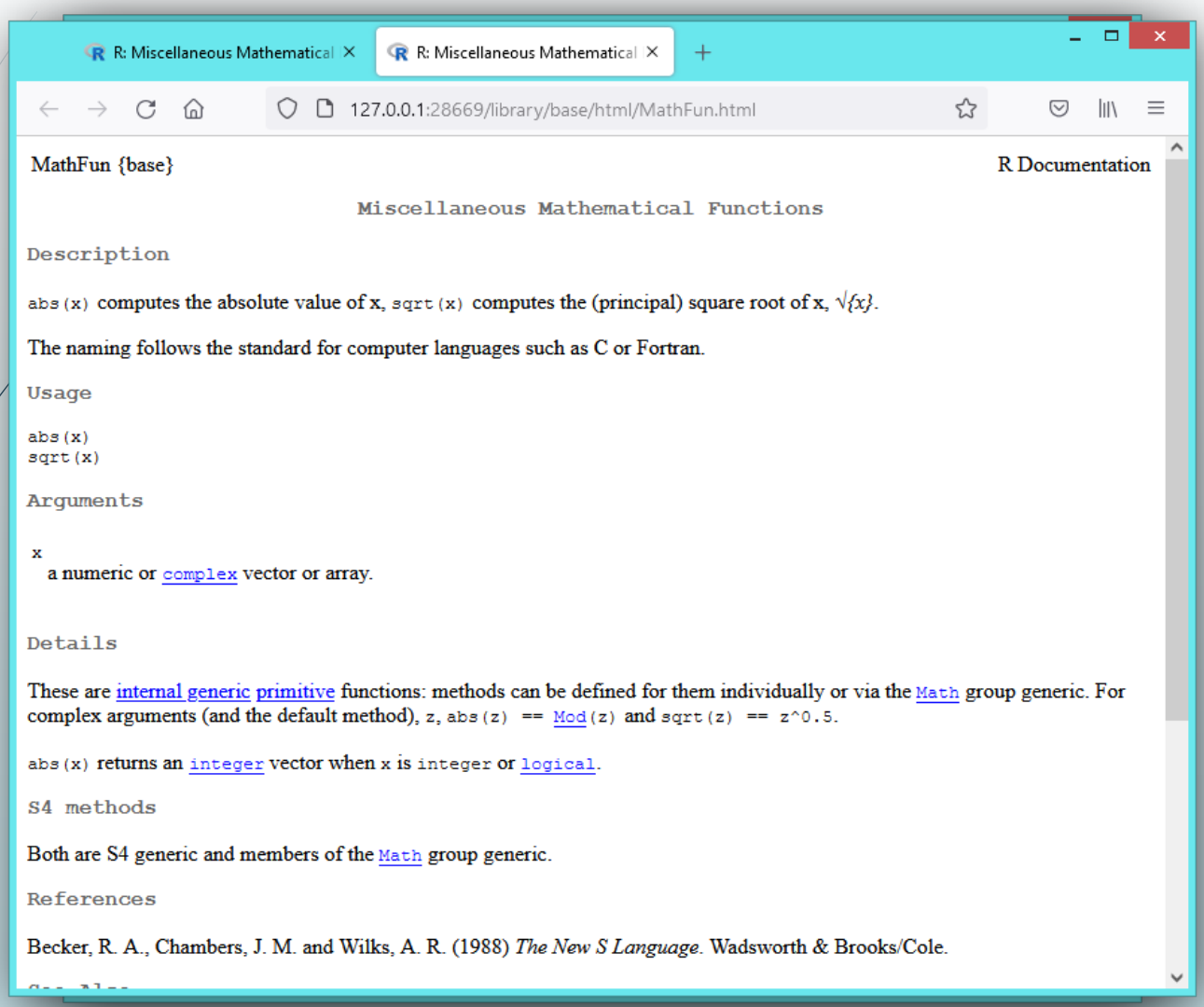
help()


R: Logarithms and Exponentials
127.0.0.1:14425/library/base/html/Log.html
log {base}
R Documentation
Logarithms and Exponentials
Description
log computes logarithms, by default natural logarithms, log10 computes common (i.e., base 10) logarithms, and log2 computes binary (i.e., base 2) logarithms. The general form log(x, base) computes logarithms with base base.
log1p(x) computes log(1+x) accurately also for |x| << 1.
exp computes the exponential function.
expm1(x) computes exp(x) - 1 accurately also for |x| << 1.
Usage
log(x, base = exp(1))
logb(x, base = exp(1))
log10(x)
log2(x)
log1p(x)
exp(x)
expm1(x)
Arguments
x
a numeric or complex vector.
base
a positive or complex number: the base with respect to which logarithms are computed. Defaults to e=exp(1).
Details

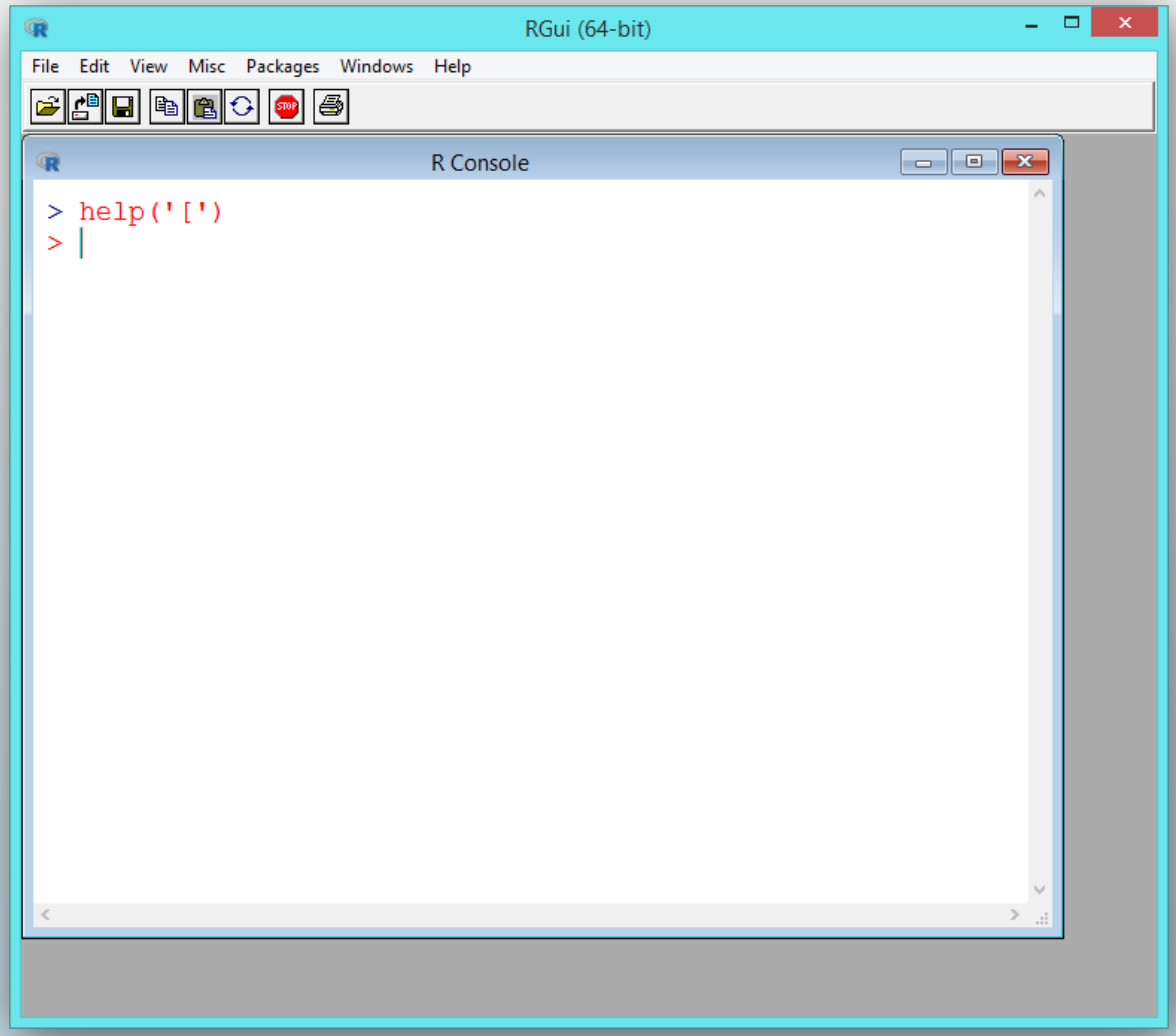
help() and ?


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> help(sqrt)
>
> ?sqrt
>

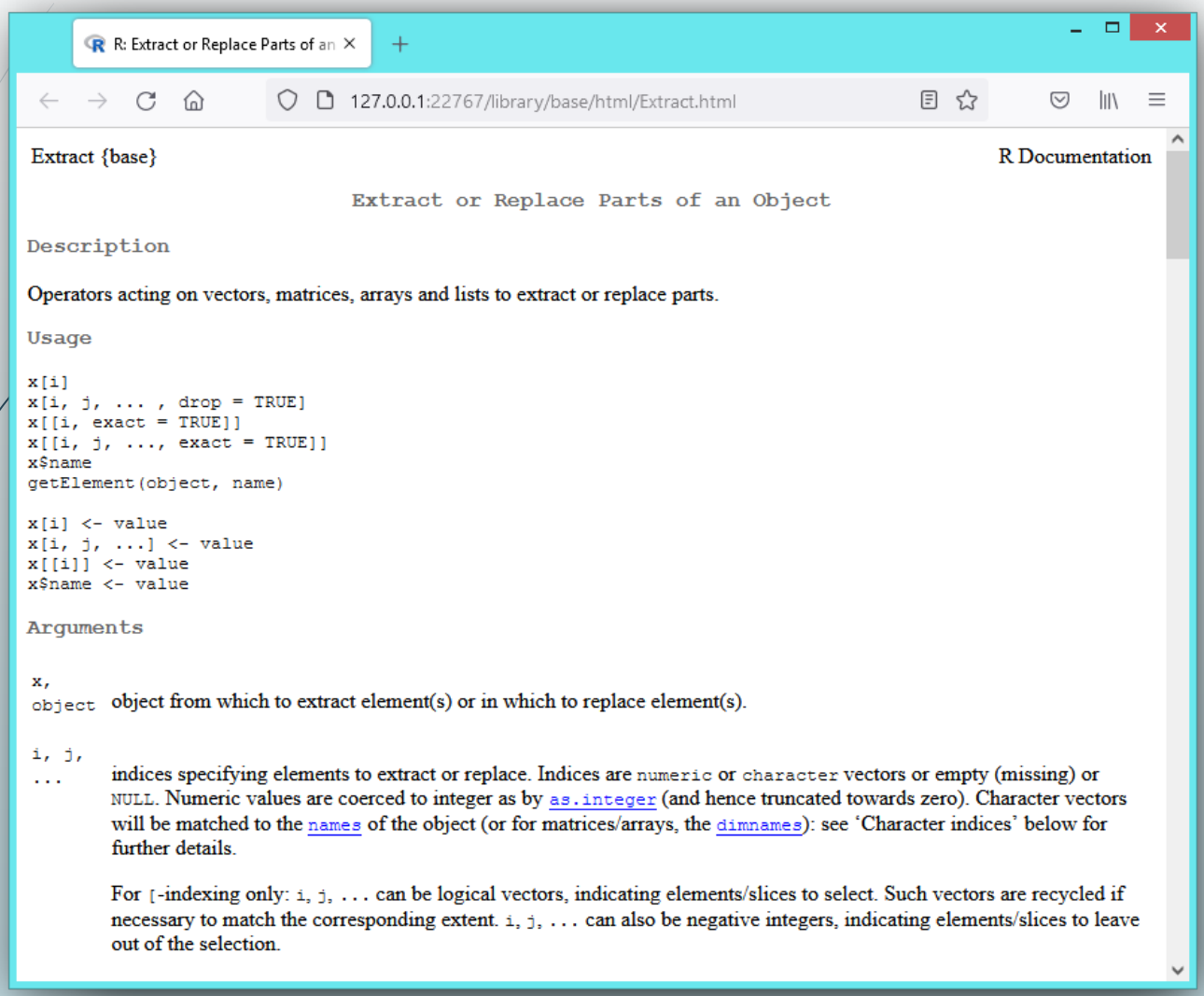
help() and ?


R: Miscellaneous Mathematical
R: Miscellaneous Mathematical
127.0.0.1:28669/library/base/html/MathFun.html
MathFun {base}
R Documentation
Miscellaneous Mathematical Functions
Description
abs(x) computes the absolute value of x, sqrt(x) computes the (principal) square root of x, √{x}.
The naming follows the standard for computer languages such as C or Fortran.
Usage
abs(x)
sqrt(x)
Arguments
x
a numeric or complex vector or array.
Details
These are internal generic primitive functions: methods can be defined for them individually or via the Math group generic. For complex arguments (and the default method), z, abs(z) == Mod(z) and sqrt(z) == z^0.5.
abs(x) returns an integer vector when x is integer or logical.
S4 methods
Both are S4 generic and members of the Math group generic.
References
Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) The New S Language. Wadsworth & Brooks/Cole.

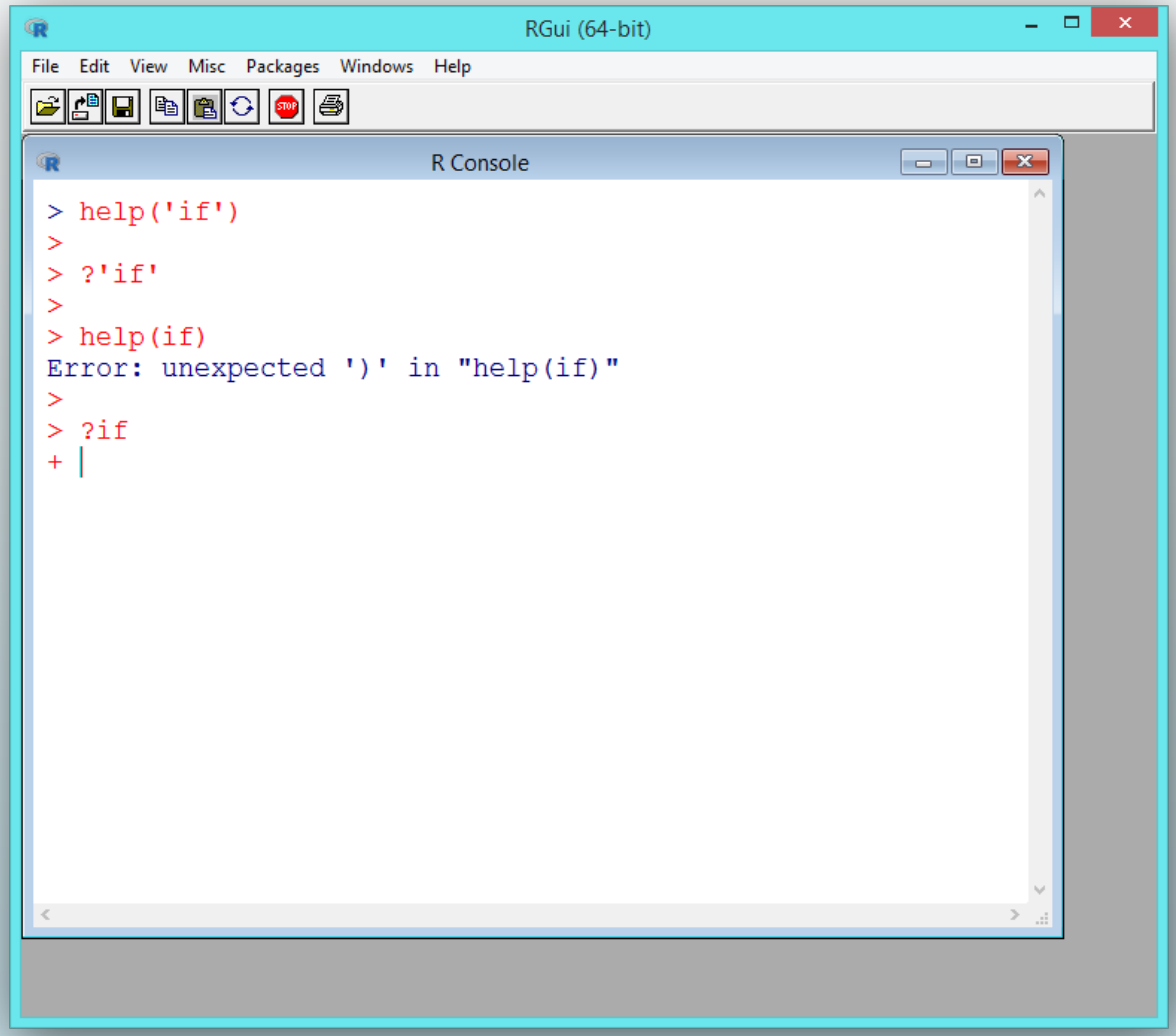
help() and ?


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> help('[')
>

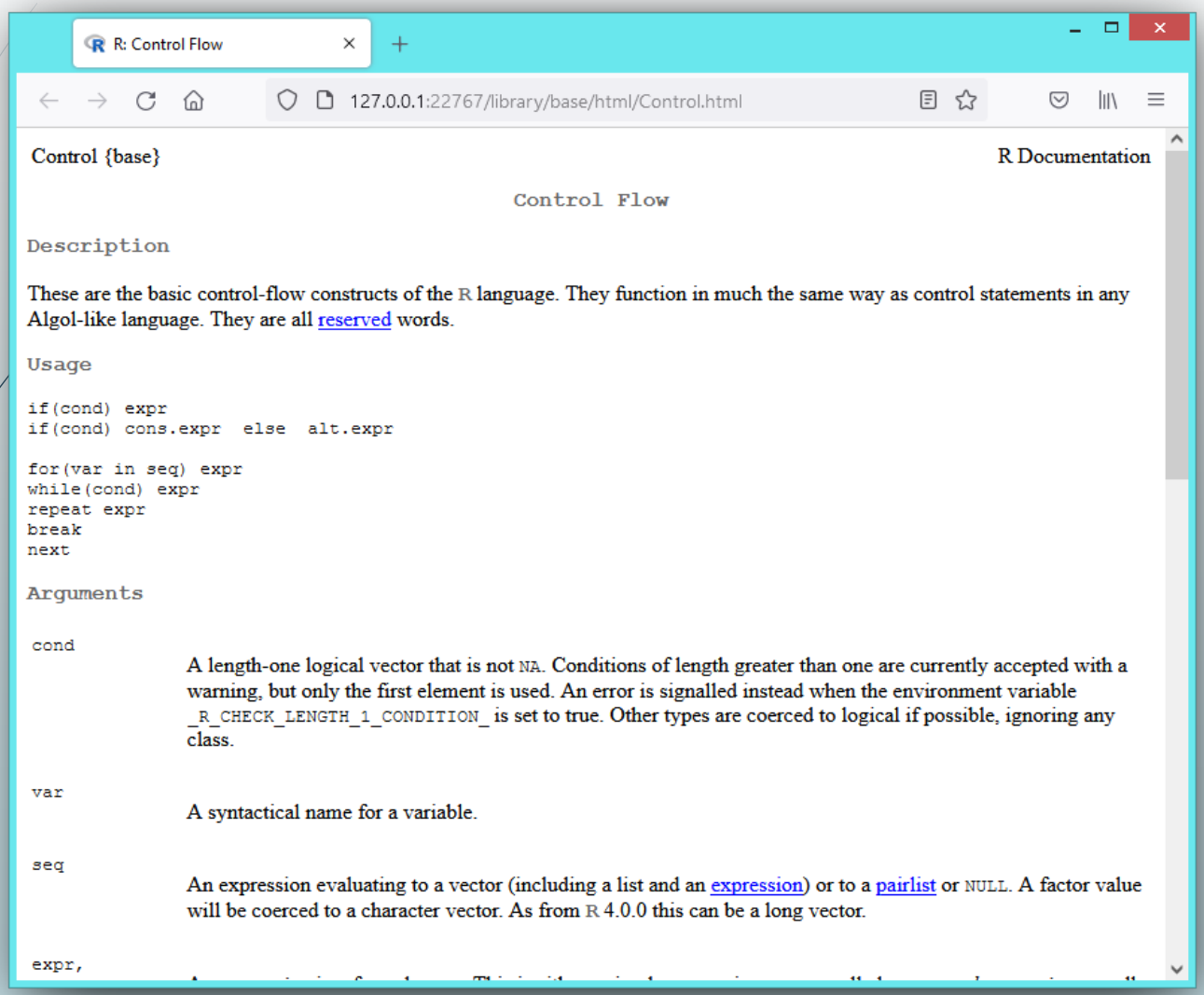
help() and ?


R: Extract or Replace Parts of an
127.0.0.1:22767/library/base/html/Extract.html
Extract {base}
R Documentation
Extract or Replace Parts of an Object
Description
Operators acting on vectors, matrices, arrays and lists to extract or replace parts.
Usage
x[i]
x[i, j, ... , drop = TRUE]
x[[i, exact = TRUE]]
x[[i, j, ..., exact = TRUE]]
x$name
getElement(object, name)
x[i] <- value
x[i, j, ...] <- value
x[[i]] <- value
x$name <- value
Arguments
x, object
object from which to extract element(s) or in which to replace element(s).
i, j, ...
indices specifying elements to extract or replace. Indices are numeric or character vectors or empty (missing) or NULL. Numeric values are coerced to integer as by as.integer (and hence truncated towards zero). Character vectors will be matched to the names of the object (or for matrices/arrays, the dimnames): see 'Character indices' below for further details.
For [-indexing only: i, j, ... can be logical vectors, indicating elements/slices to select. Such vectors are recycled if necessary to match the corresponding extent. i, j, ... can also be negative integers, indicating elements/slices to leave out of the selection.

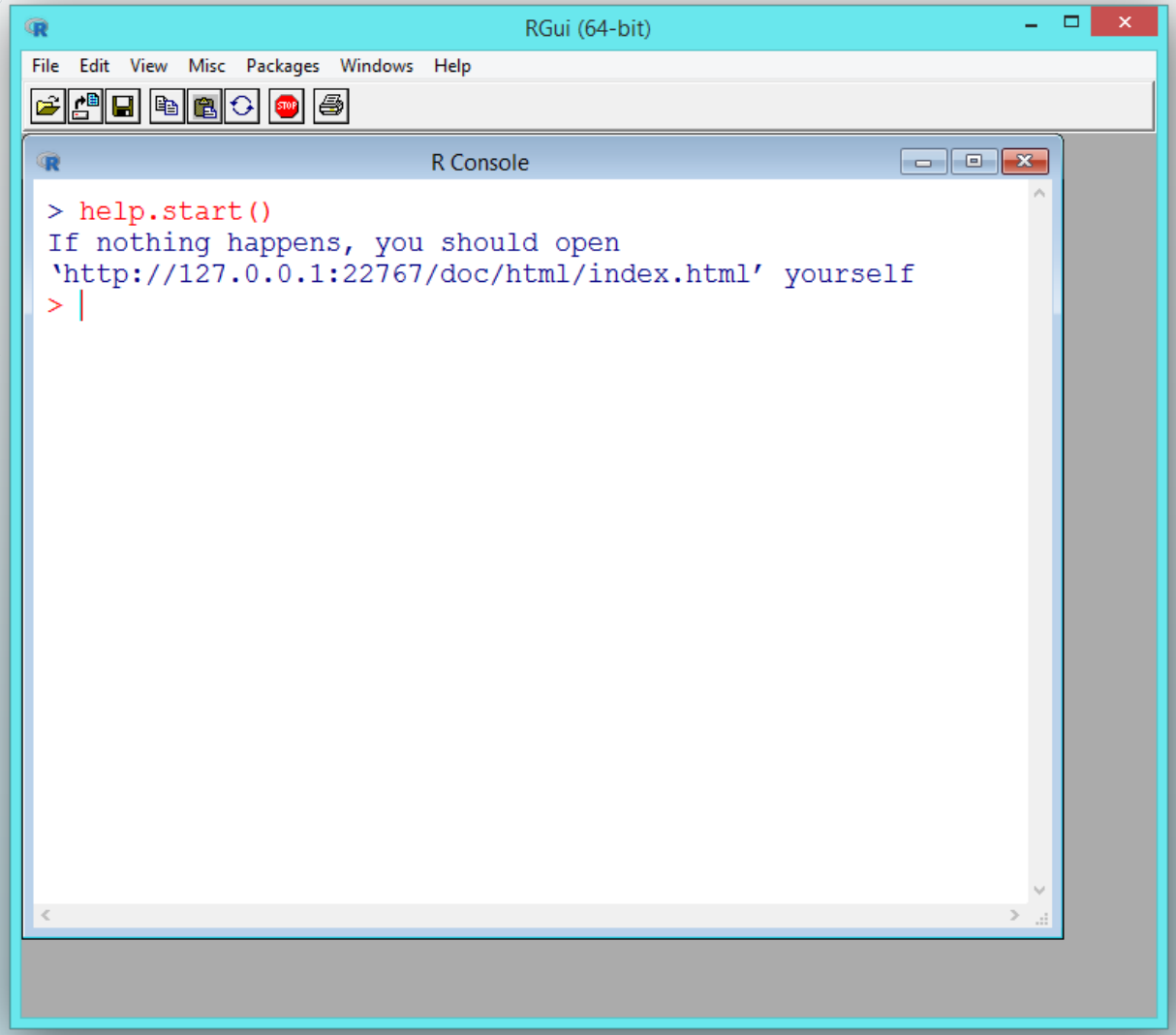
help() and ?


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> help('if')
>
> ?'if'
>
> help(if)
Error: unexpected ')' in "help(if)"
>
> ?if
+

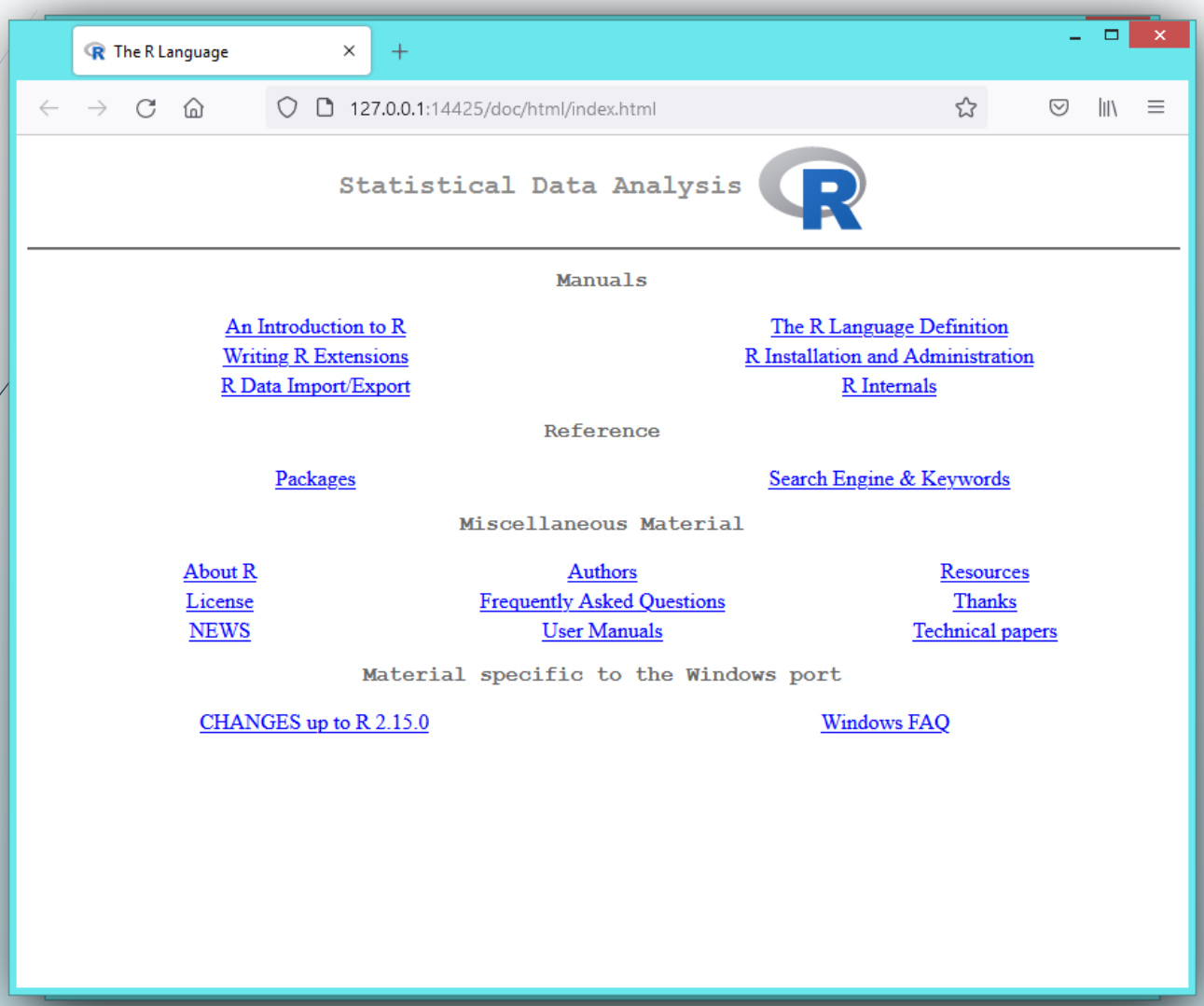
help() and ?


R: Control Flow
127.0.0.1:22767/library/base/html/Control.html
Control {base}
R Documentation
Control Flow
Description
These are the basic control-flow constructs of the R language. They function in much the same way as control statements in any Algol-like language. They are all reserved words.
Usage
if(cond) expr
if(cond) cons.expr else alt.expr
for(var in seq) expr
while(cond) expr
repeat expr
break
next
Arguments
cond
A length-one logical vector that is not NA. Conditions of length greater than one are currently accepted with a warning, but only the first element is used. An error is signalled instead when the environment variable _R_CHECK_LENGTH_1_CONDITION_ is set to true. Other types are coerced to logical if possible, ignoring any class.
var
A syntactical name for a variable.
seq
An expression evaluating to a vector (including a list and an expression) or to a pairlist or NULL. A factor value will be coerced to a character vector. As from R 4.0.0 this can be a long vector.
expr,

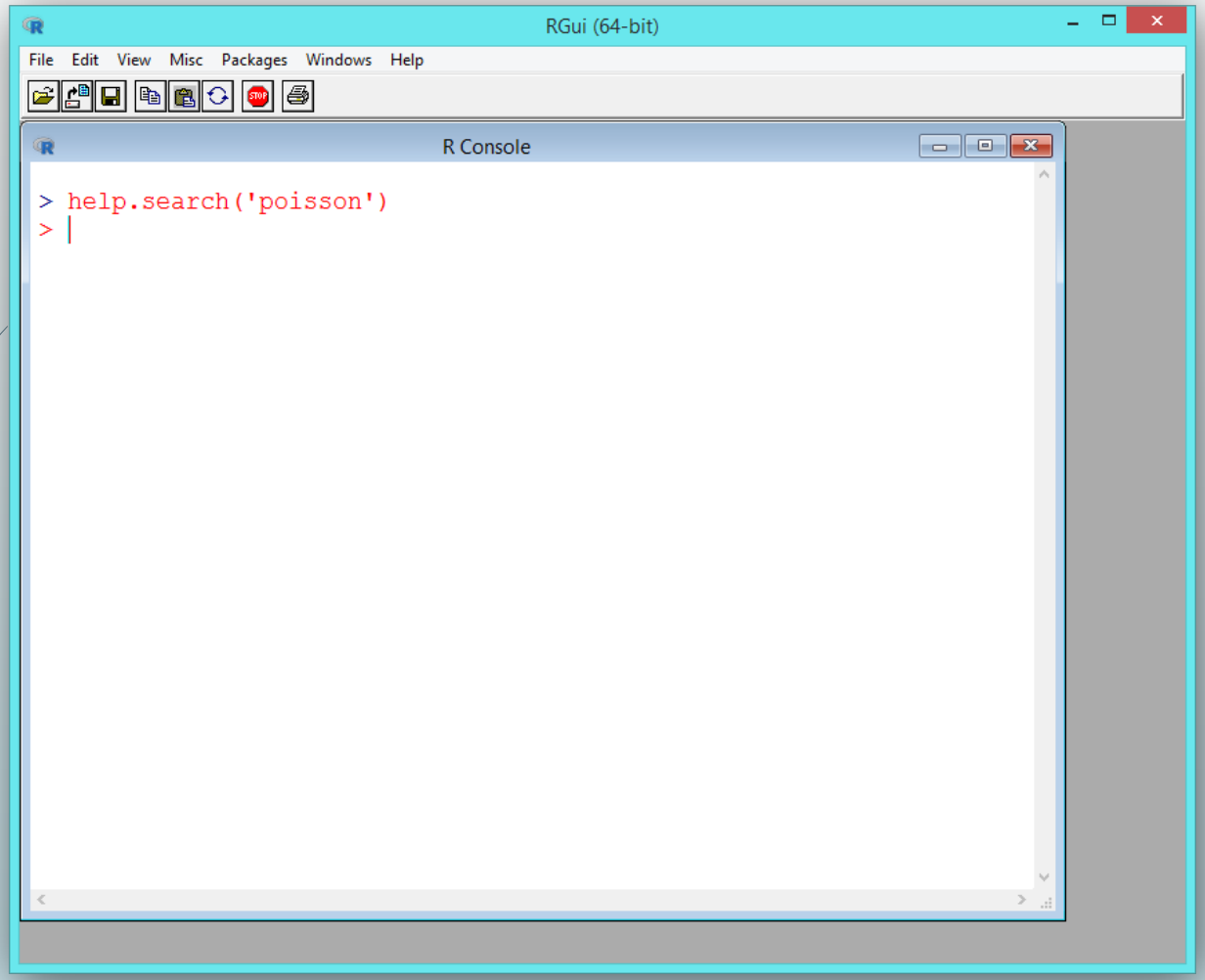
help.start()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> help.start()
If nothing happens, you should open
'http://127.0.0.1:22767/doc/html/index.html' yourself
>

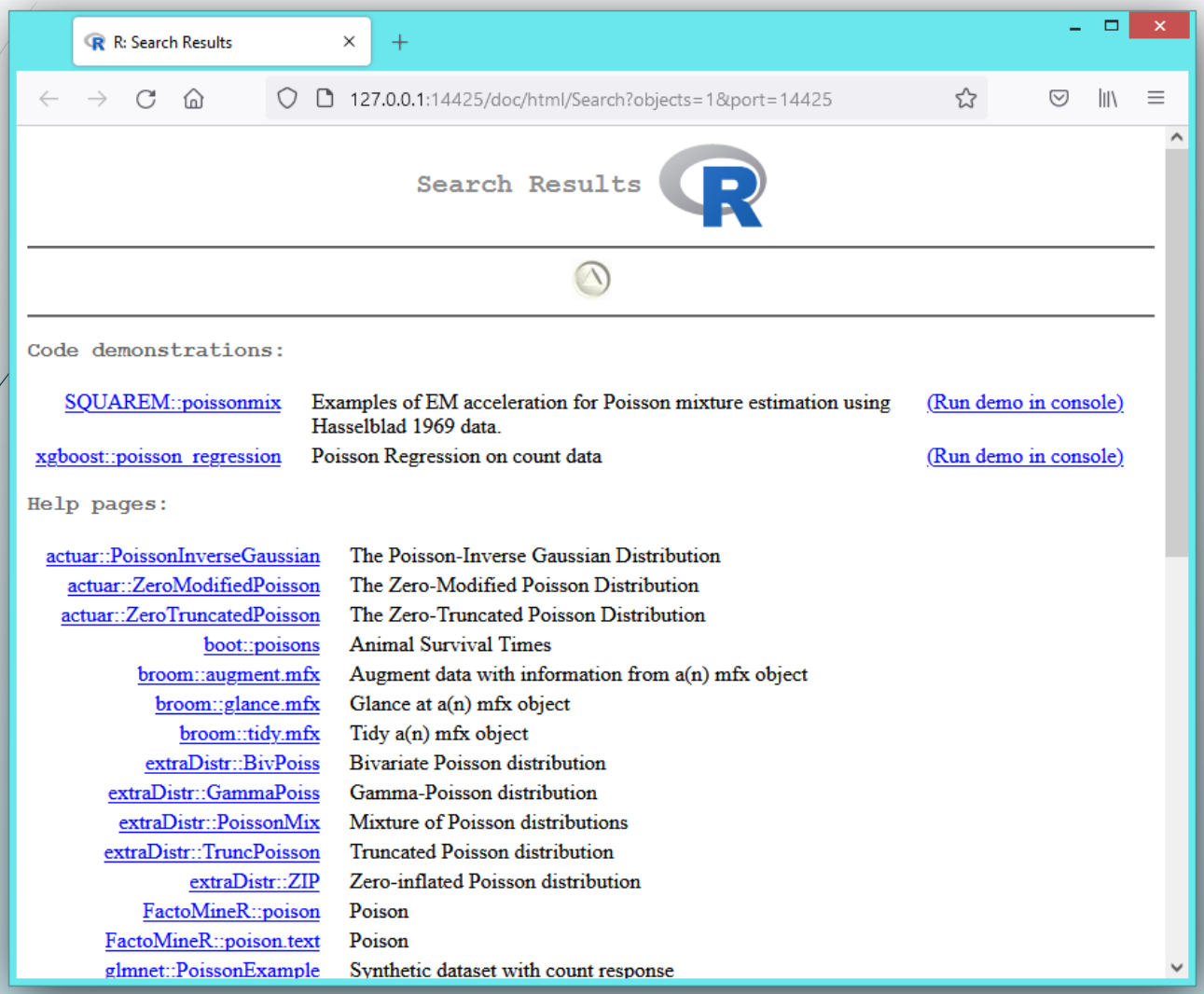
help.start()


The R Language
127.0.0.1:14425/doc/html/index.html
Statistical Data Analysis
Manuals
An Introduction to R
Writing R Extensions
R Data Import/Export
The R Language Definition
R Installation and Administration
R Internals
Reference
Packages
Search Engine & Keywords
Miscellaneous Material
About R
License
NEWS
Authors
Frequently Asked Questions
User Manuals
Resources
Thanks
Technical papers
Material specific to the Windows port
CHANGES up to R 2.15.0
Windows FAQ

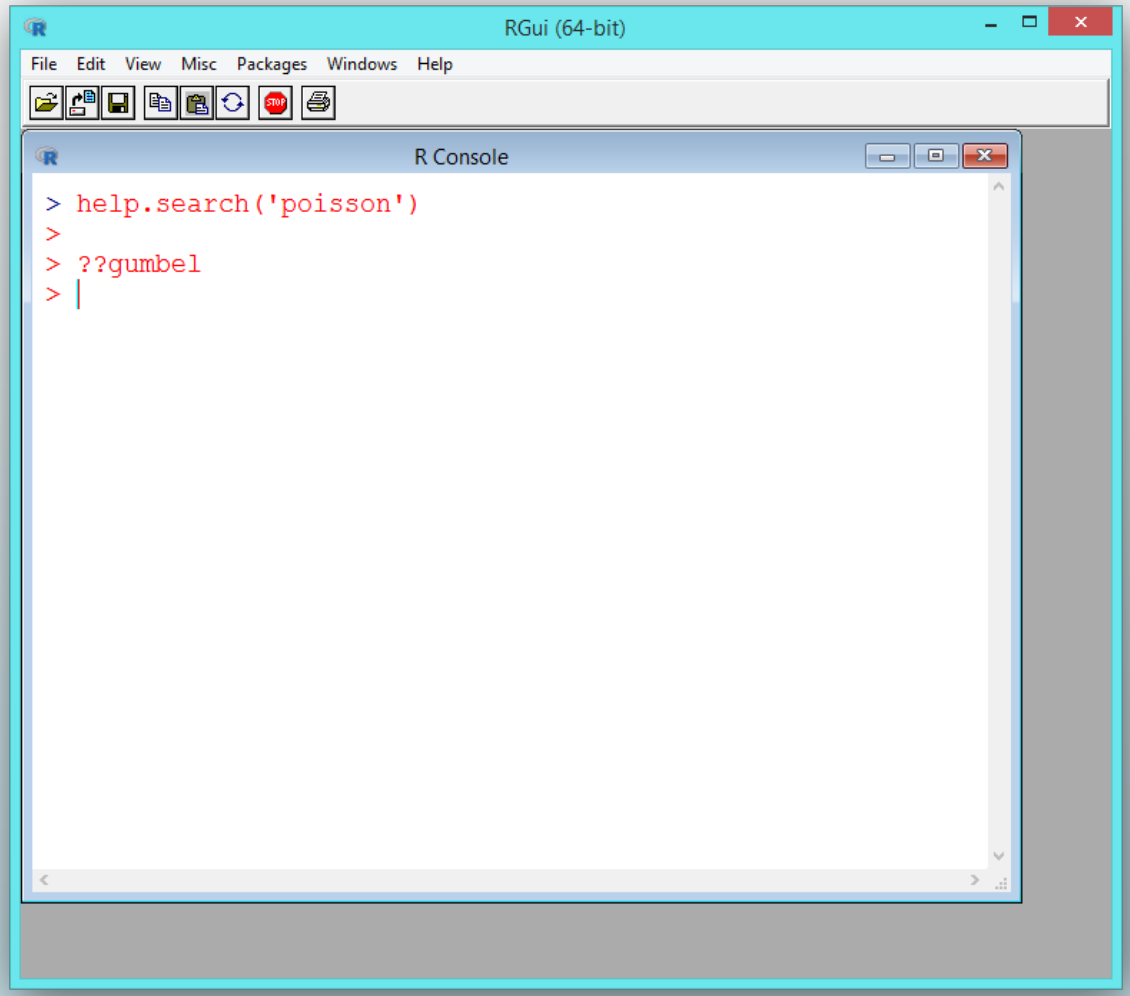
help.search()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> help.search('poisson')
>

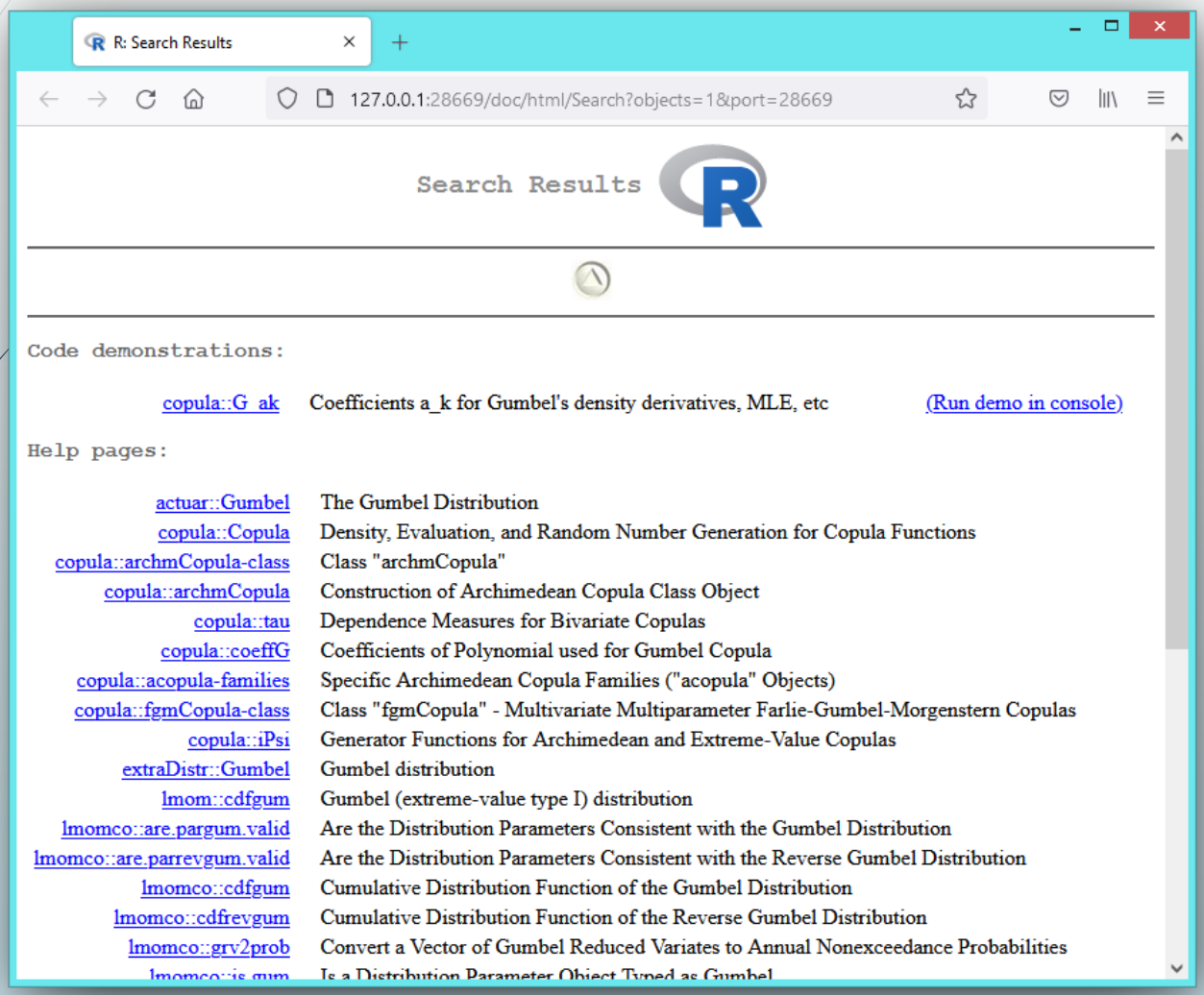
help.search()


R: Search Results
127.0.0.1:14425/doc/html/Search?objects=1&port=14425
Search Results
Code demonstrations:
SQUAREM::poissonmix
Examples of EM acceleration for Poisson mixture estimation using Hasselblad 1969 data.
(Run demo in console)
xgboost::poisson_regression
Poisson Regression on count data
(Run demo in console)
Help pages:
actuar::PoissonInverseGaussian
The Poisson-Inverse Gaussian Distribution
actuar::ZeroModifiedPoisson
The Zero-Modified Poisson Distribution
actuar::ZeroTruncatedPoisson
The Zero-Truncated Poisson Distribution
boot::poisons
Animal Survival Times
broom::augment.mfx
Augment data with information from a(n) mfx object
broom::glance.mfx
Glance at a(n) mfx object
broom::tidy.mfx
Tidy a(n) mfx object
extraDistr::BivPoiss
Bivariate Poisson distribution
extraDistr::GammaPoiss
Gamma-Poisson distribution
extraDistr::PoissonMix
Mixture of Poisson distributions
extraDistr::TruncPoisson
Truncated Poisson distribution
extraDistr::ZIP
Zero-inflated Poisson distribution
FactoMineR::poison
Poison
FactoMineR::poison.text
Poison
glmnet::PoissonExample
Synthetic dataset with count response

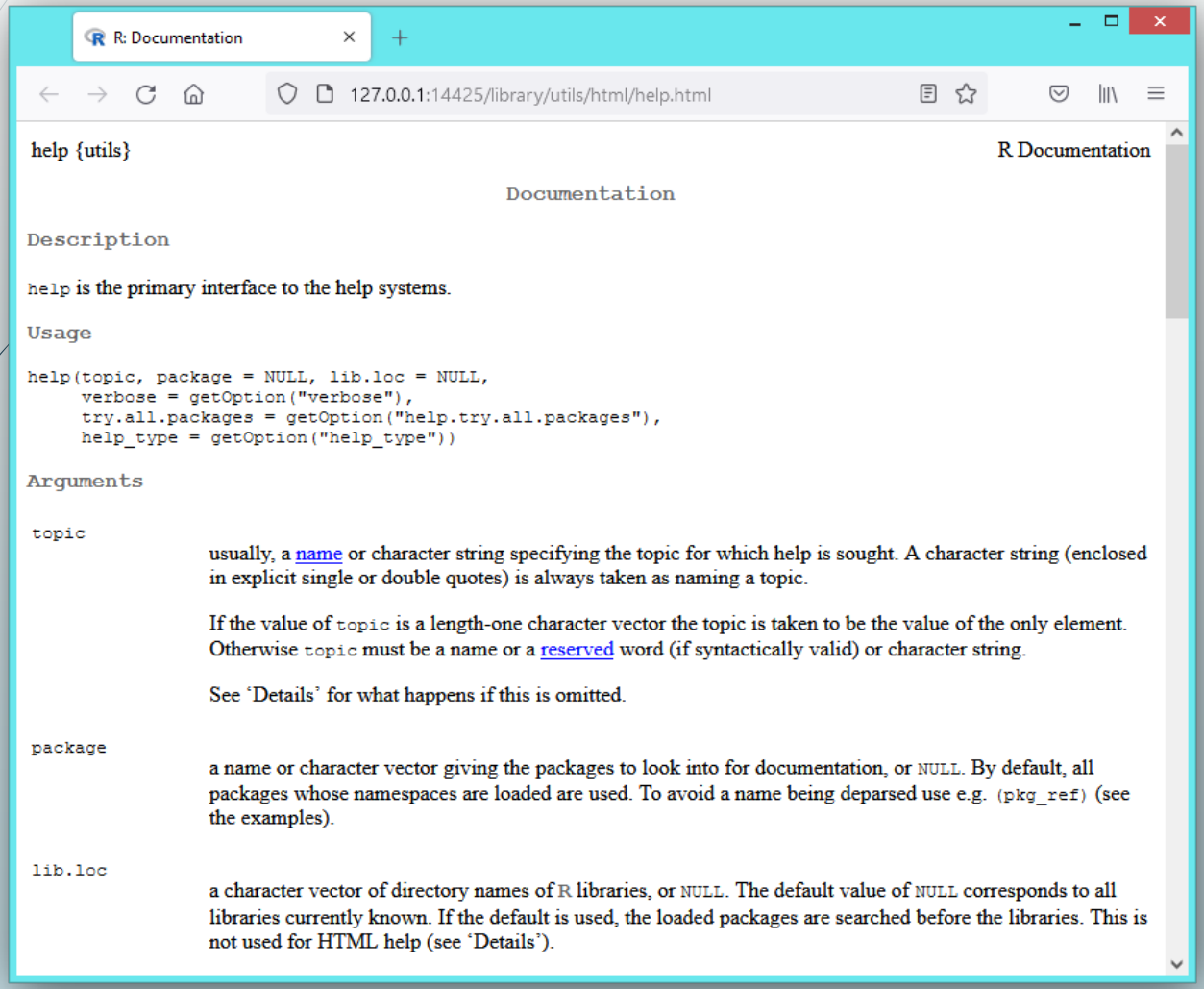
help.search() and ??



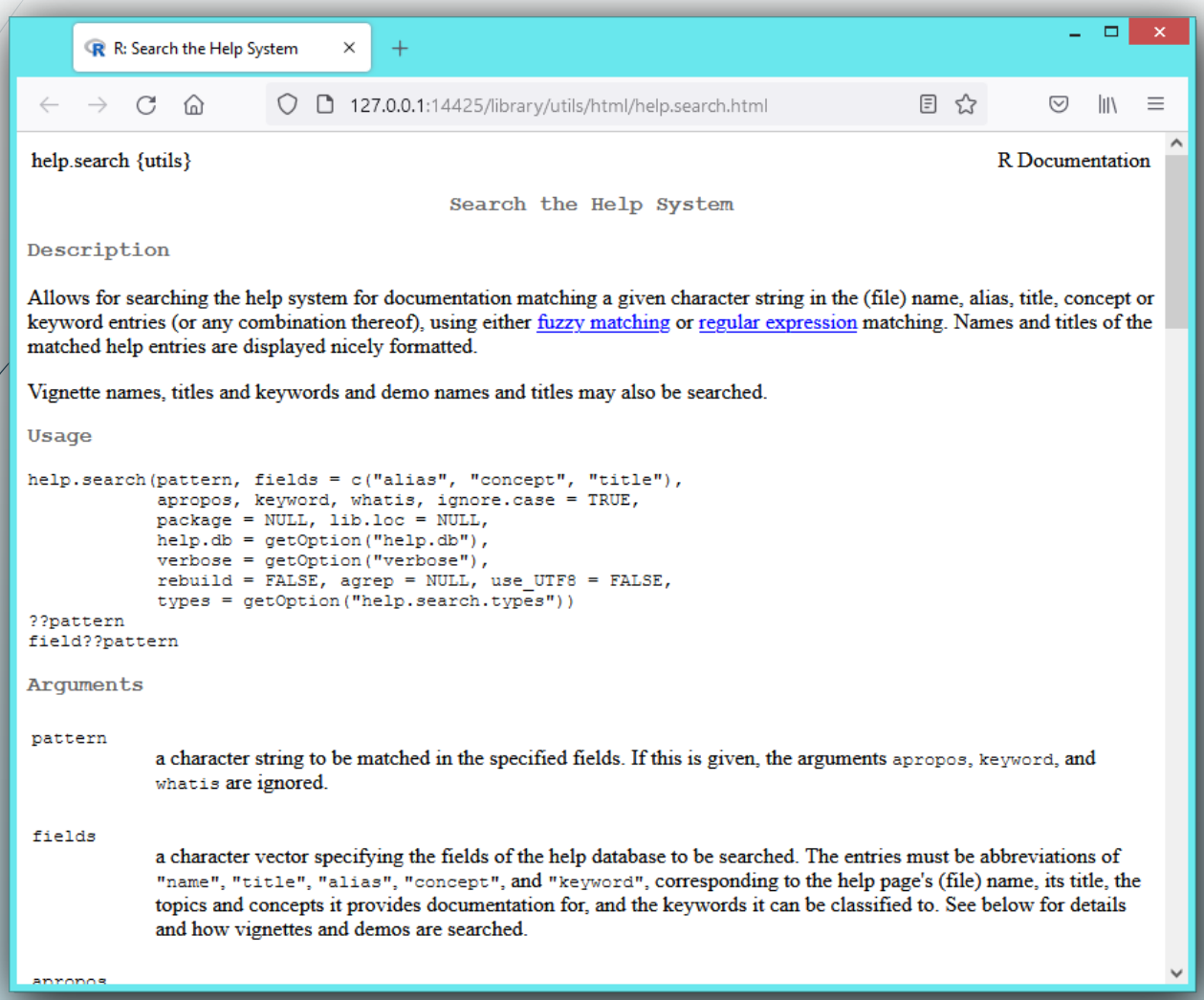
help.search() and ??



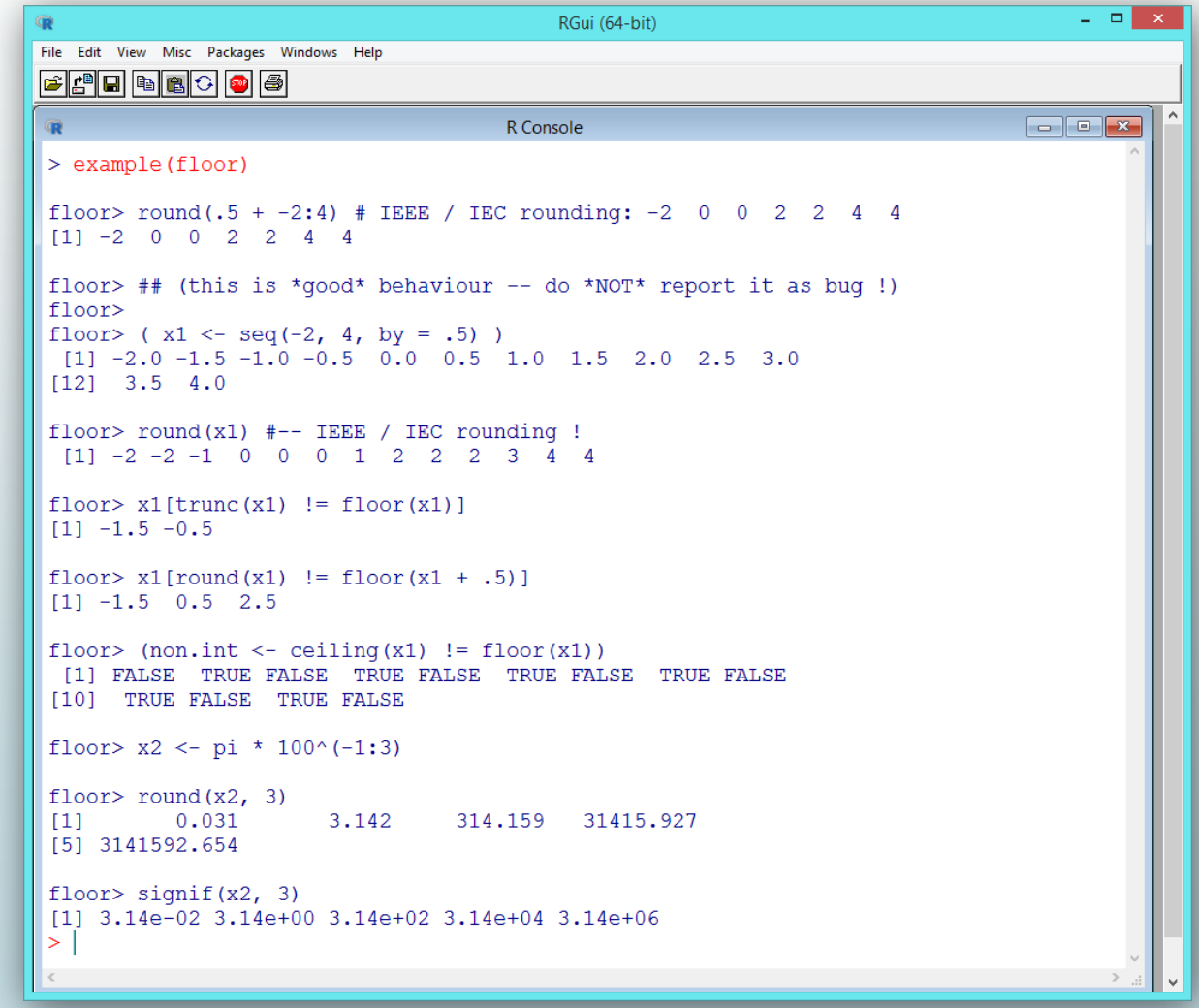
?help.search and ?help



?help.search and ?help



example()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> example(floor)
floor> round(.5 + -2:4) # IEEE / IEC rounding: -2 0 0 2 2 4 4
[1] -2 0 0 2 2 4 4
floor> ## (this is *good* behaviour -- do *NOT* report it as bug !)
floor>
floor> (x1 <- seq(-2, 4, by = .5))
[1] -2.0 -1.5 -1.0 -0.5 0.0 0.5 1.0 1.5 2.0 2.5 3.0
[12] 3.5 4.0
floor> round(x1) #-- IEEE / IEC rounding !
[1] -2 -2 -1 0 0 0 1 2 2 2 3 4 4
floor> x1[trunc(x1) != floor(x1)]
[1] -1.5 -0.5
floor> x1[round(x1) != floor(x1 + .5)]
[1] -1.5 0.5 2.5
floor> (non.int <- ceiling(x1) != floor(x1))
[1] FALSE TRUE FALSE TRUE FALSE TRUE FALSE TRUE FALSE
[10] TRUE FALSE TRUE FALSE
floor> x2 <- pi * 100^(-1:3)
floor> round(x2, 3)
[1] 0.031 3.142 314.159 31415.927
[5] 3141592.654
floor> signif(x2, 3)
[1] 3.14e-02 3.14e+00 3.14e+02 3.14e+04 3.14e+06
>

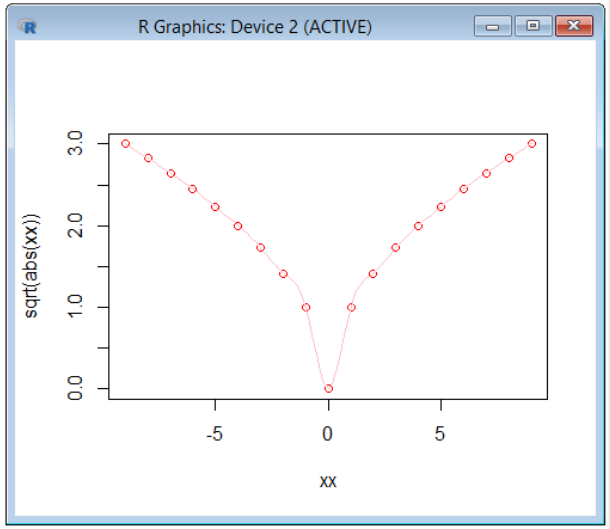
example()

RGui (64-bit)

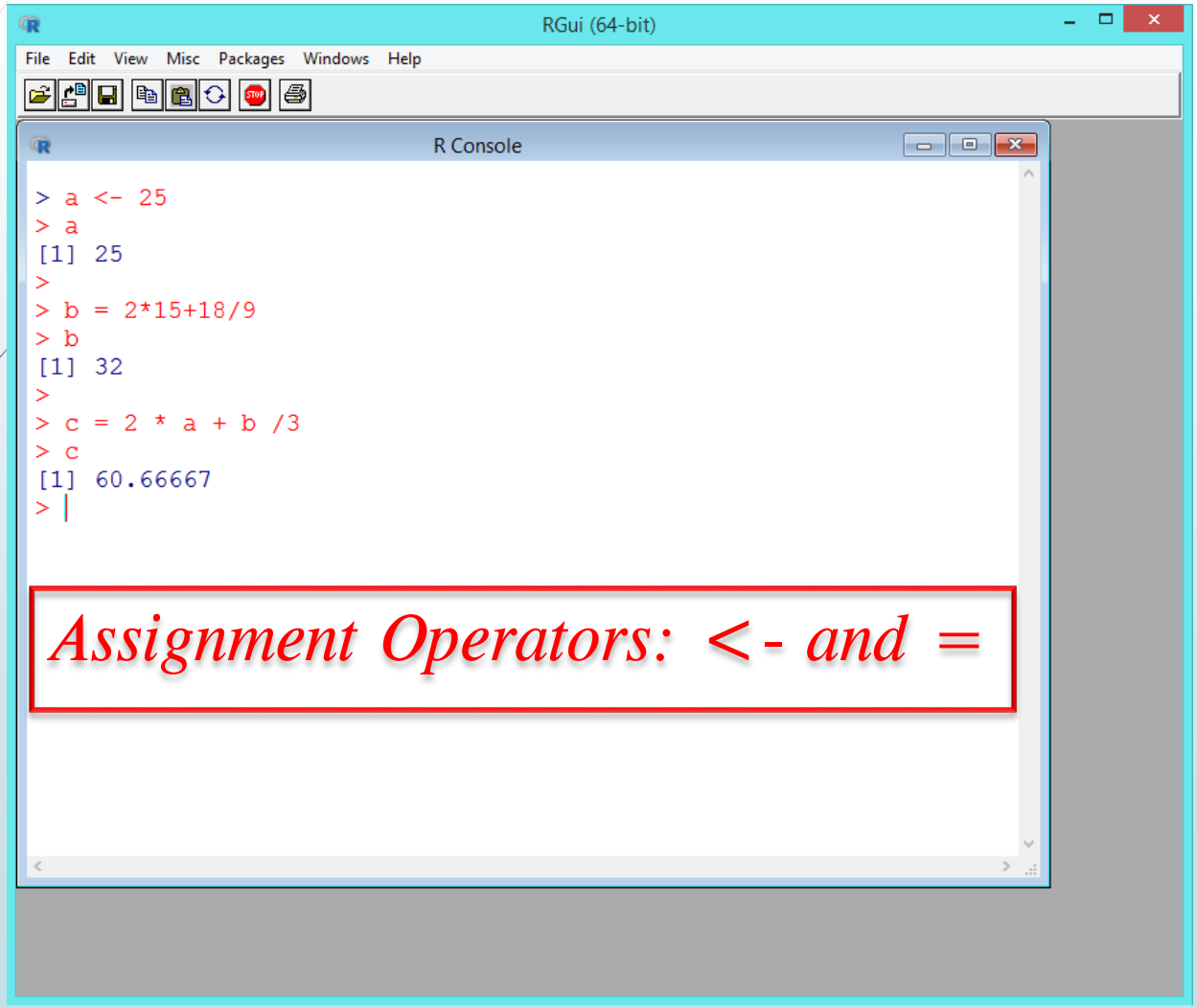
File History Resize Windows

R Console

```
> example(sqrt)

sqrt> require(stats) # for spline

sqrt> require(graphics)

sqrt> xx <- -9:9

sqrt> plot(xx, sqrt(abs(xx)),  col = "red")
Waiting to confirm page change...

sqrt> lines(spline(xx, sqrt(abs(xx)), n=101), col = "pink")
>
```



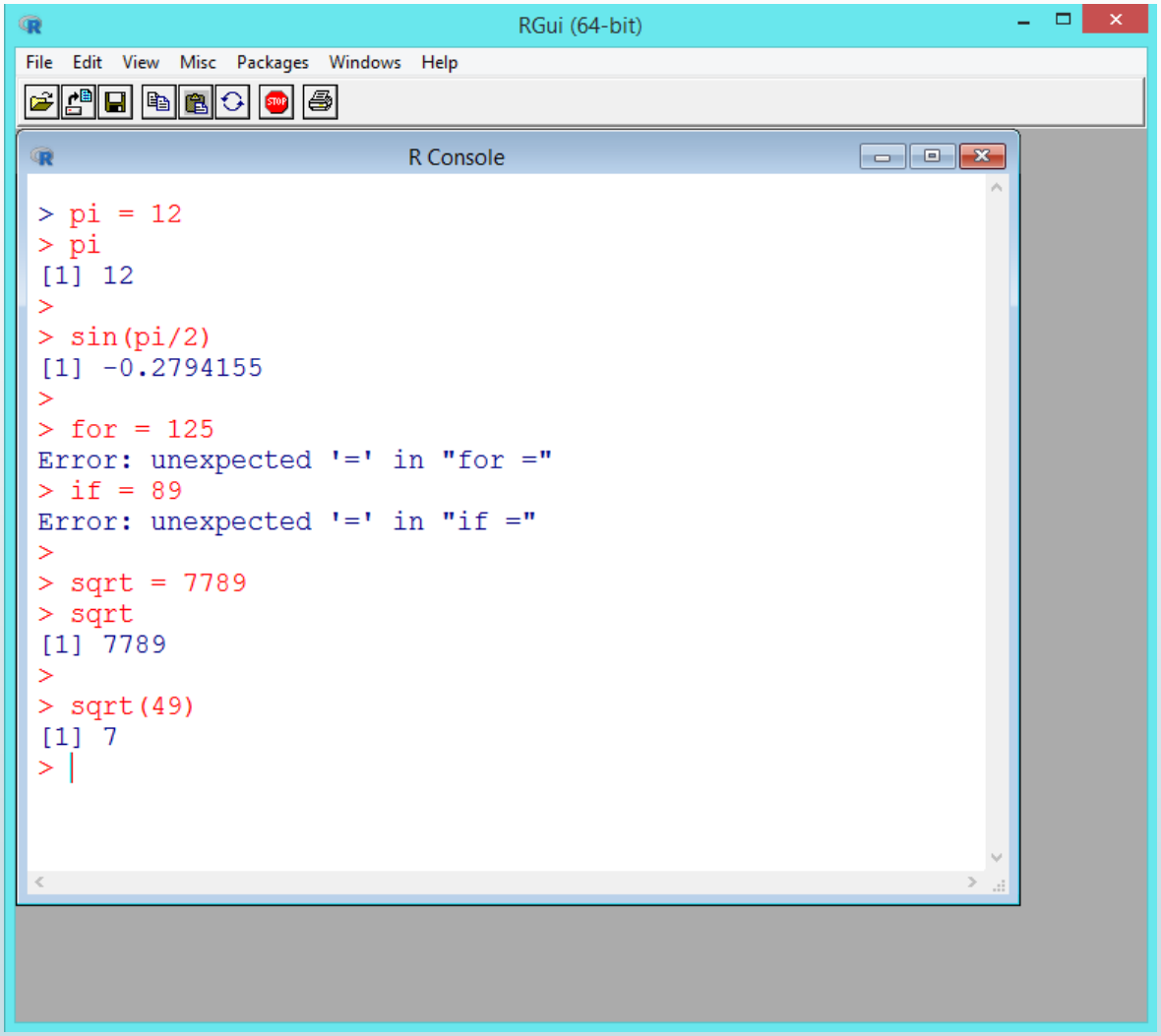
Assignment


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> a <- 25
> a
[1] 25
>
> b = 2*15+18/9
> b
[1] 32
>
> c = 2 * a + b /3
> c
[1] 60.66667
>
Assignment Operators: <- and =

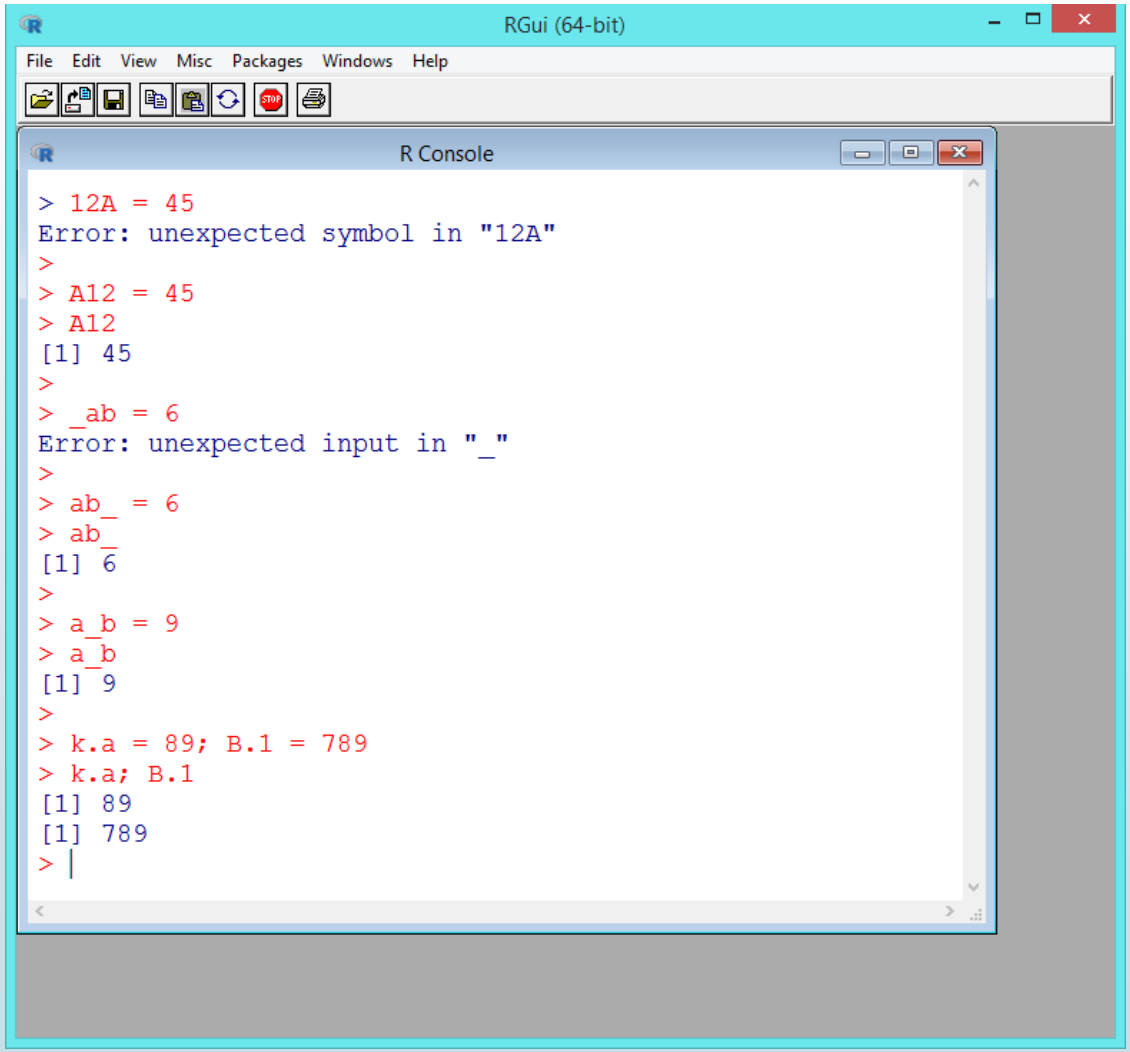
Assignment

- All alphanumeric symbols are allowed1 (and in some countries this includes accented letters) plus '.' and '_'.
- A name must start with '.' or a letter, and if it starts with '.' the second character must not be a digit.
- Names are effectively unlimited in length.

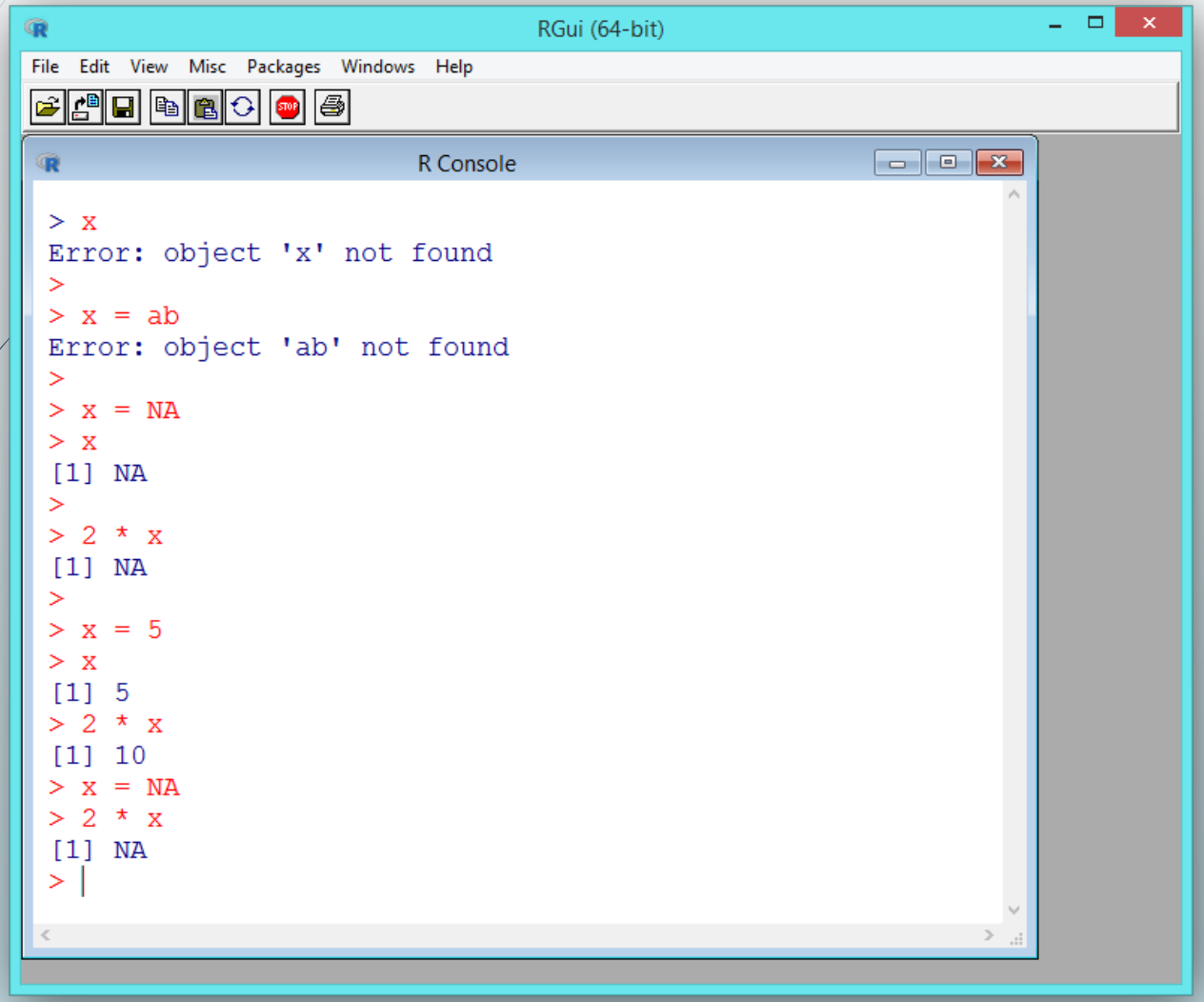
Assignment


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> pi = 12
> pi
[1] 12
>
> sin(pi/2)
[1] -0.2794155
>
> for = 125
Error: unexpected '=' in "for ="
> if = 89
Error: unexpected '=' in "if ="
>
> sqrt = 7789
> sqrt
[1] 7789
>
> sqrt(49)
[1] 7
>

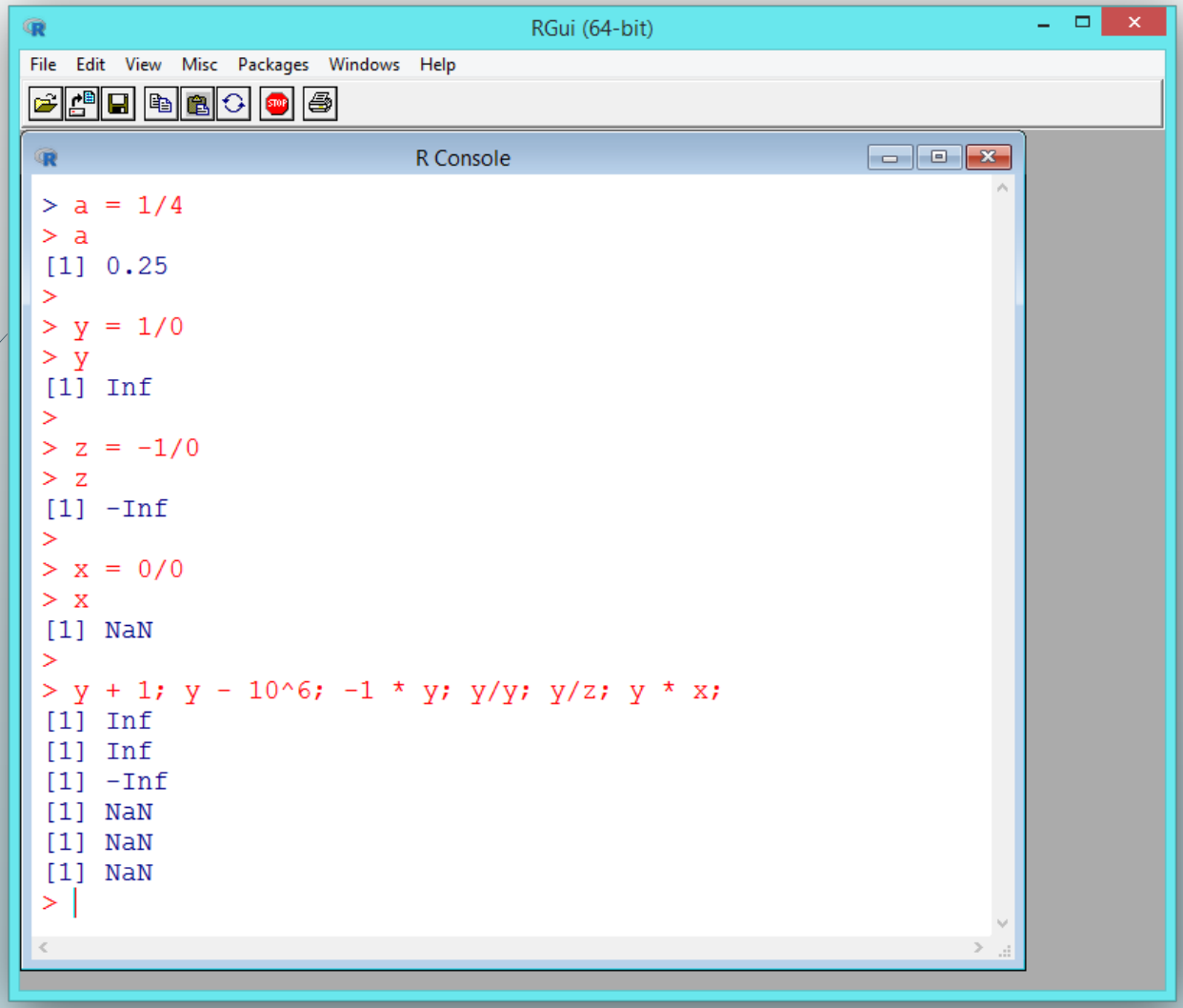
Assignment


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> 12A = 45
Error: unexpected symbol in "12A"
>
> A12 = 45
> A12
[1] 45
>
> _ab = 6
Error: unexpected input in "_"
>
> ab_ = 6
> ab_
[1] 6
>
> a_b = 9
> a_b
[1] 9
>
> k.a = 89; B.1 = 789
> k.a; B.1
[1] 89
[1] 789
>

Missing values or NA

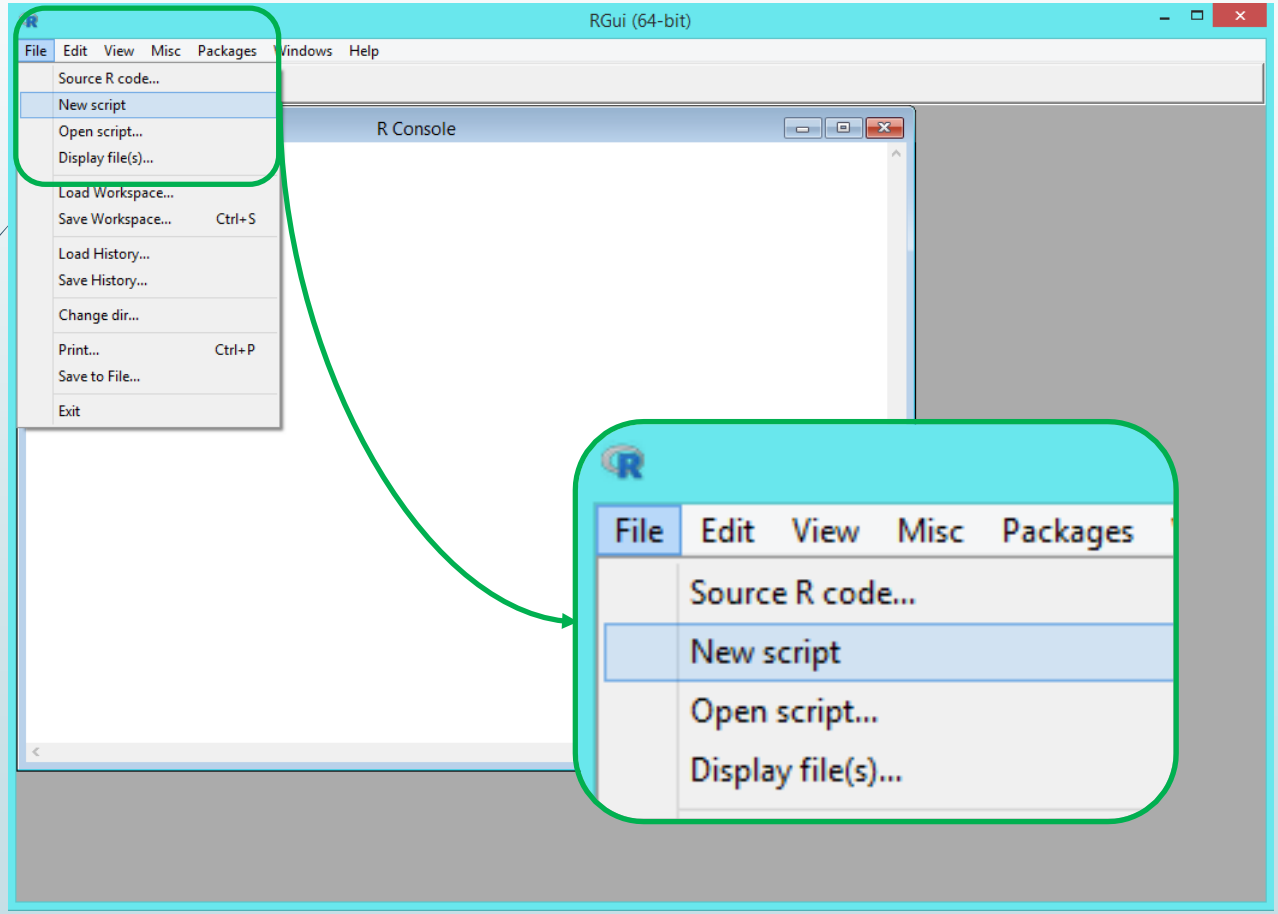


NaN and Inf


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> a = 1/4
> a
[1] 0.25
>
> y = 1/0
> y
[1] Inf
>
> z = -1/0
> z
[1] -Inf
>
> x = 0/0
> x
[1] NaN
>
> y + 1; y - 10^6; -1 * y; y/y; y/z; y * x;
[1] Inf
[1] Inf
[1] -Inf
[1] NaN
[1] NaN
[1] NaN
>

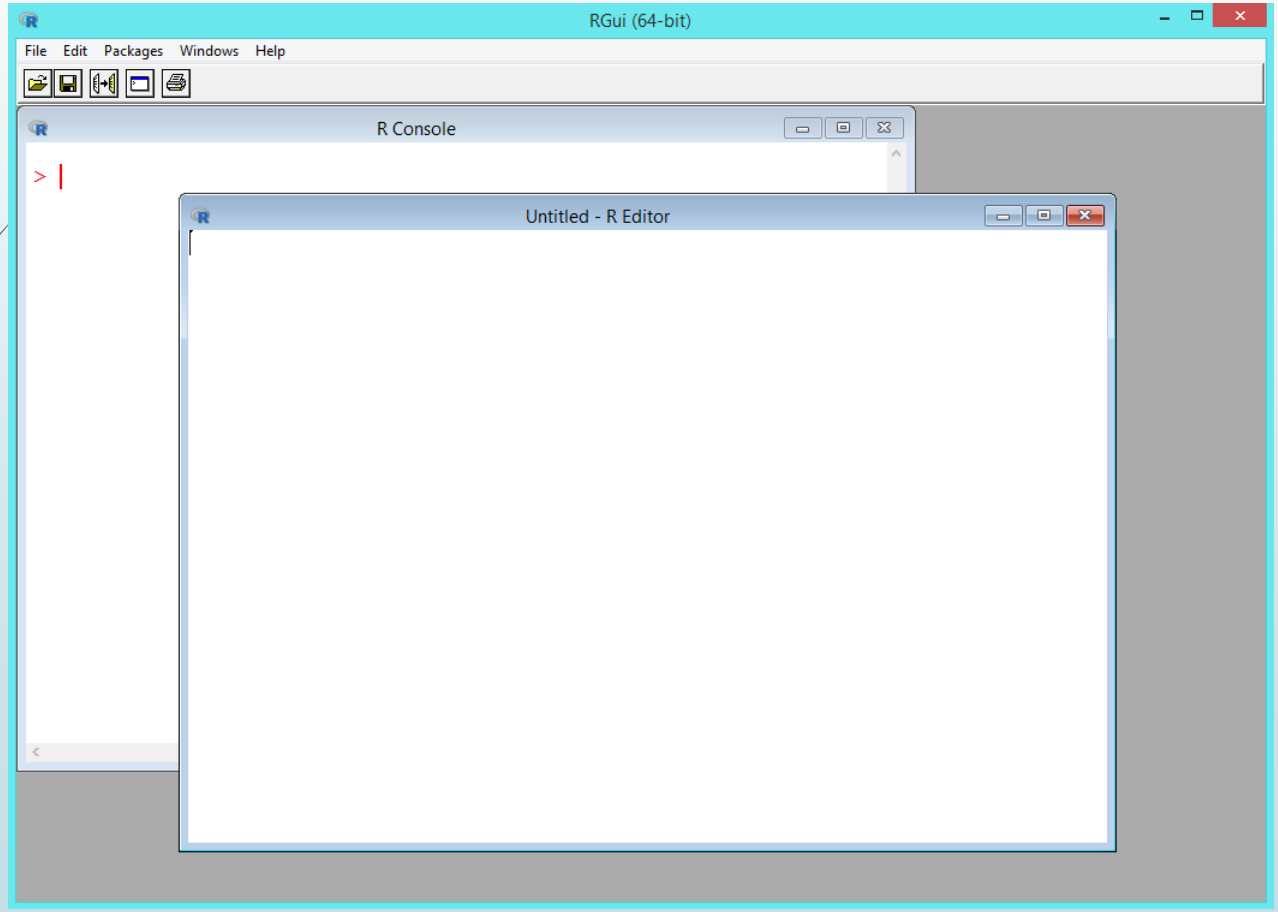
R Editor and Scripts

- Creating a New Script



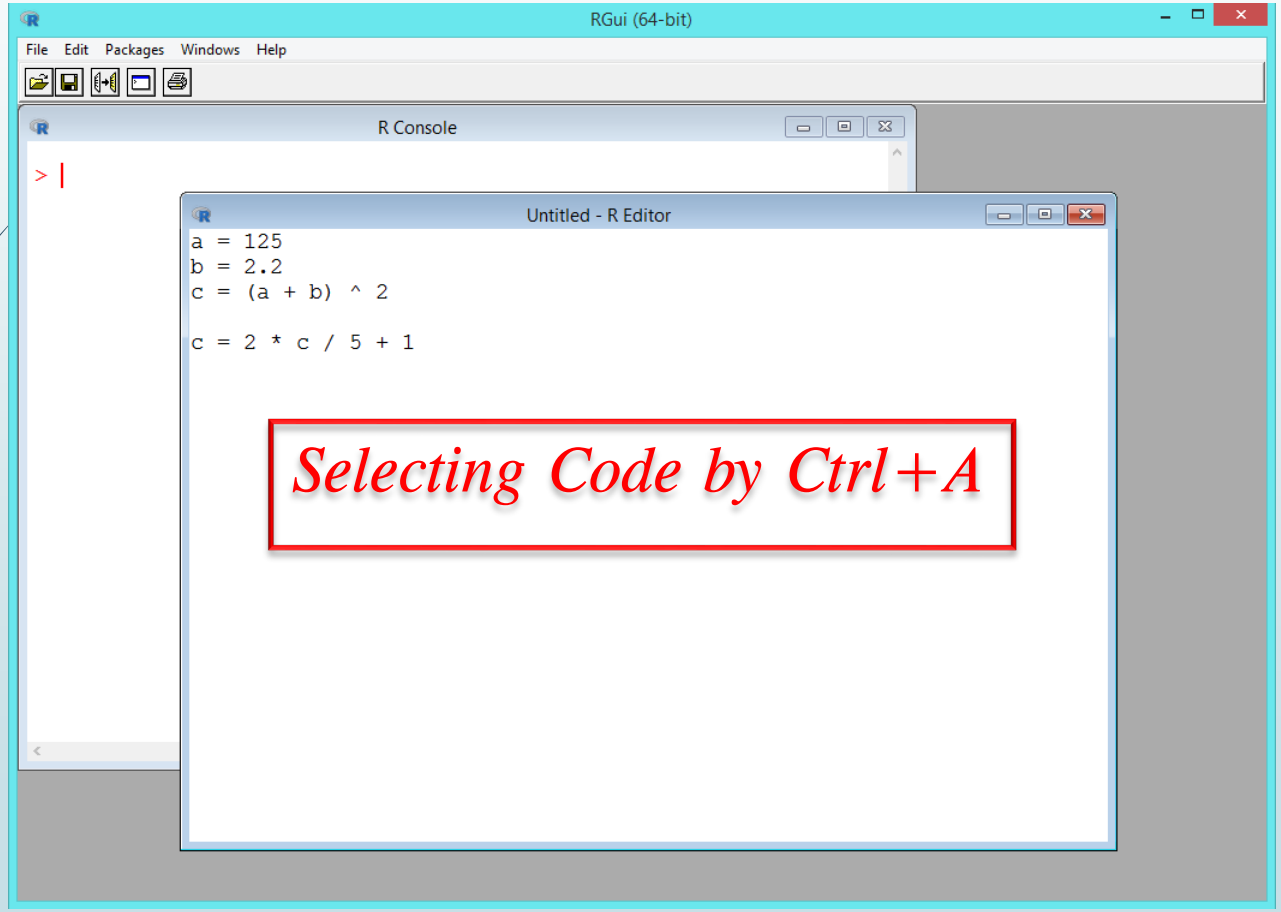
R Editor and Scripts

- Creating a New Script (1)



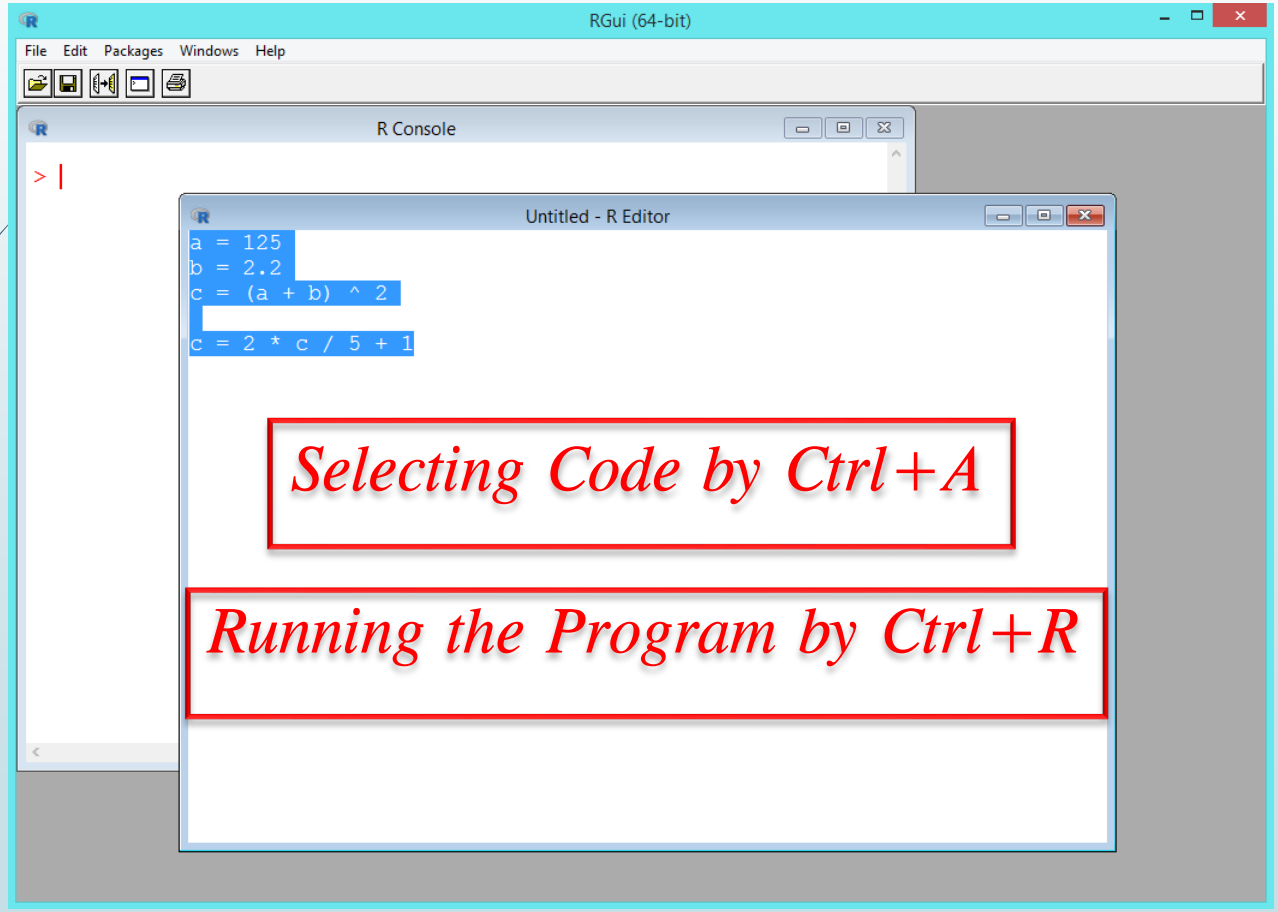
R Editor and Scripts

- Creating a New Script (2)



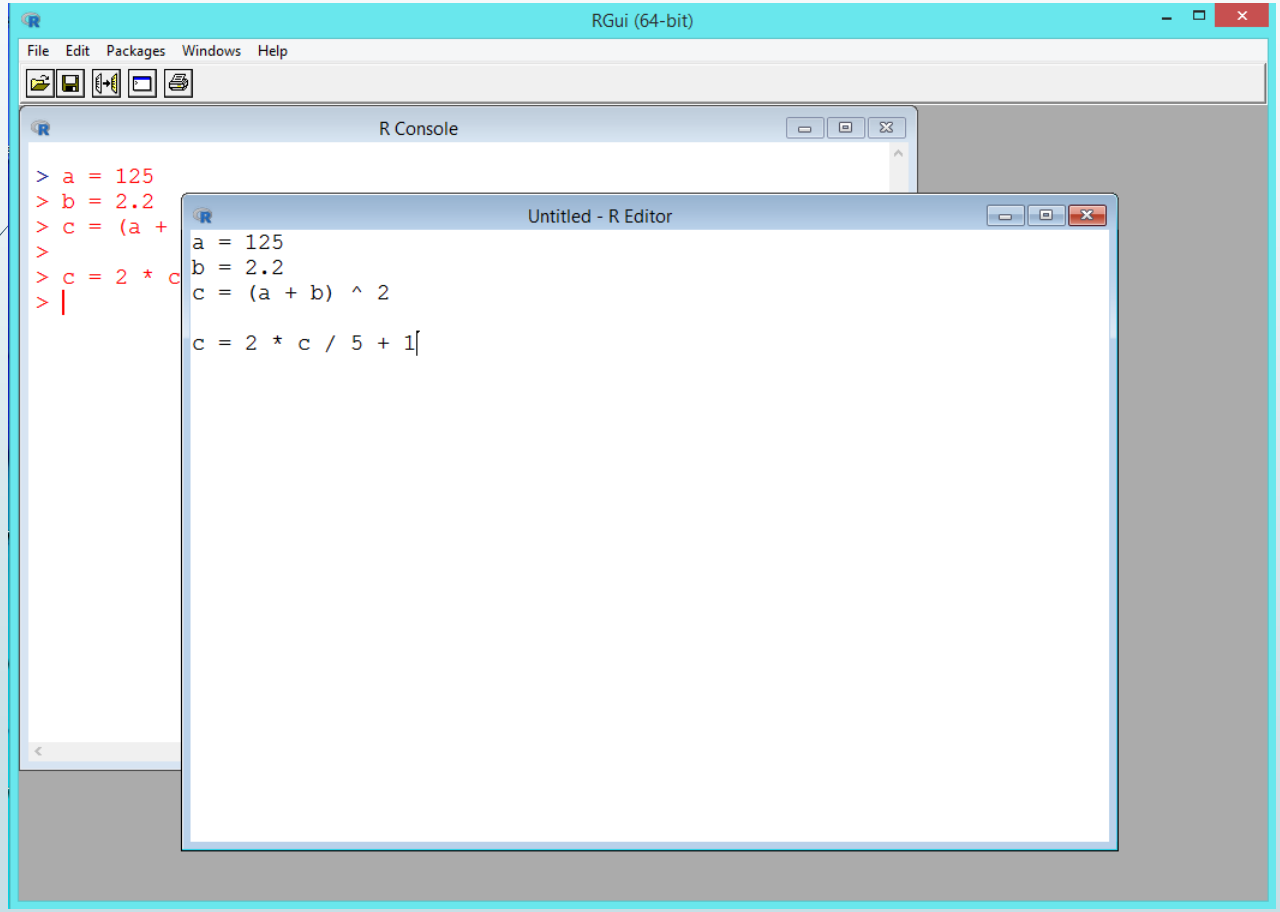
R Editor and Scripts

- Running a Program (1)



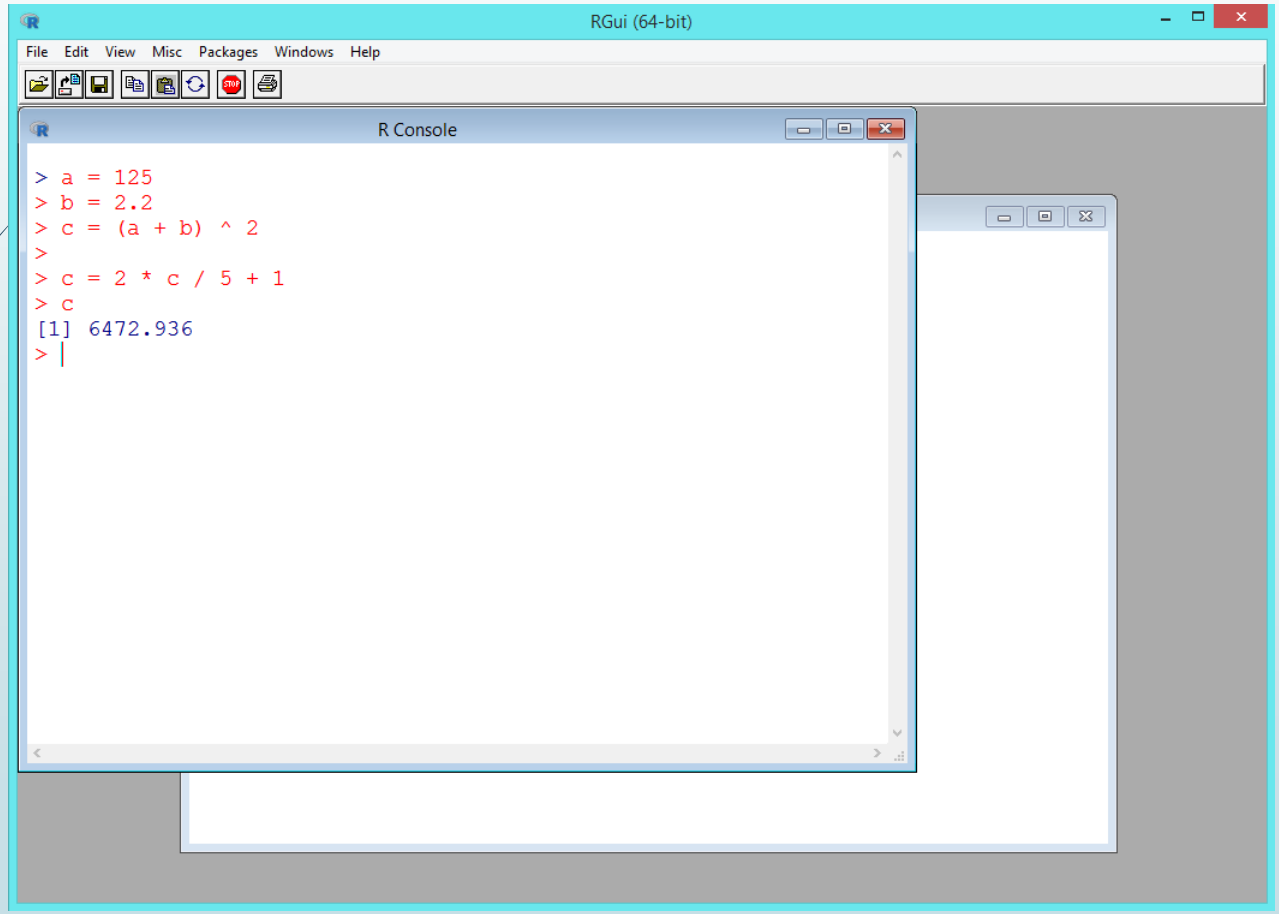
R Editor and Scripts

- Running a Program (2)



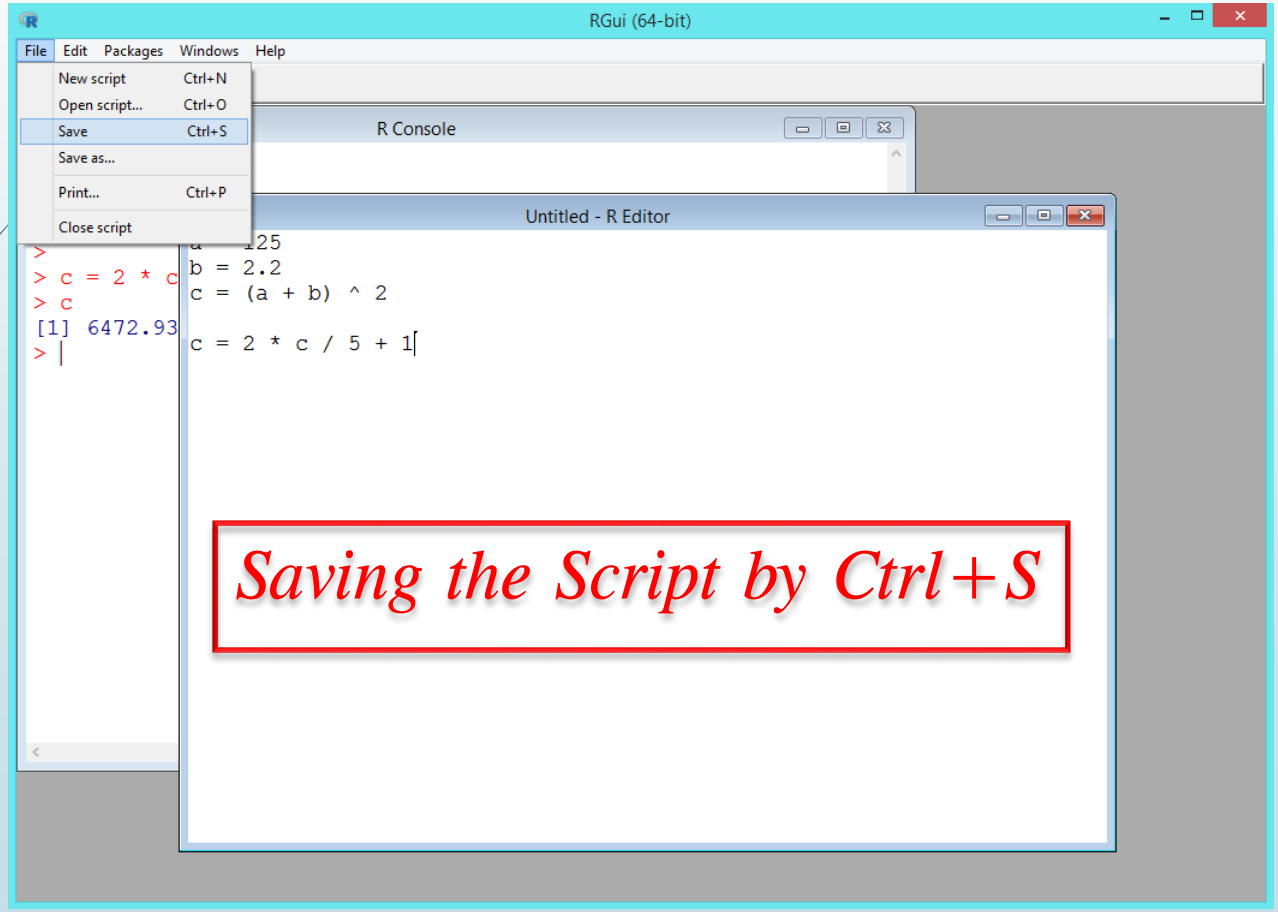
R Editor and Scripts

- Running a Program (3)



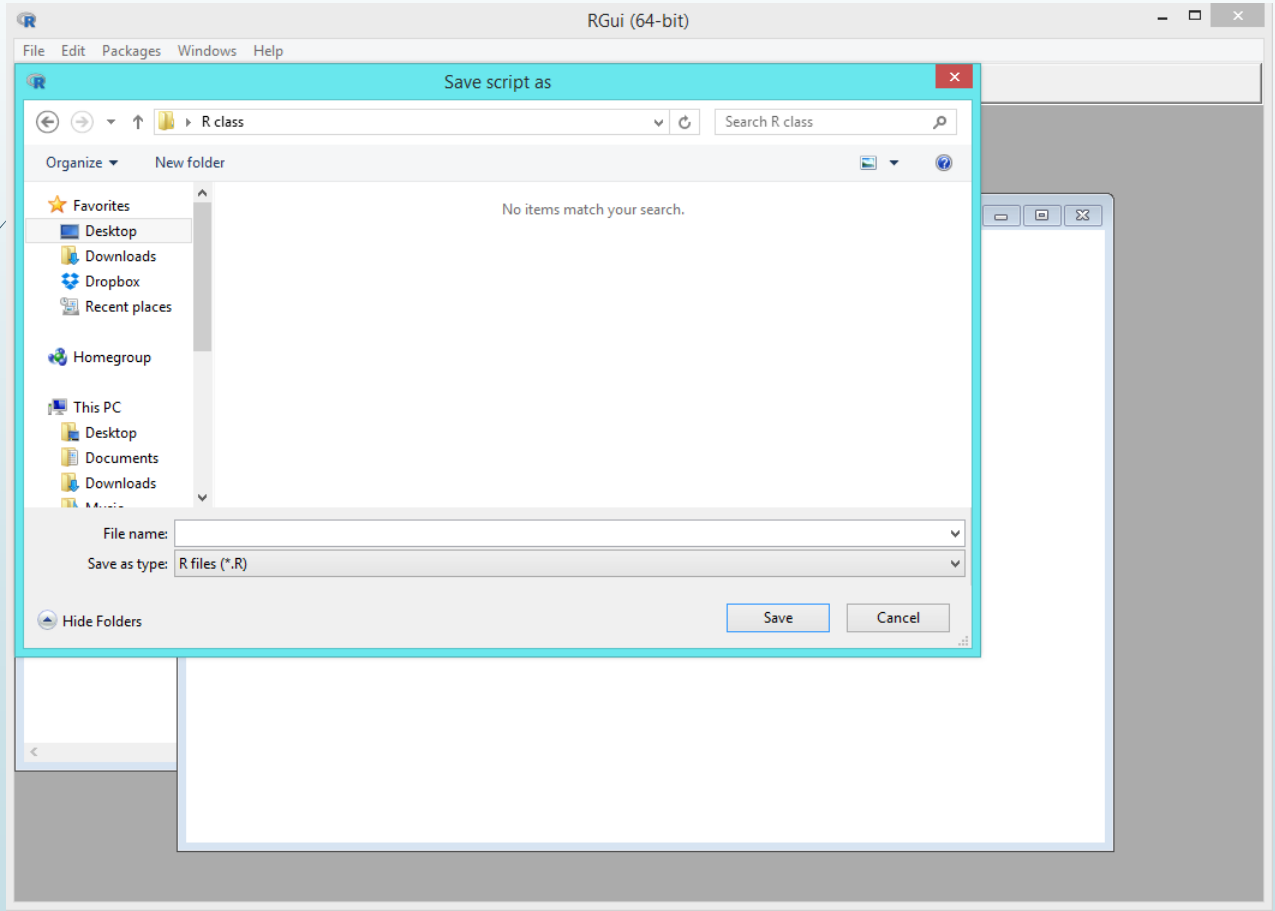
R Editor and Scripts

- Saving a Script (1)



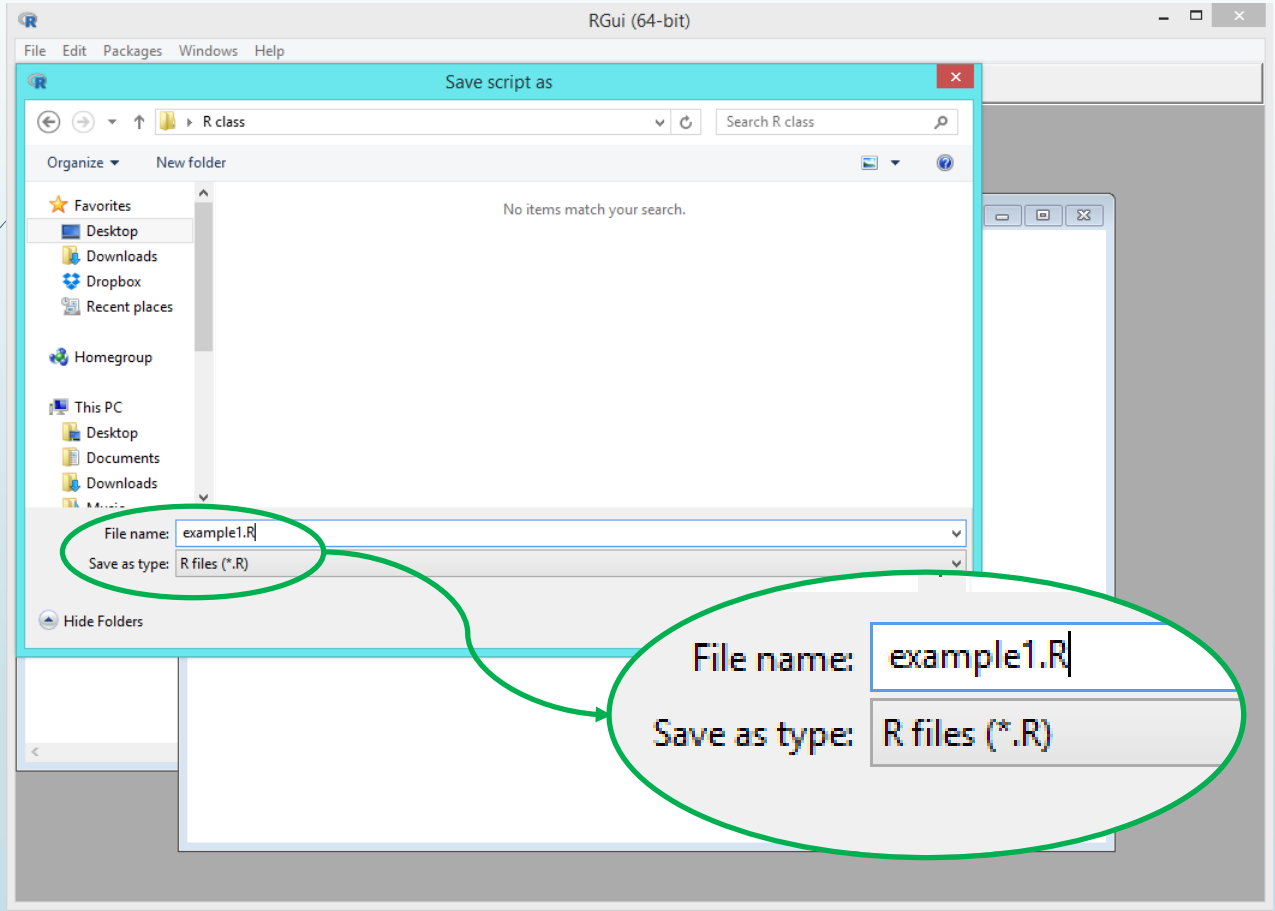
R Editor and Scripts

- Saving a Script (2)



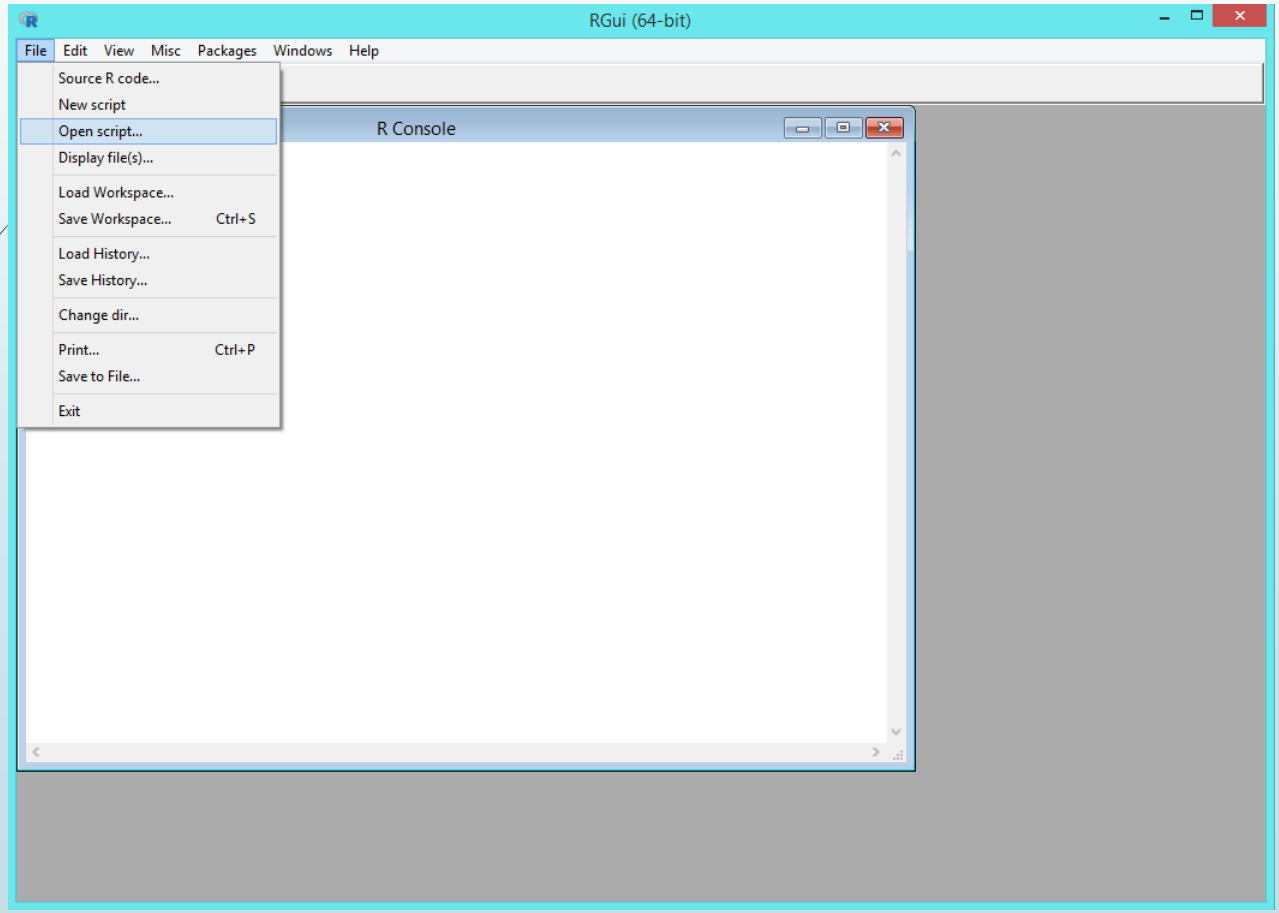
R Editor and Scripts

Saving a Script (3)



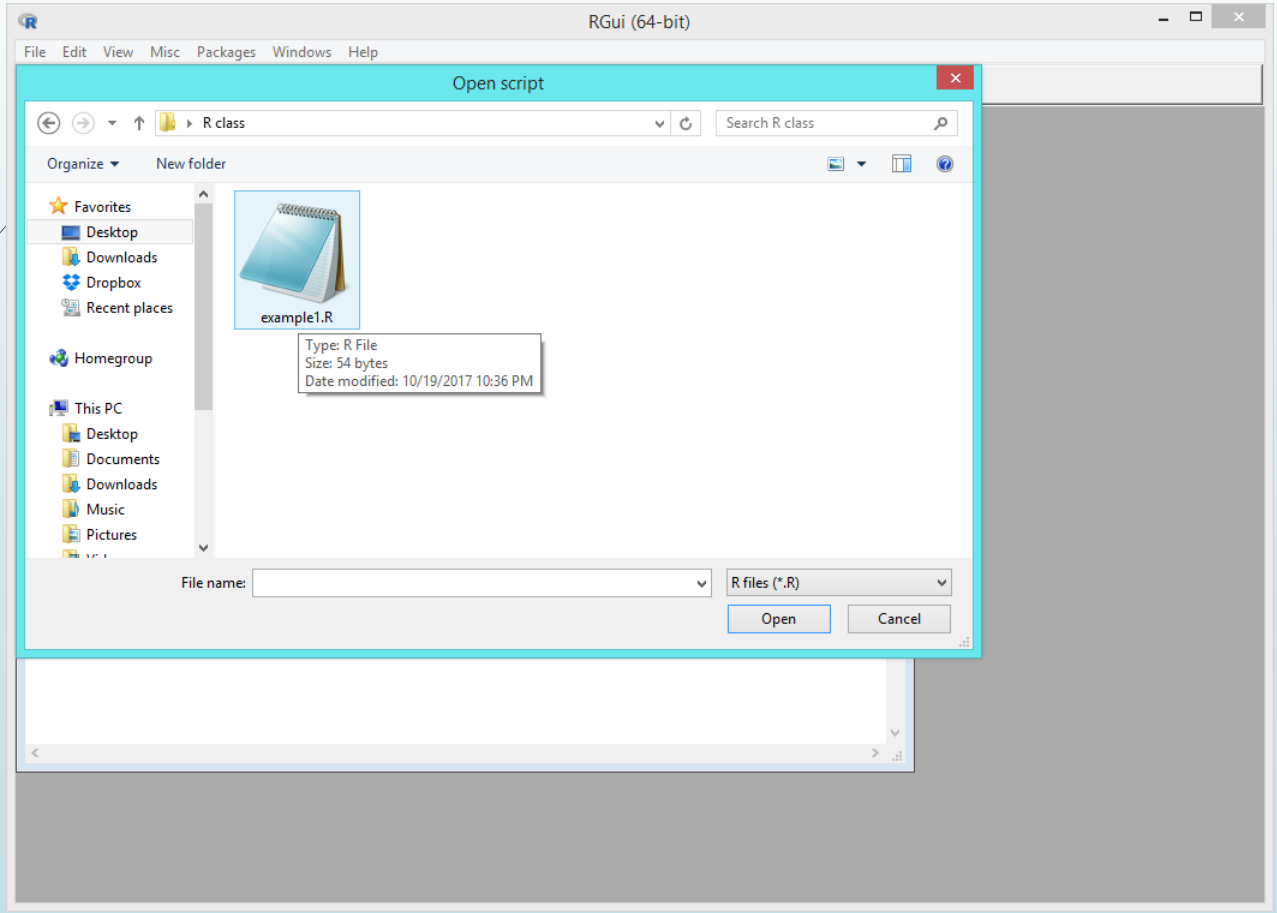
R Editor and Scripts

- Opening a Script (1)



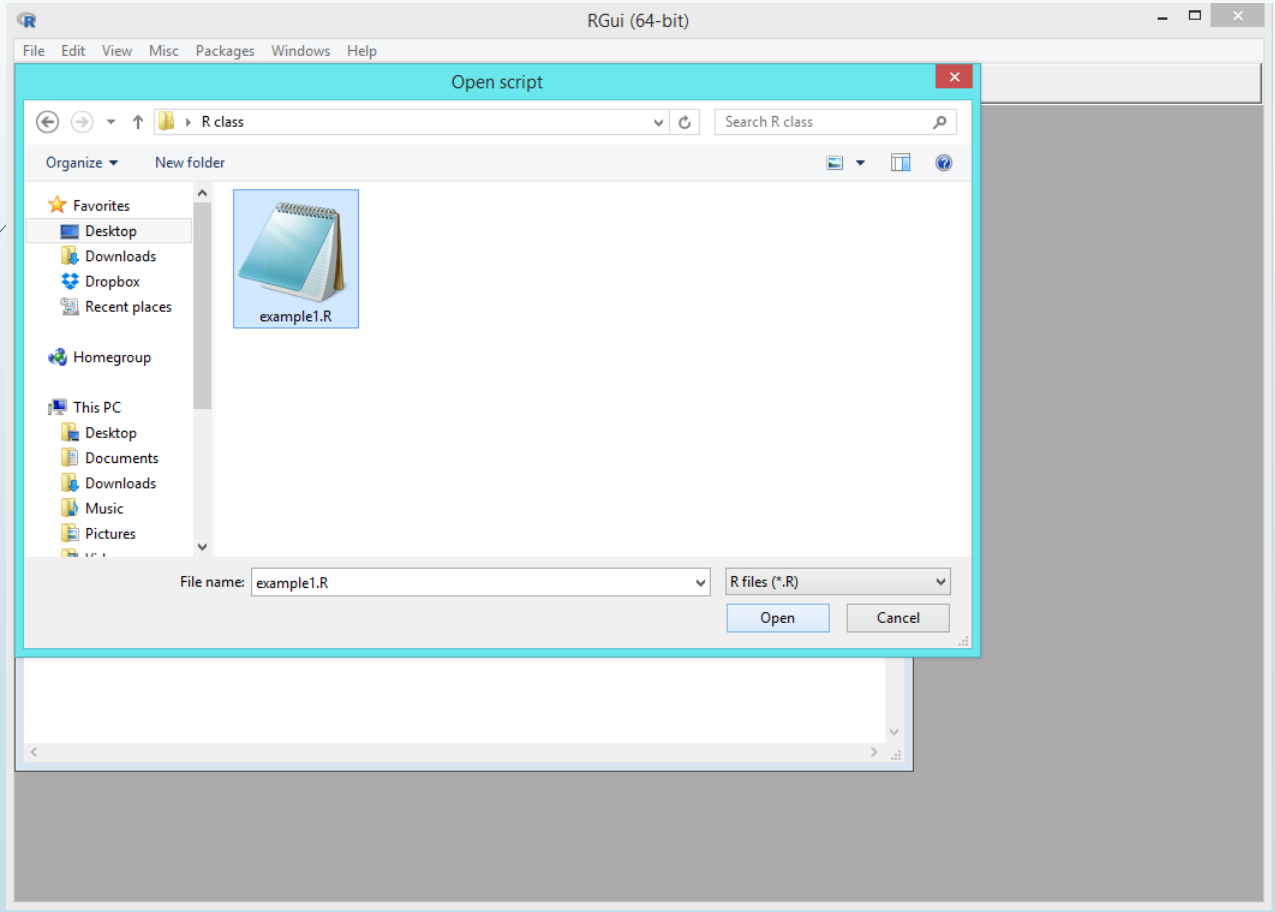
R Editor and Scripts

- Opening a Script (2)



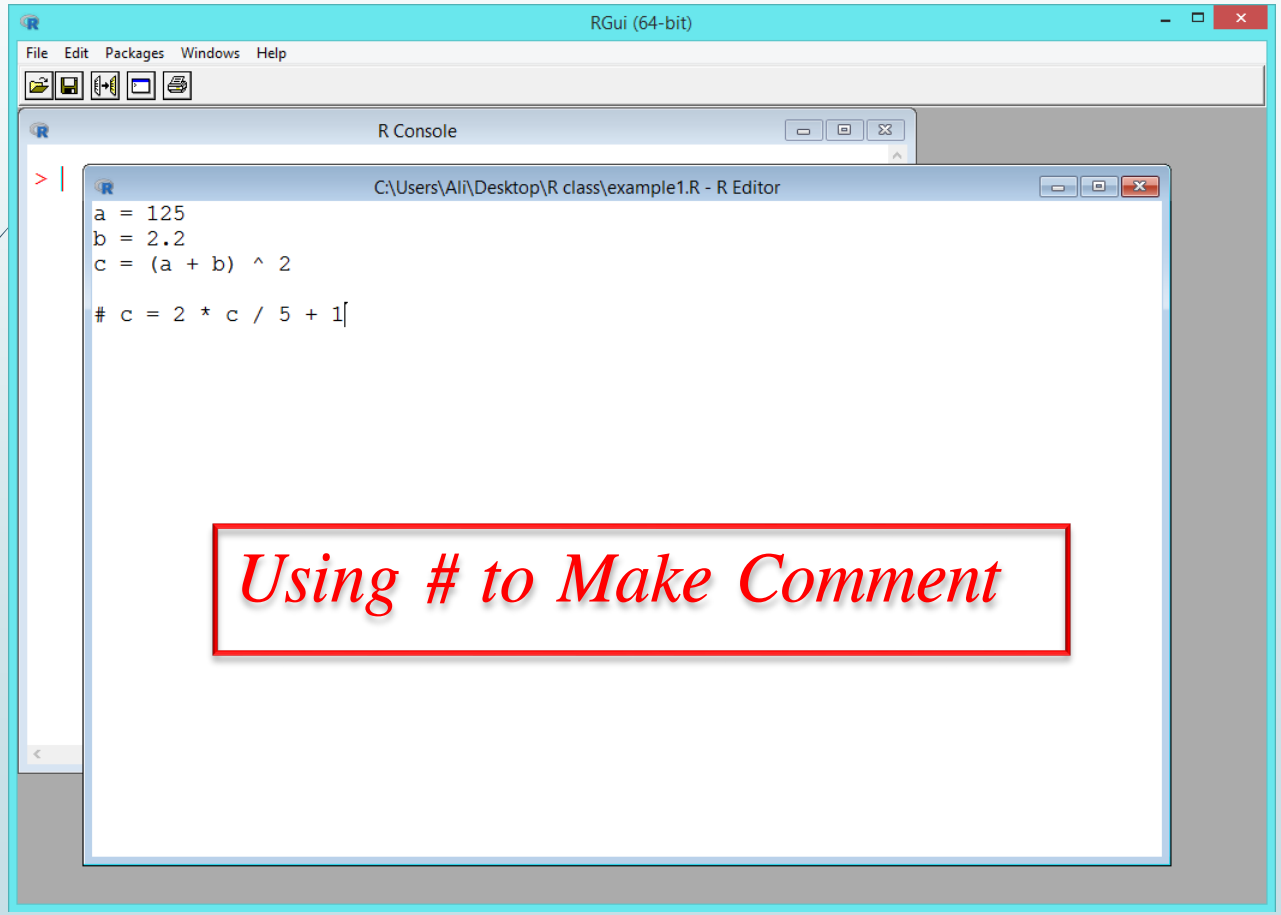
R Editor and Scripts

- Opening a Script (3)



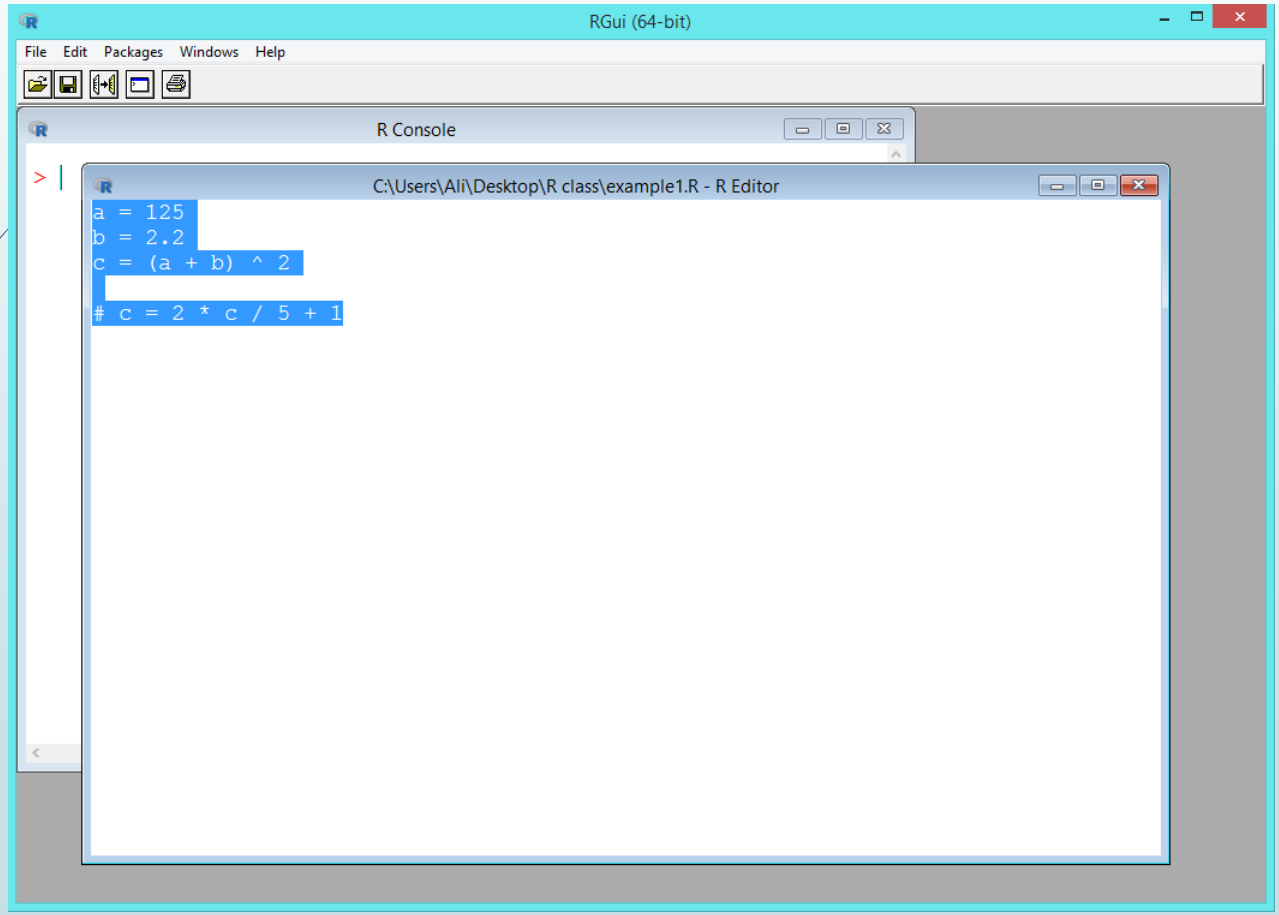
Comment

- Making a Command Inactive (1)



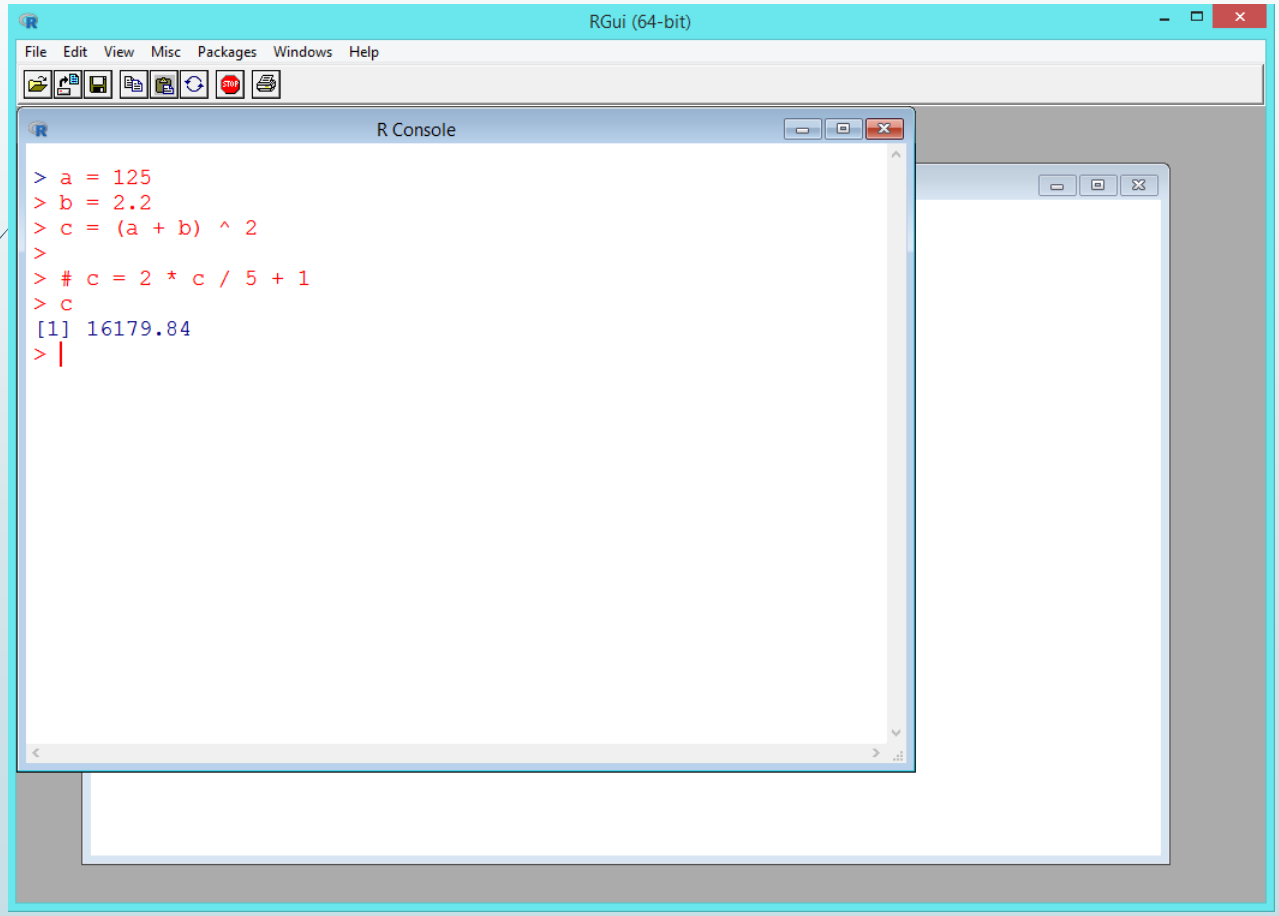
Comment

- Making a Command Inactive (2)



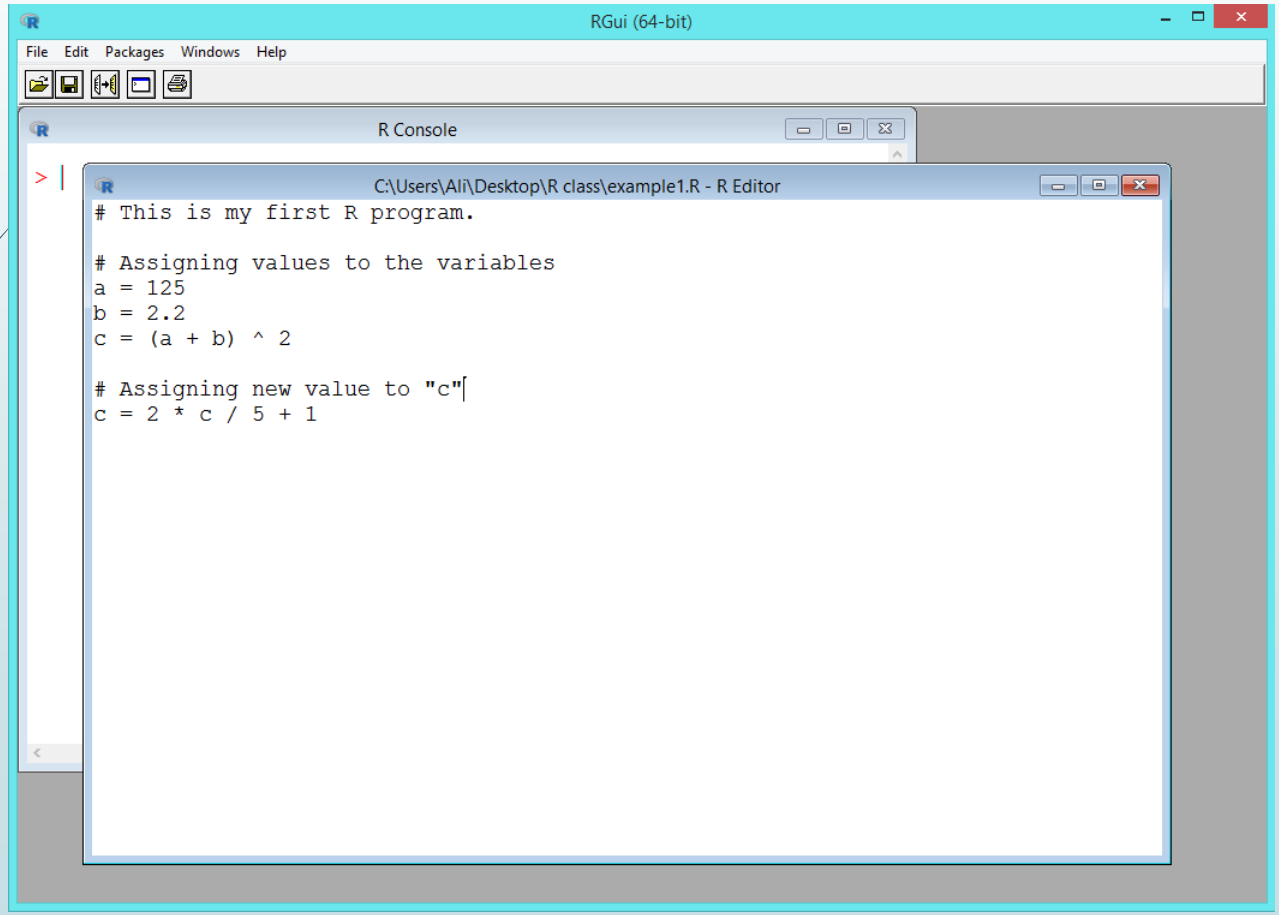
Comment

- Making a Command Inactive (3)



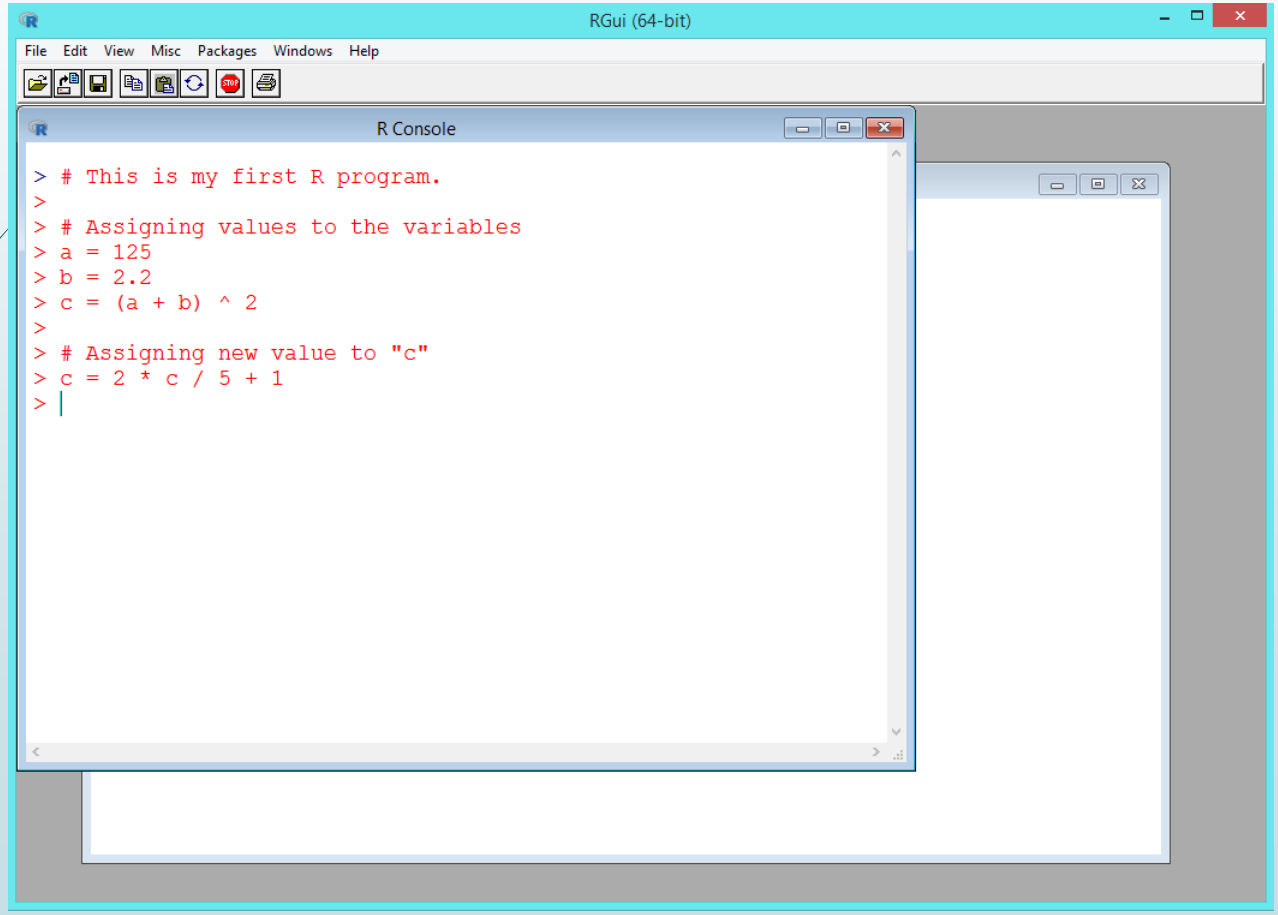
Comment

- Adding Descriptions and Explanations (1)



Comment

- Adding Descriptions and Explanations (2)

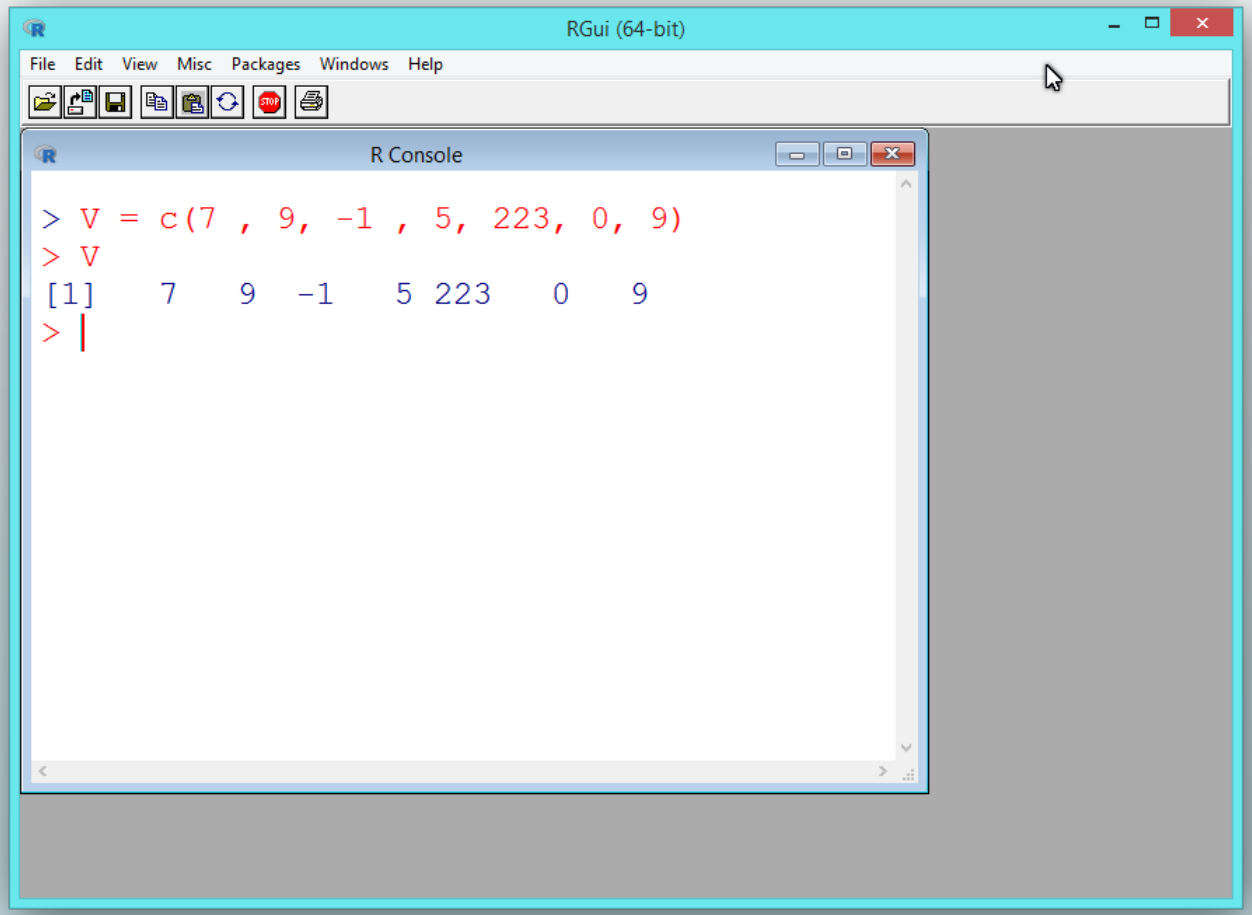


Data Structures

Vectors, Matrices, Data Frames, Arrays, Lists, Strings, Factors

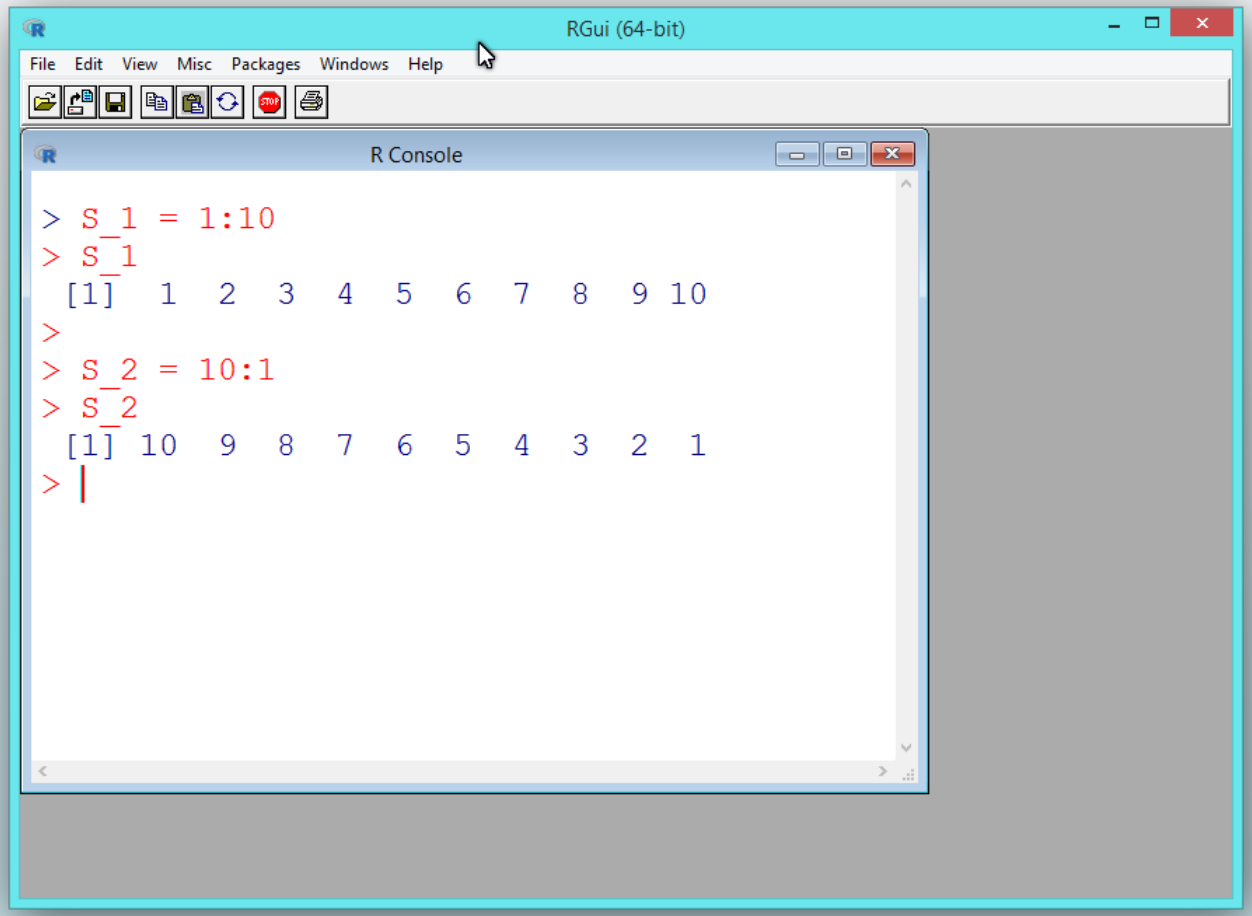
Vector

- A Simple Vector



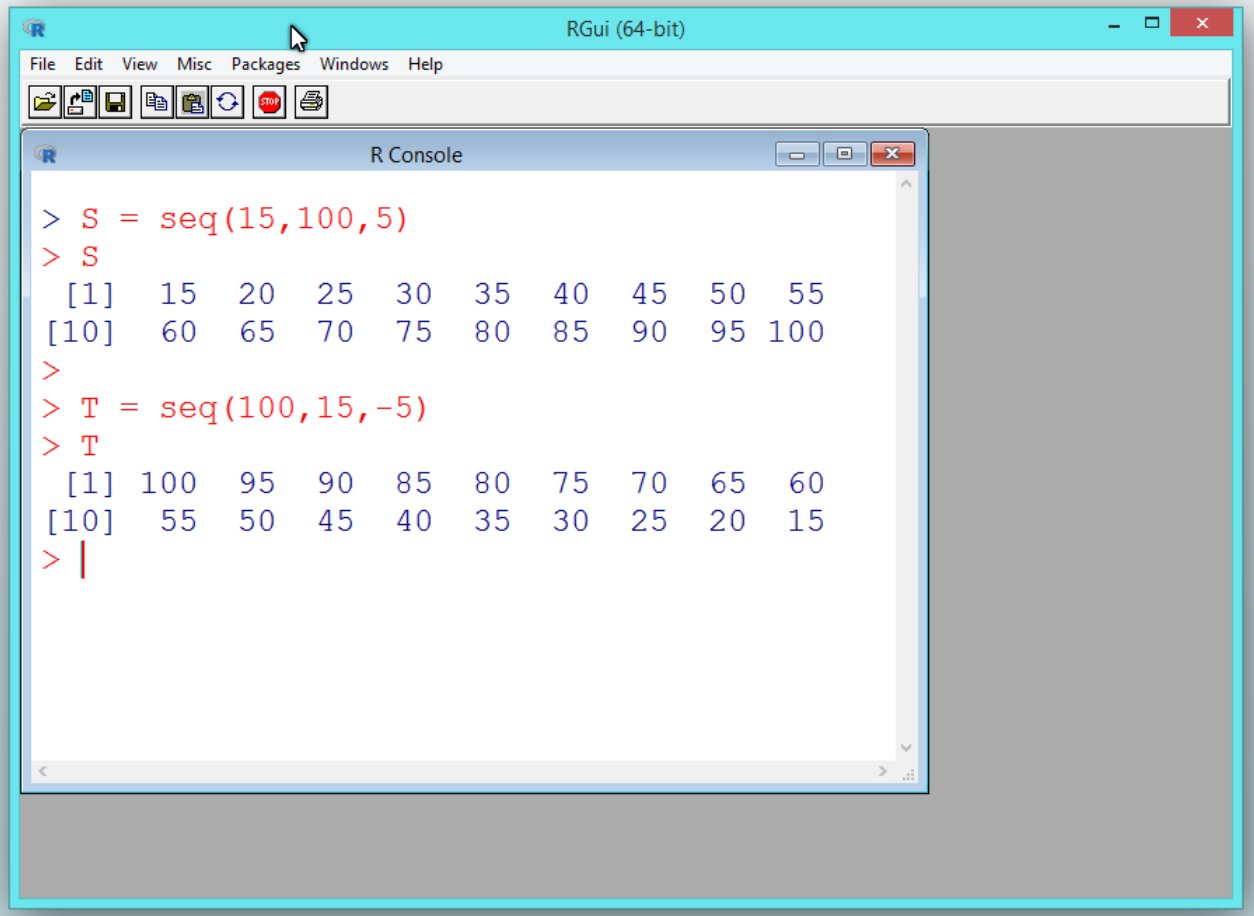
Vector

- Simple Sequences



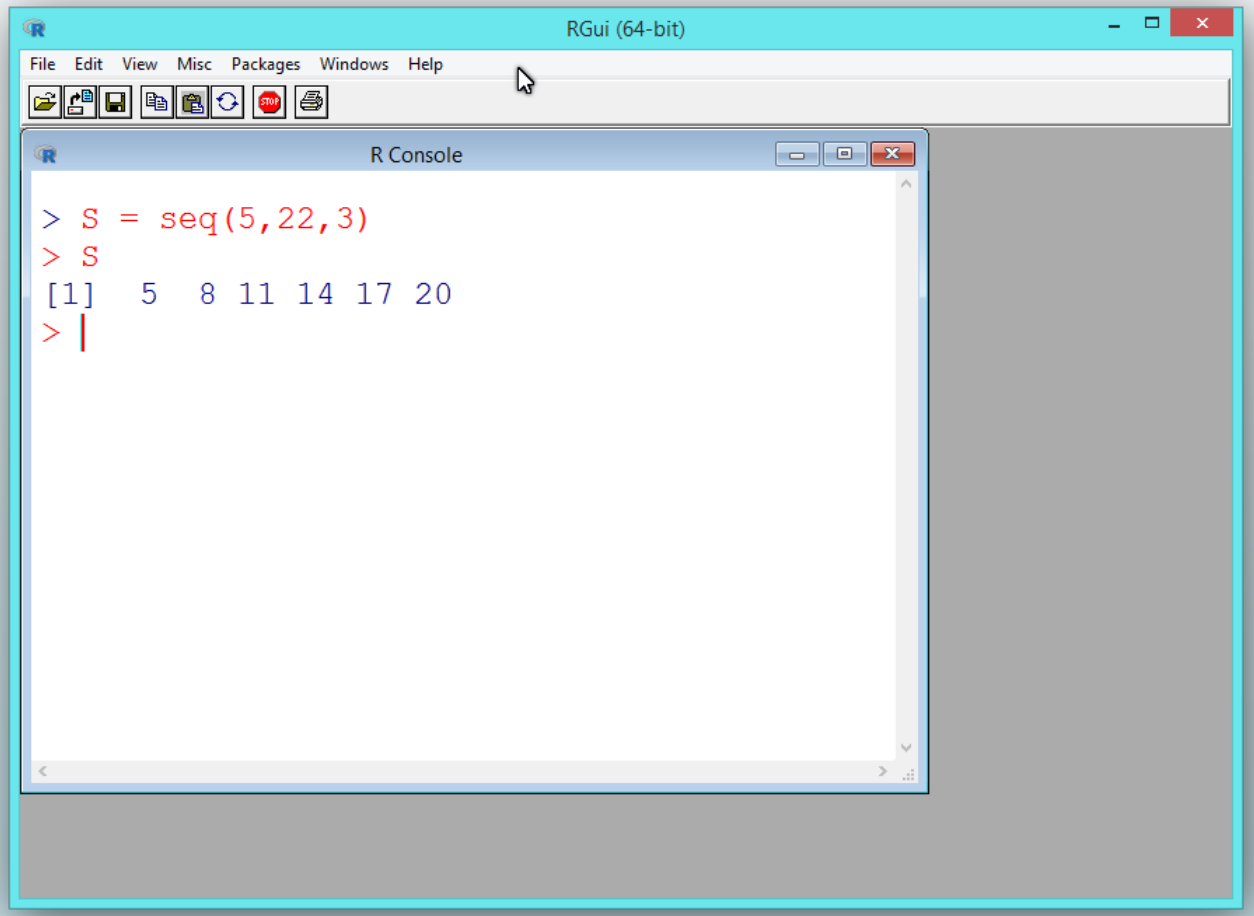
Vector

- Sequences (1)



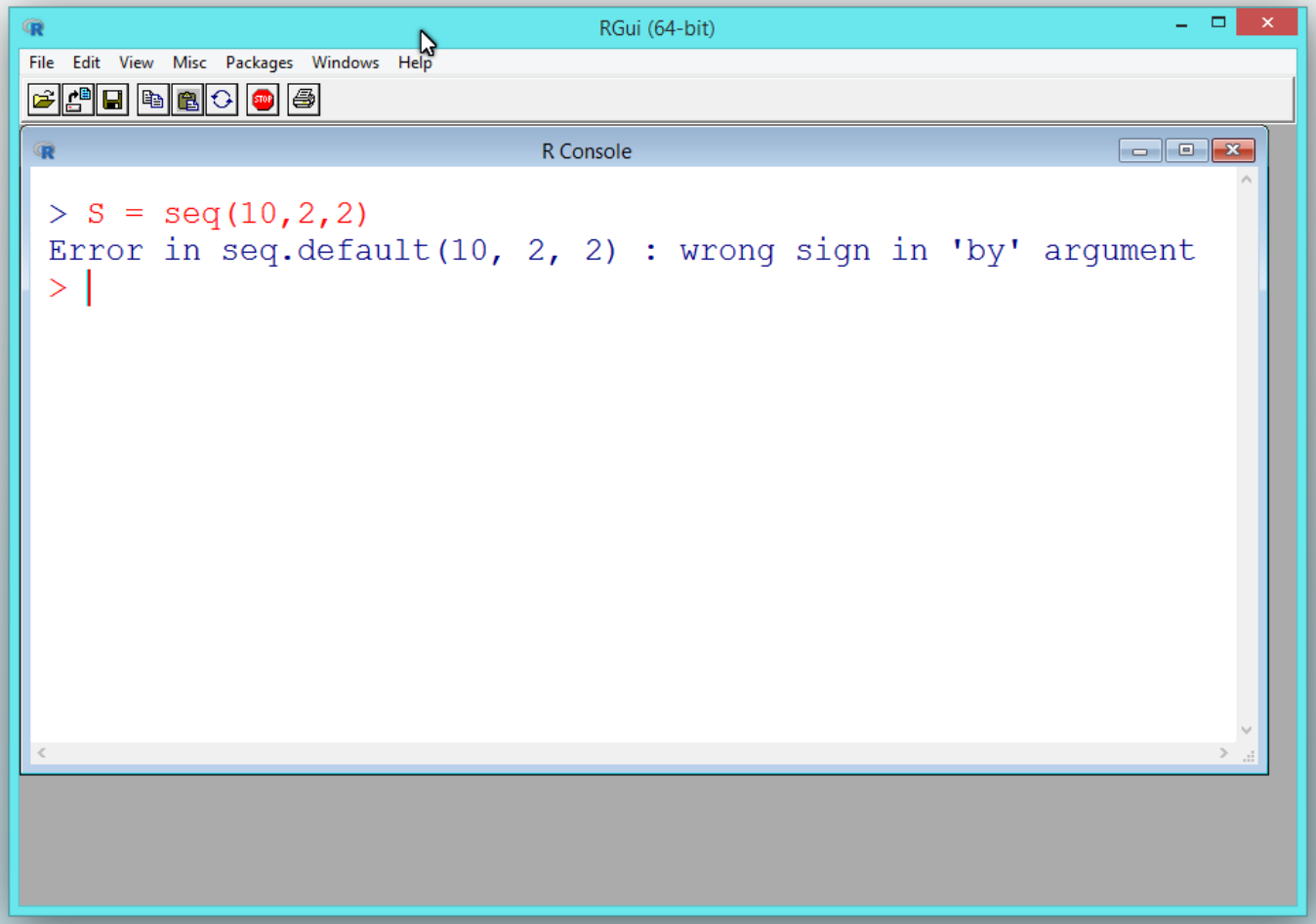
Vector

- Sequences (2)



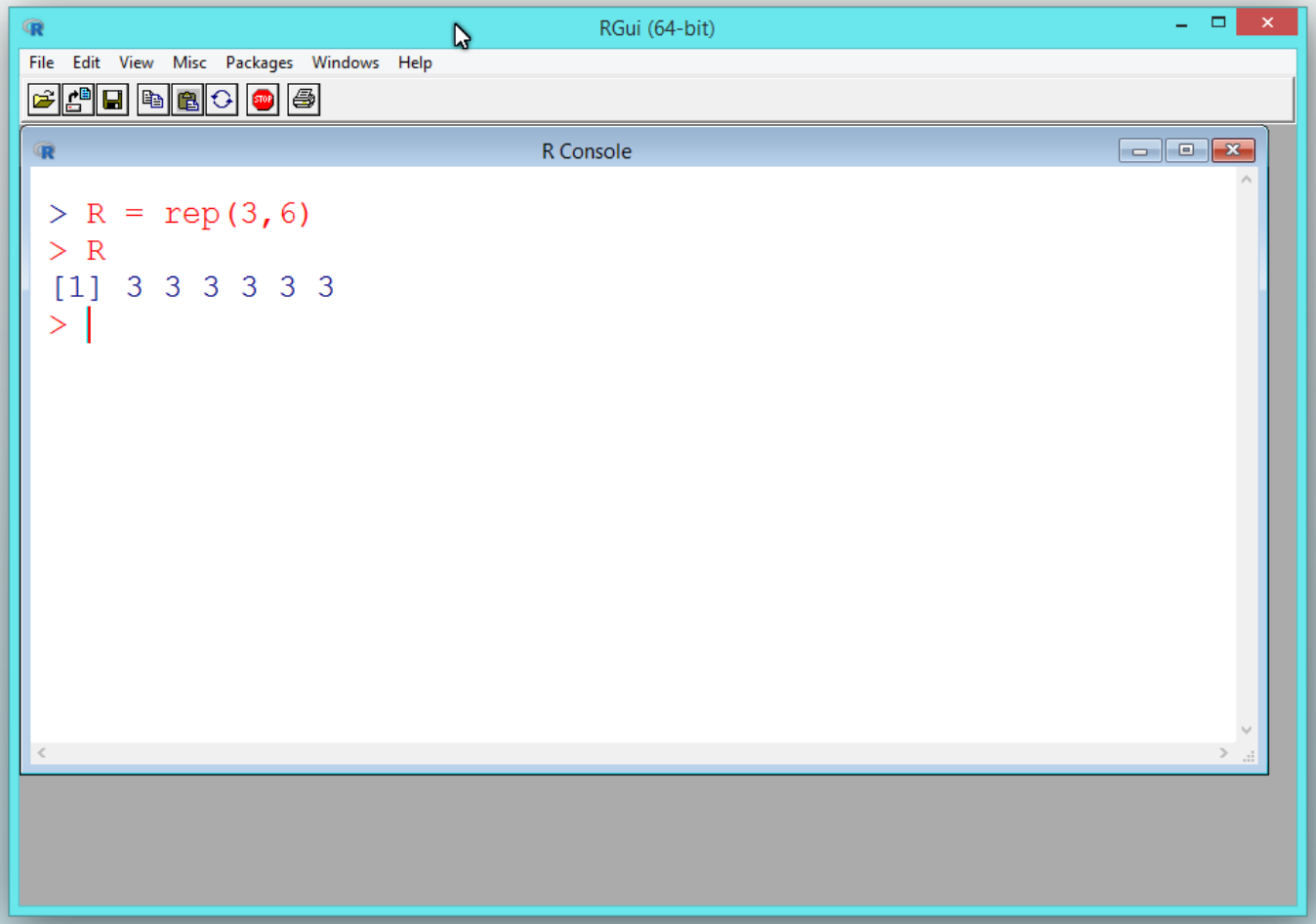
Vector

- Sequences (3)



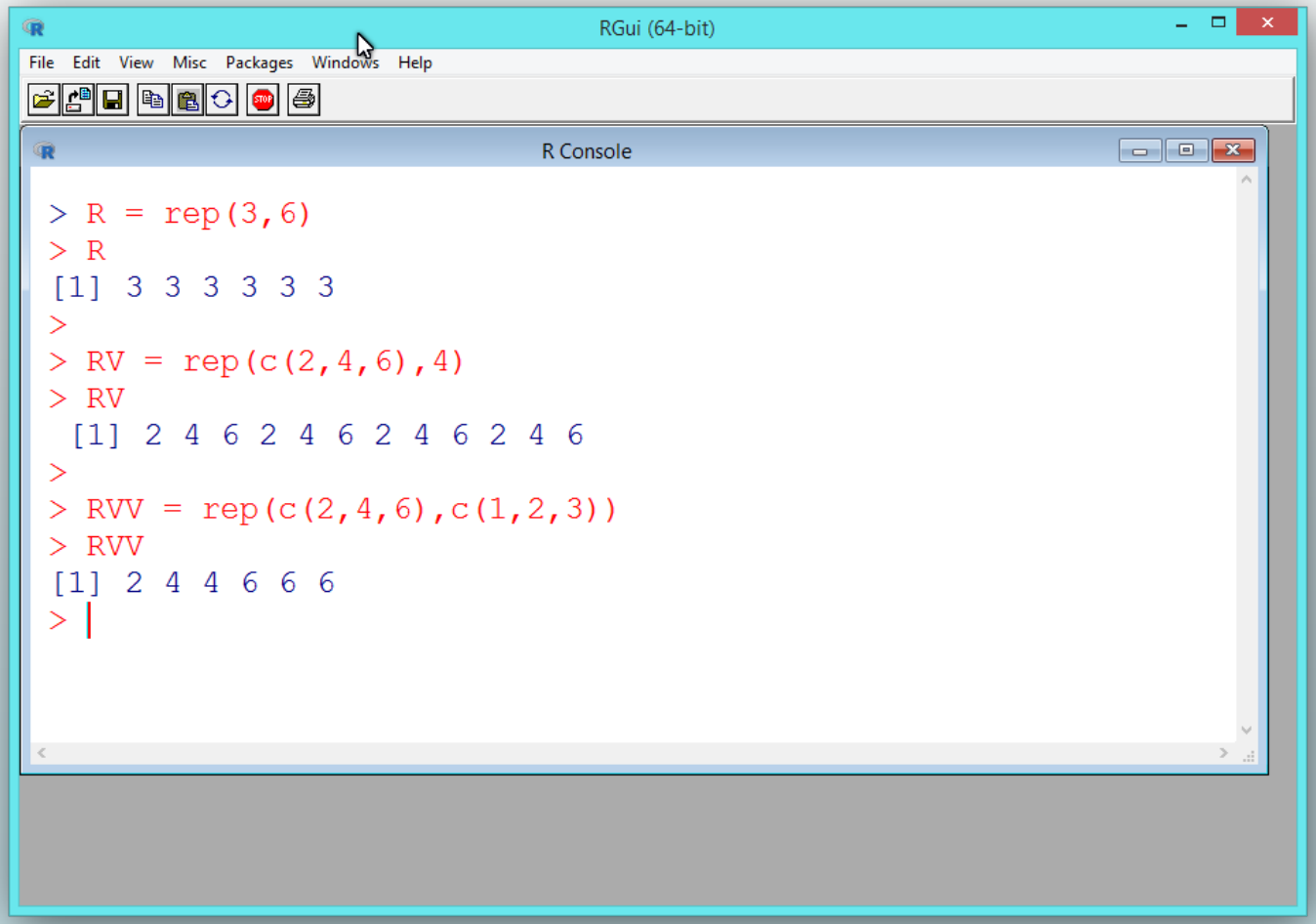
Vector

- Sequences with Repeated Elements (1)



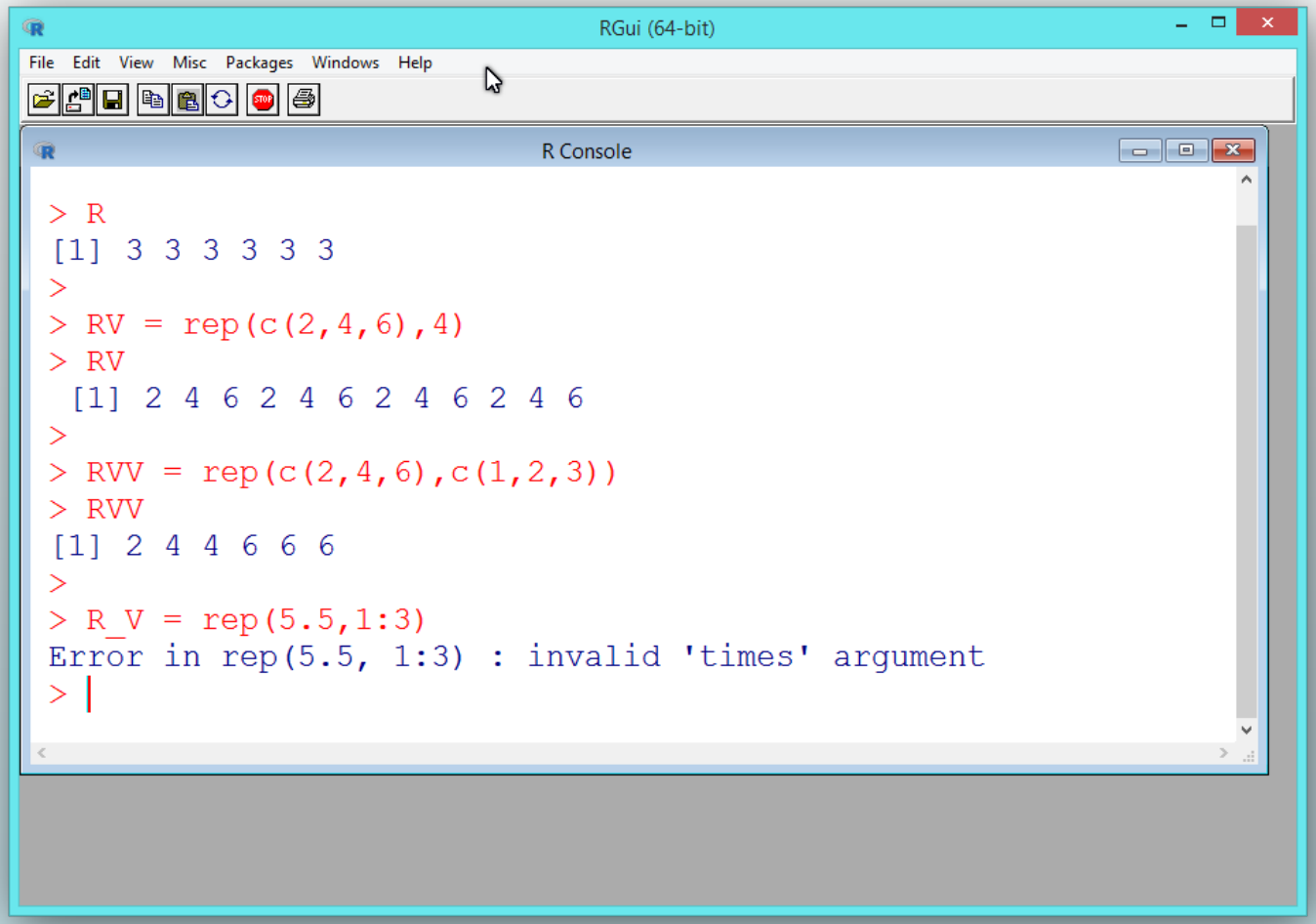
Vector

- Sequences with Repeated Elements (2)



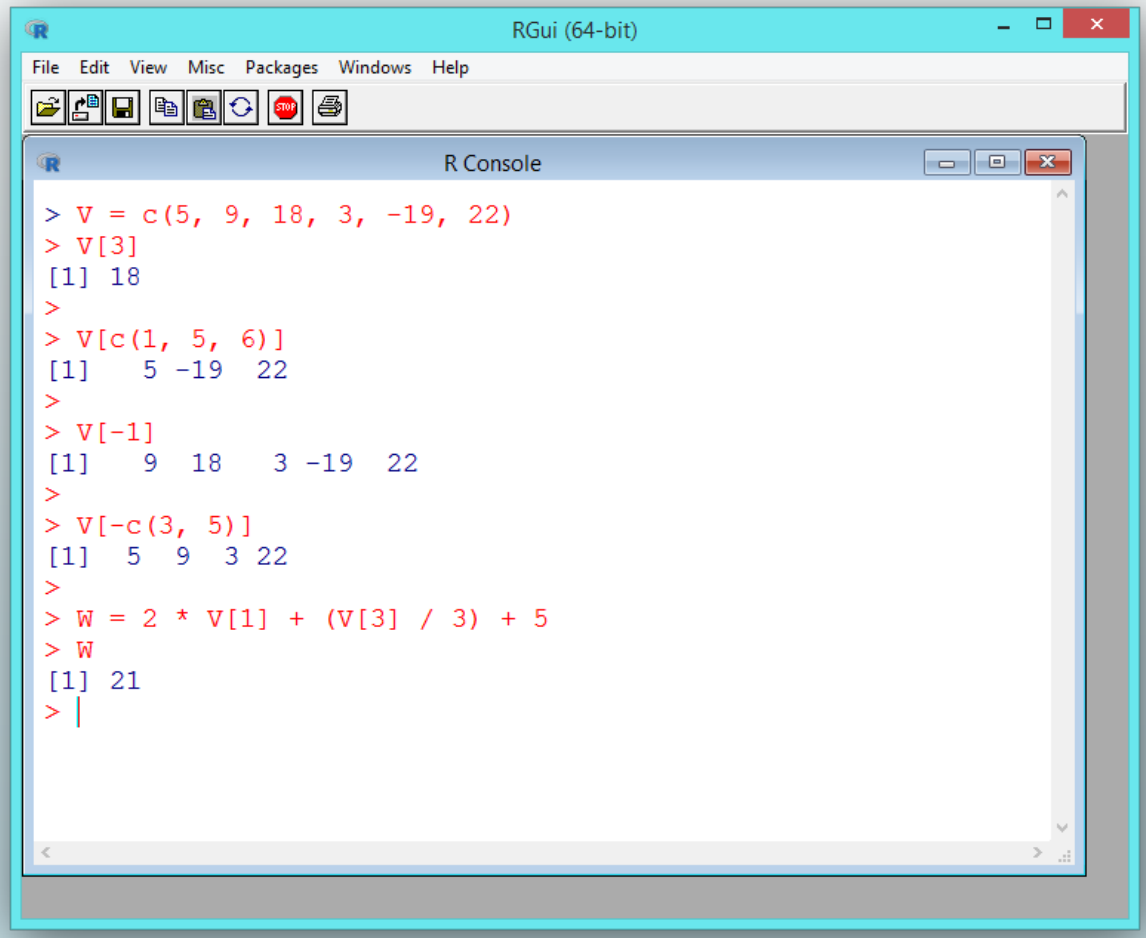
Vector

Sequences with Repeated Elements (3)



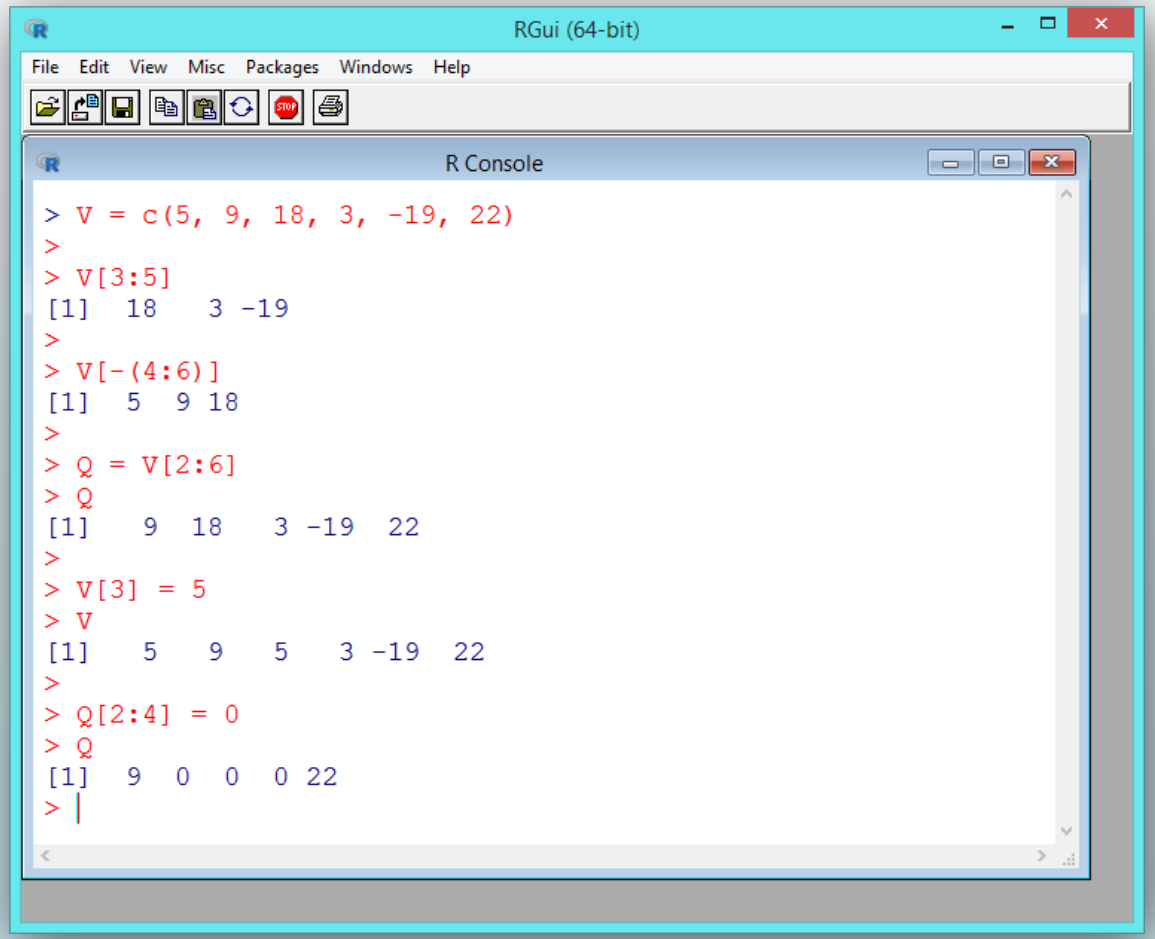
Vector

- Addressing Vector Elements



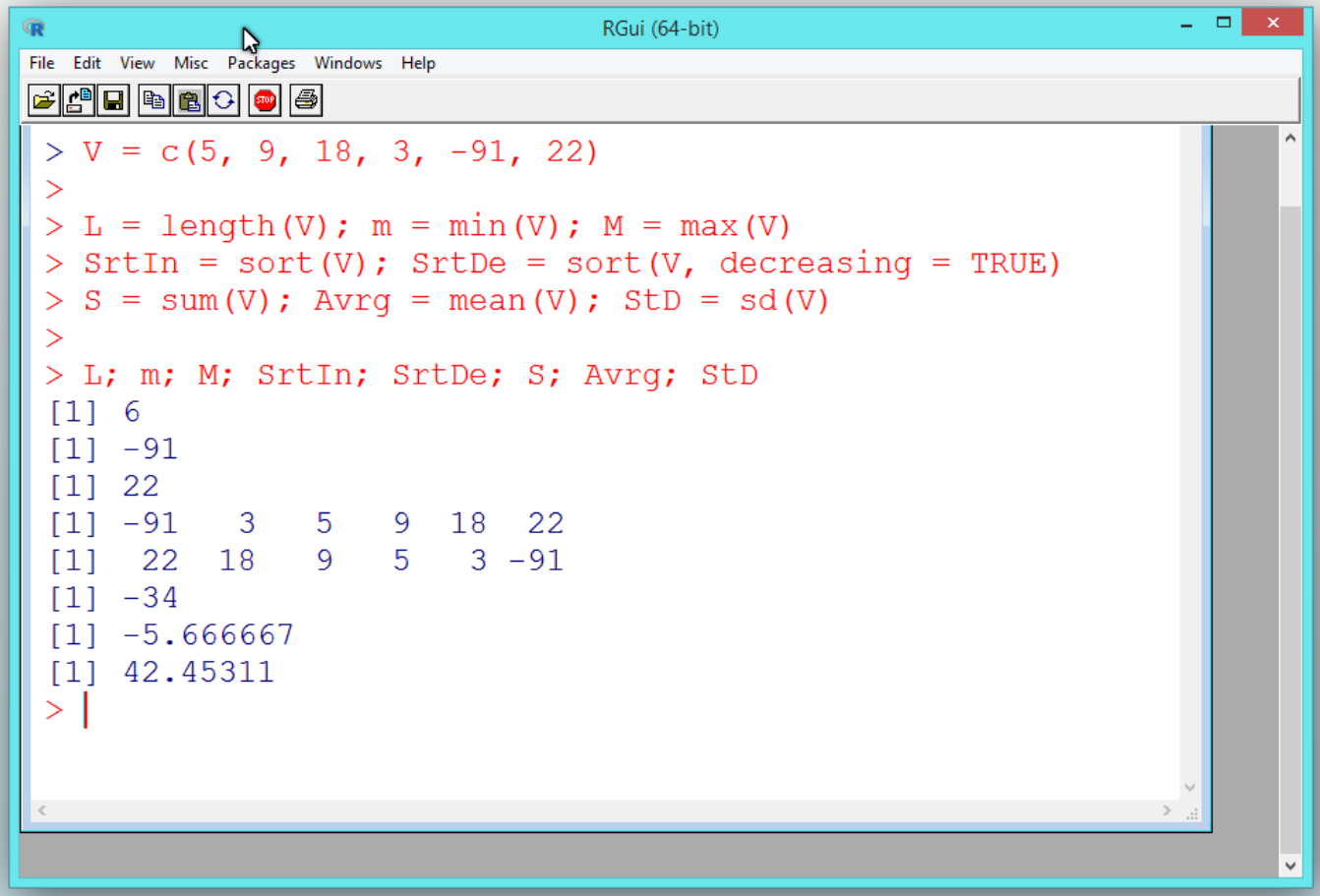
Vector

- Vector Slice



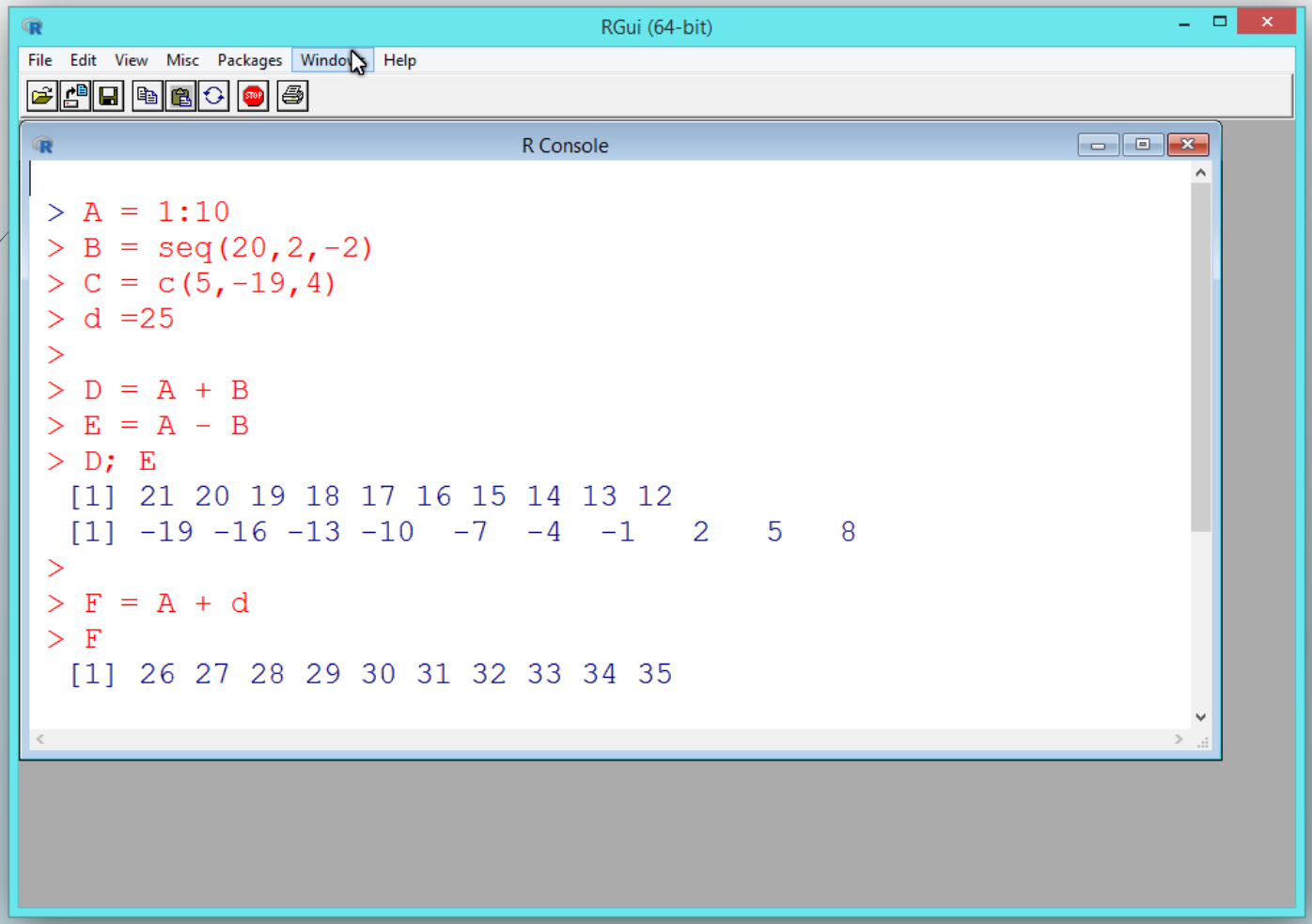
Vector

- Some Built-in Functions for Vectors



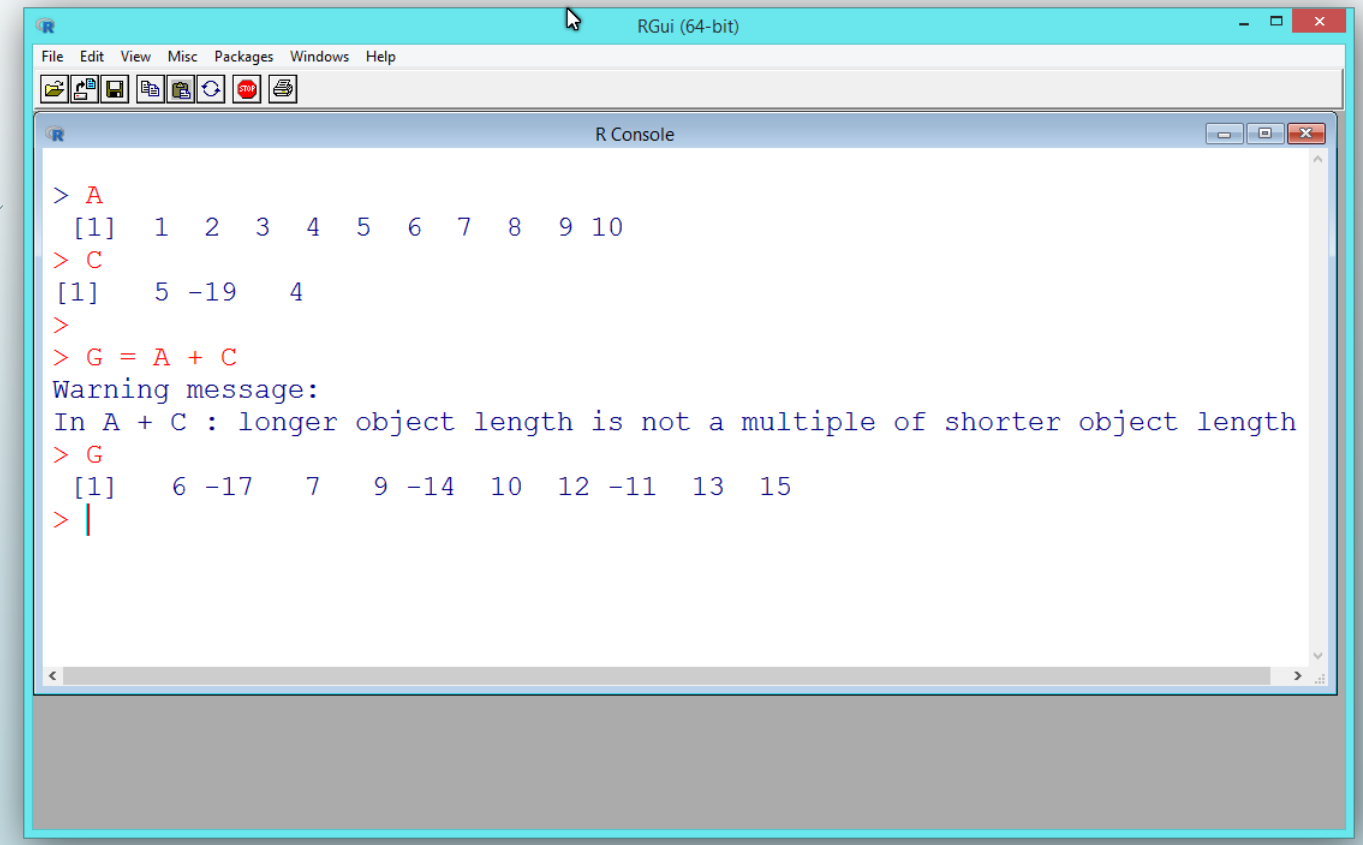
Vector

Some Mathematical Operations (1)



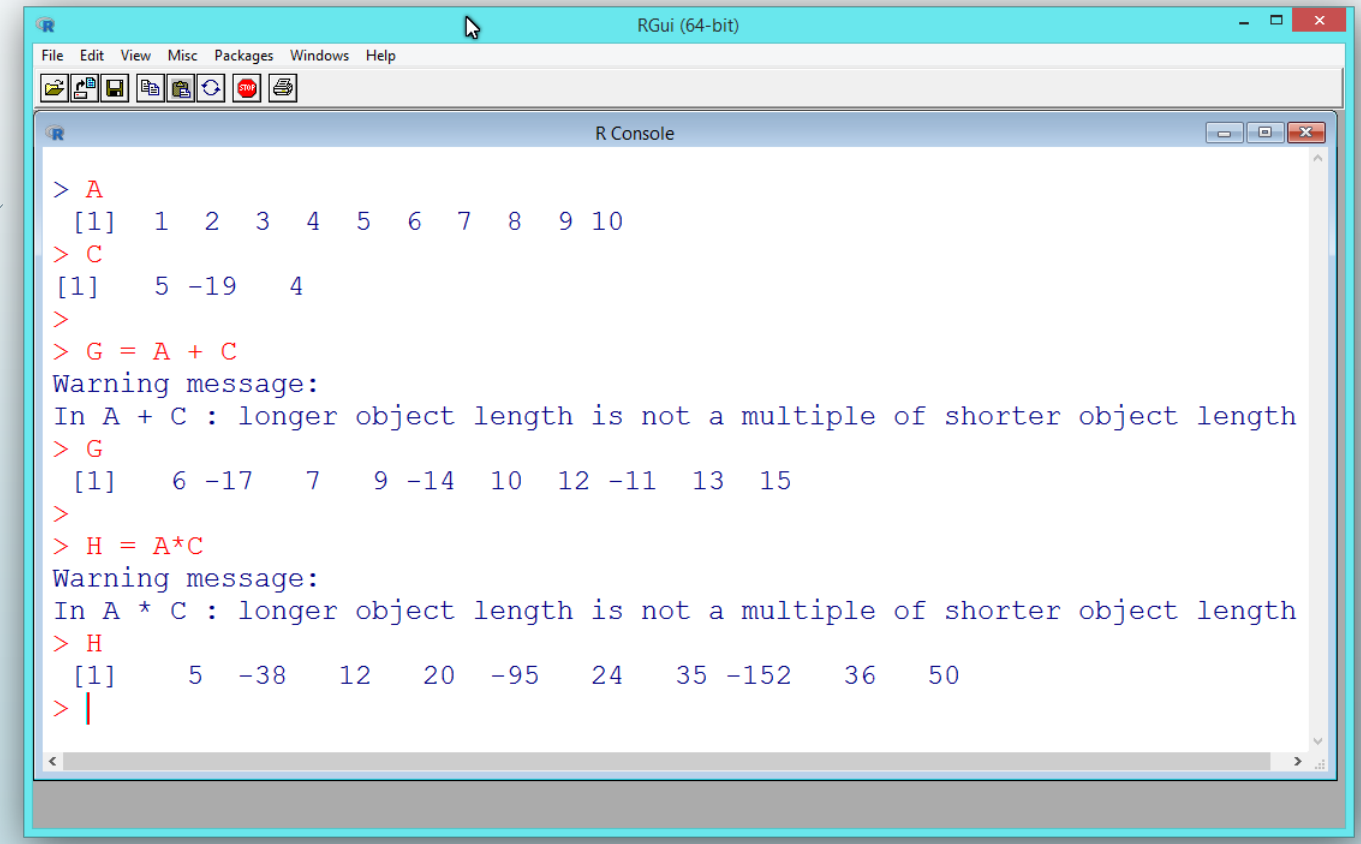
Vector

- Some Mathematical Operations (2)



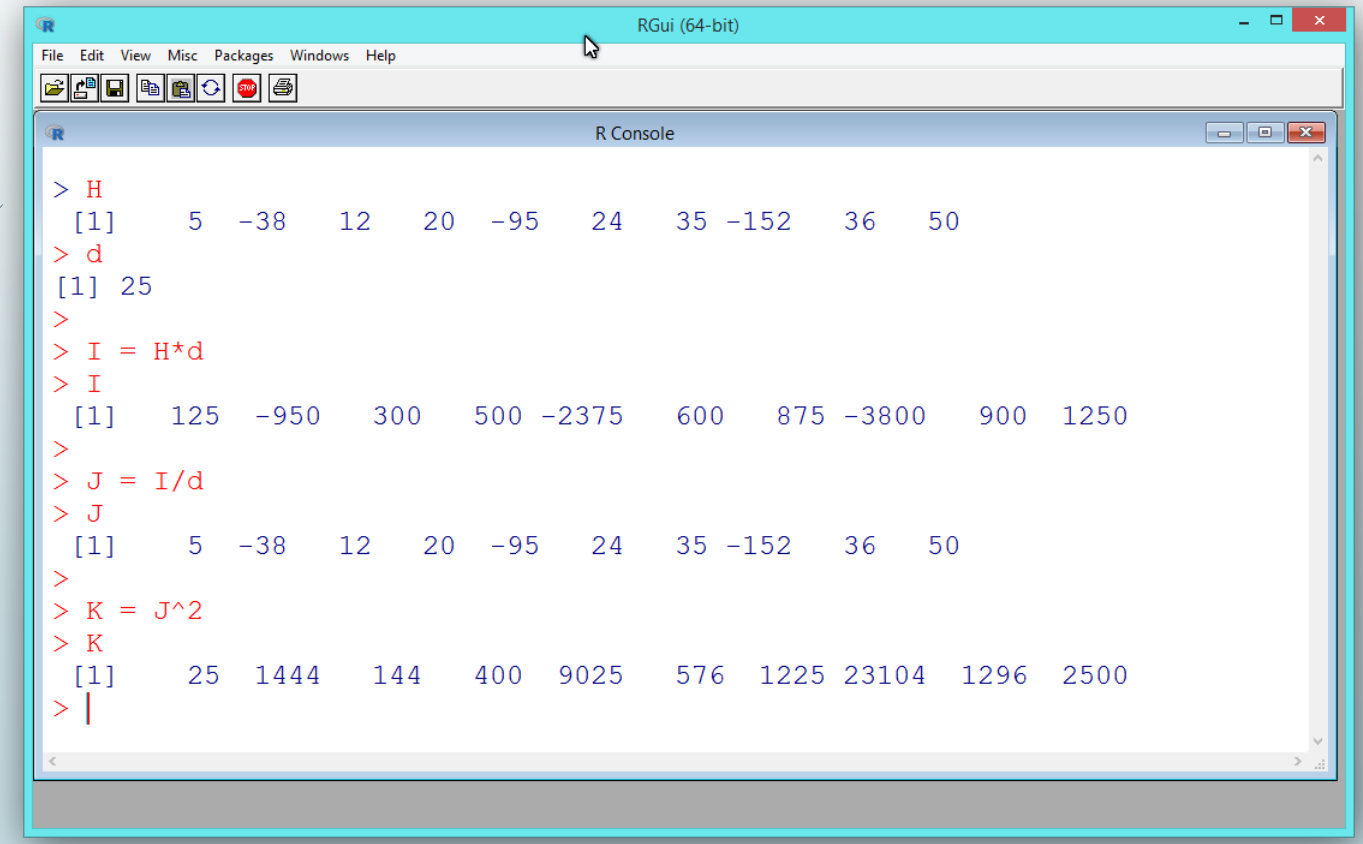
Vector

- Some Mathematical Operations (3)



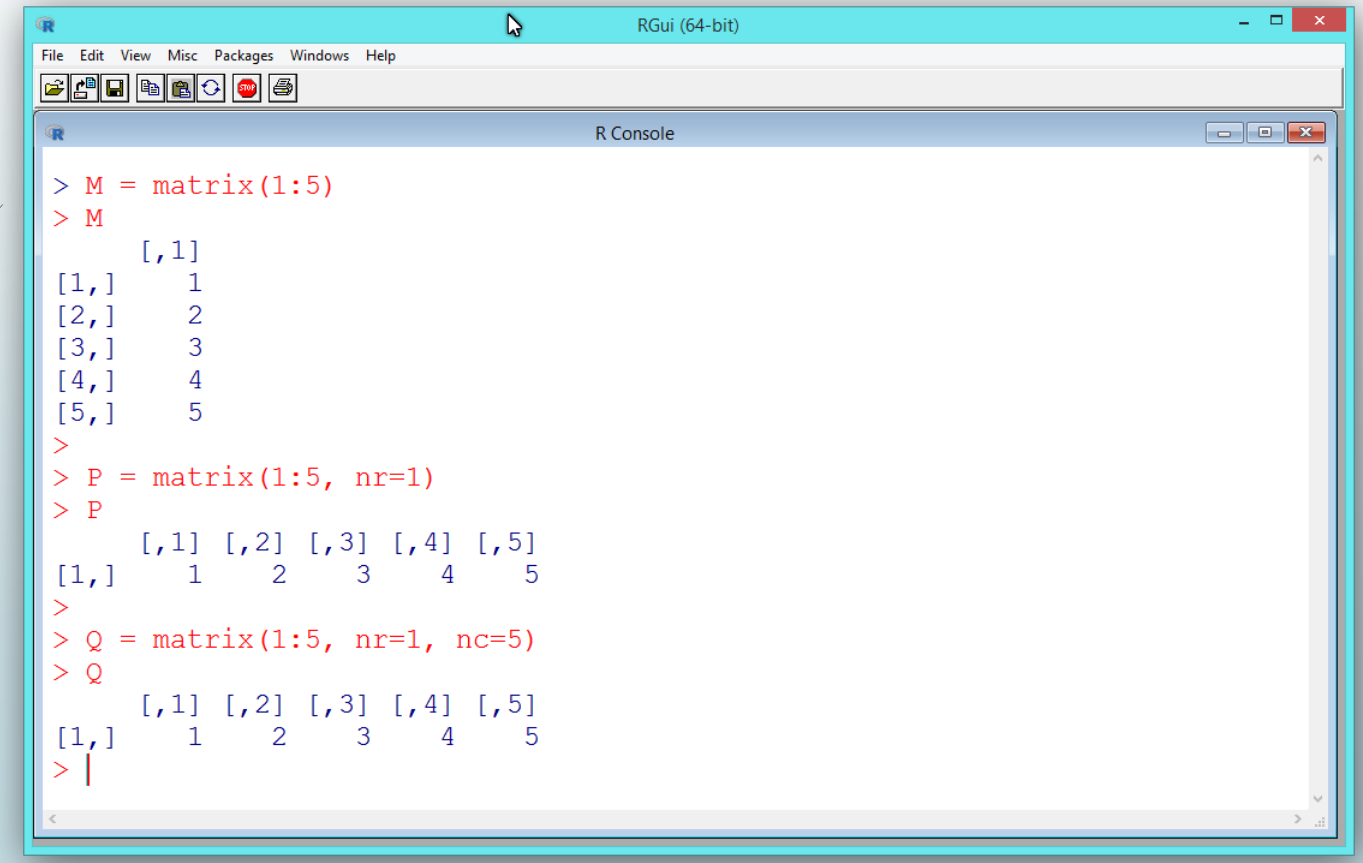
Vector

- Some Mathematical Operations (4)



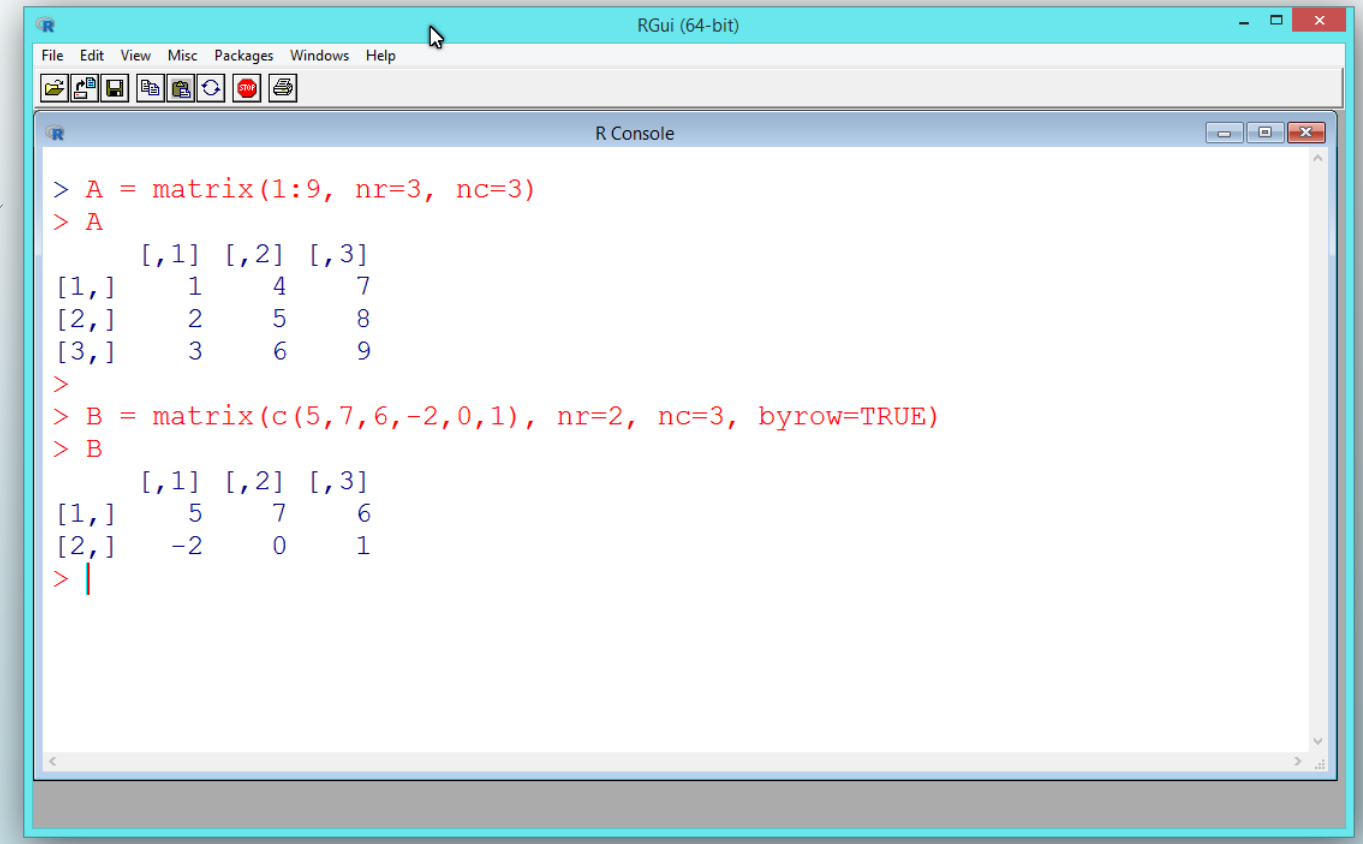
Matrix

- Assignment and Arguments (1)



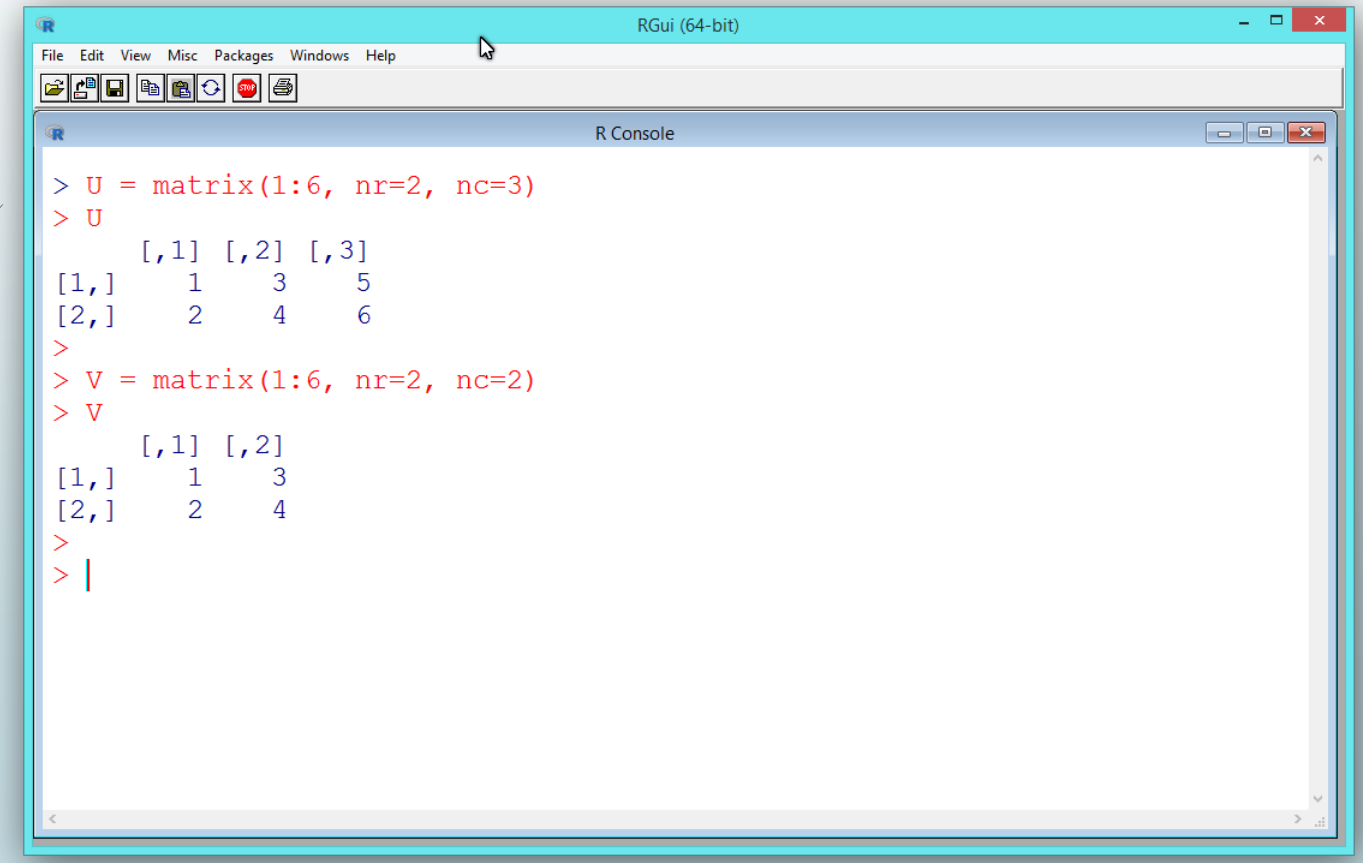
Matrix

- Assignment and Arguments (2)



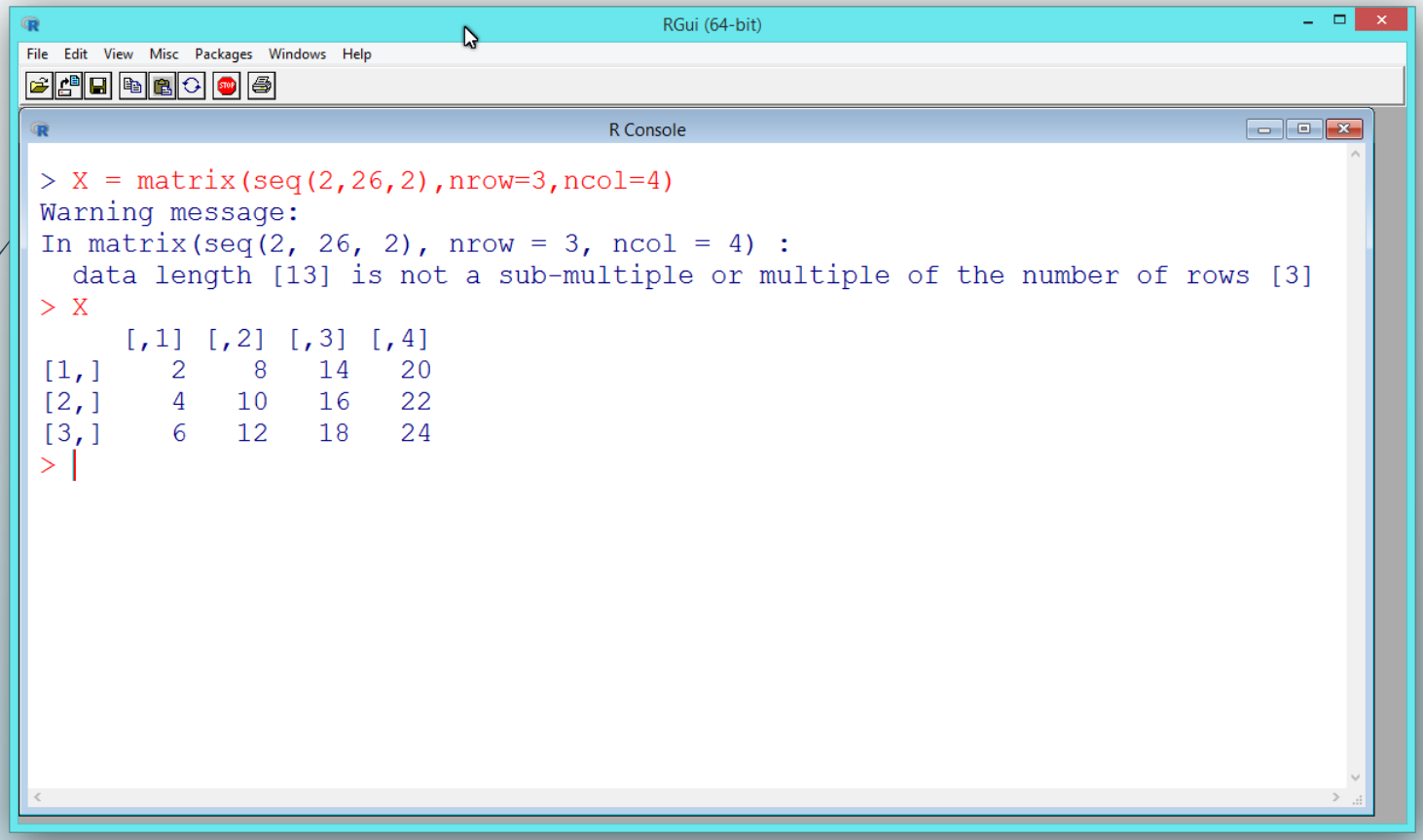
Matrix

- Assignment and Arguments (3)



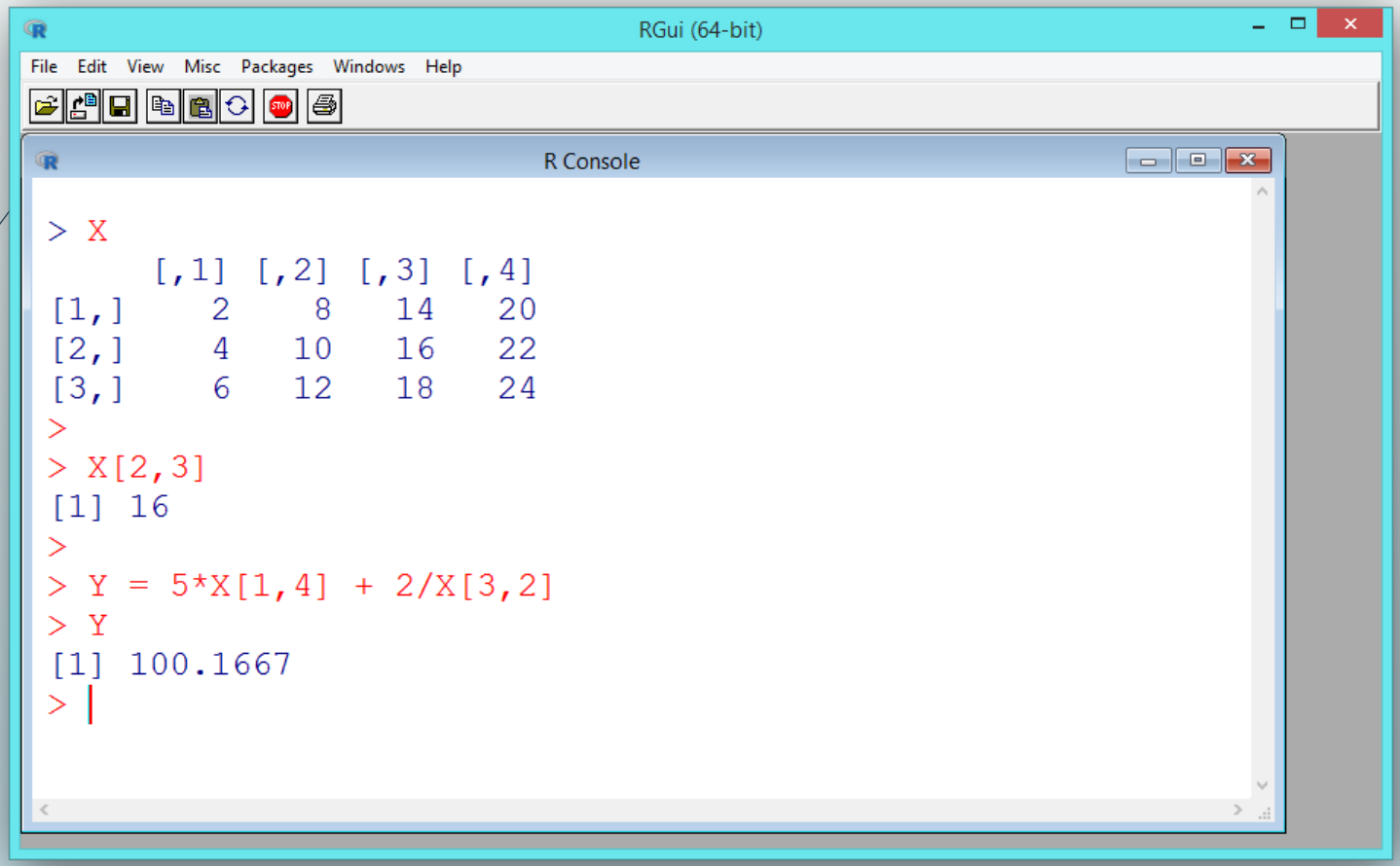
Matrix

- Assignment and Arguments (4)



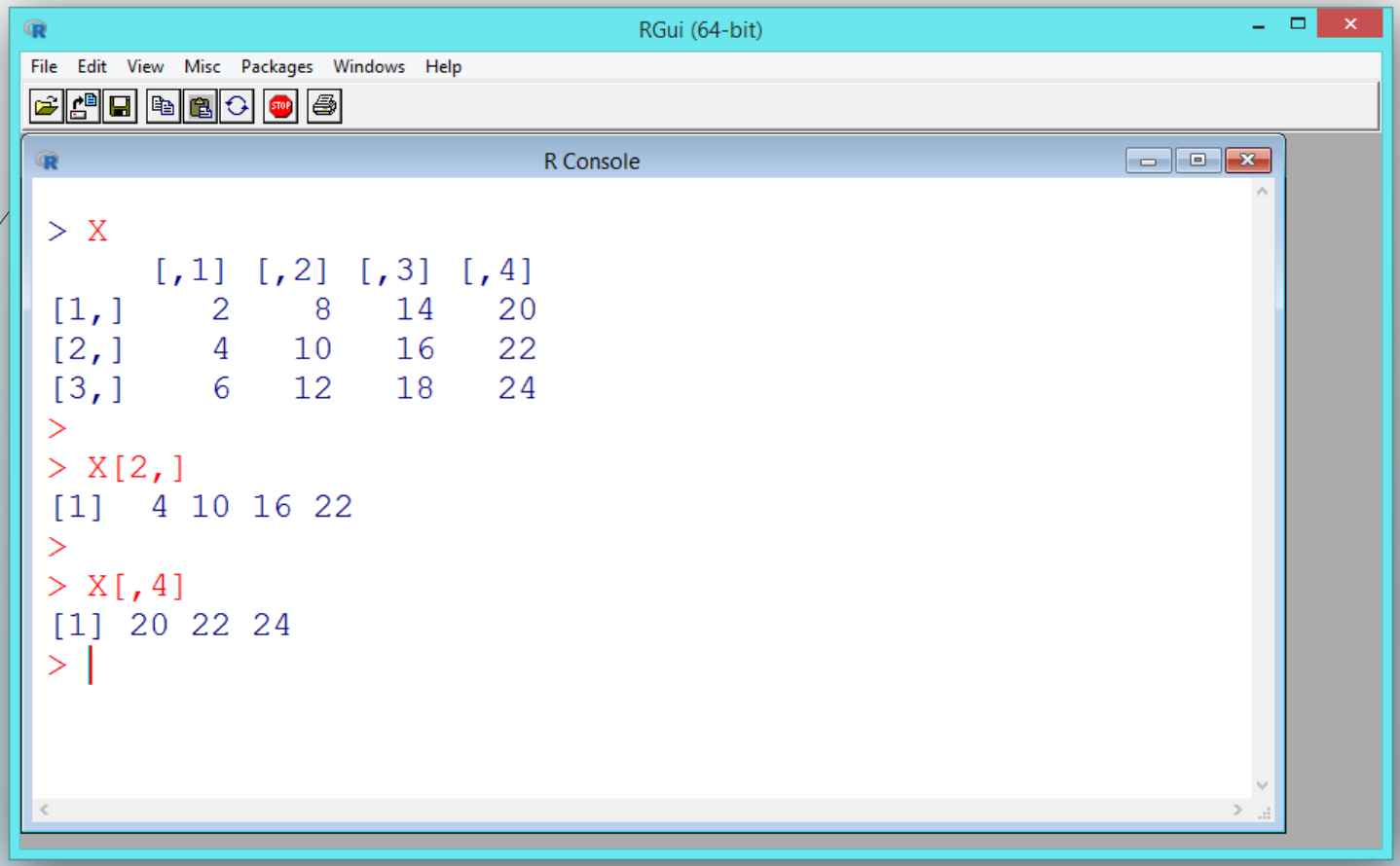
Matrix

- Addressing Matrix Elements



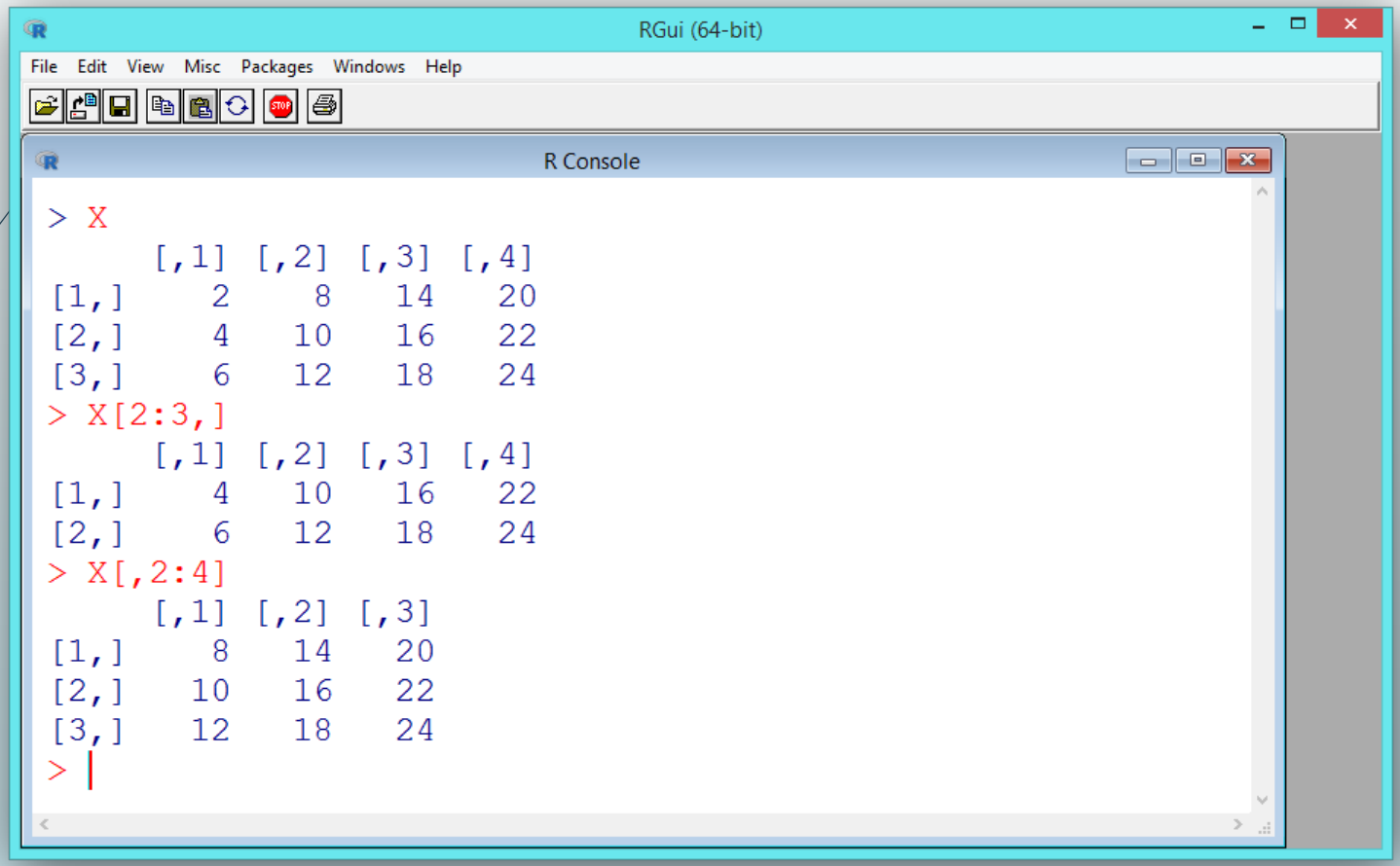
Matrix

- Addressing Matrix Rows and Columns (1)



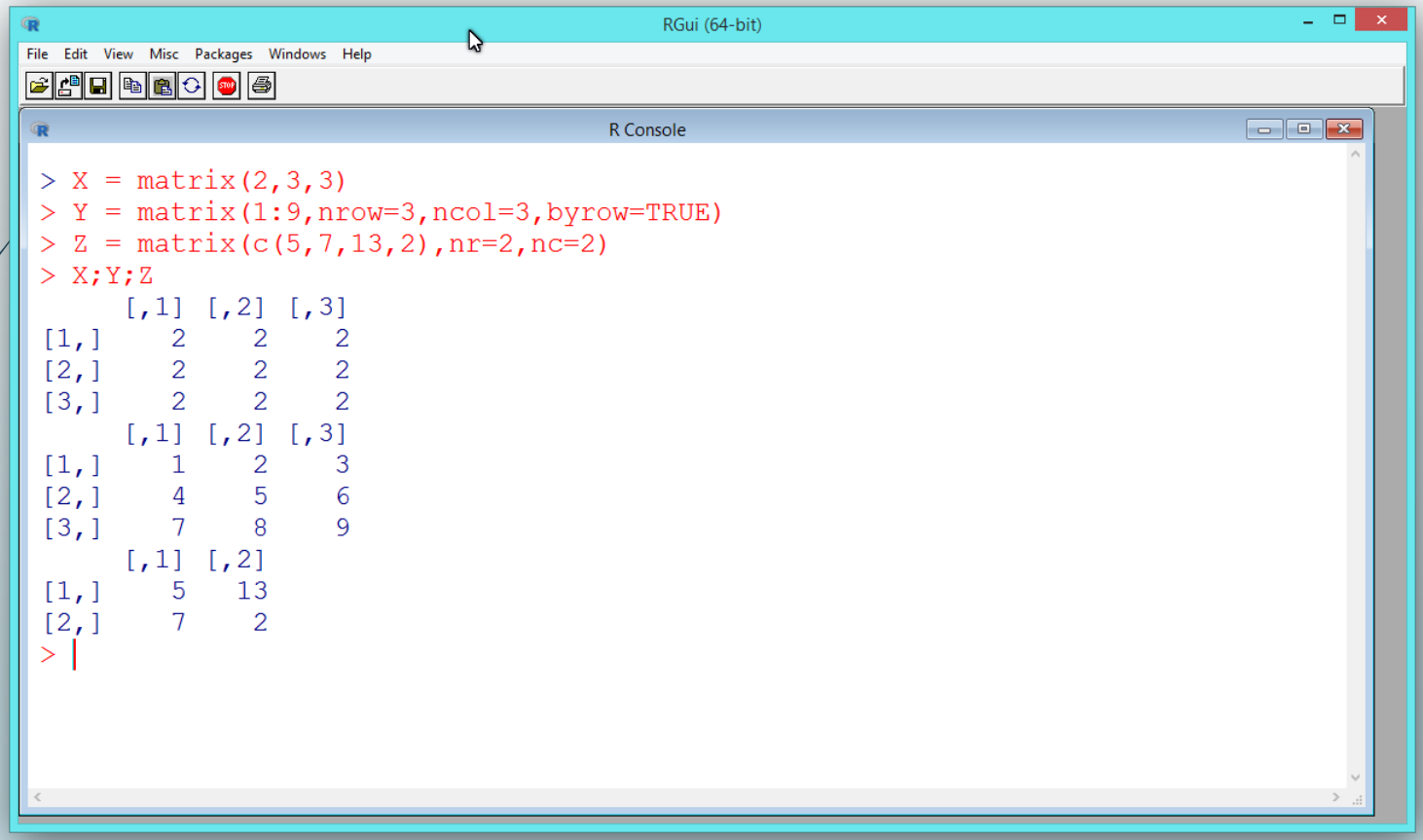
Matrix

- Addressing Matrix Rows and Columns (2)



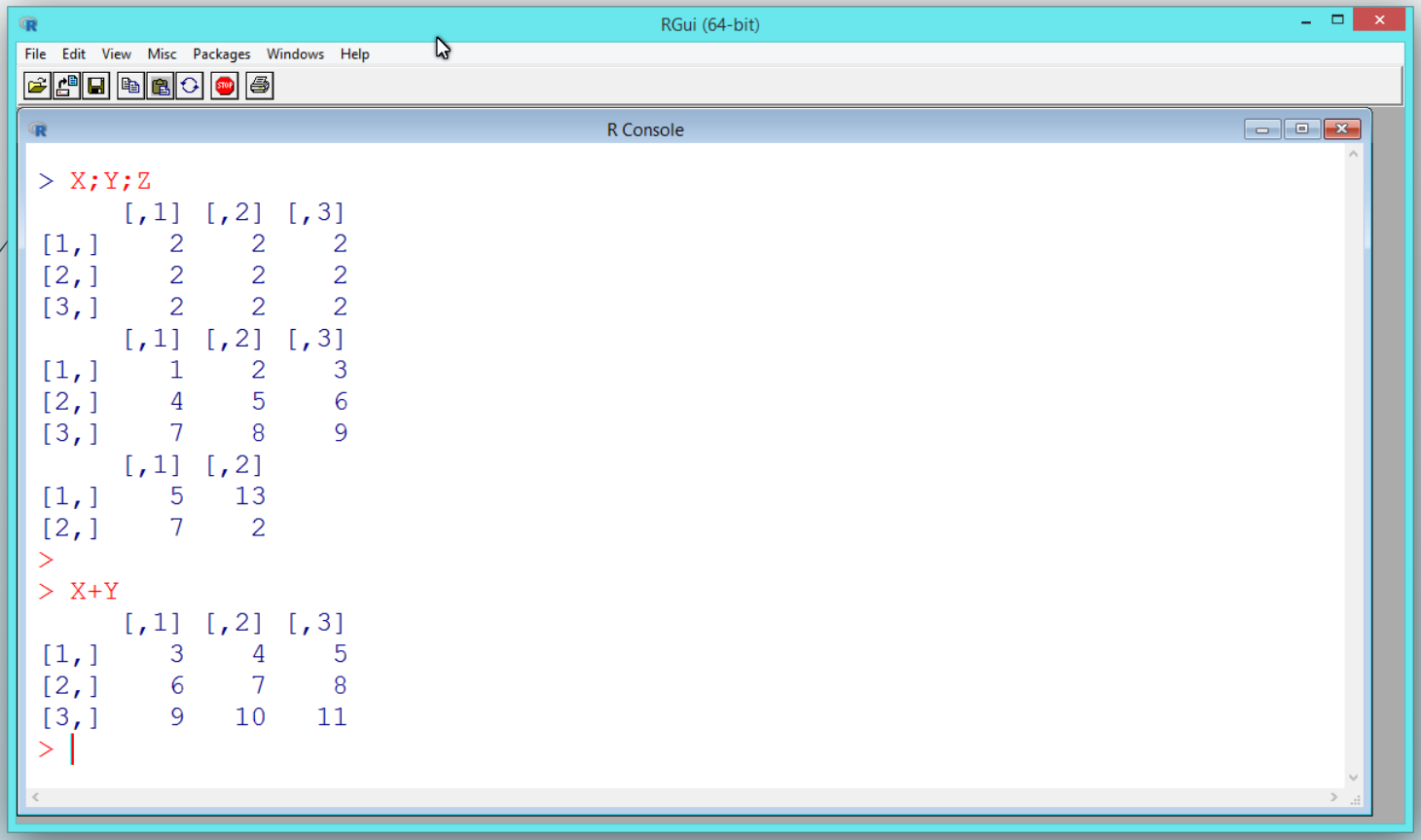
Matrix

- Some Mathematical Operations (1)



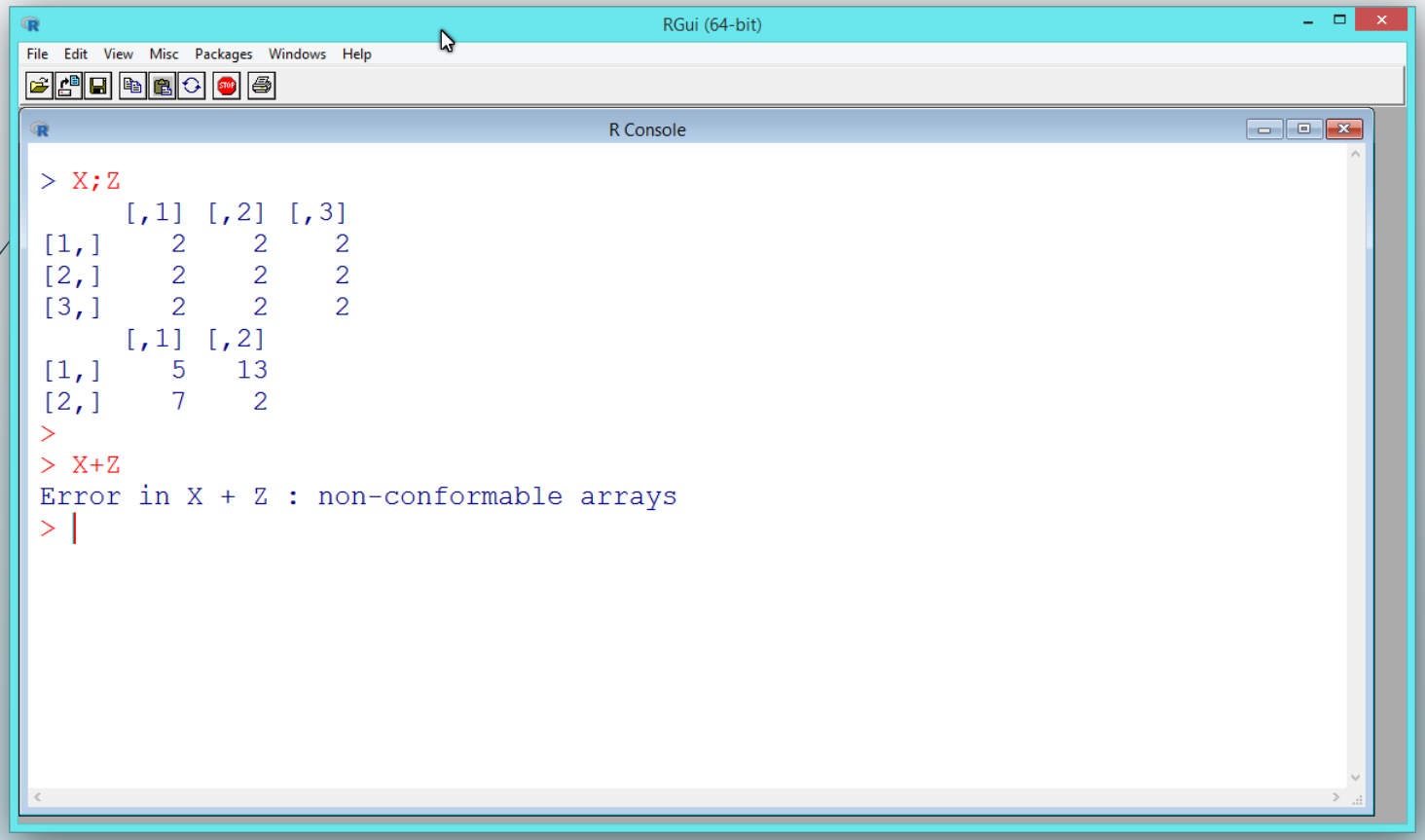
Matrix

- Some Mathematical Operations (2)



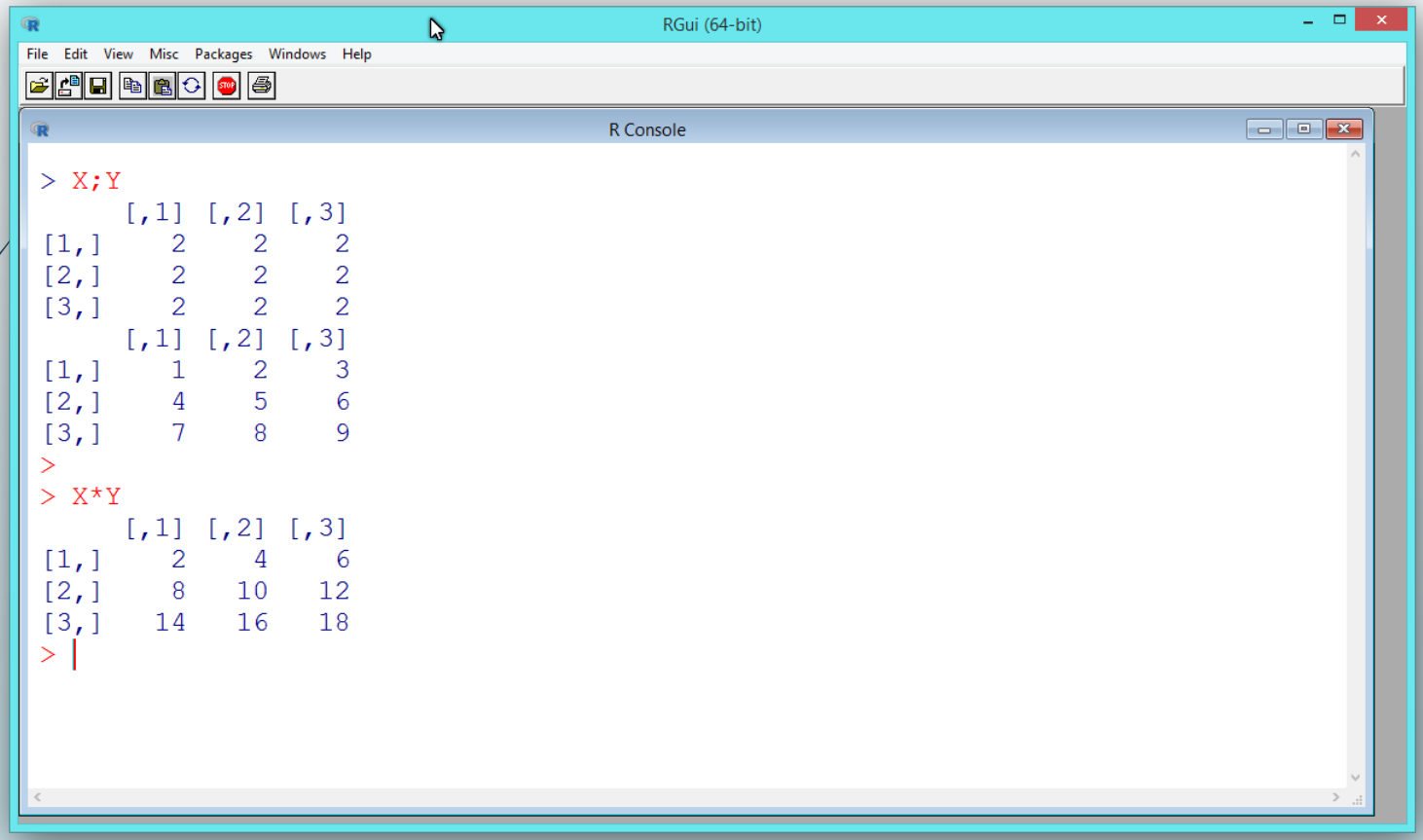
Matrix

- Some Mathematical Operations (3)



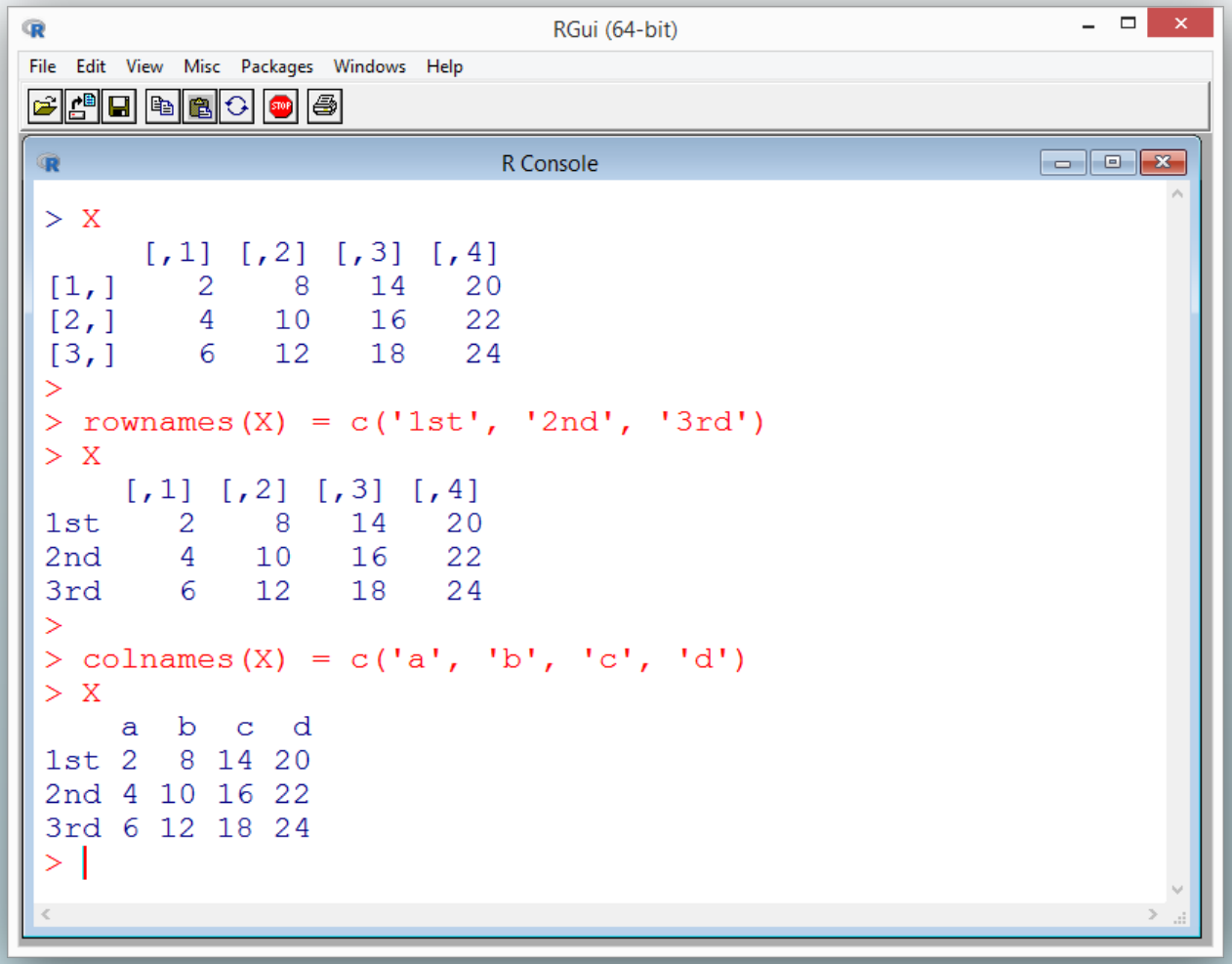
Matrix

- Some Mathematical Operations (4)



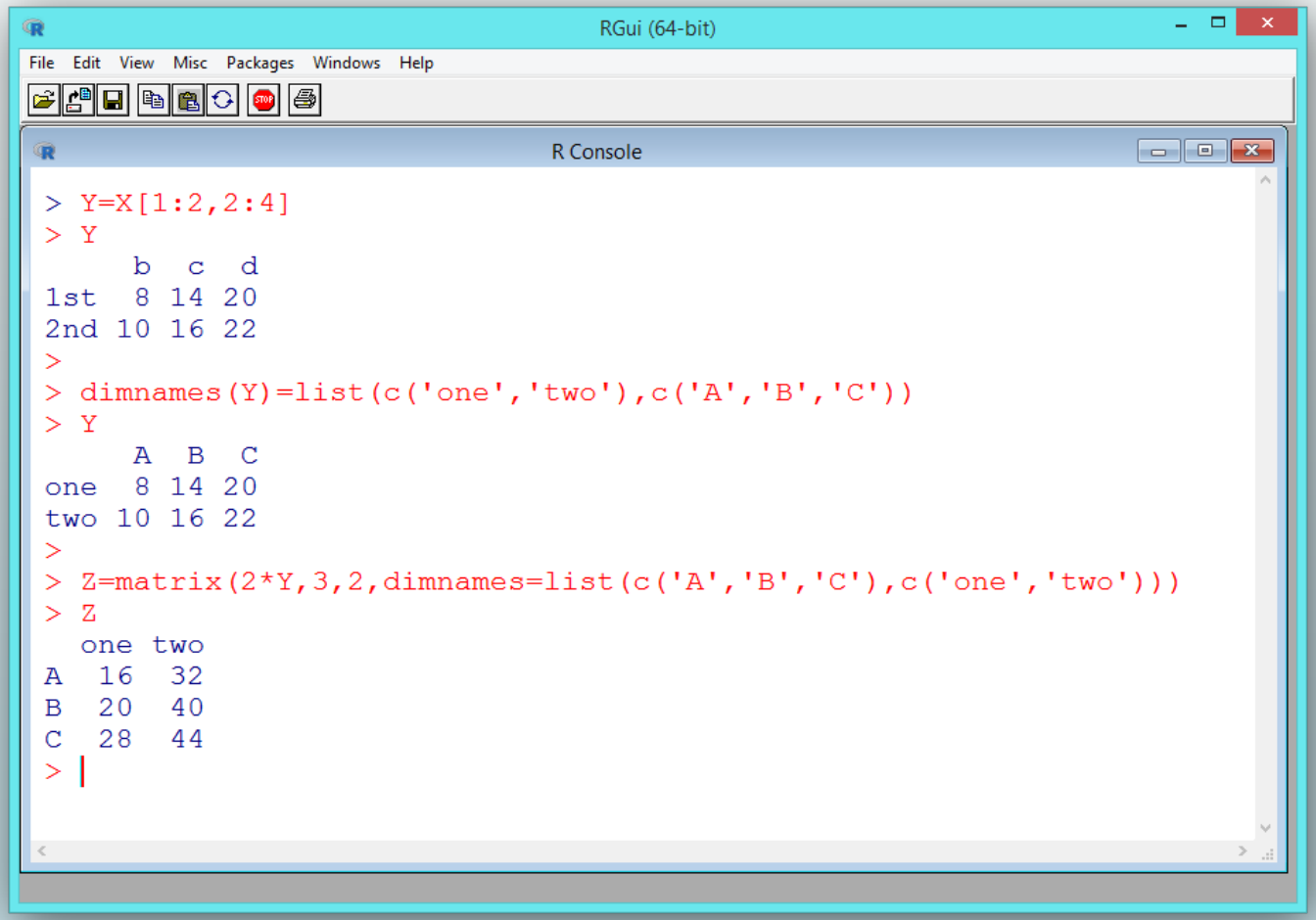
Matrix

Naming Matrix Rows and Columns (1)



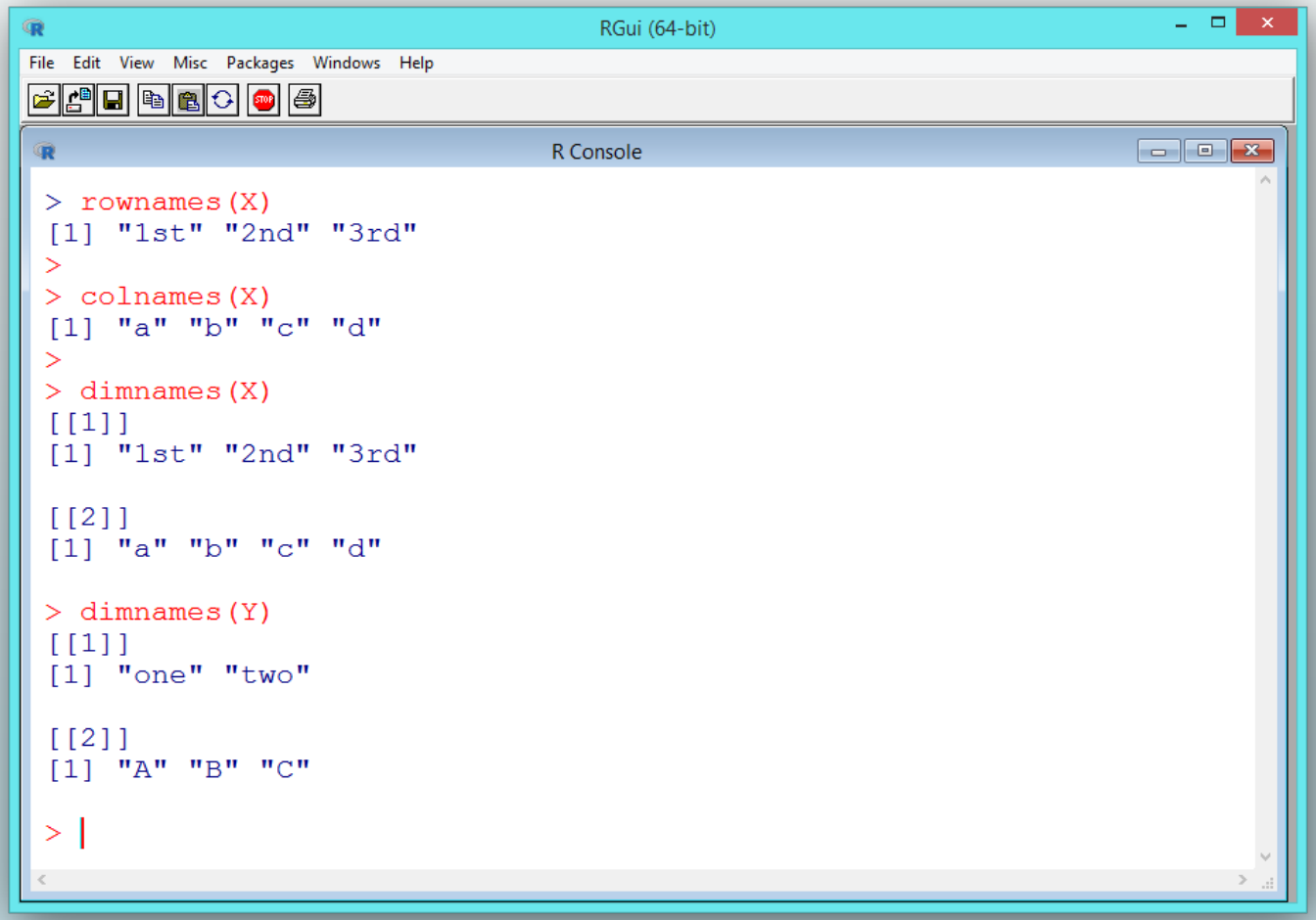
Matrix

- Naming Matrix Rows and Columns (2)



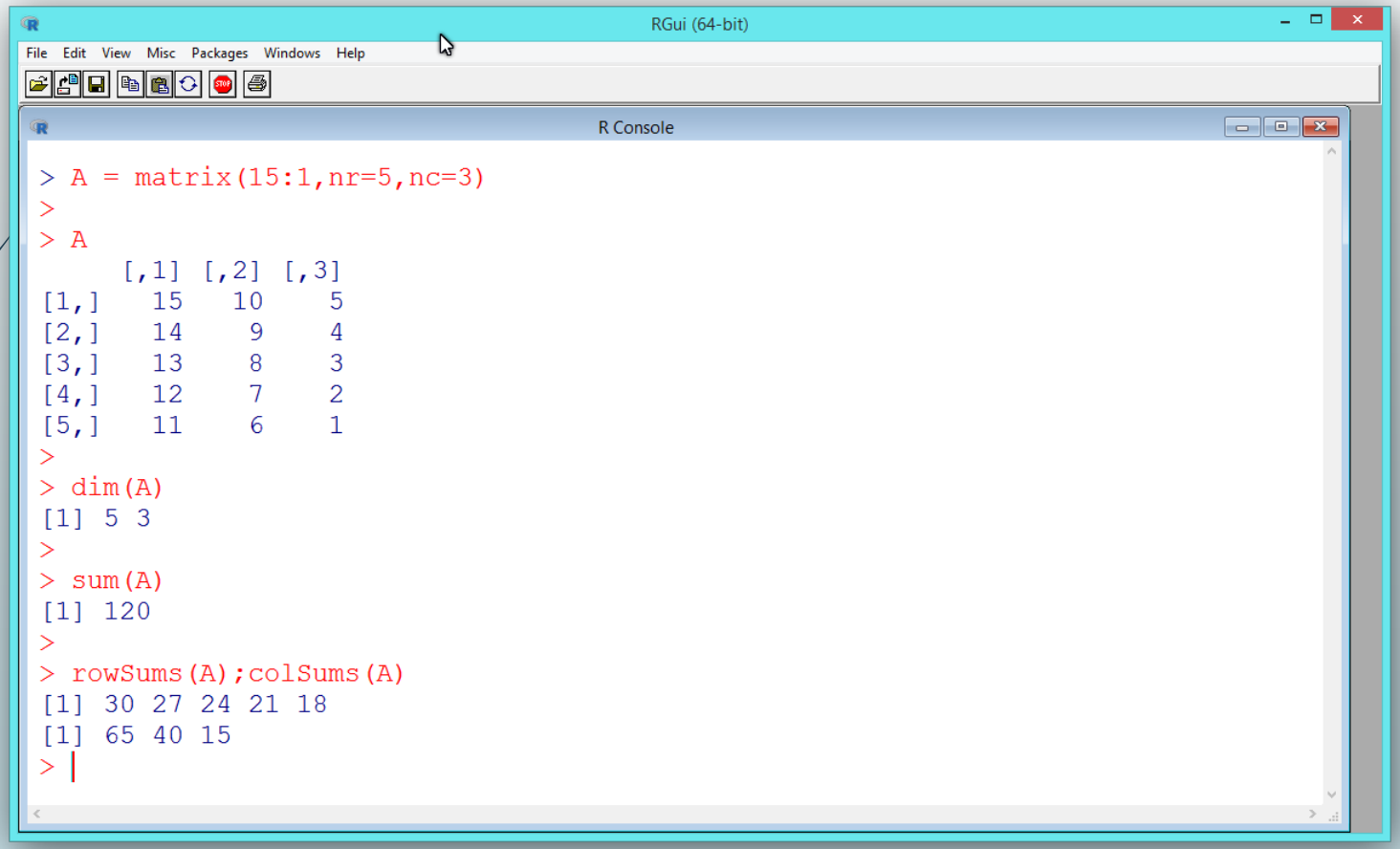
Matrix

- Naming Matrix Rows and Columns (3)



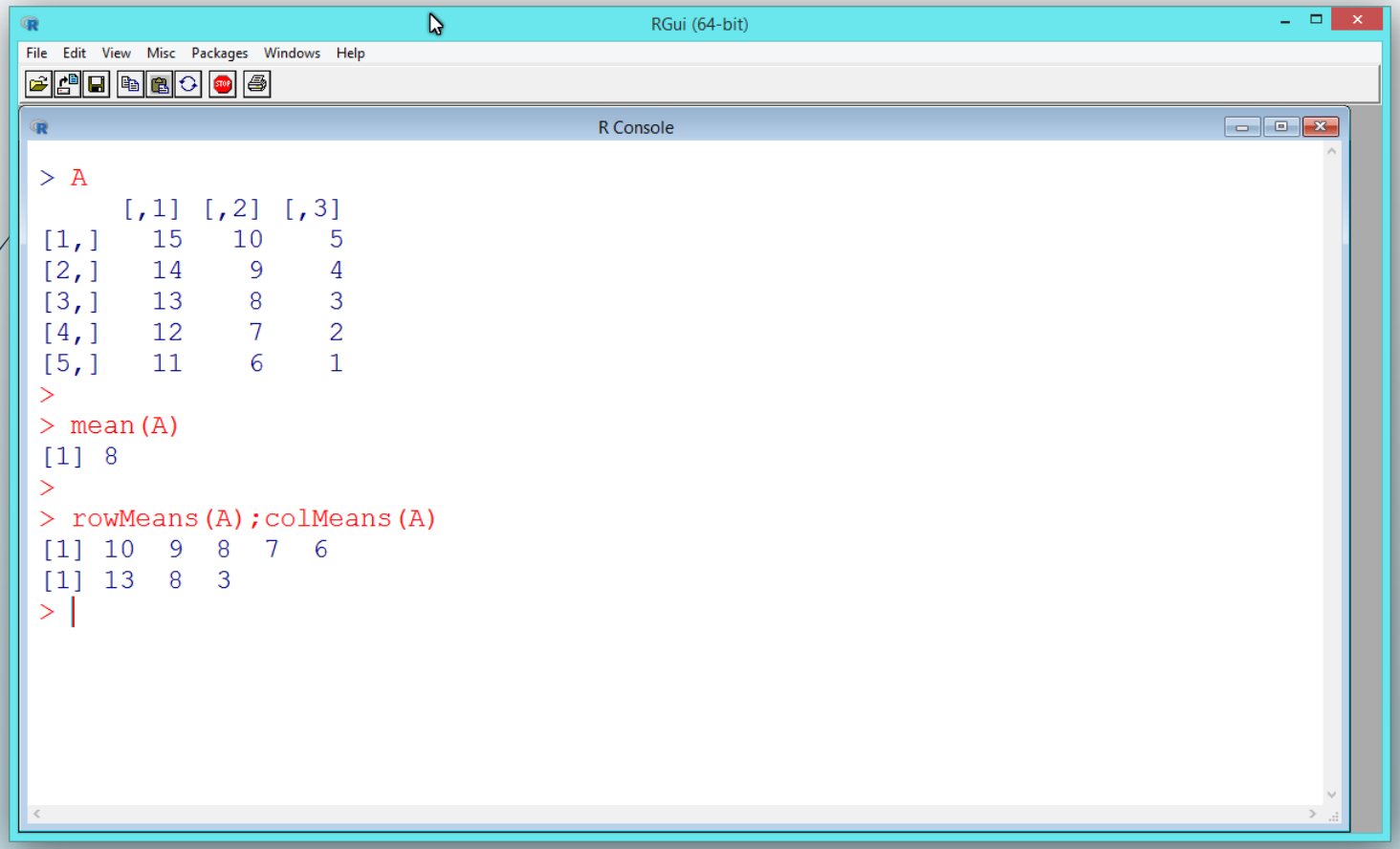
Matrix

Some Built-in Functions for Matrices (1)



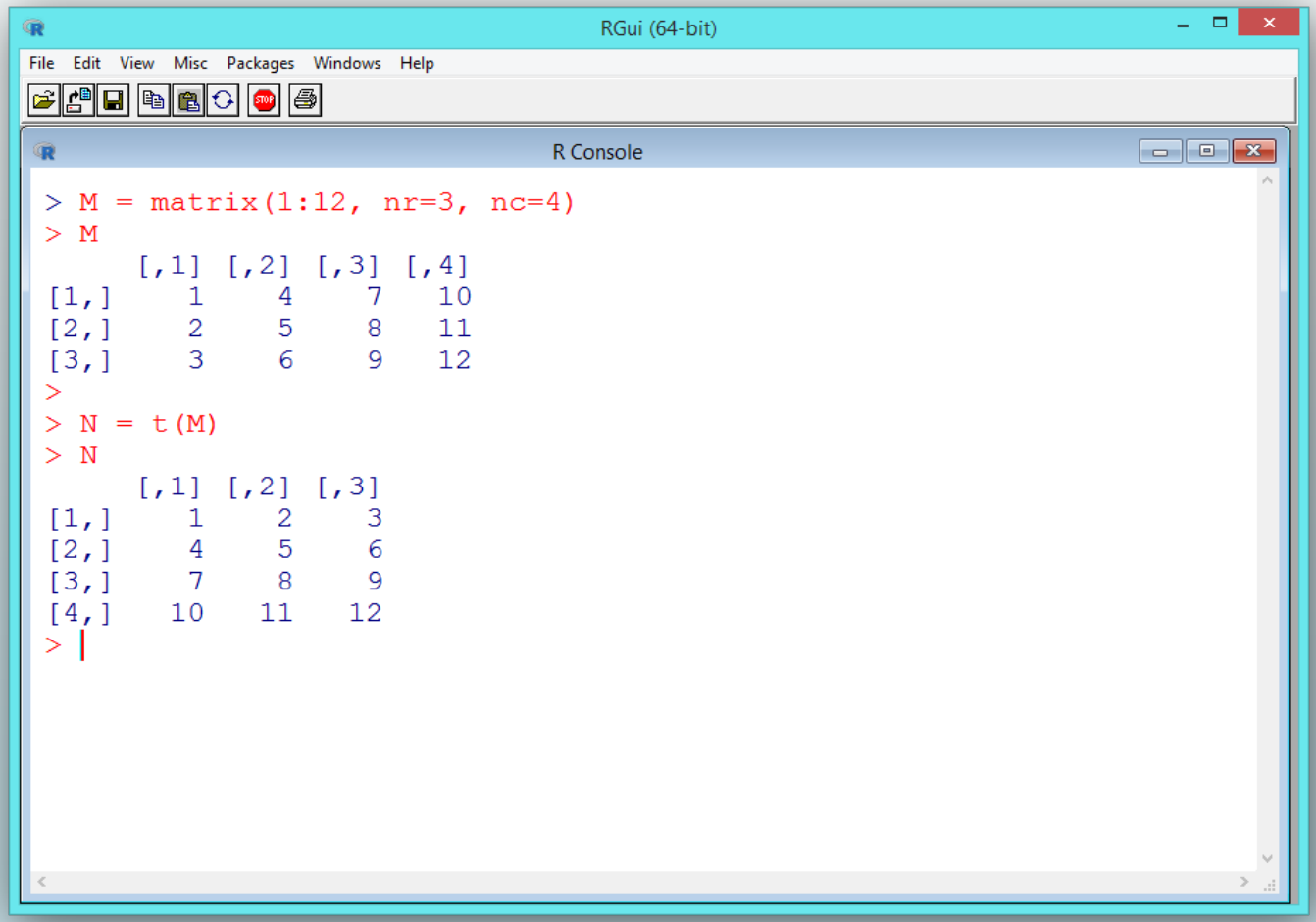
Matrix

- Some Built-in Functions for Matrices (2)



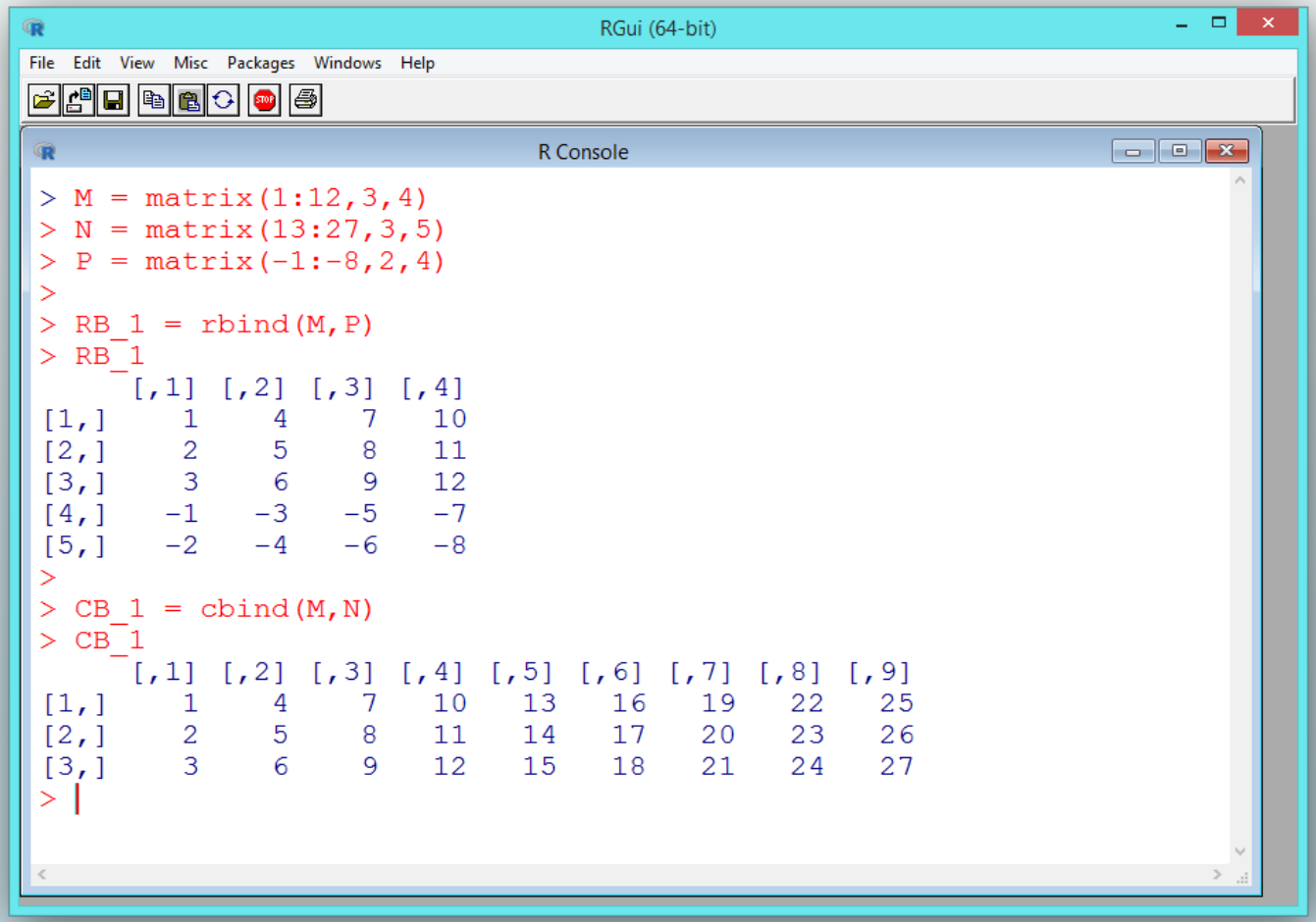
Matrix

- Some Built-in Functions for Matrices (3)



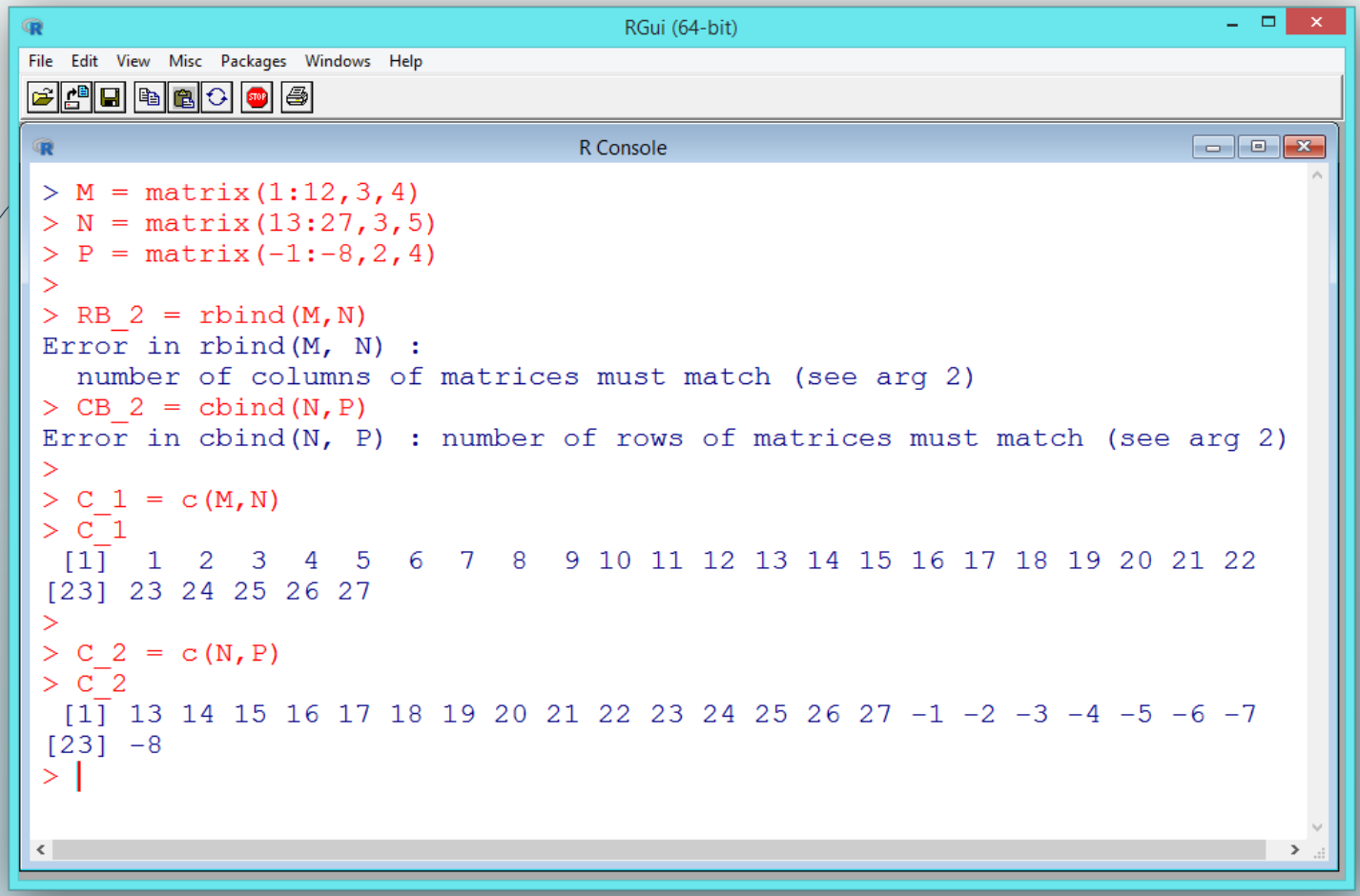
Matrix

Some Built-in Functions for Matrices (4)



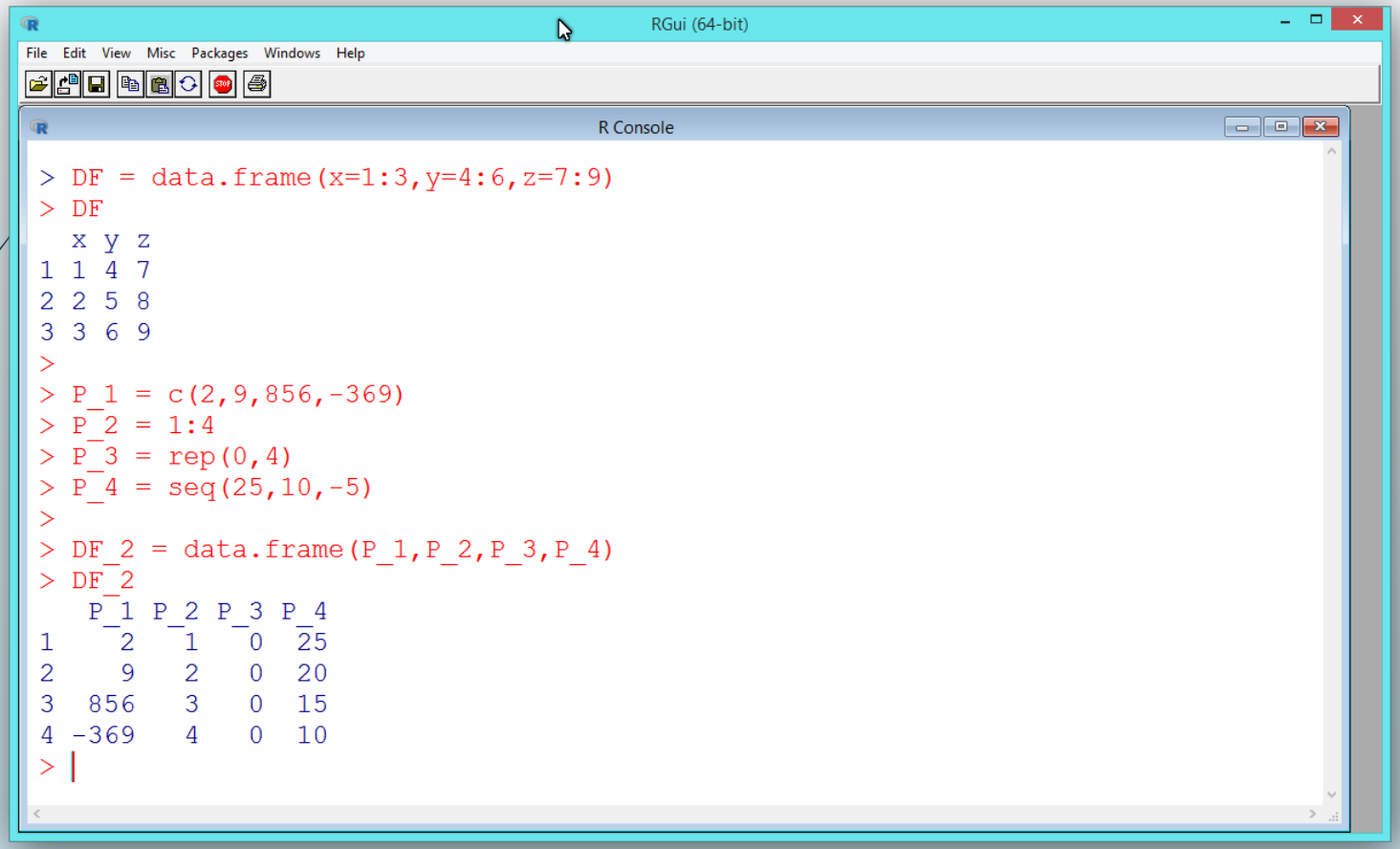
Matrix

- Some Built-in Functions for Matrices (5)



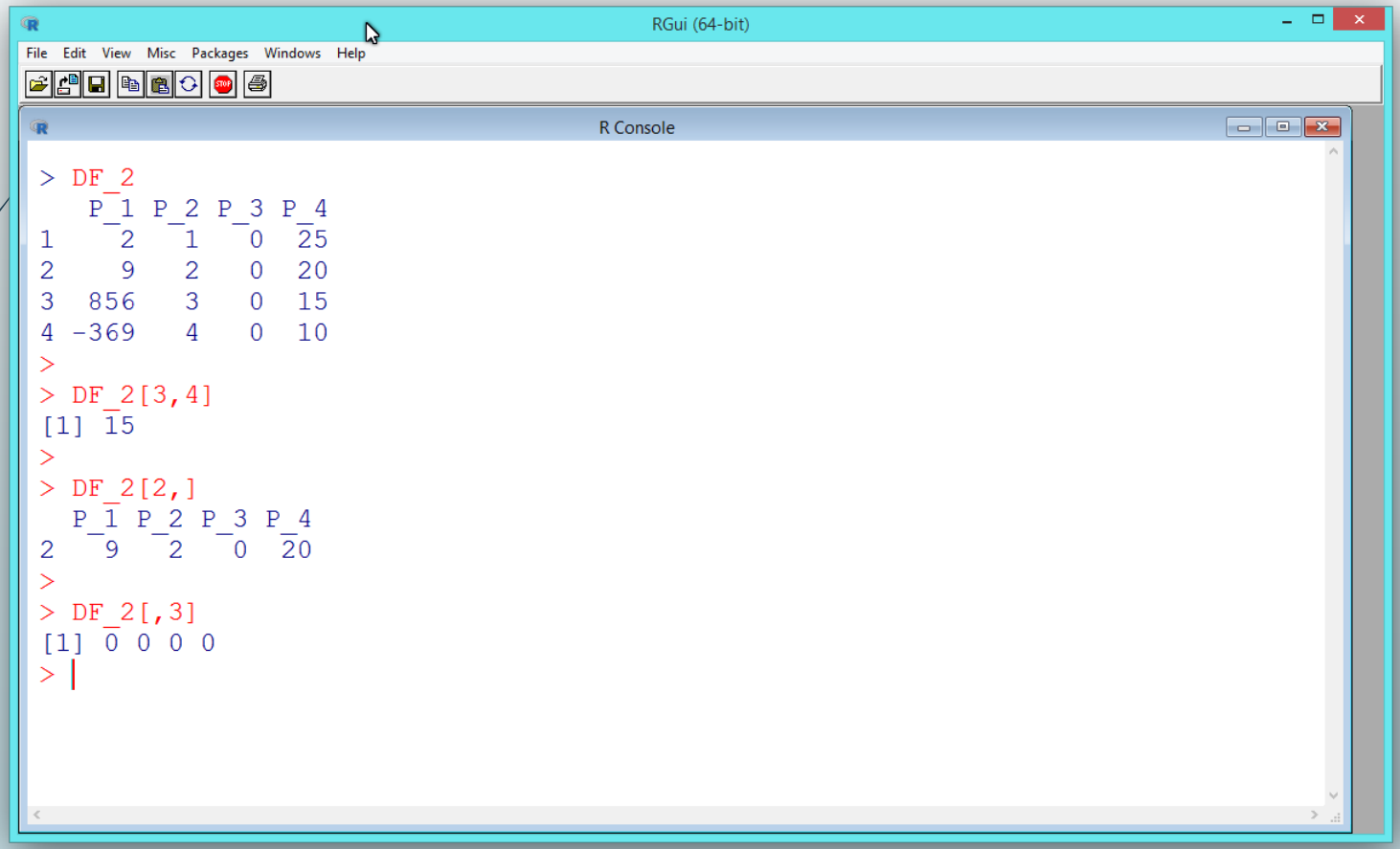
Data Frame

- Assignment



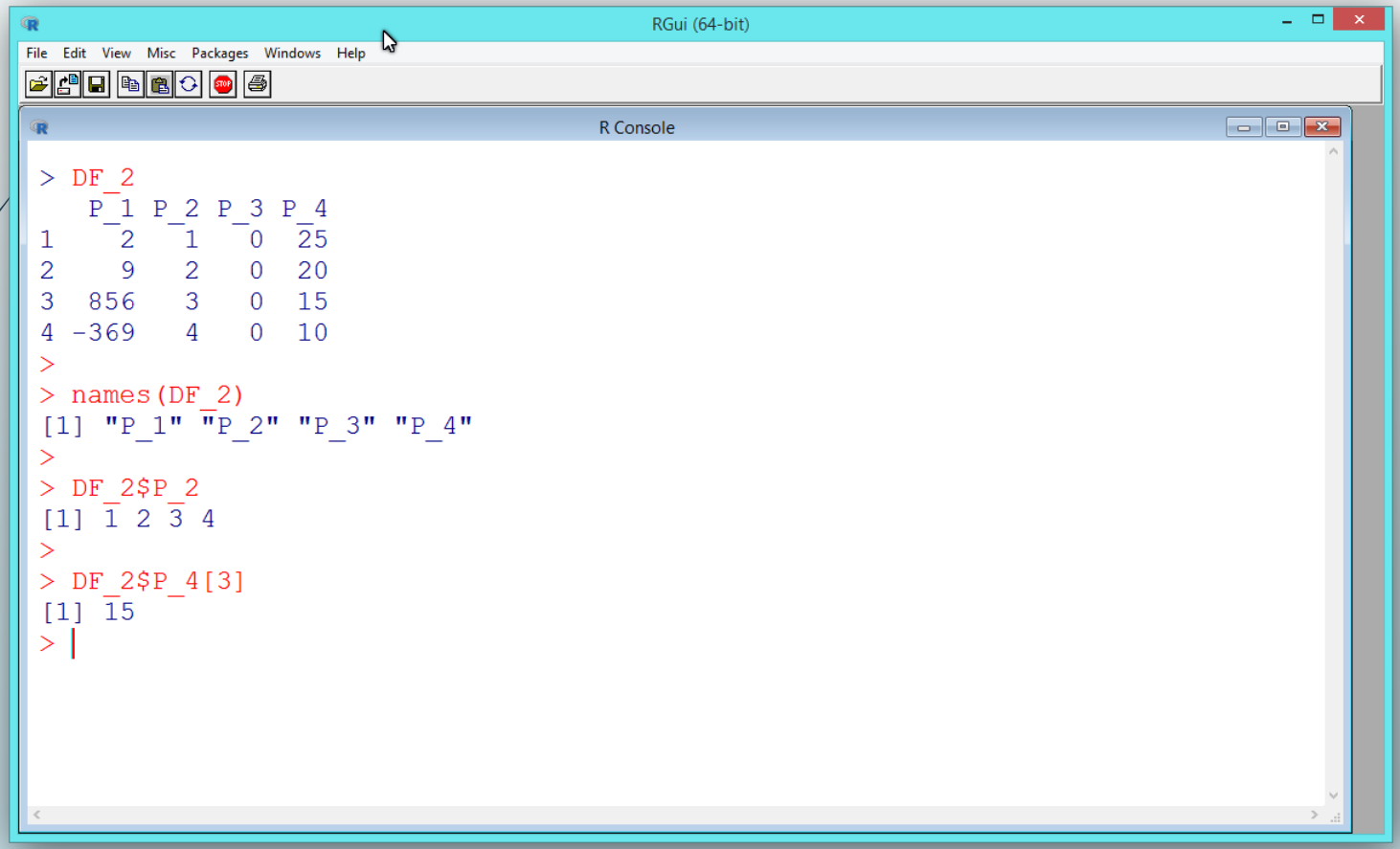
Data Frame

- Addressing Data Frame Elements, Rows and Columns (1)



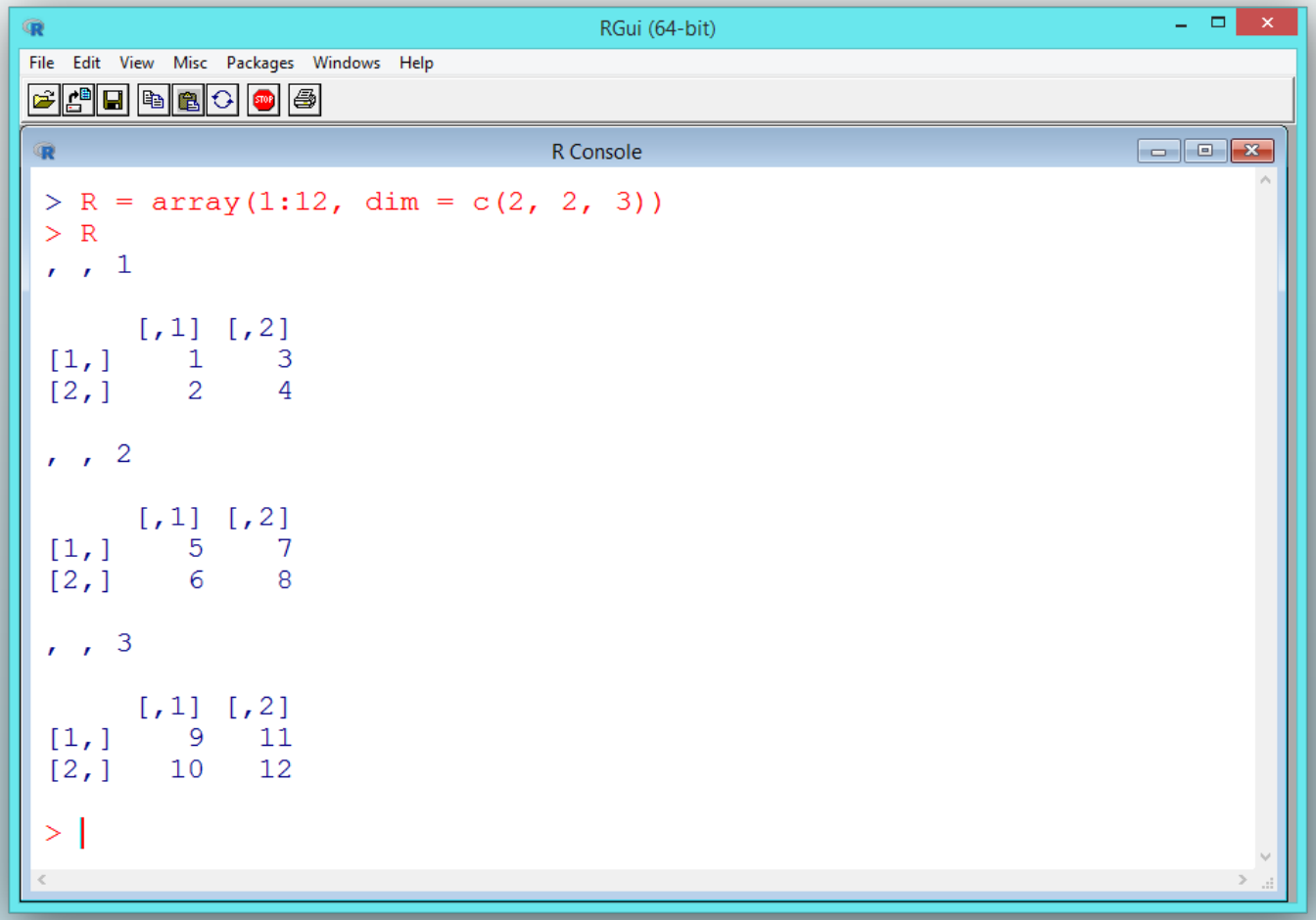
Data Frame

- Addressing Data Frame Elements, Rows and Columns (2)



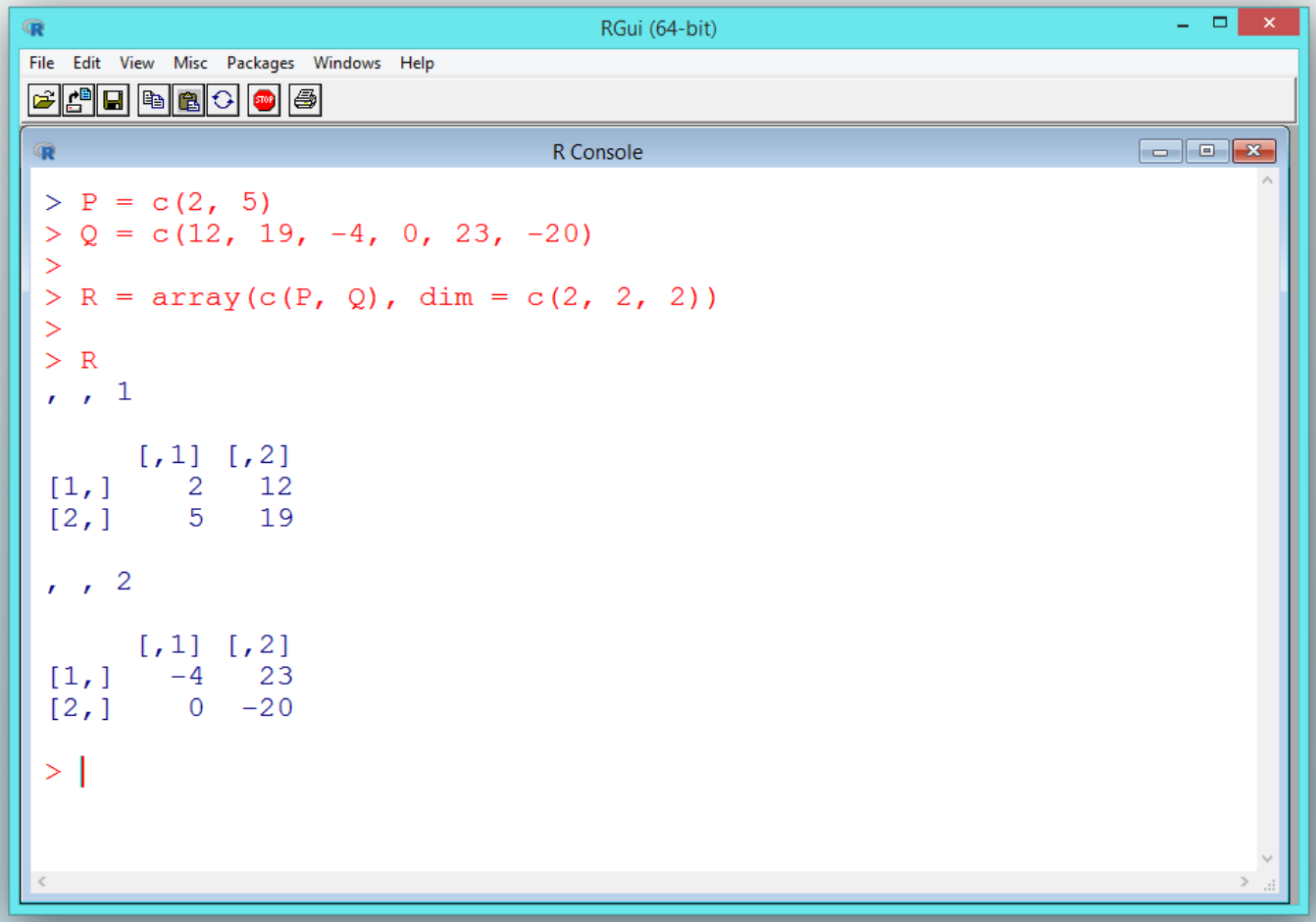
Array

- Assignment (1)



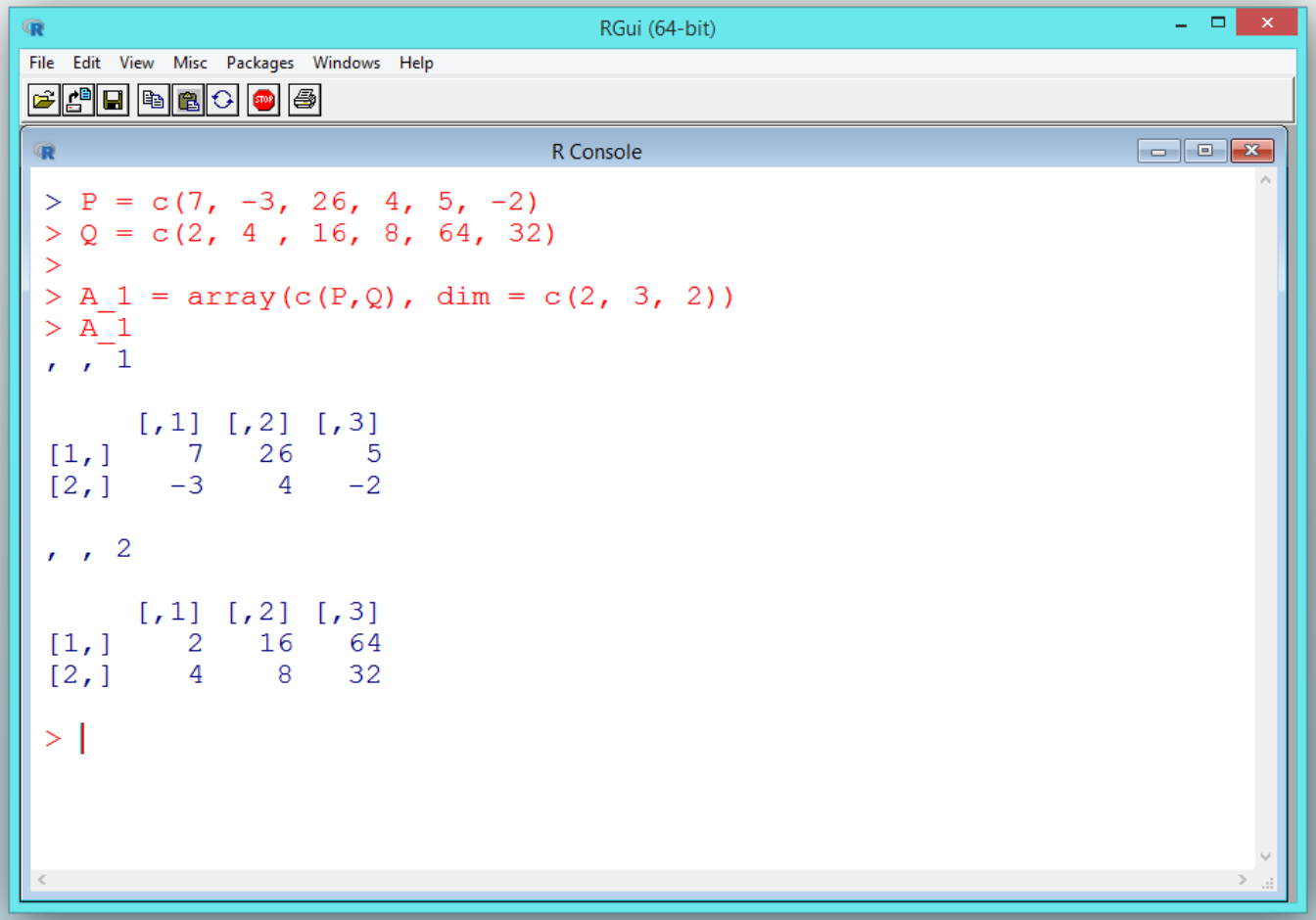
Array

- Assignment (2)



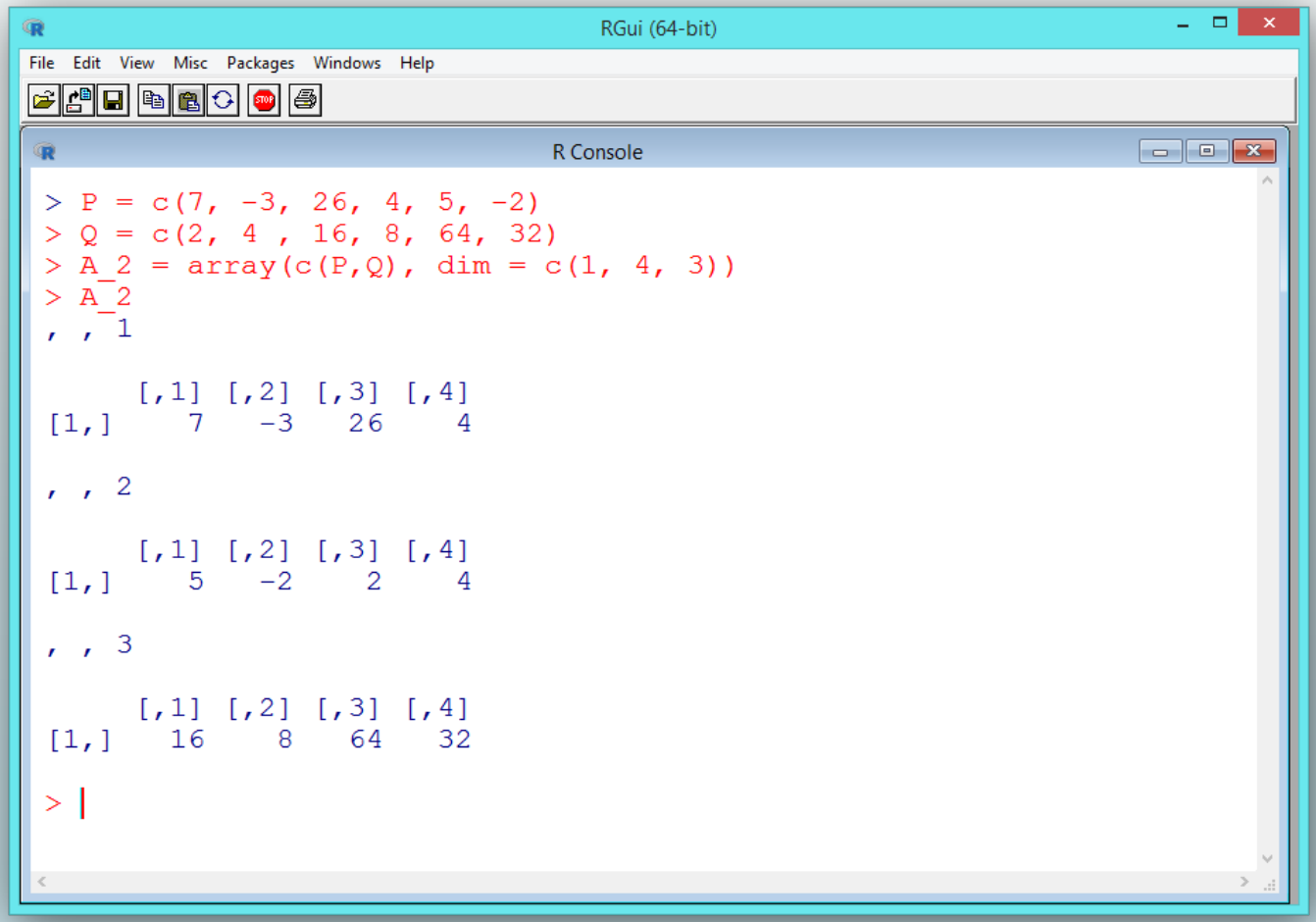
Array

- Assignment (3)



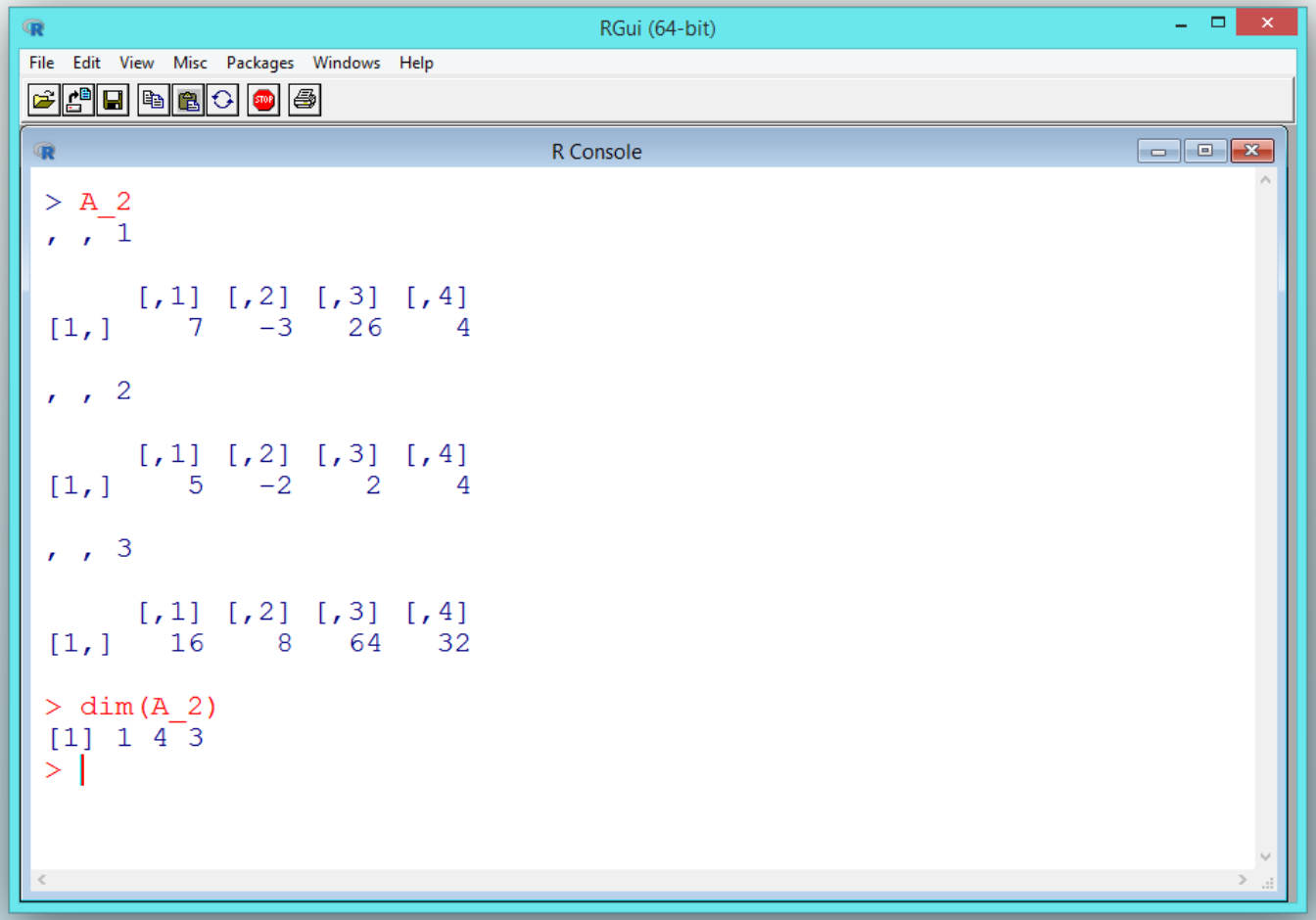
Array

- Assignment (4)



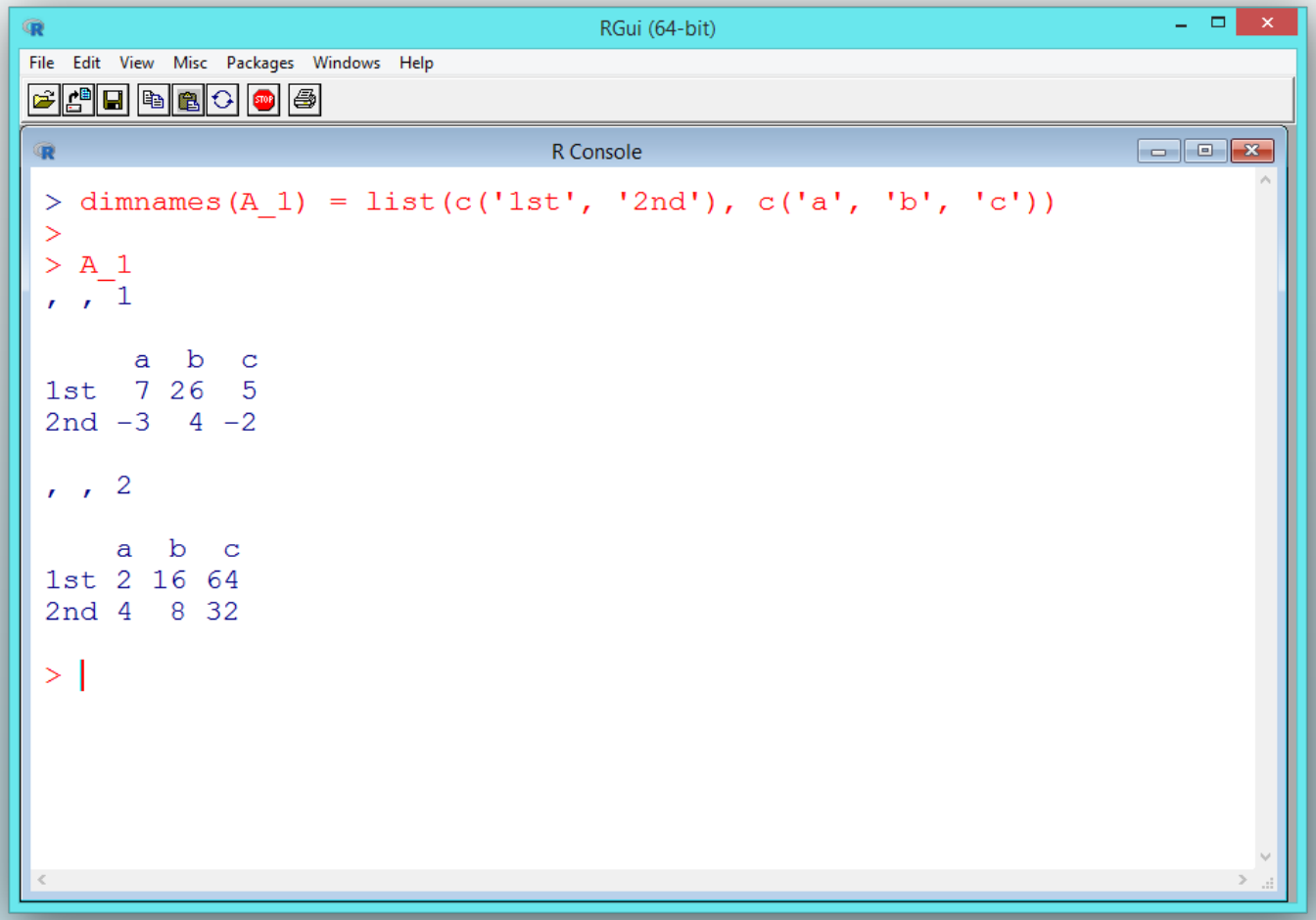
Array

- Array Dimensions



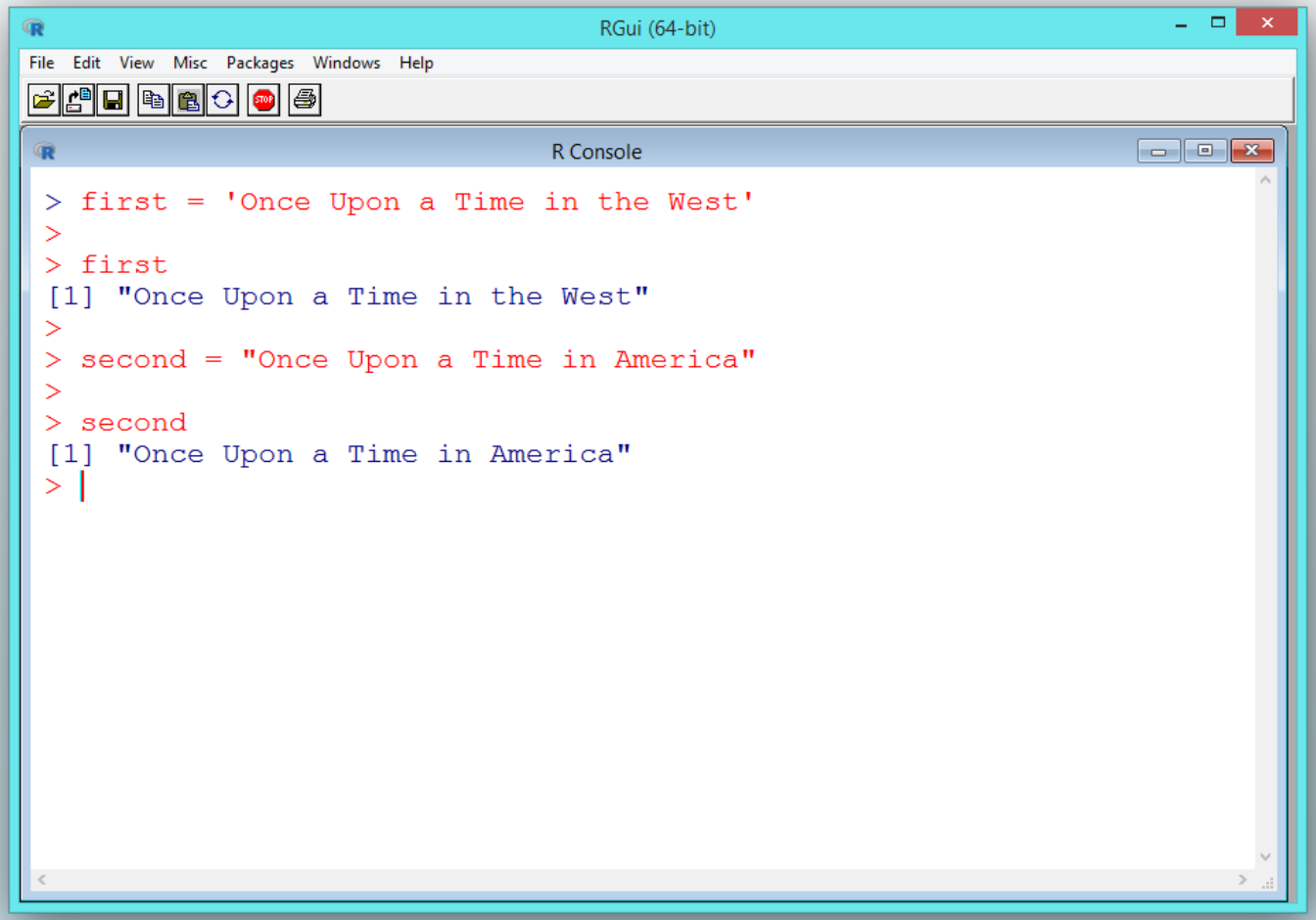
Array

- Naming the Array Dimensions



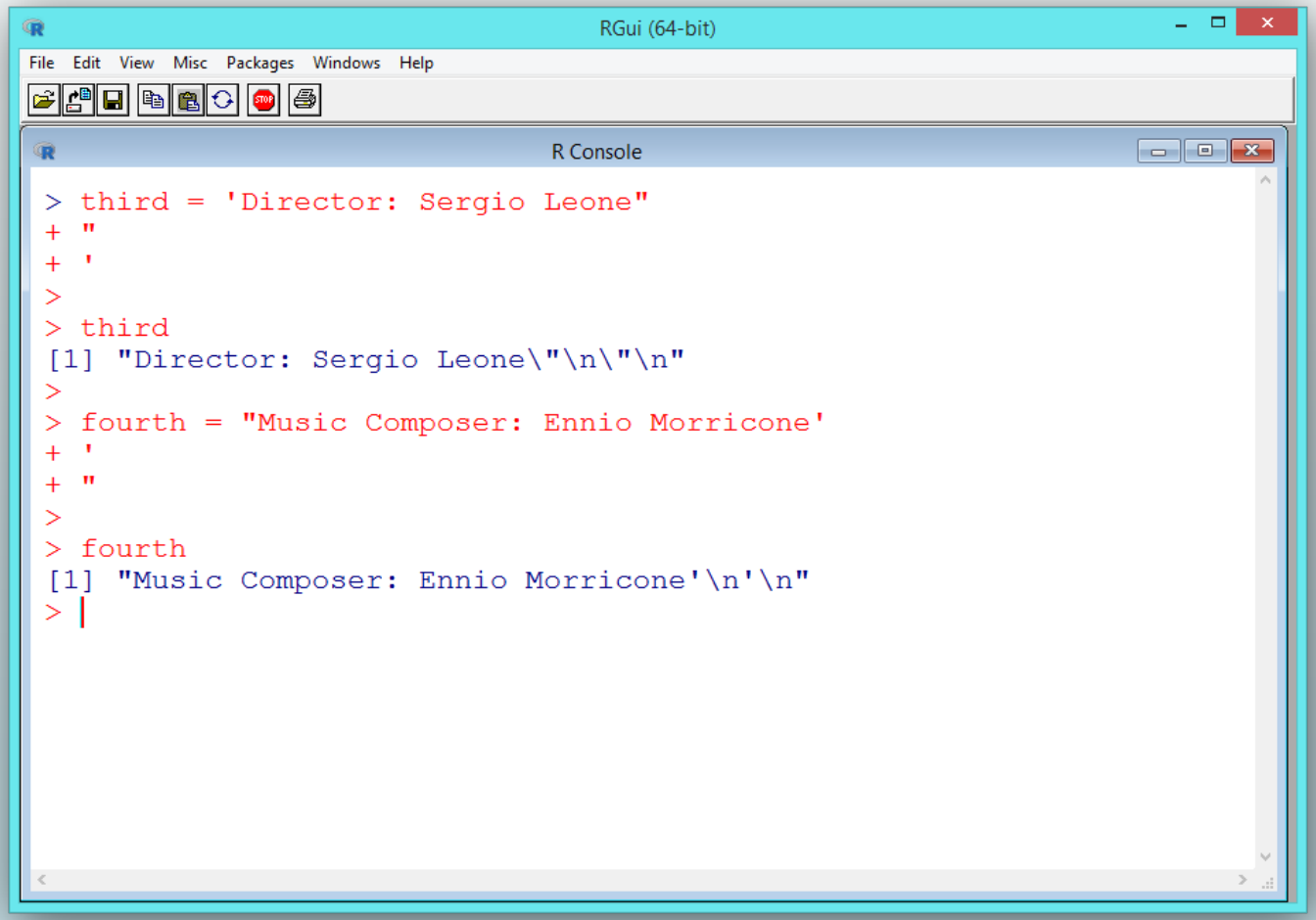
String

- Assignment (1)



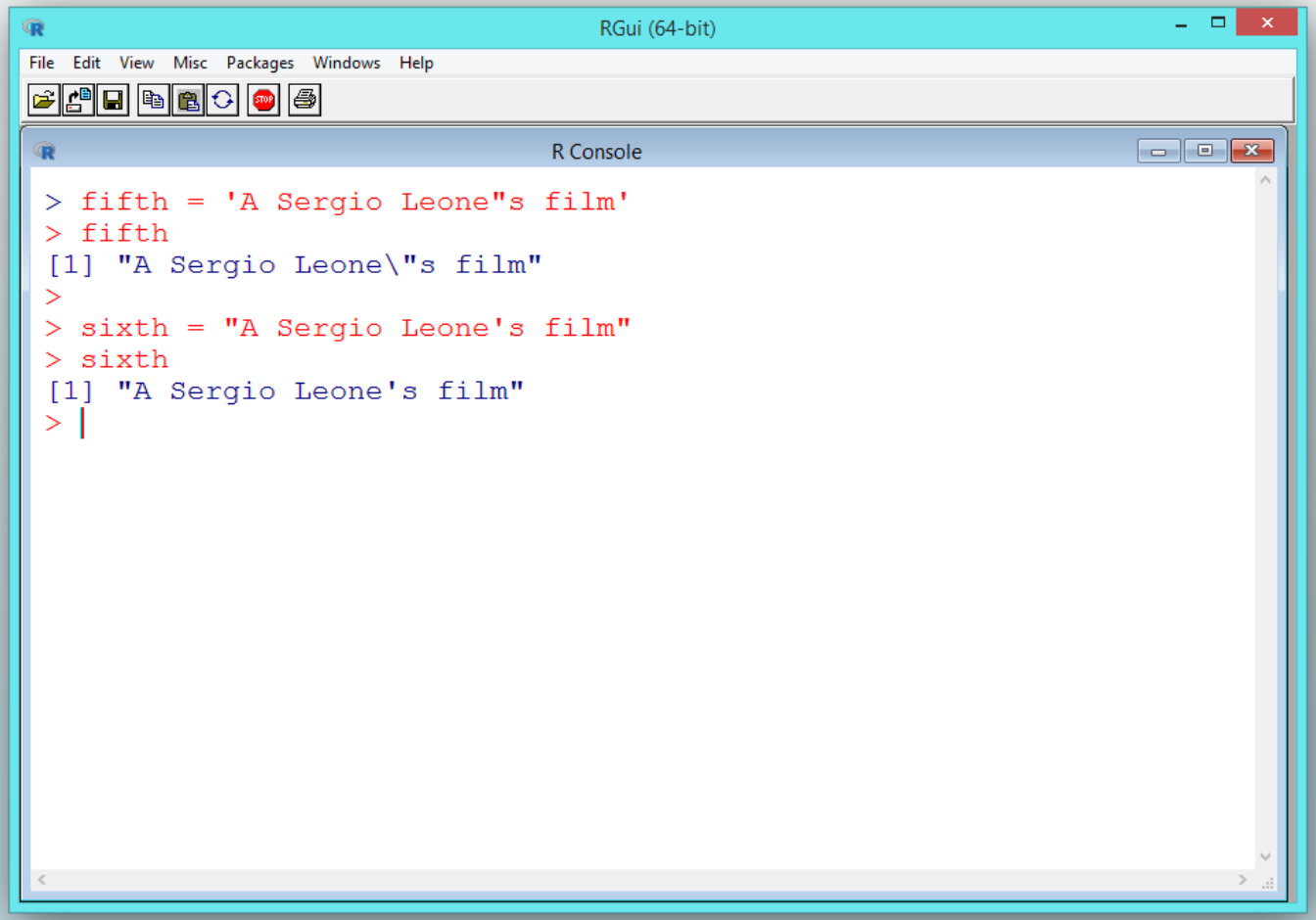
String

- Assignment (2)



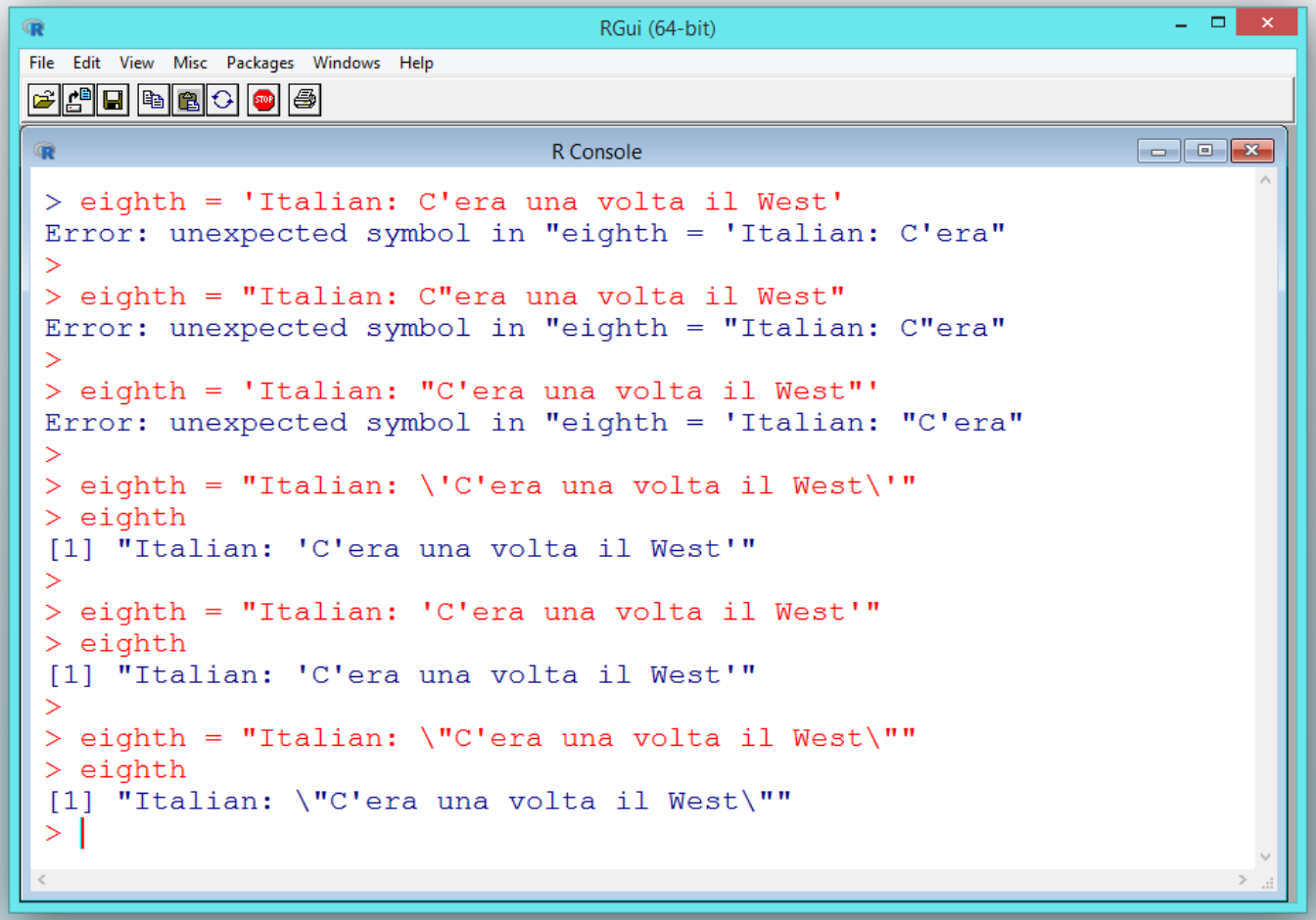
String

- Assignment (3)



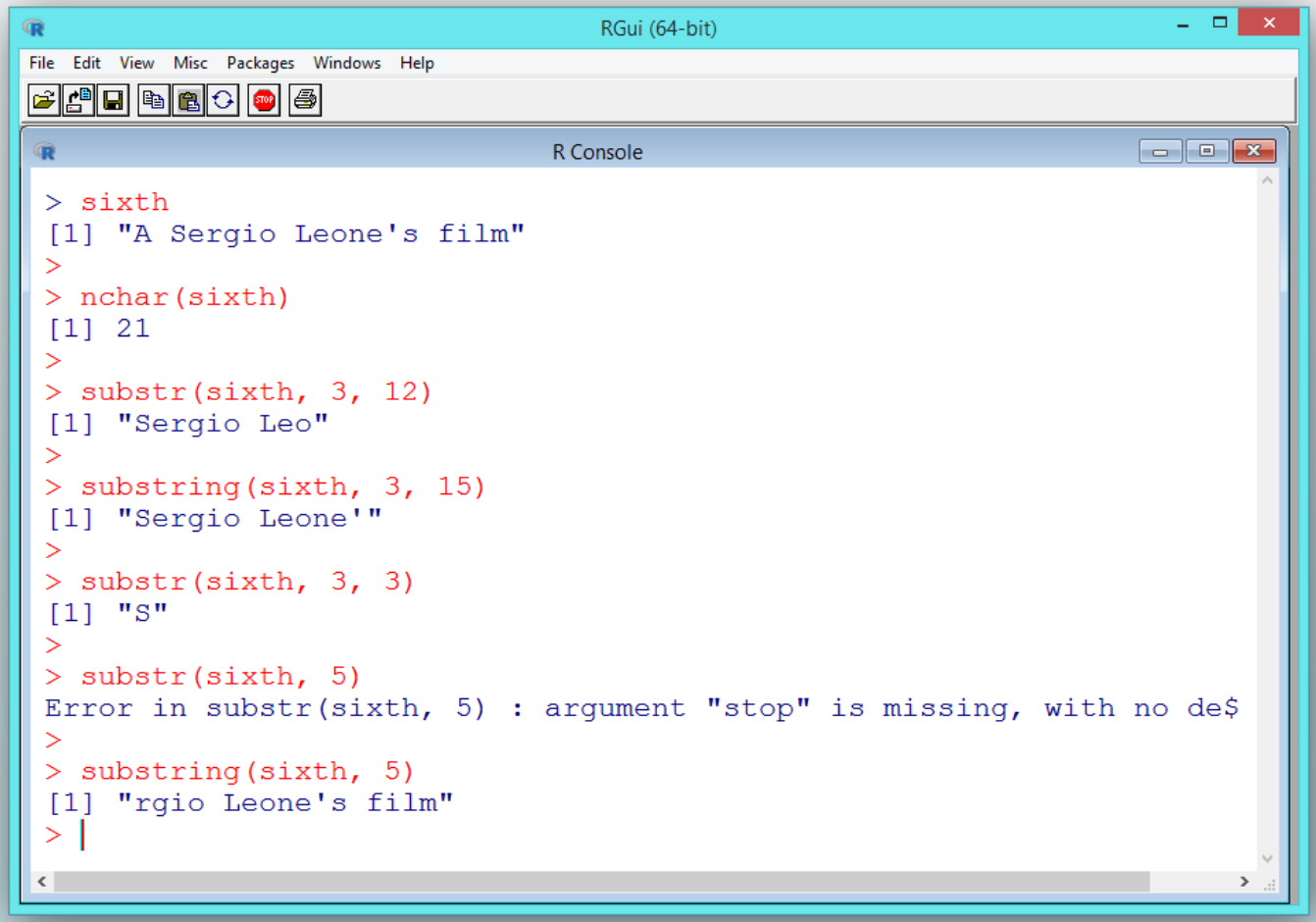
String

- Assignment (4)



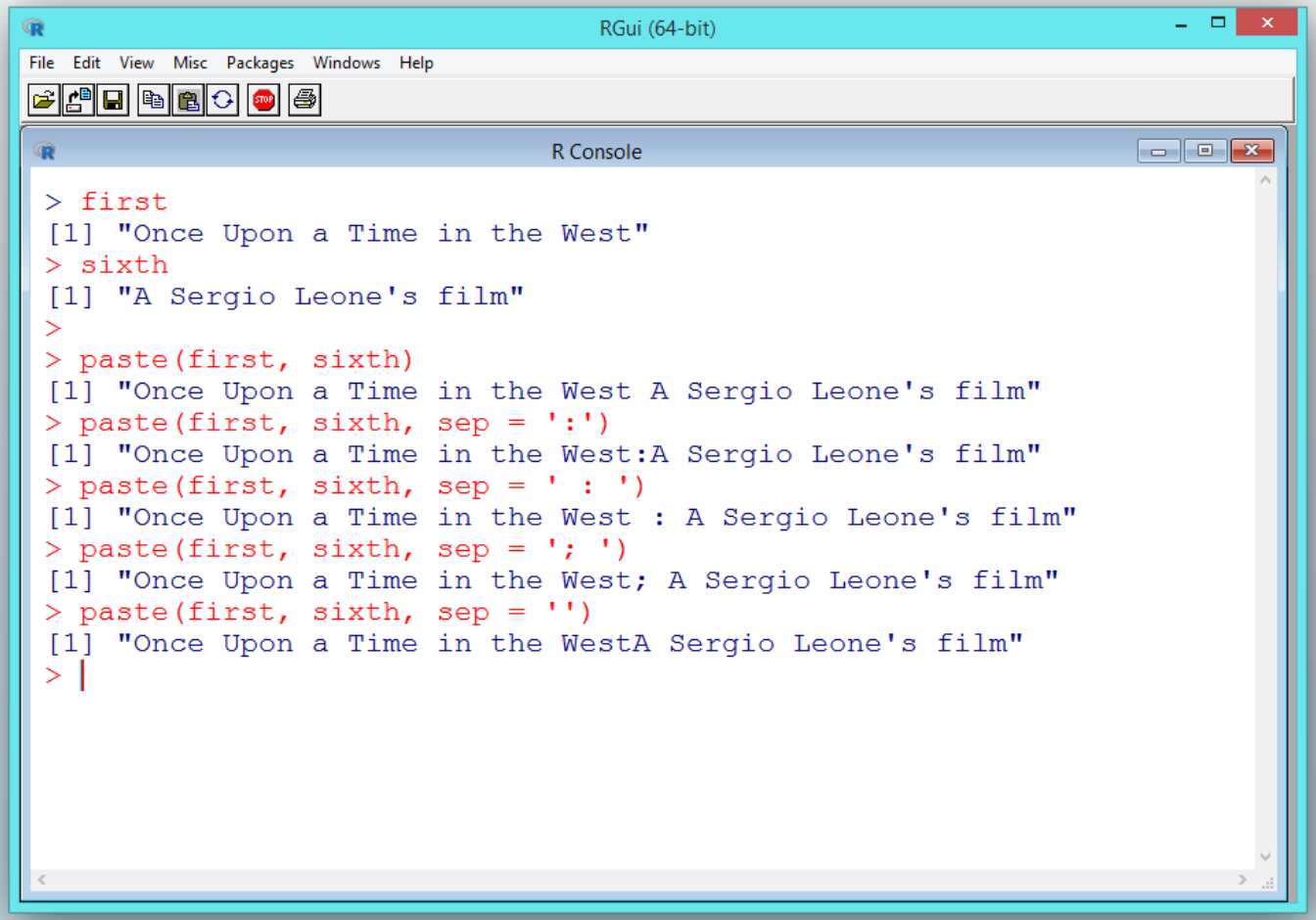
String

- Substrings



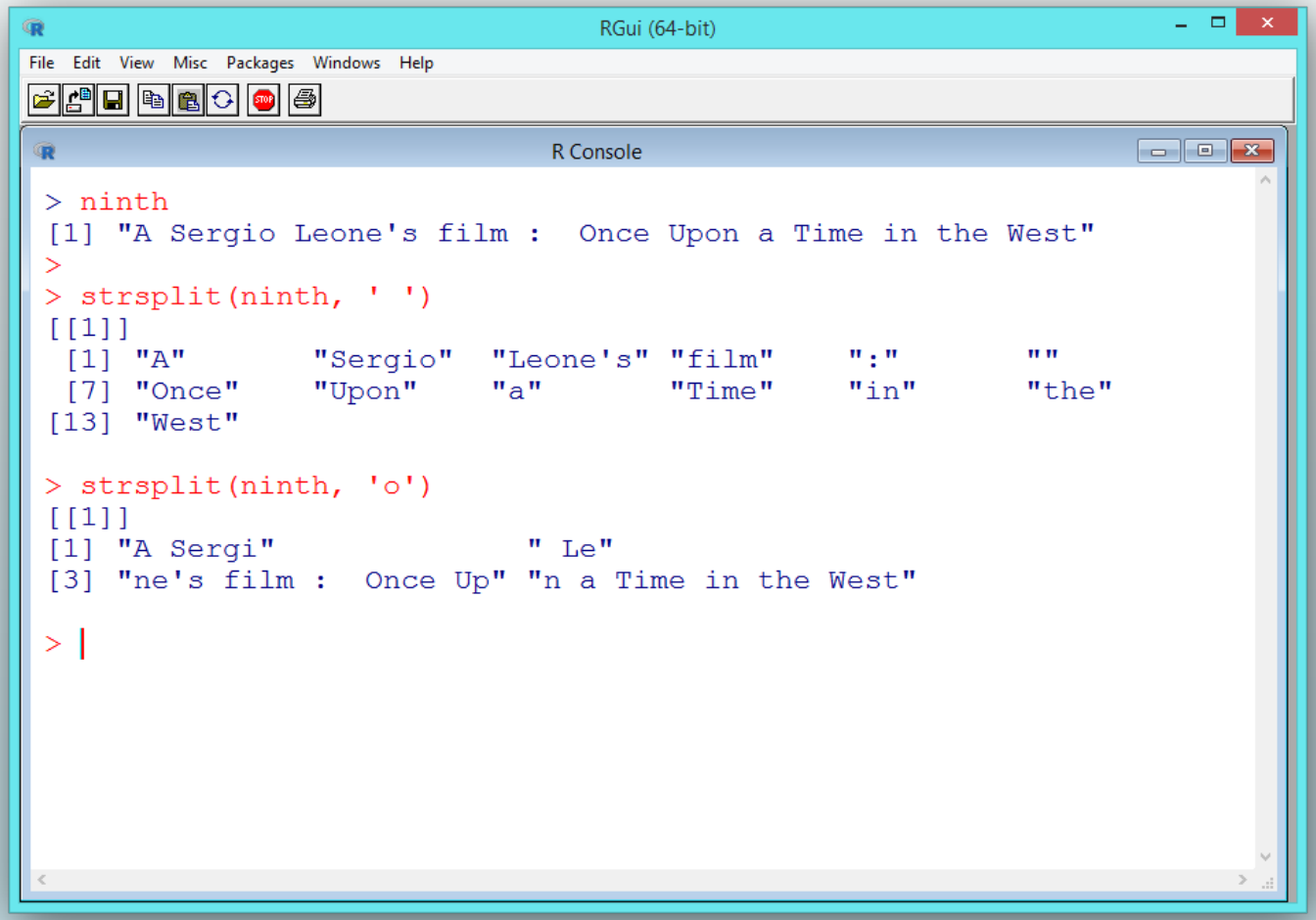
String

- Pasting Strings



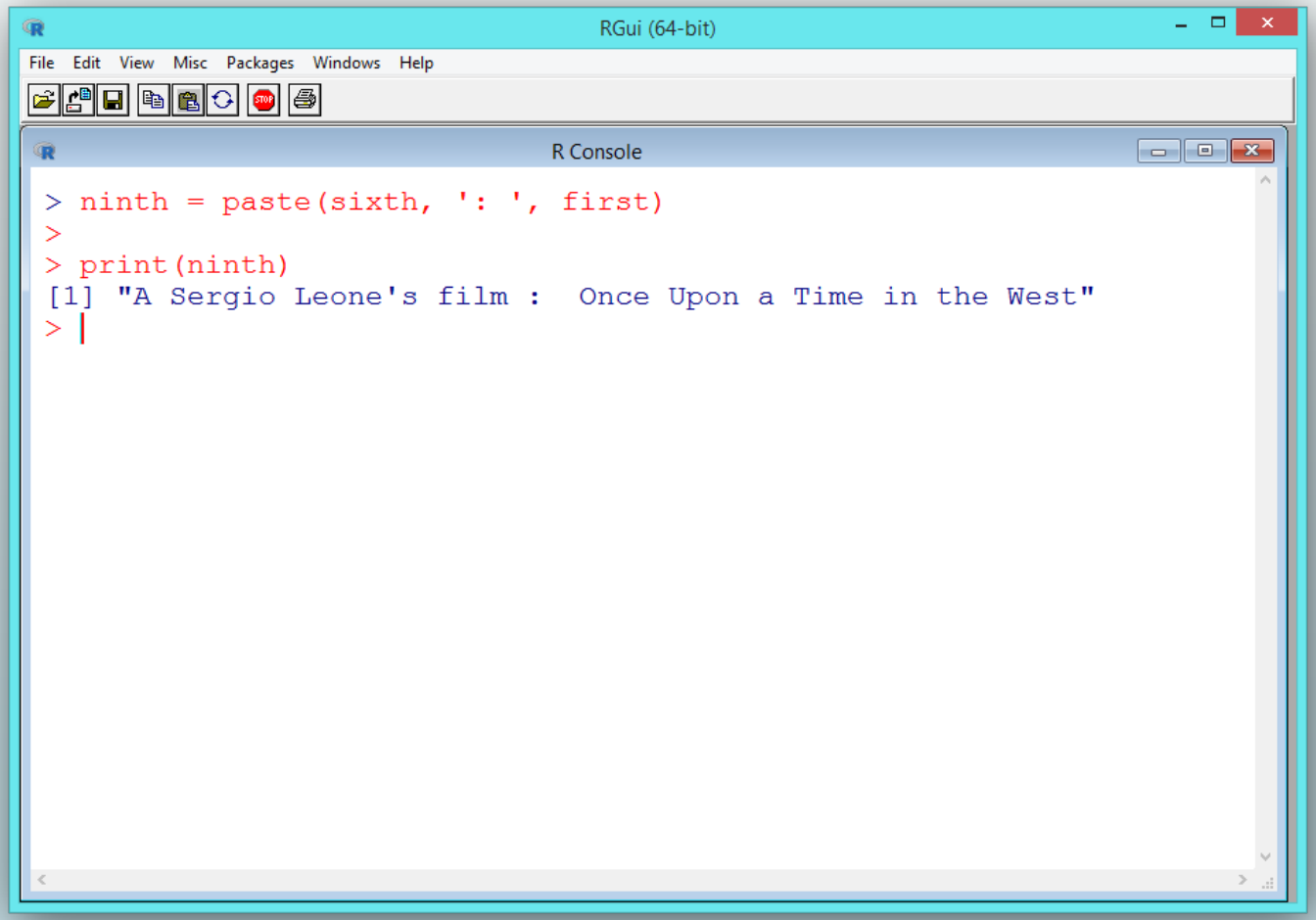
String

- Splitting a String



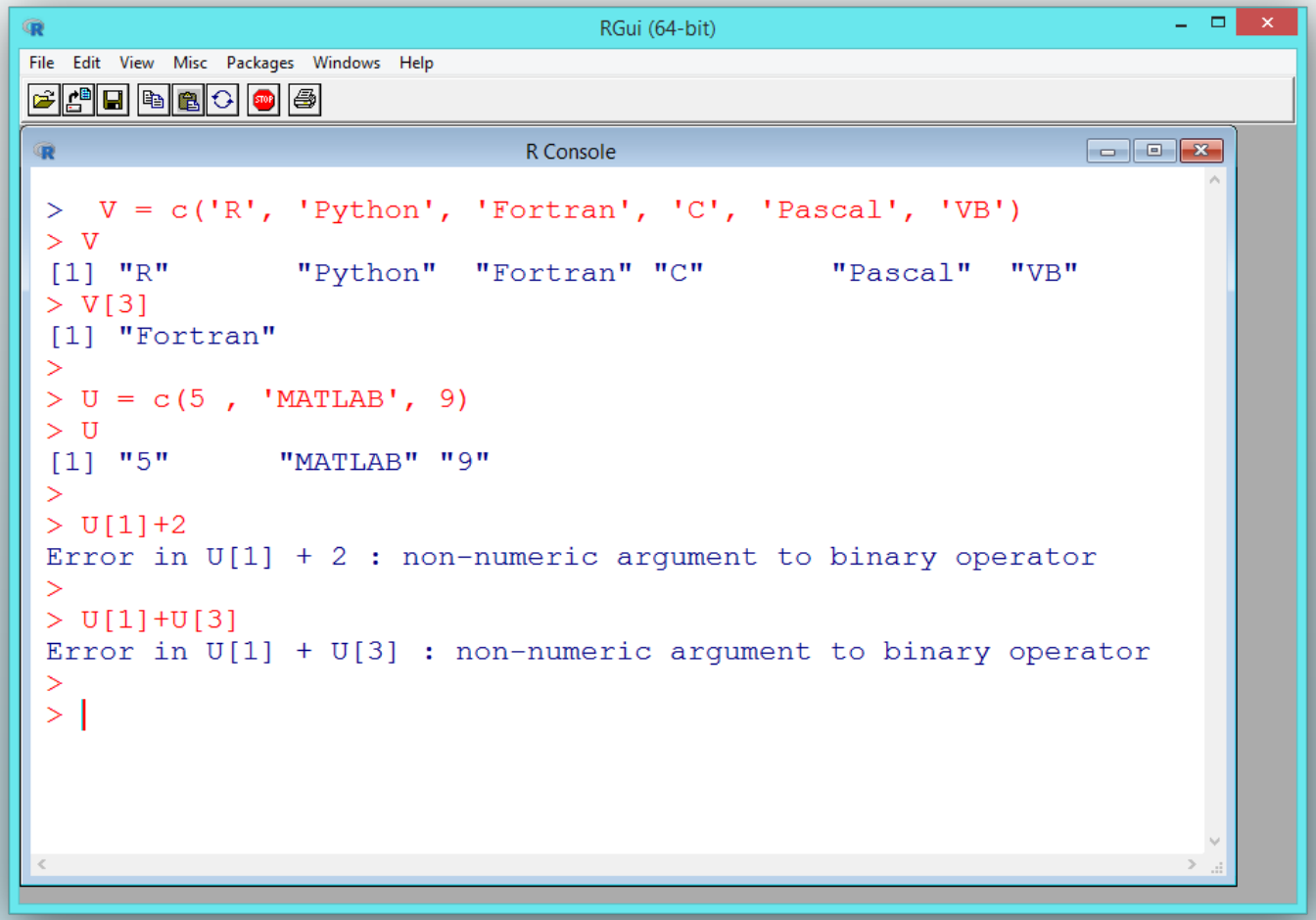
String

- Printing a String

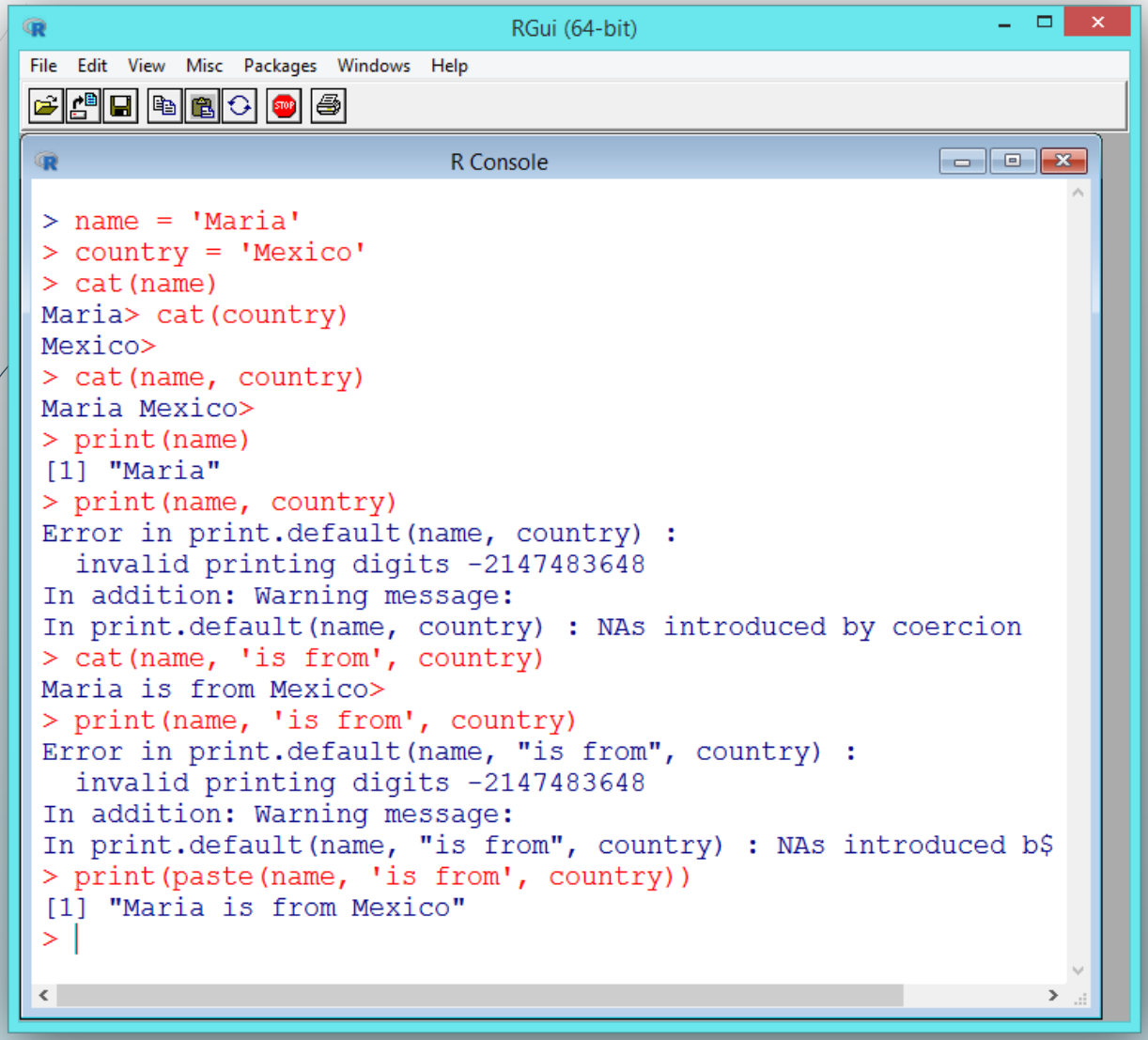


String

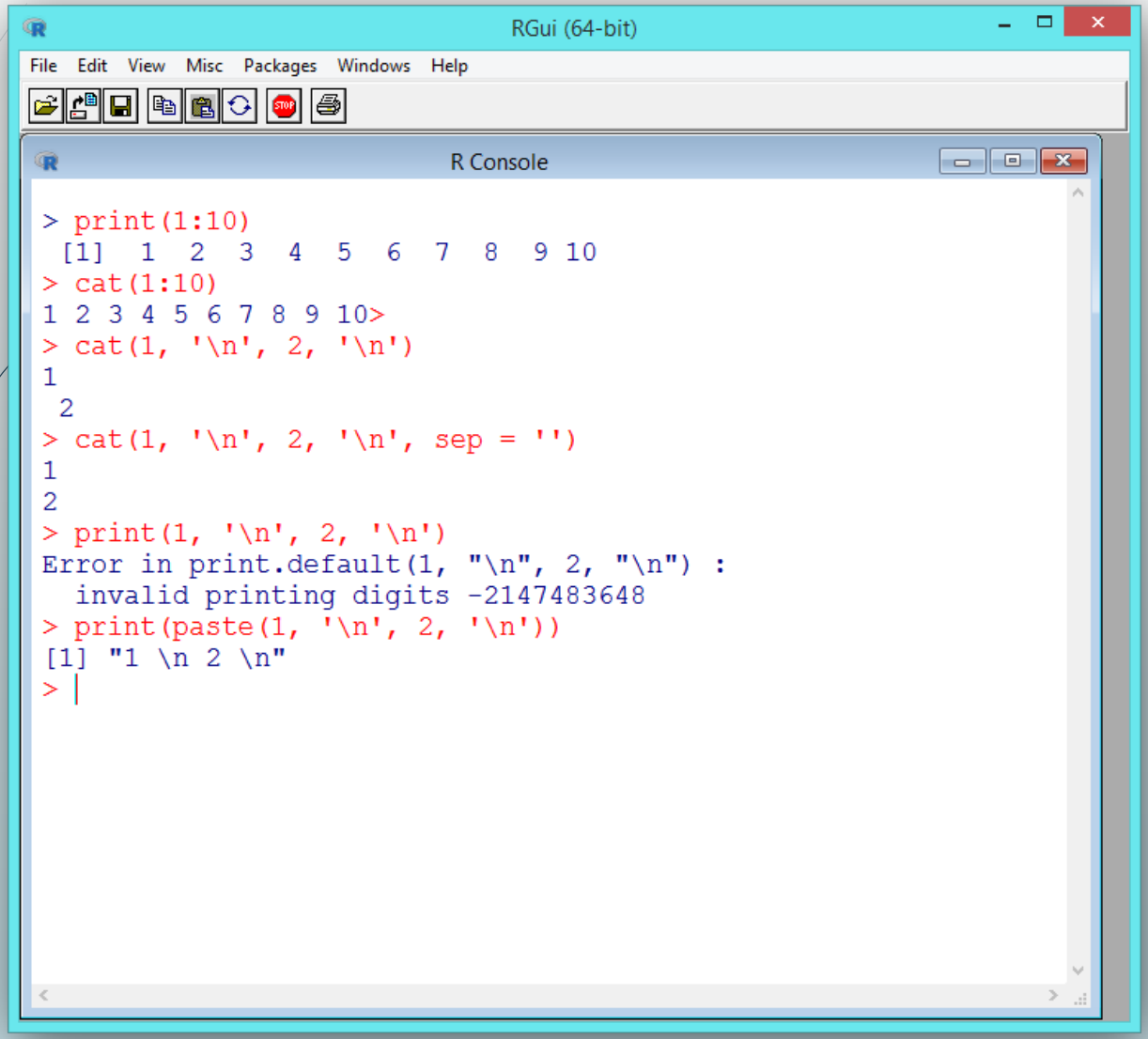
- String Vector



cat and print (1)

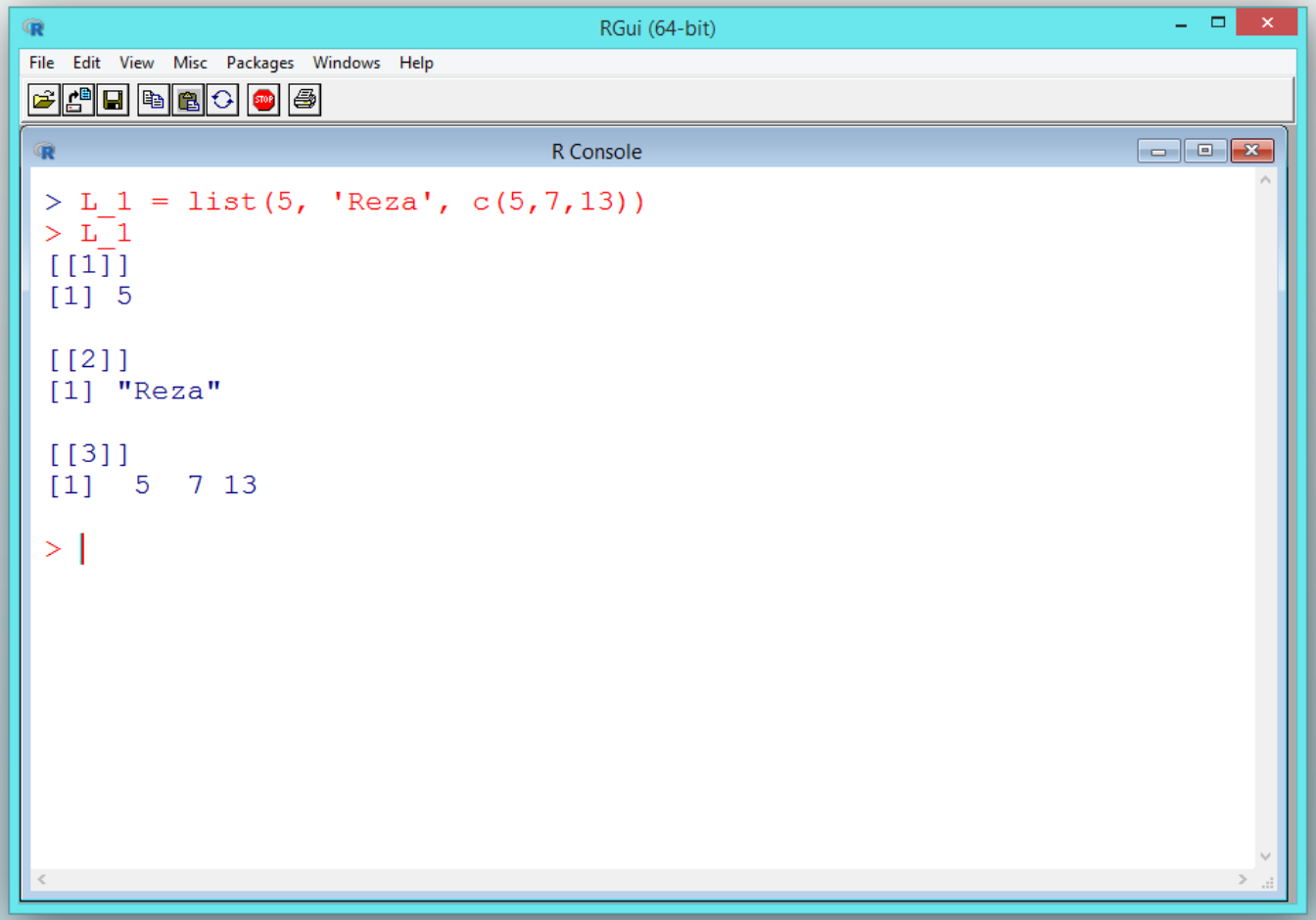


cat and print (2)



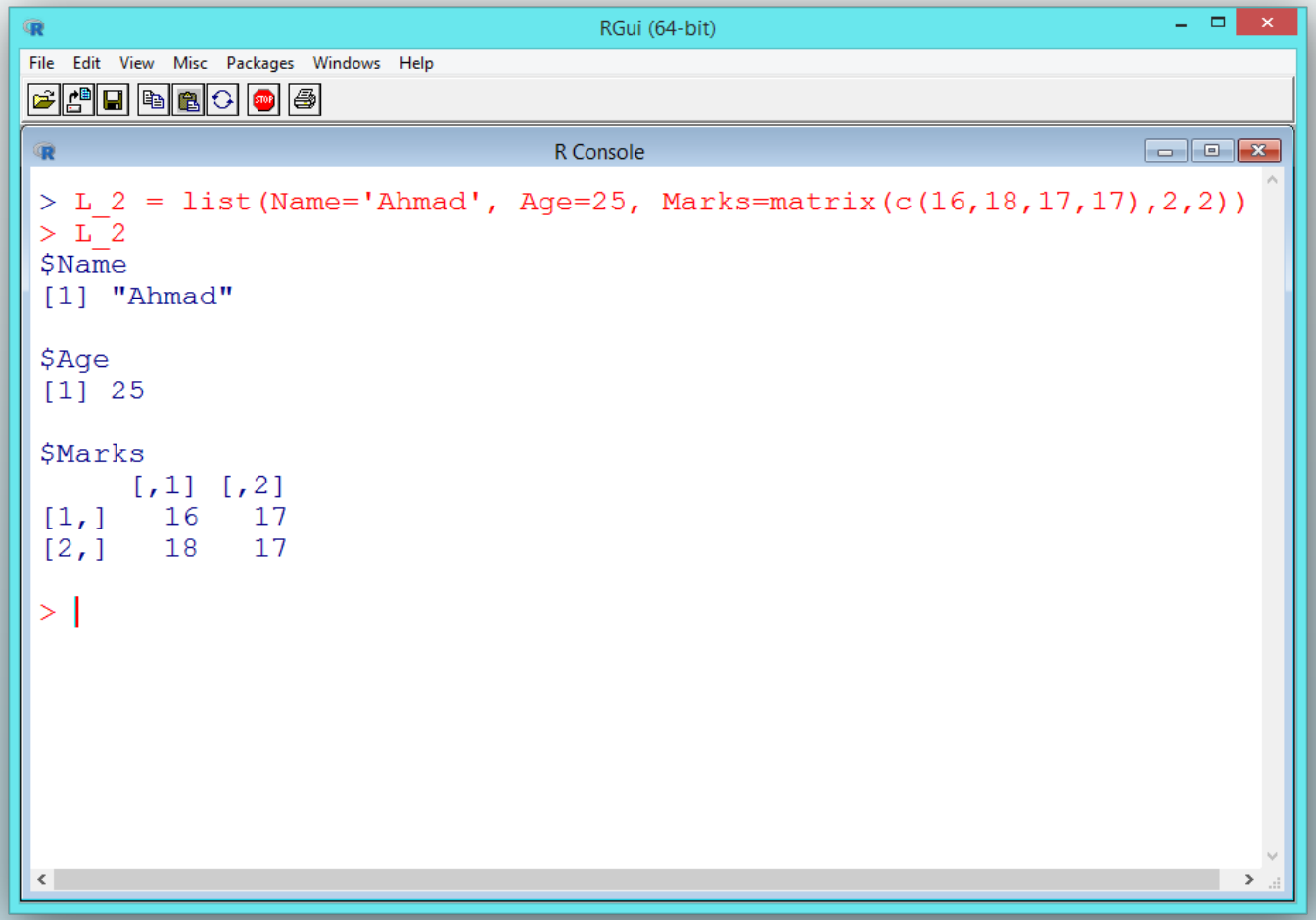
List

- Assignment (1)



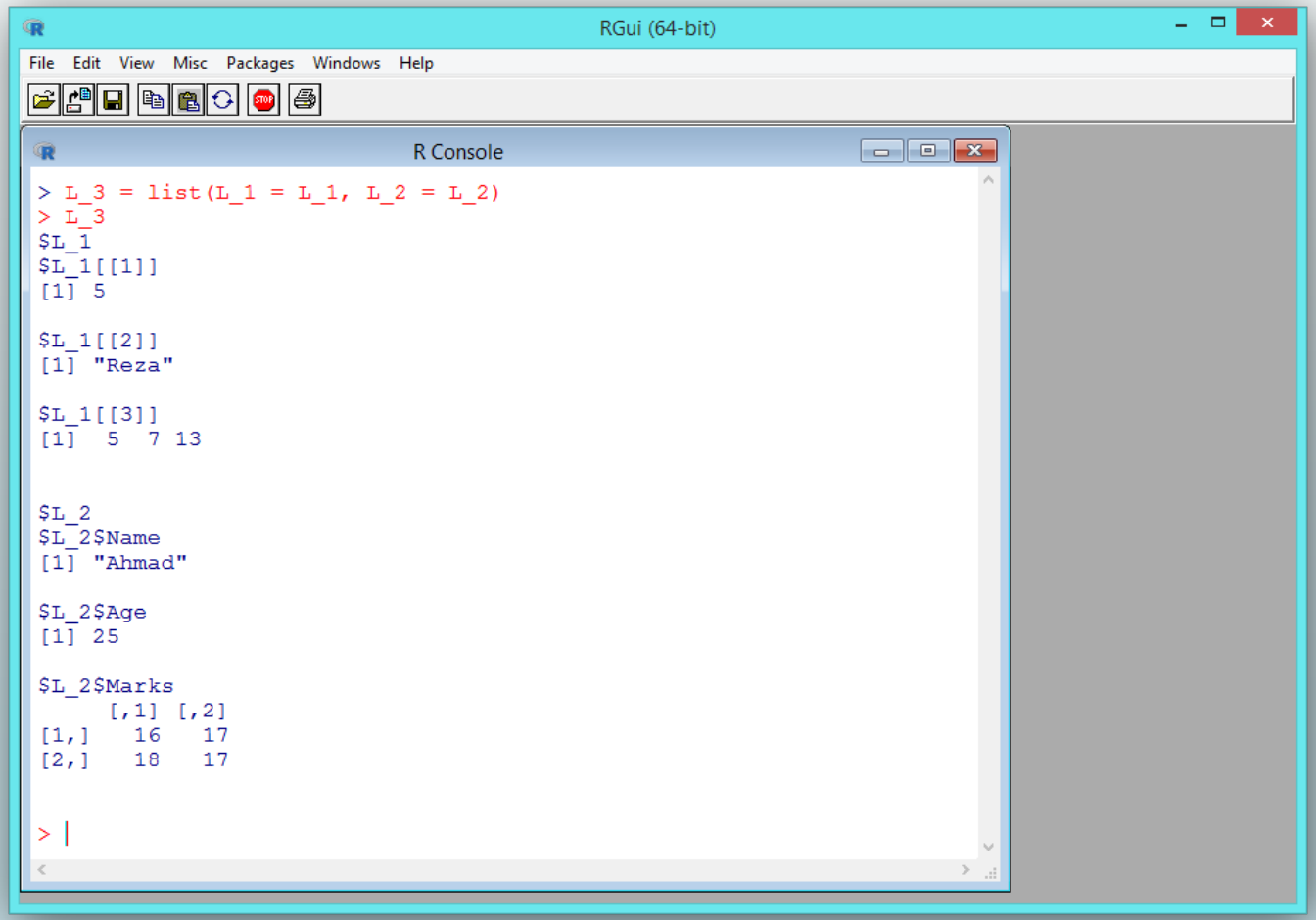
List

- Assignment (2)



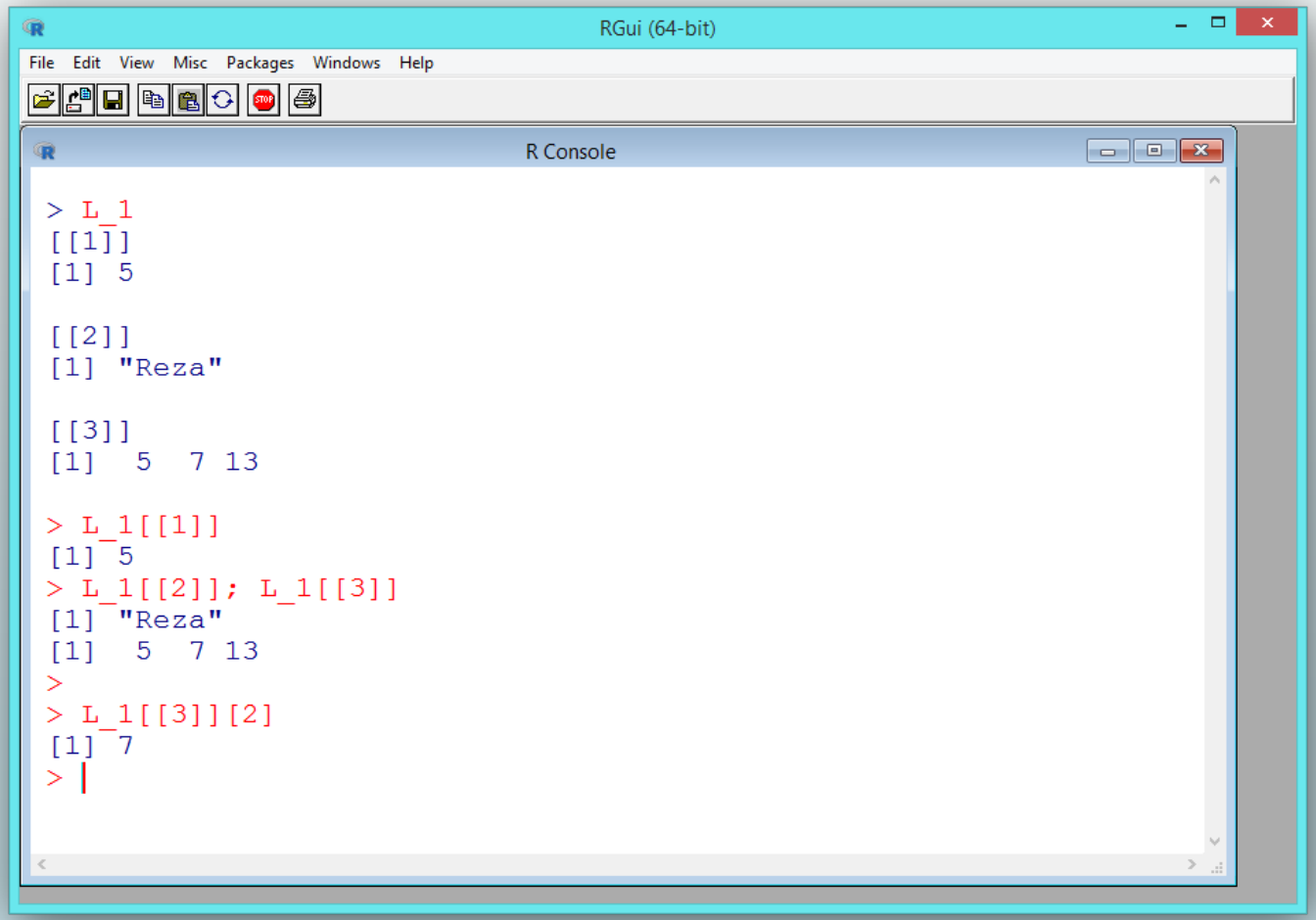
List

- Assignment (3)



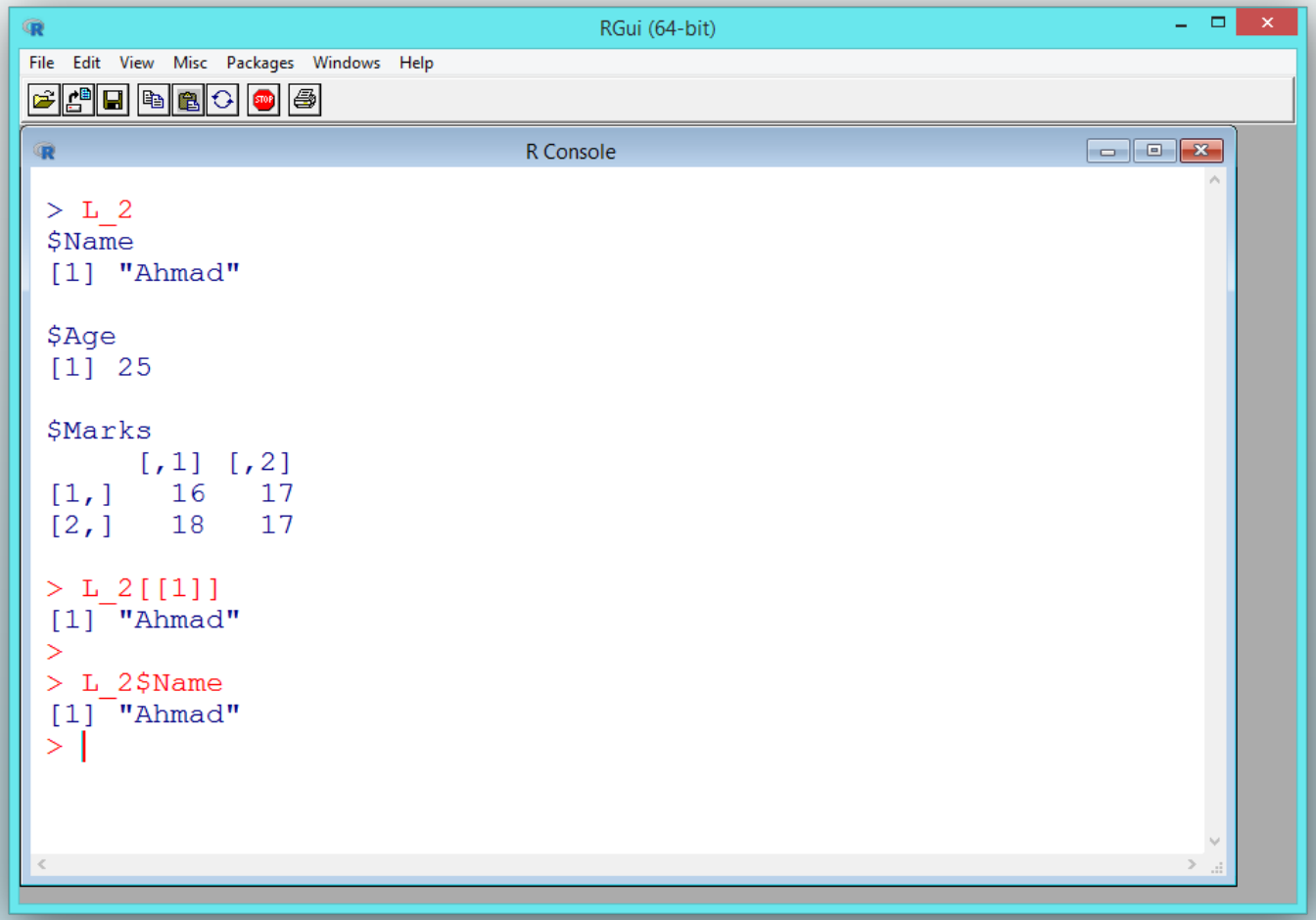
List

- Addressing the List Members (1)



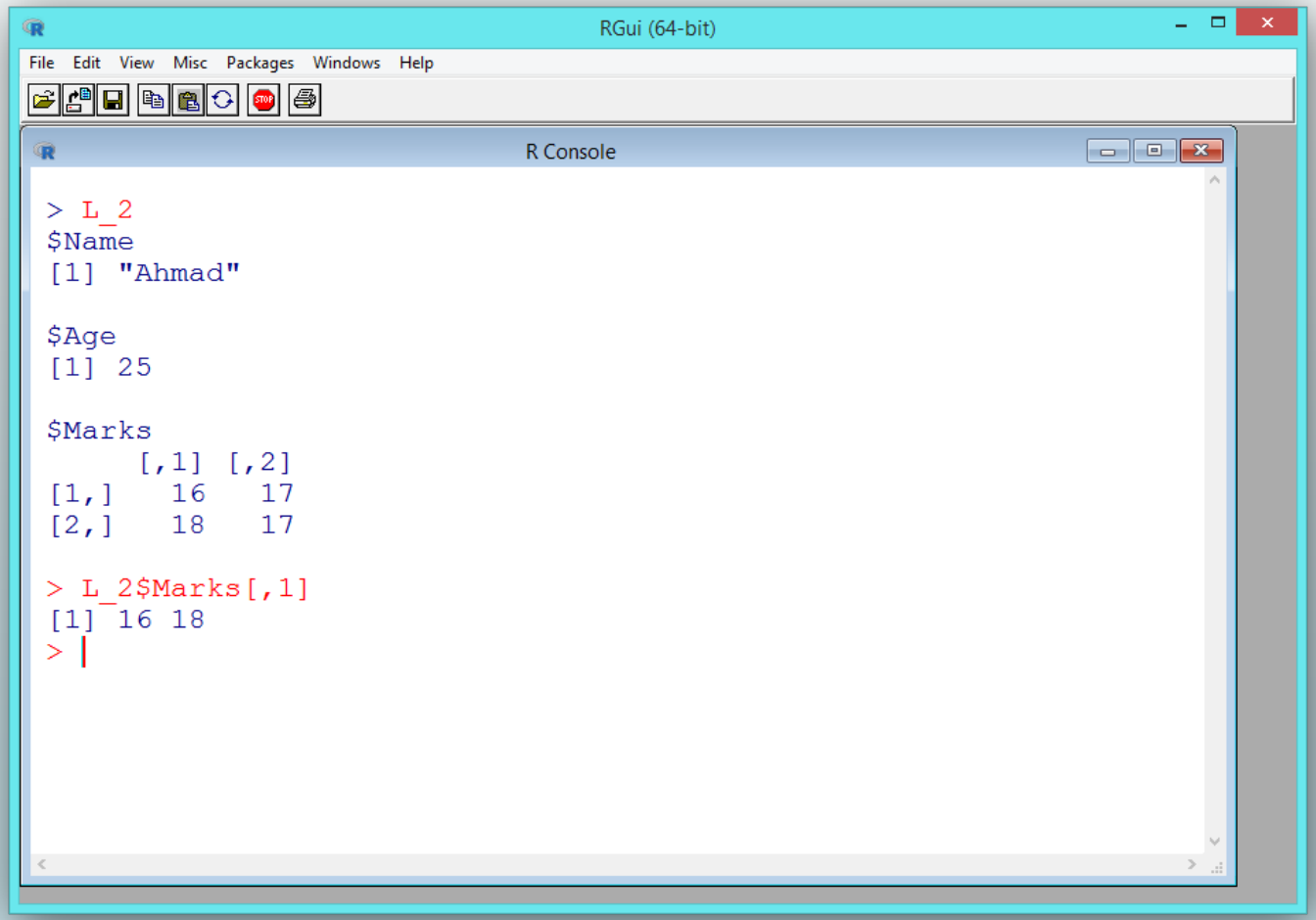
List

- Addressing the List Members (2)



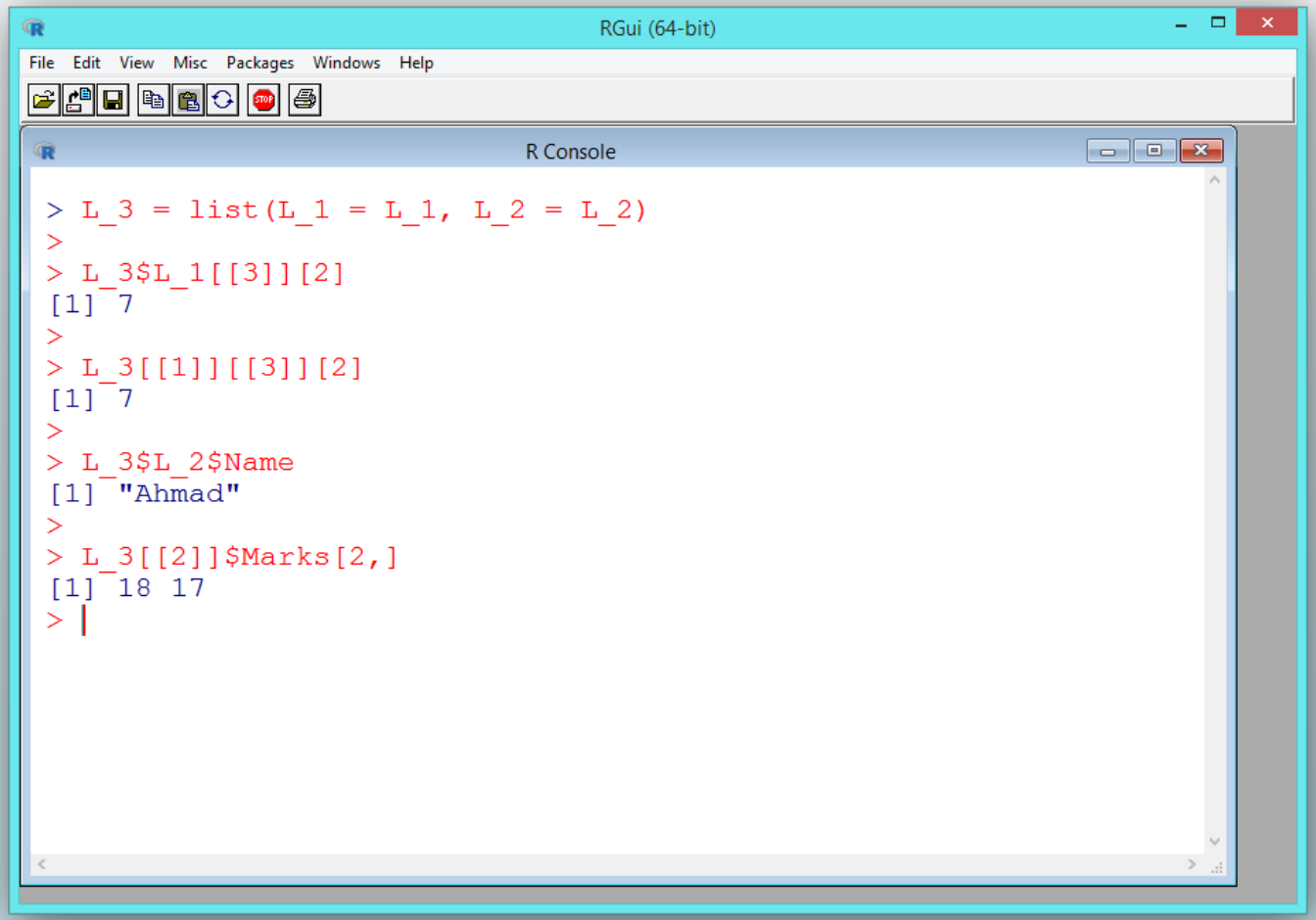
List

- Addressing the List Members (3)



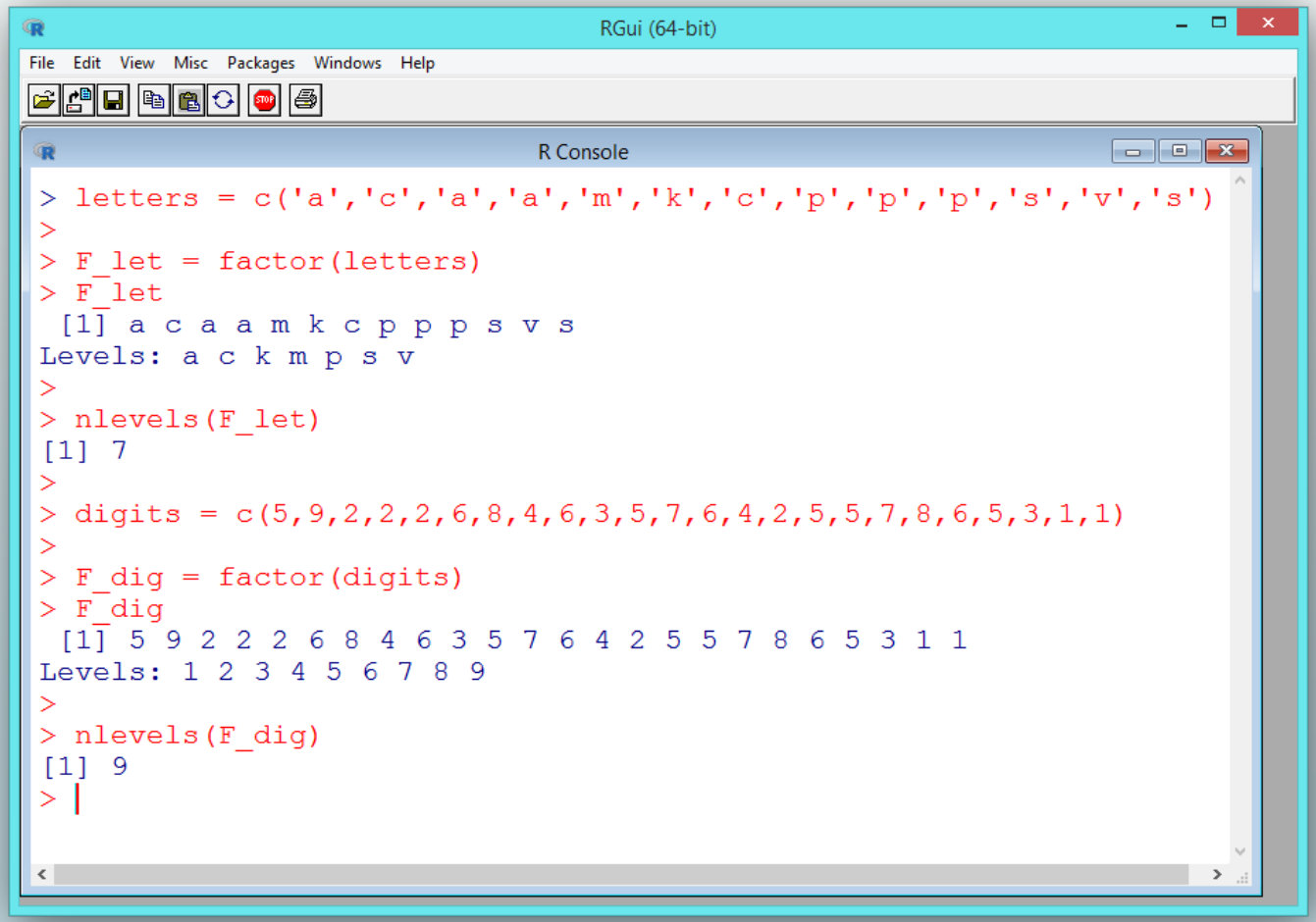
List

- Addressing the List Members (4)



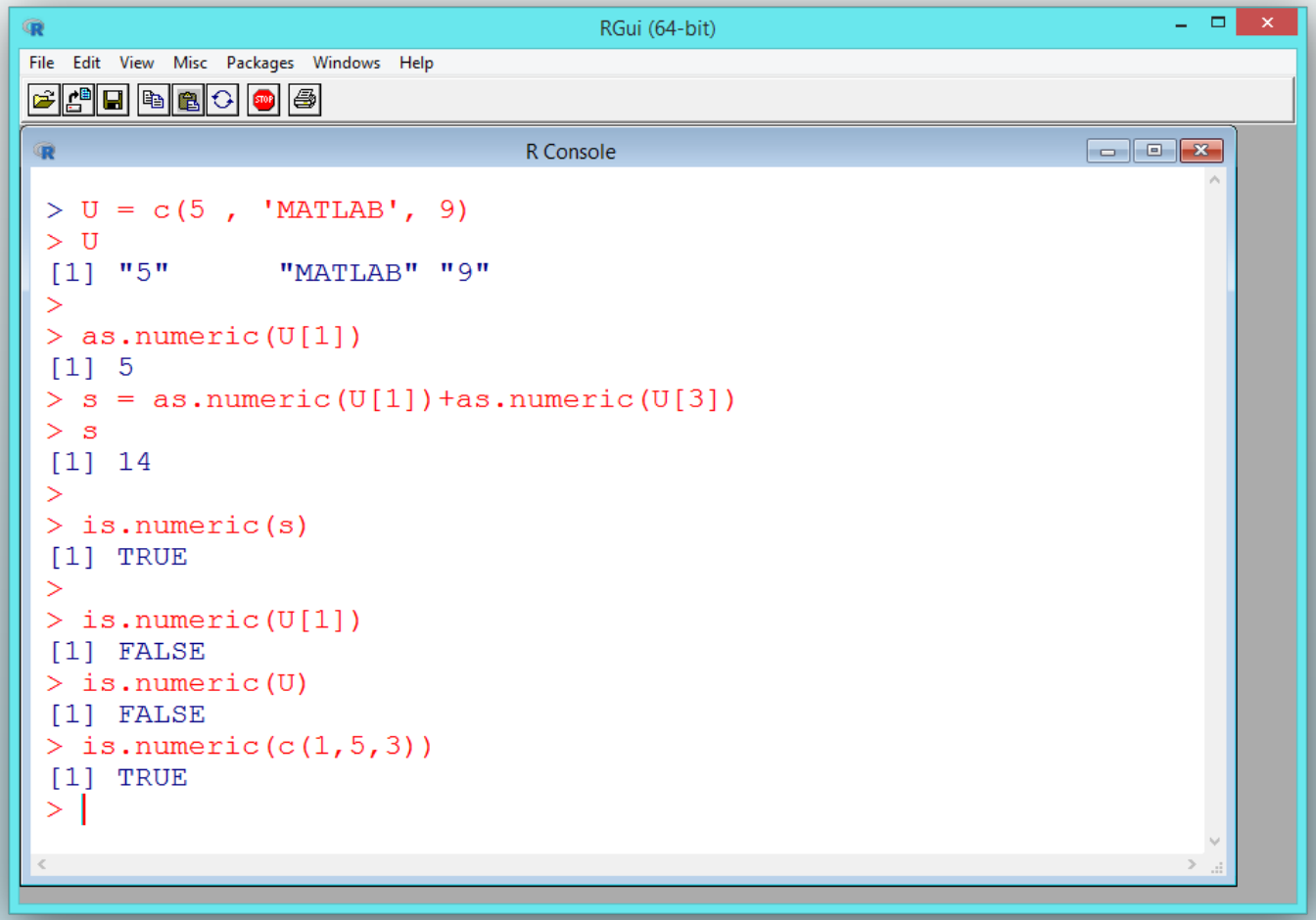
Factor

- Assignment



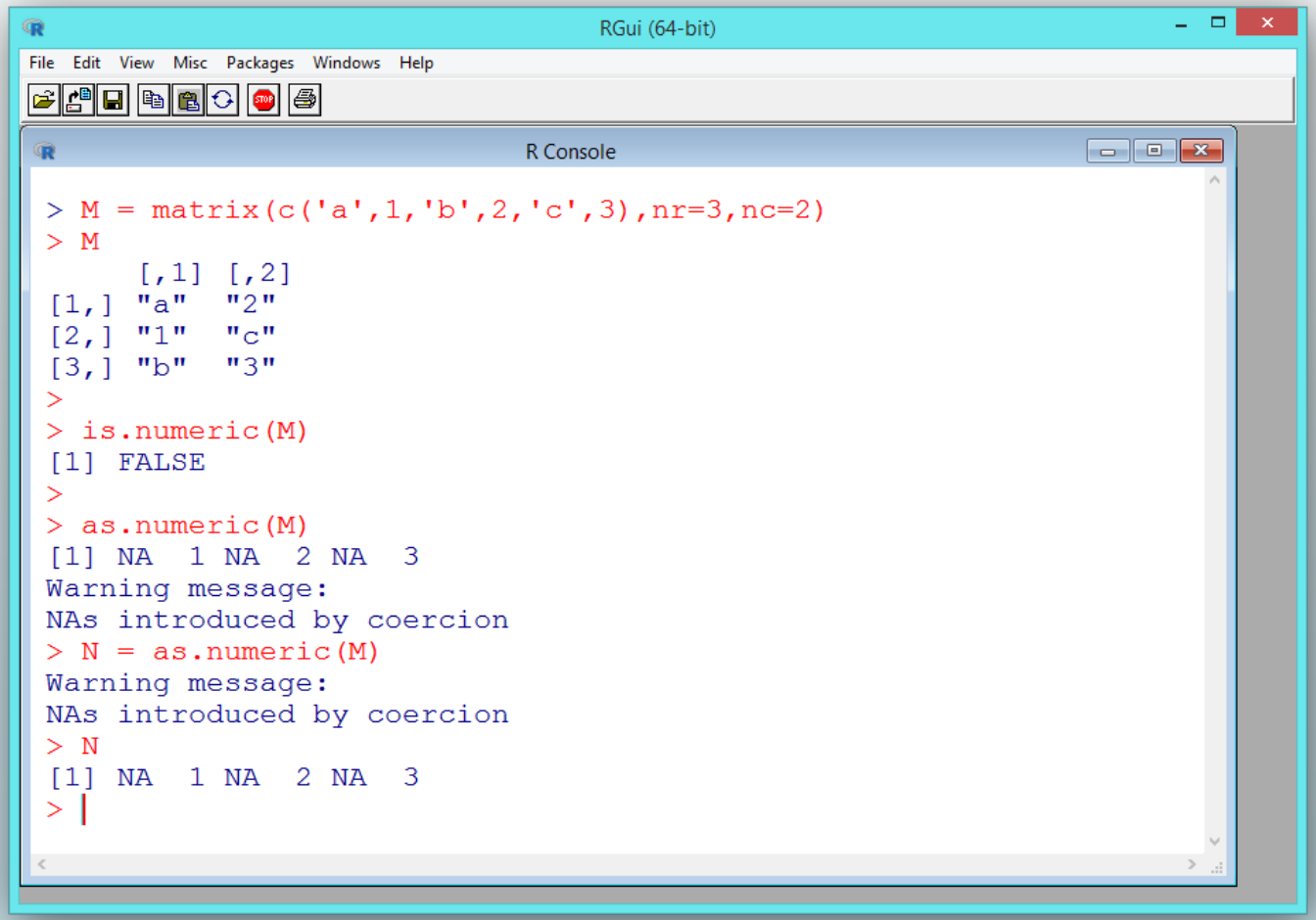
Identification and Transformation

- `as.numeric` and `is.numeric` (1)



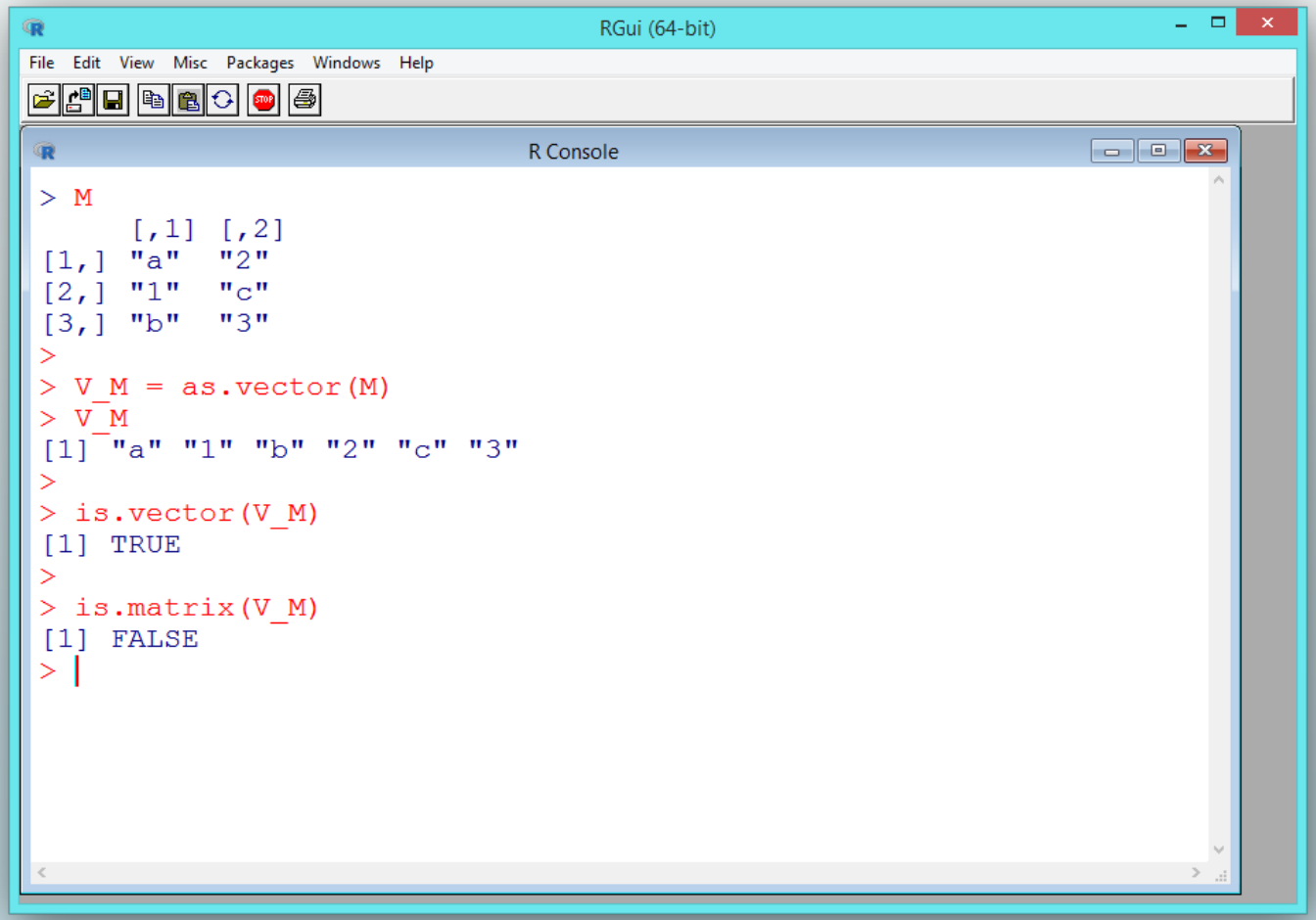
Identification and Transformation

- `as.numeric` and `is.numeric` (2)



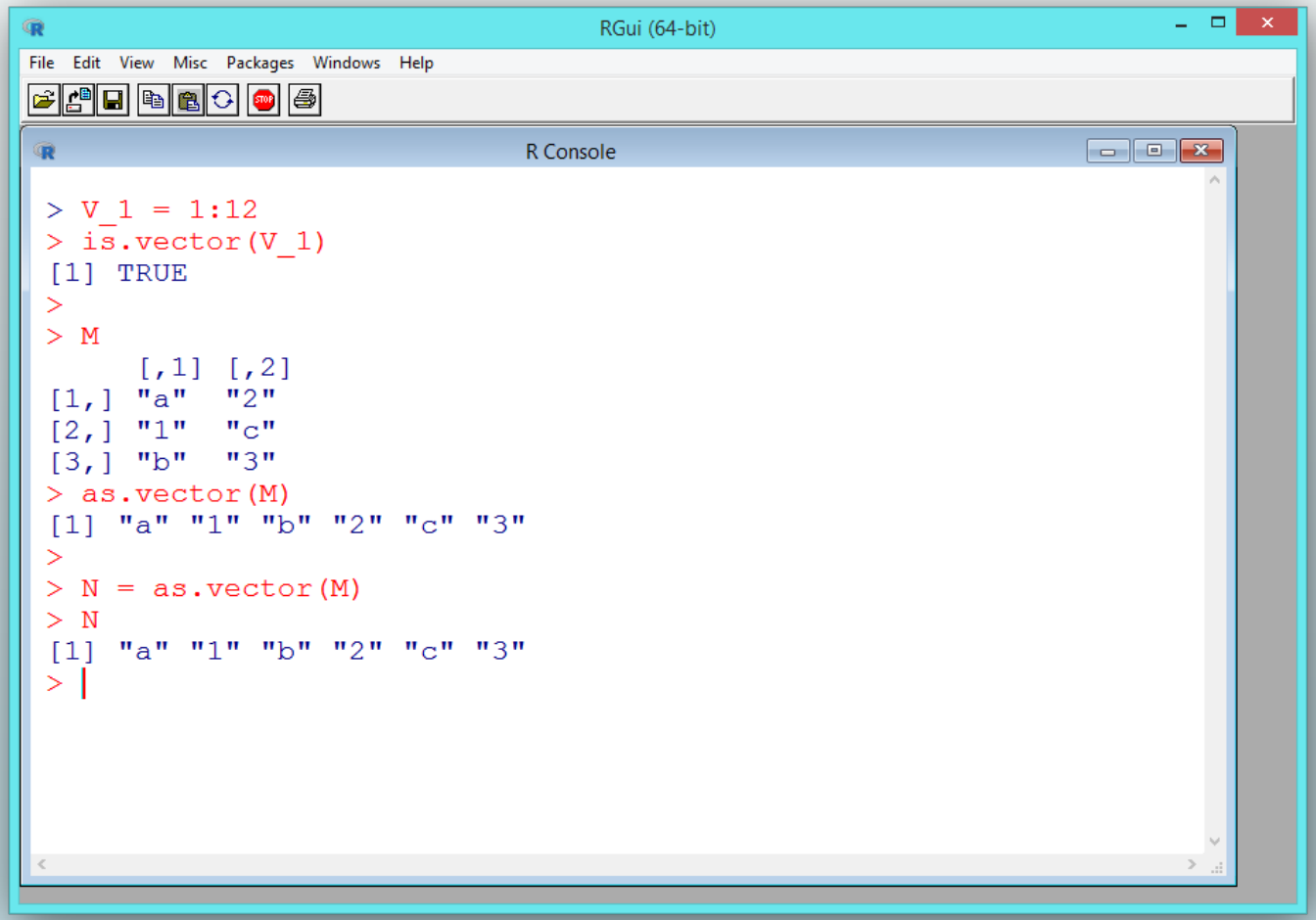
Identification and Transformation

- `as.vector` and `is.vector` (1)



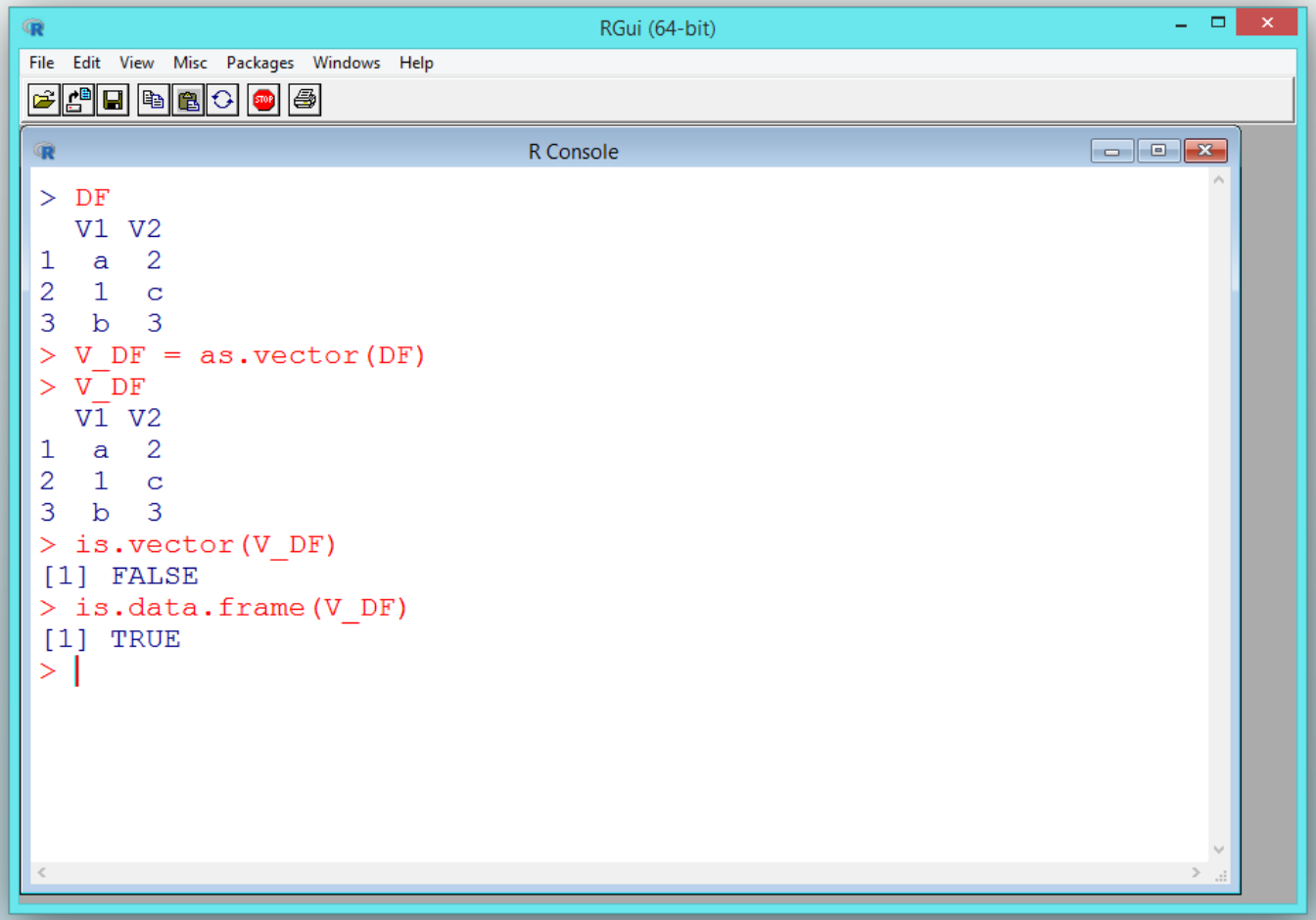
Identification and Transformation

- `as.vector` and `is.vector` (2)



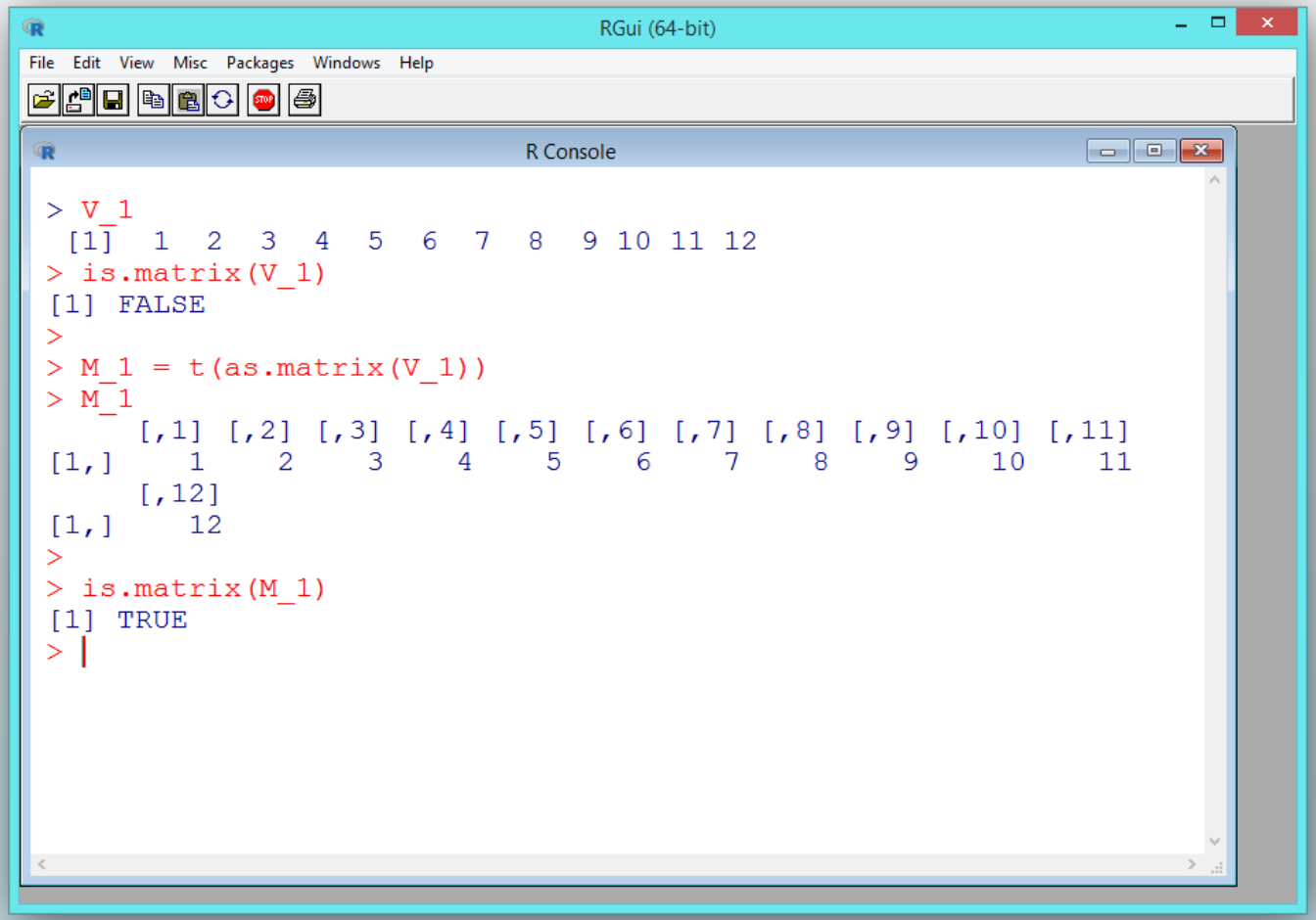
Identification and Transformation

- `as.vector` and `is.vector` (3)



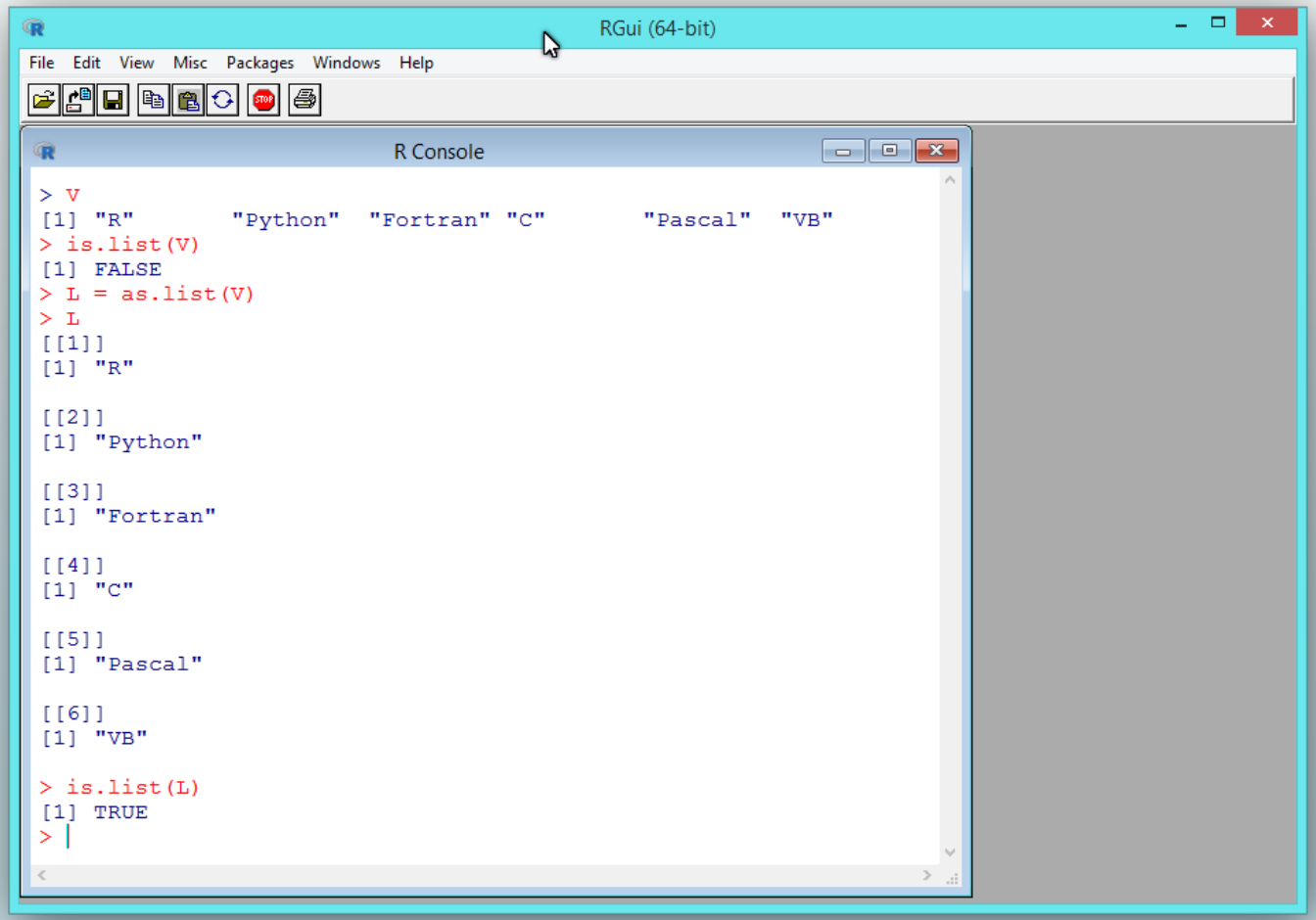
Identification and Transformation

- `as.matrix` and `is.matrix`



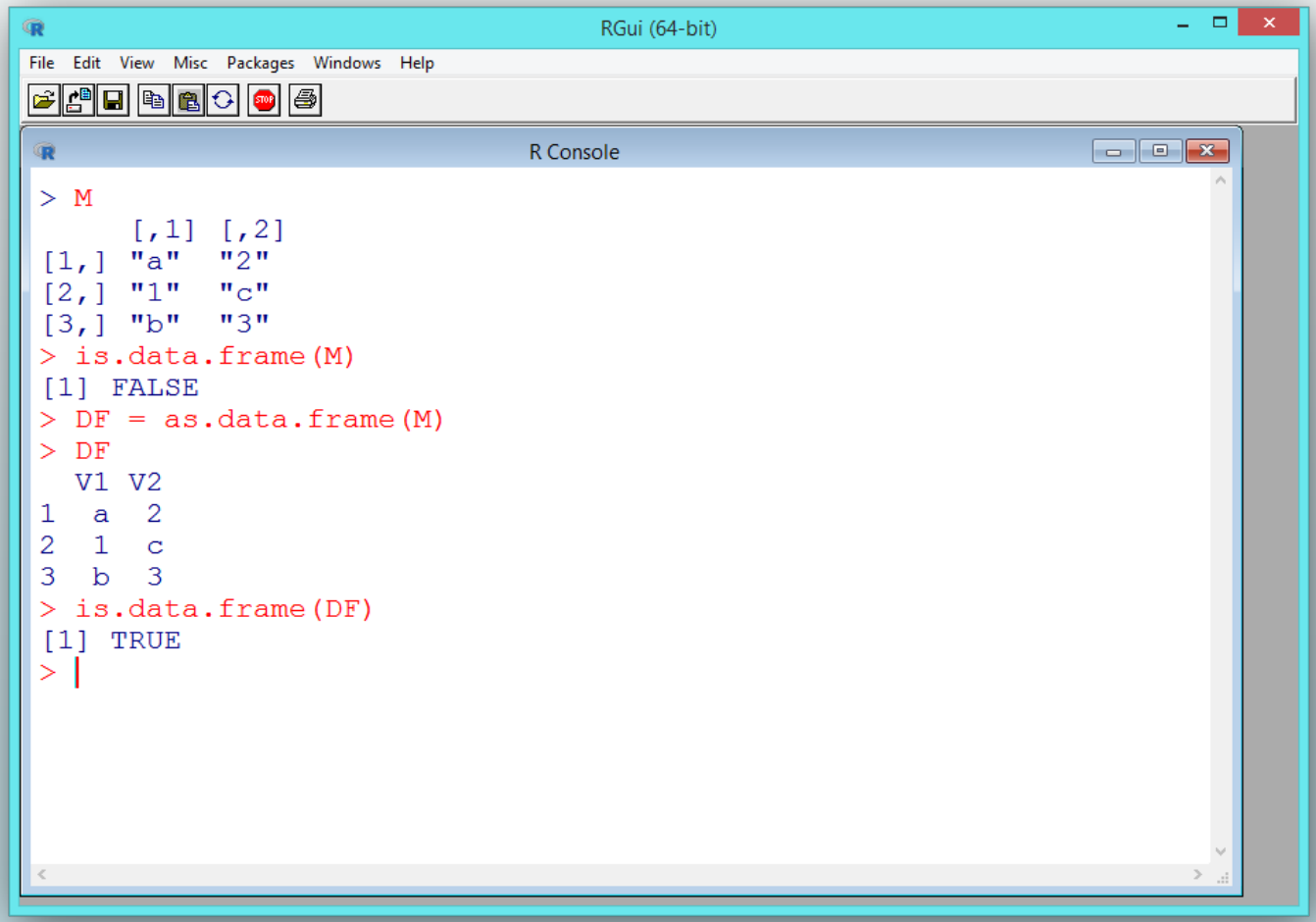
Identification and Transformation

- `as.list` and `is.list`

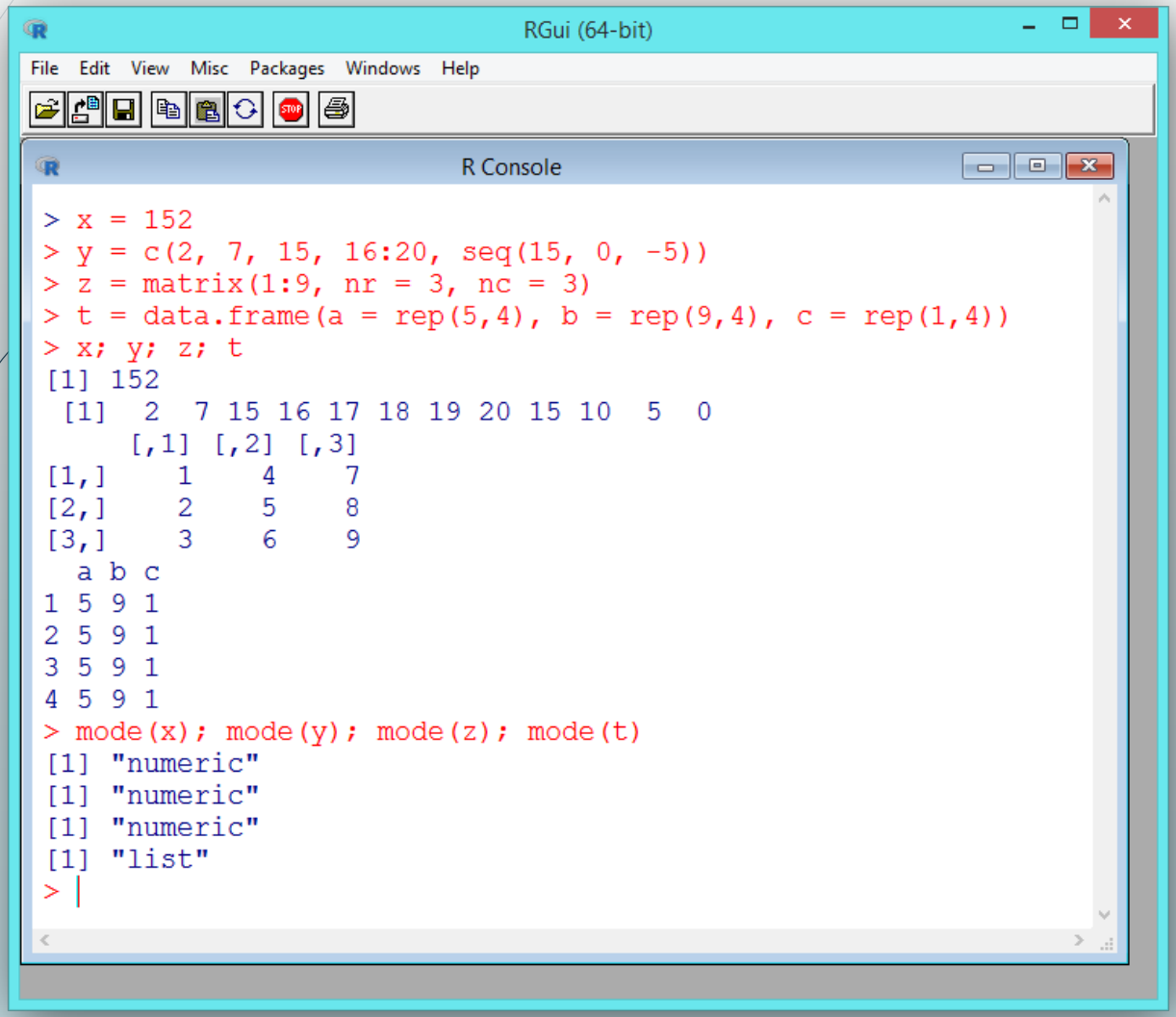


Identification and Transformation

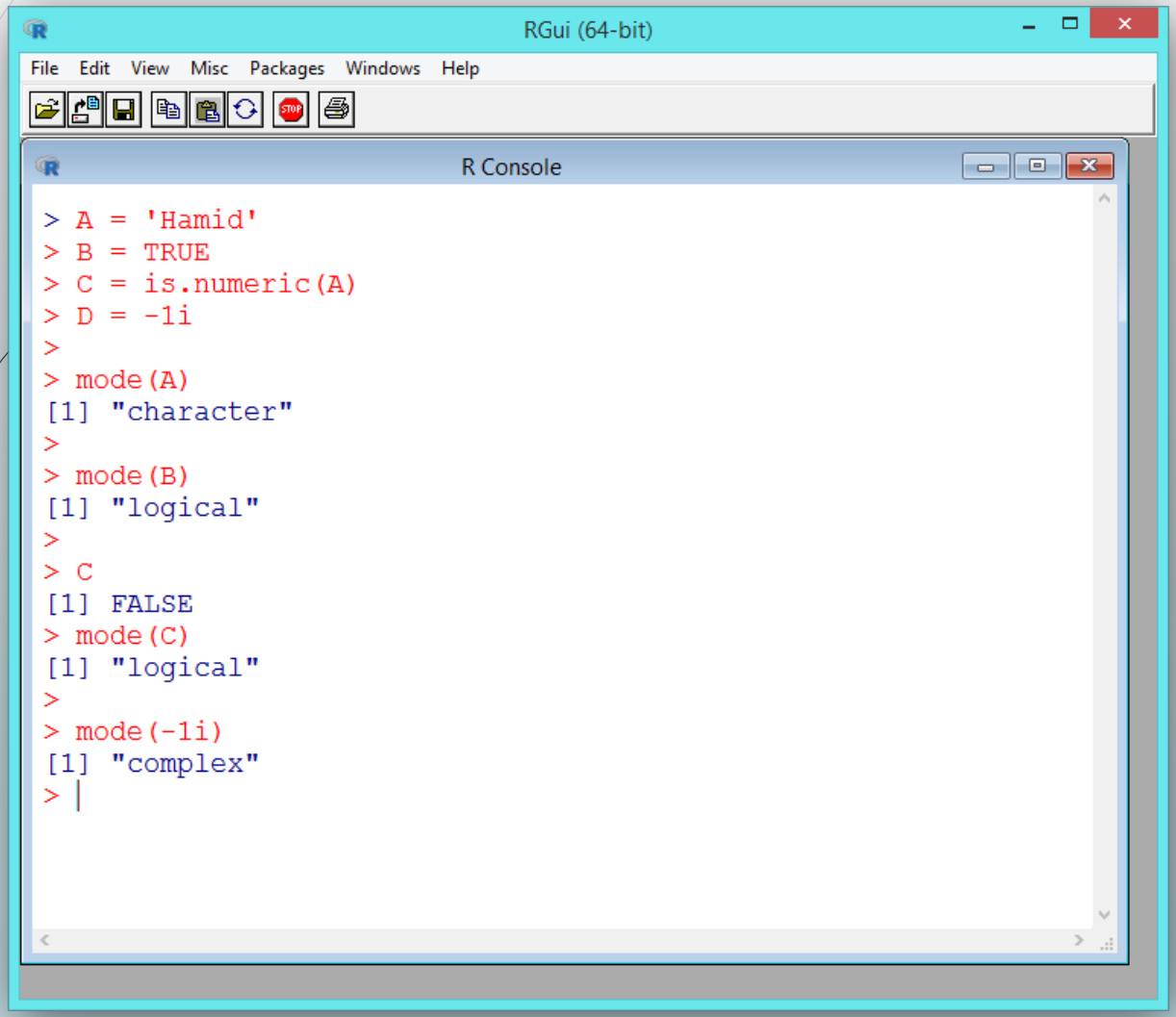
- `as.data.frame` and `is.data.frame`



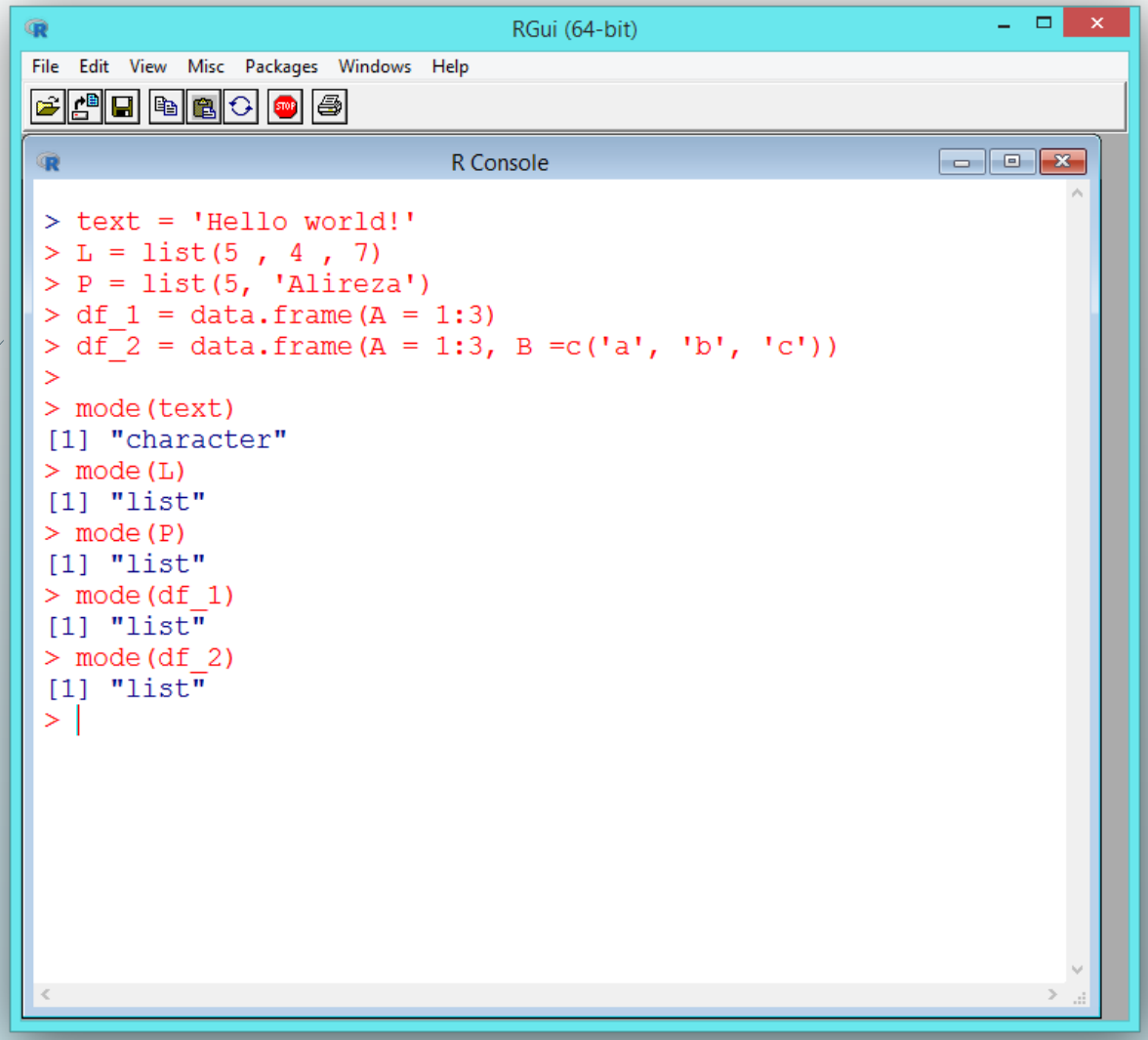
mode


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> x = 152
> y = c(2, 7, 15, 16:20, seq(15, 0, -5))
> z = matrix(1:9, nr = 3, nc = 3)
> t = data.frame(a = rep(5,4), b = rep(9,4), c = rep(1,4))
> x; y; z; t
[1] 152
 [1] 2 7 15 16 17 18 19 20 15 10 5 0
     [,1] [,2] [,3]
[1,]   1   4   7
[2,]   2   5   8
[3,]   3   6   9
  a b c
1 5 9 1
2 5 9 1
3 5 9 1
4 5 9 1
> mode(x); mode(y); mode(z); mode(t)
[1] "numeric"
[1] "numeric"
[1] "numeric"
[1] "list"
>

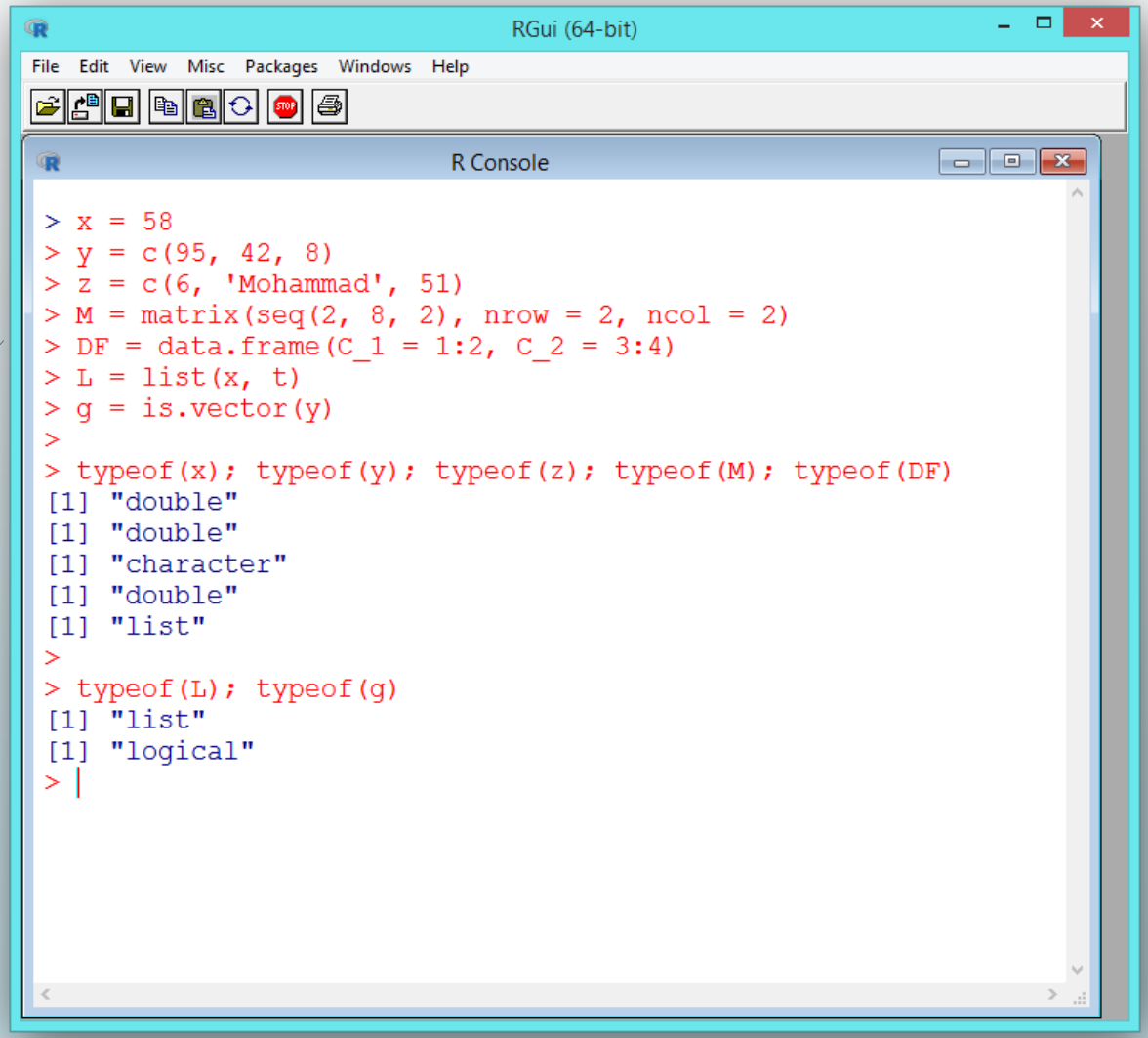
mode


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> A = 'Hamid'
> B = TRUE
> C = is.numeric(A)
> D = -1i
>
> mode(A)
[1] "character"
>
> mode(B)
[1] "logical"
>
> C
[1] FALSE
> mode(C)
[1] "logical"
>
> mode(-1i)
[1] "complex"
>

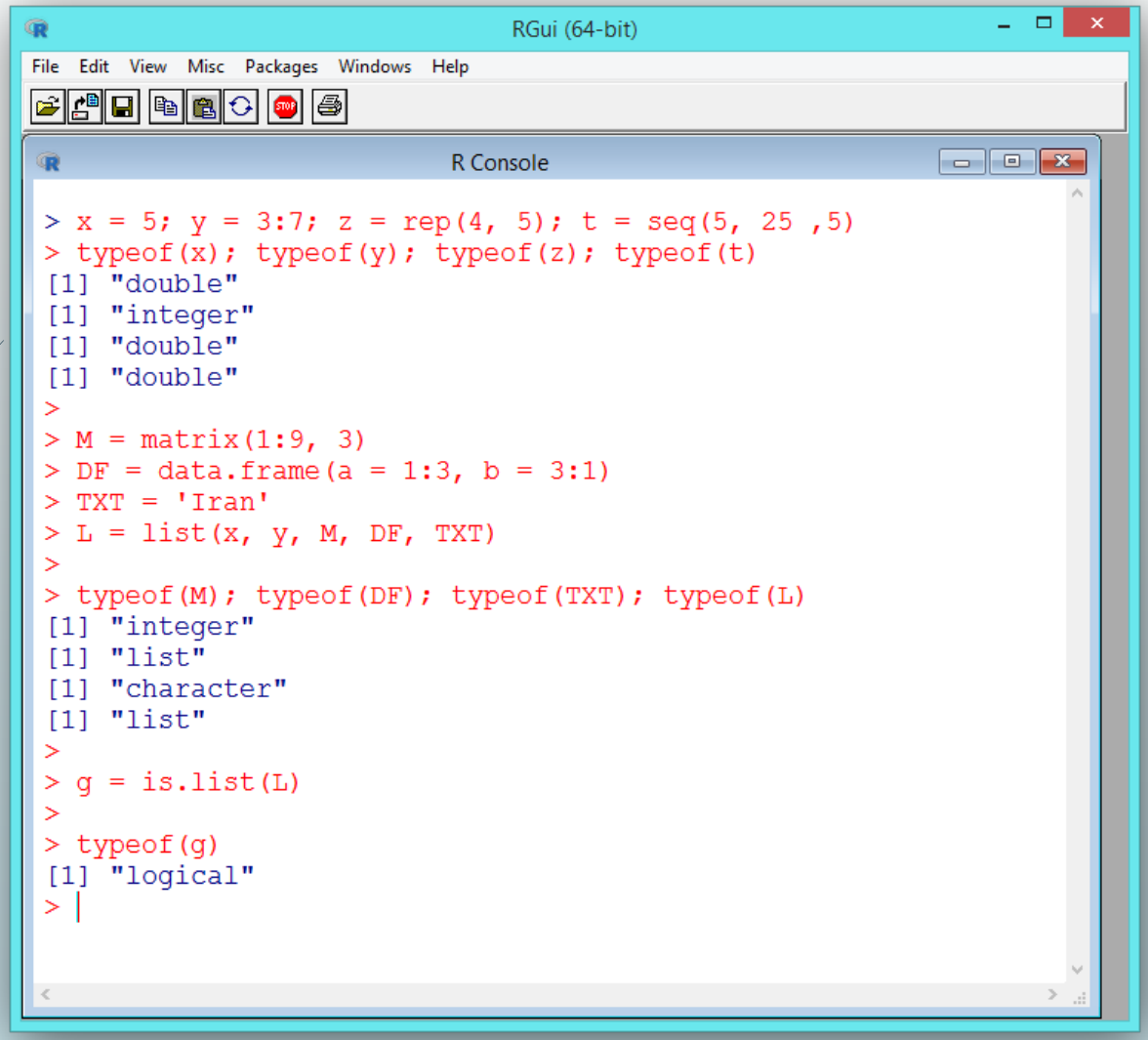
mode


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> text = 'Hello world!'
> L = list(5 , 4 , 7)
> P = list(5, 'Alireza')
> df_1 = data.frame(A = 1:3)
> df_2 = data.frame(A = 1:3, B =c('a', 'b', 'c'))
>
> mode(text)
[1] "character"
> mode(L)
[1] "list"
> mode(P)
[1] "list"
> mode(df_1)
[1] "list"
> mode(df_2)
[1] "list"
>

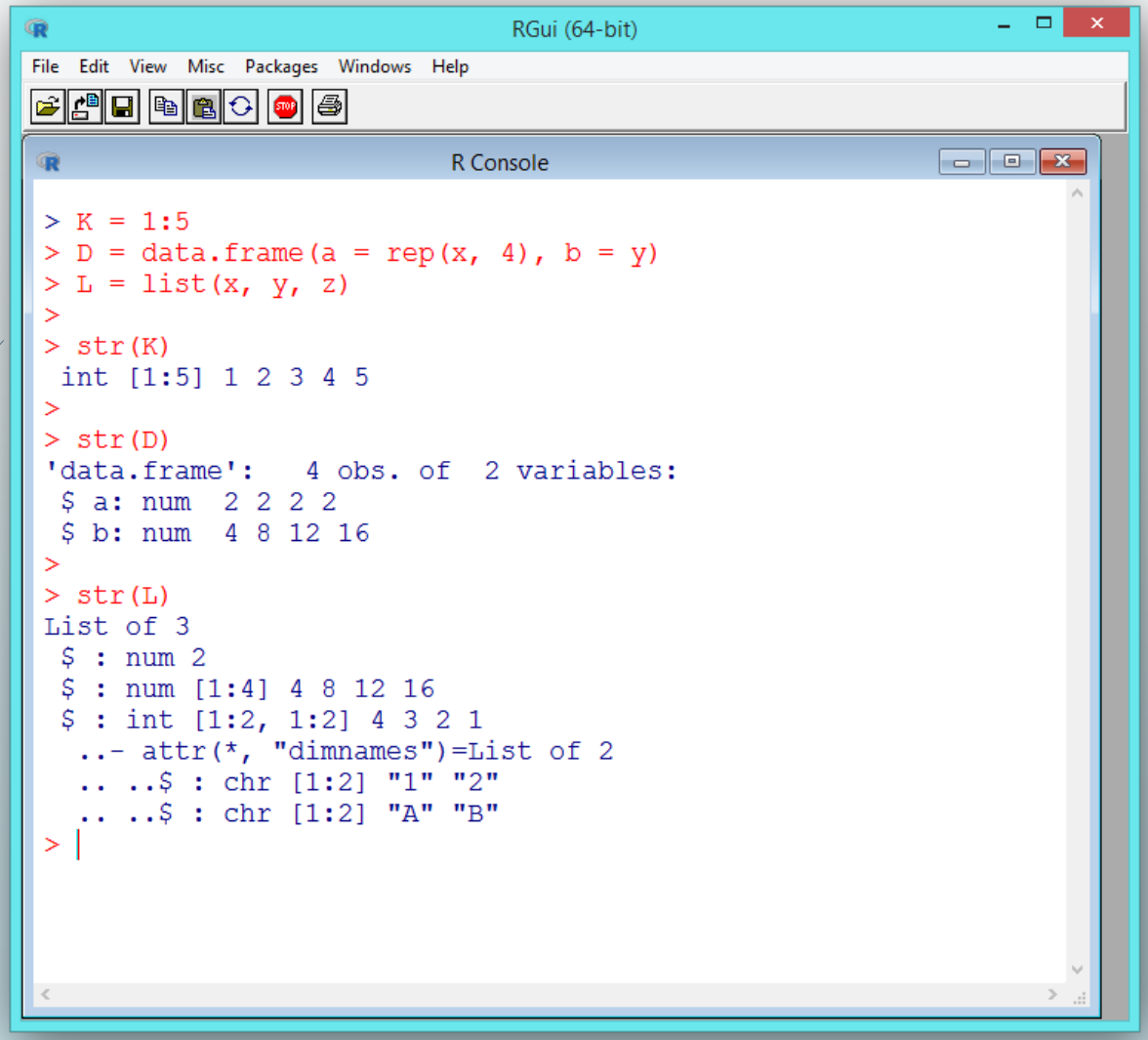
typeof


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> x = 58
> y = c(95, 42, 8)
> z = c(6, 'Mohammad', 51)
> M = matrix(seq(2, 8, 2), nrow = 2, ncol = 2)
> DF = data.frame(C_1 = 1:2, C_2 = 3:4)
> L = list(x, t)
> g = is.vector(y)
>
> typeof(x); typeof(y); typeof(z); typeof(M); typeof(DF)
[1] "double"
[1] "double"
[1] "character"
[1] "double"
[1] "list"
>
> typeof(L); typeof(g)
[1] "list"
[1] "logical"
>

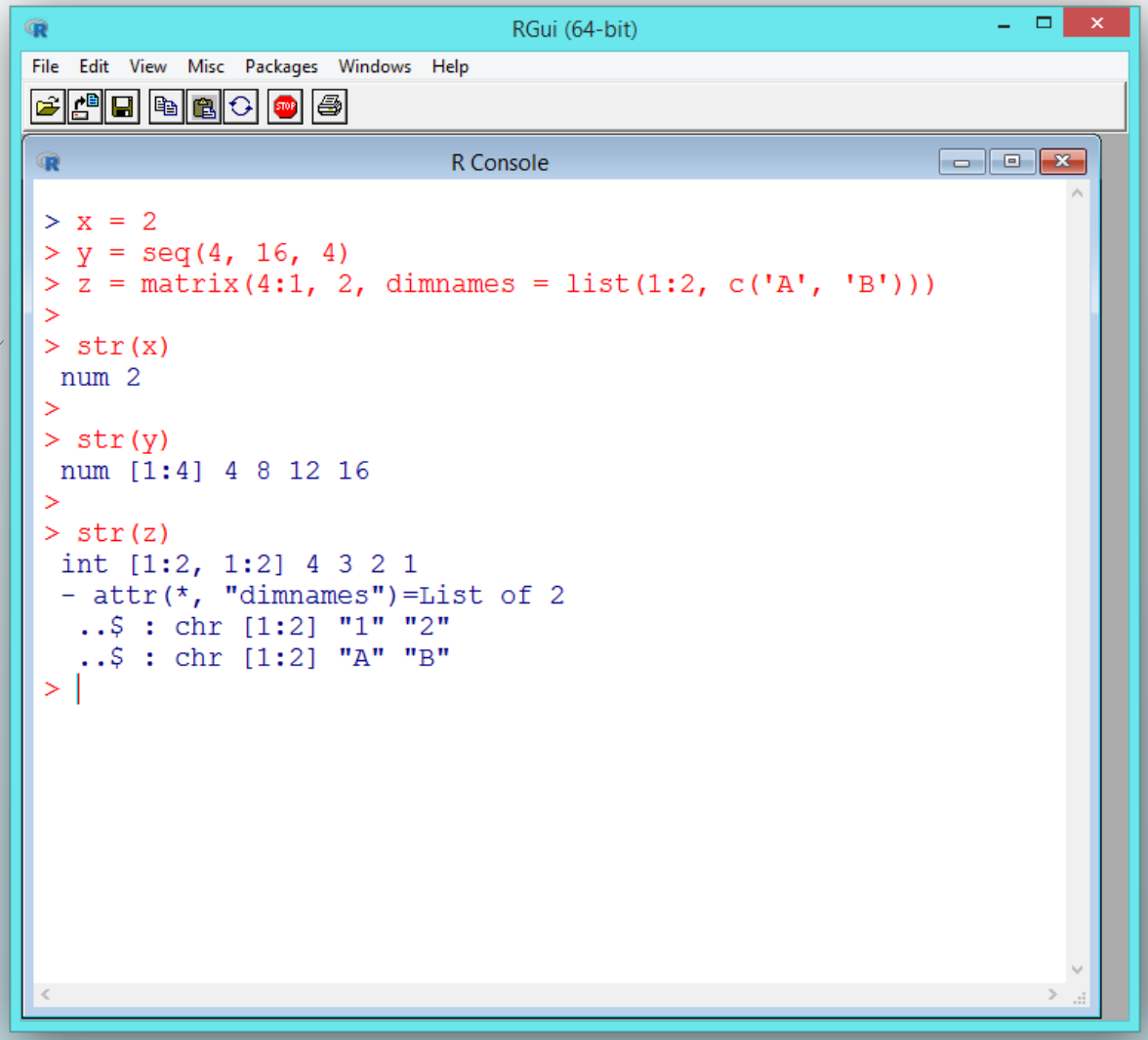
typeof


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> x = 5; y = 3:7; z = rep(4, 5); t = seq(5, 25 ,5)
> typeof(x); typeof(y); typeof(z); typeof(t)
[1] "double"
[1] "integer"
[1] "double"
[1] "double"
>
> M = matrix(1:9, 3)
> DF = data.frame(a = 1:3, b = 3:1)
> TXT = 'Iran'
> L = list(x, y, M, DF, TXT)
>
> typeof(M); typeof(DF); typeof(TXT); typeof(L)
[1] "integer"
[1] "list"
[1] "character"
[1] "list"
>
> g = is.list(L)
>
> typeof(g)
[1] "logical"
>

str


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> K = 1:5
> D = data.frame(a = rep(x, 4), b = y)
> L = list(x, y, z)
>
> str(K)
 int [1:5] 1 2 3 4 5
>
> str(D)
'data.frame':   4 obs. of 2 variables:
 $ a: num 2 2 2 2
 $ b: num 4 8 12 16
>
> str(L)
List of 3
 $: num 2
 $: num [1:4] 4 8 12 16
 $: int [1:2, 1:2] 4 3 2 1
  ..- attr(*, "dimnames")=List of 2
  .. ..$: chr [1:2] "1" "2"
  .. ..$: chr [1:2] "A" "B"
>

str

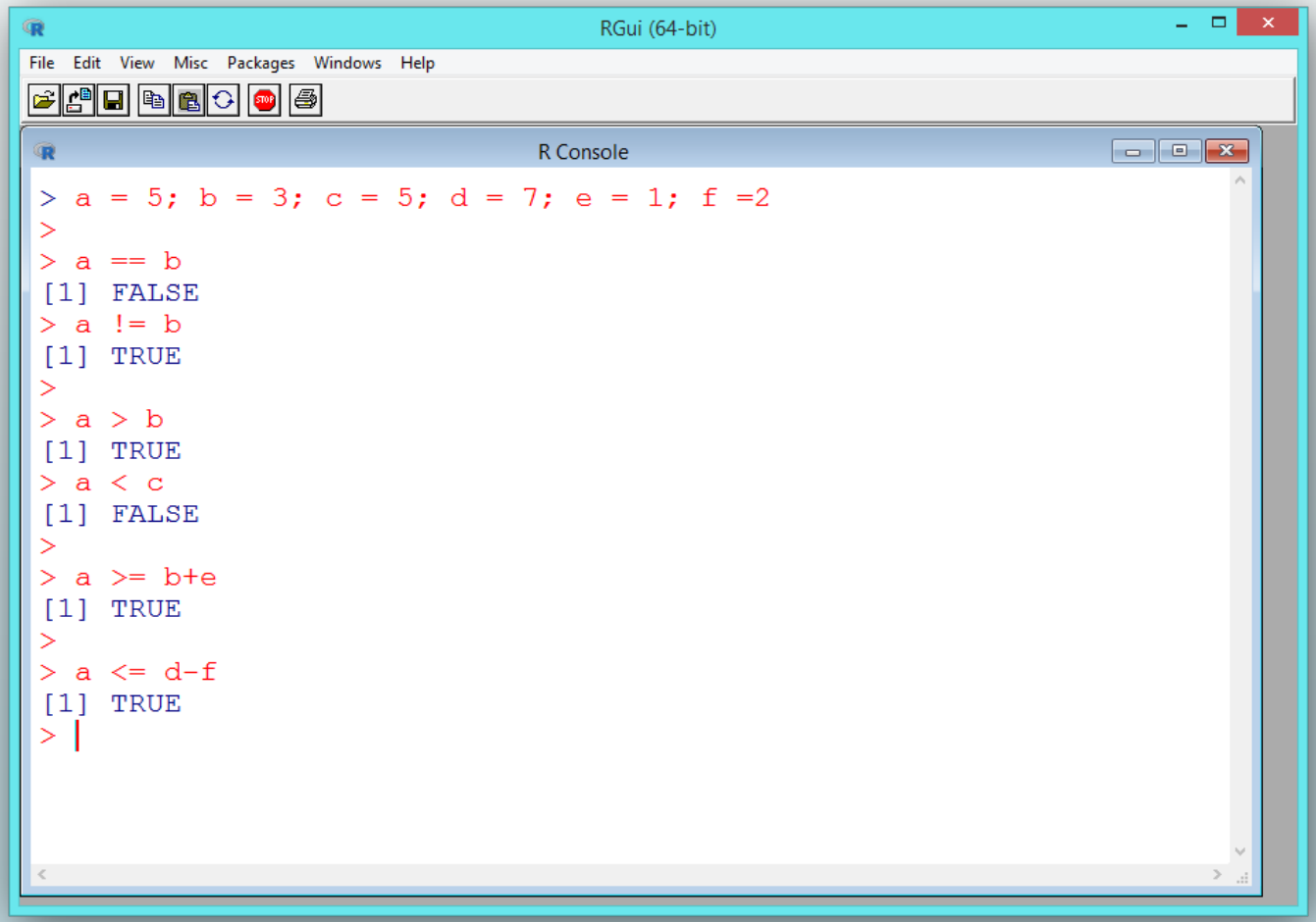

RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> x = 2
> y = seq(4, 16, 4)
> z = matrix(4:1, 2, dimnames = list(1:2, c('A', 'B')))
>
> str(x)
 num 2
>
> str(y)
 num [1:4] 4 8 12 16
>
> str(z)
 int [1:2, 1:2] 4 3 2 1
 - attr(*, "dimnames")=List of 2
  ..$: chr [1:2] "1" "2"
  ..$: chr [1:2] "A" "B"
>

Control Structures

Conditional Statements and Loops

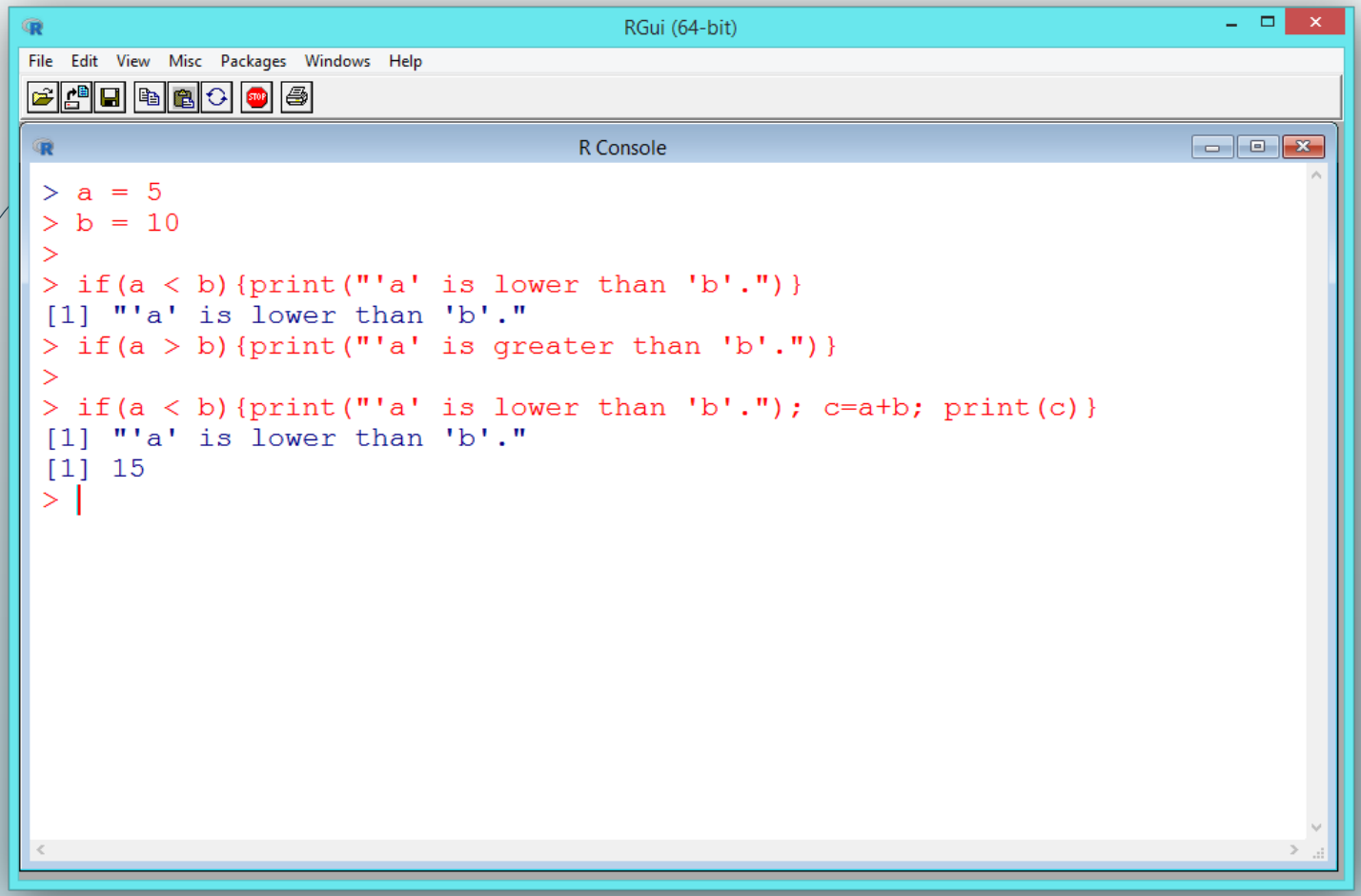
Relational Operators

- Relational Operators



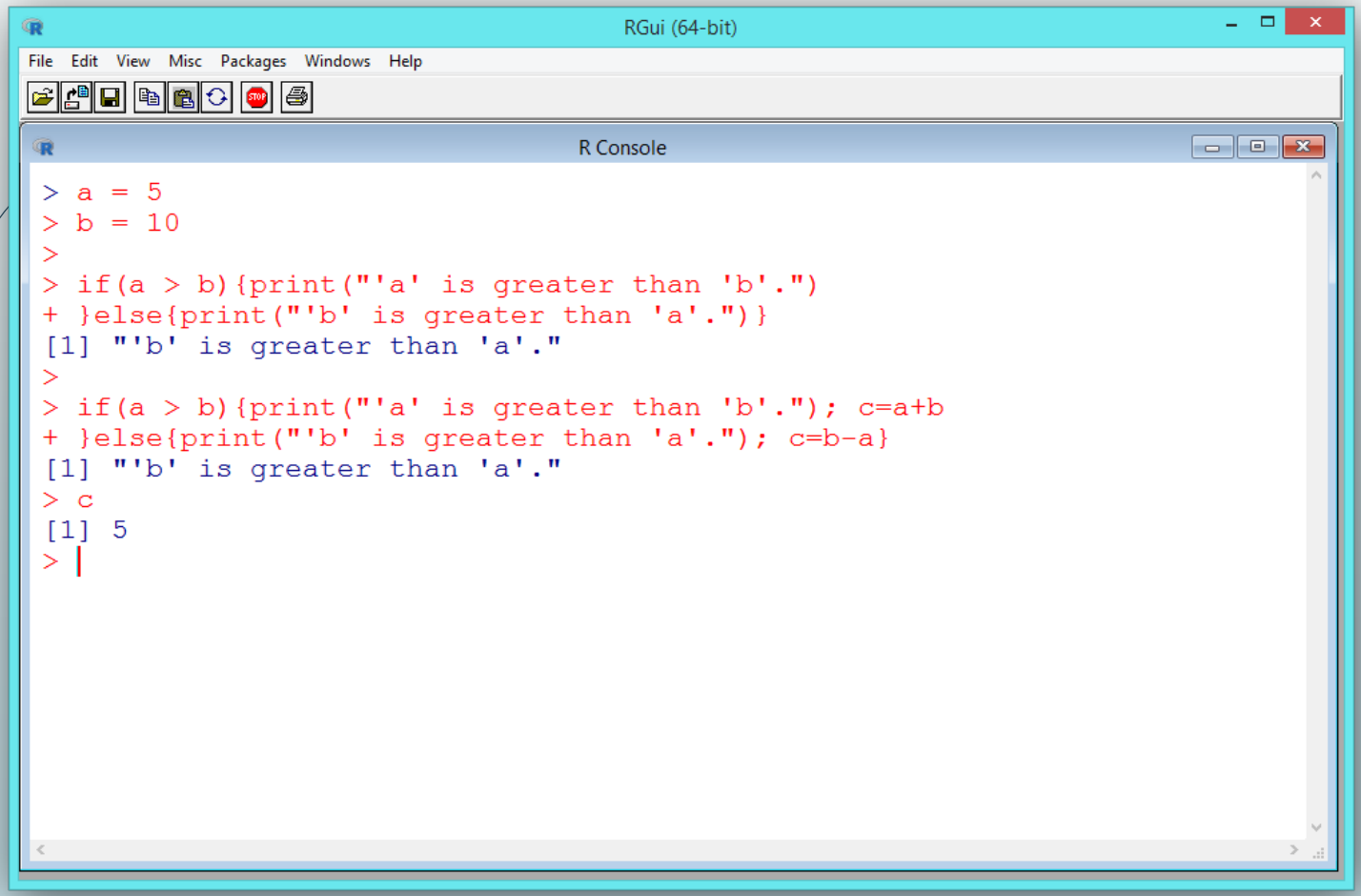
Conditional Statements

- `if` ... Statements



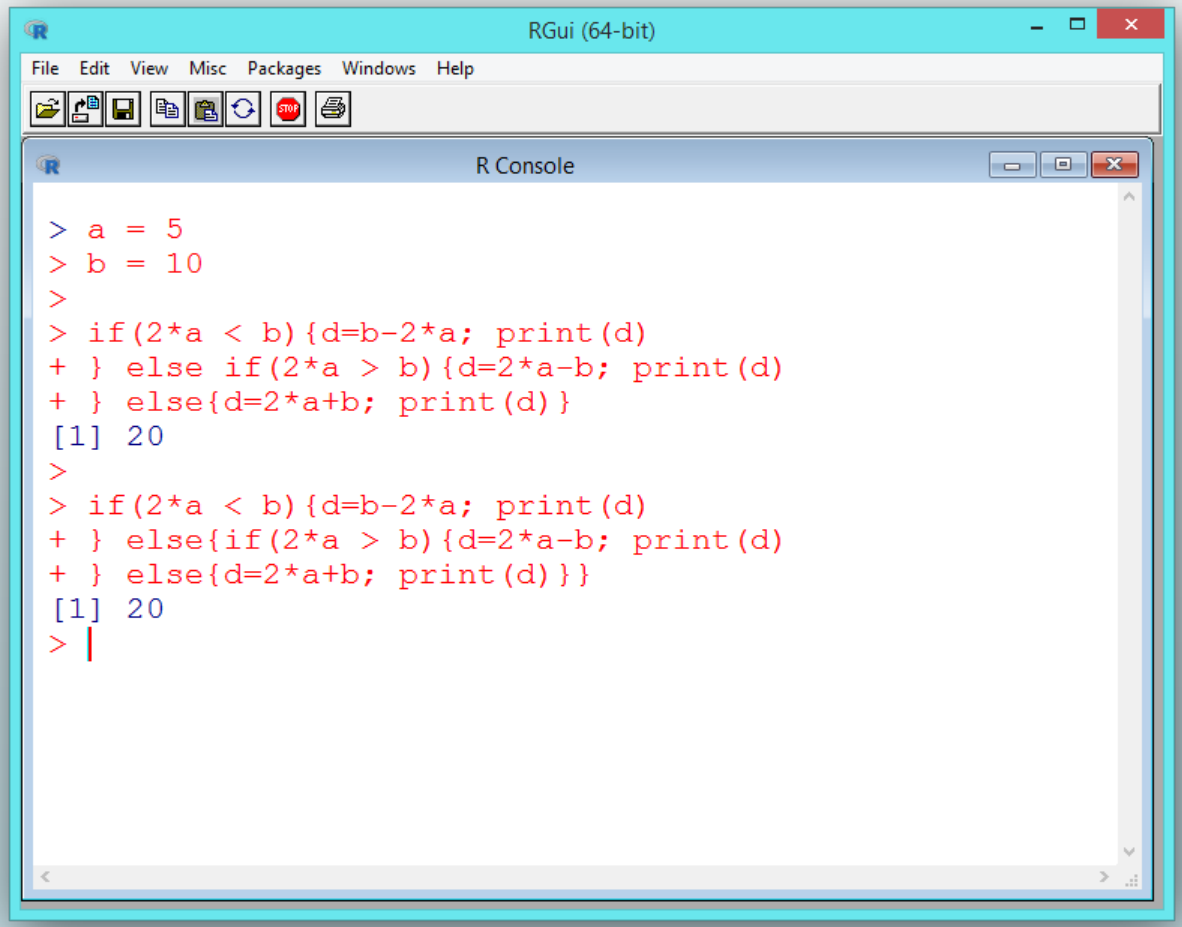
Conditional Statements

- `if … else` Statements (1)



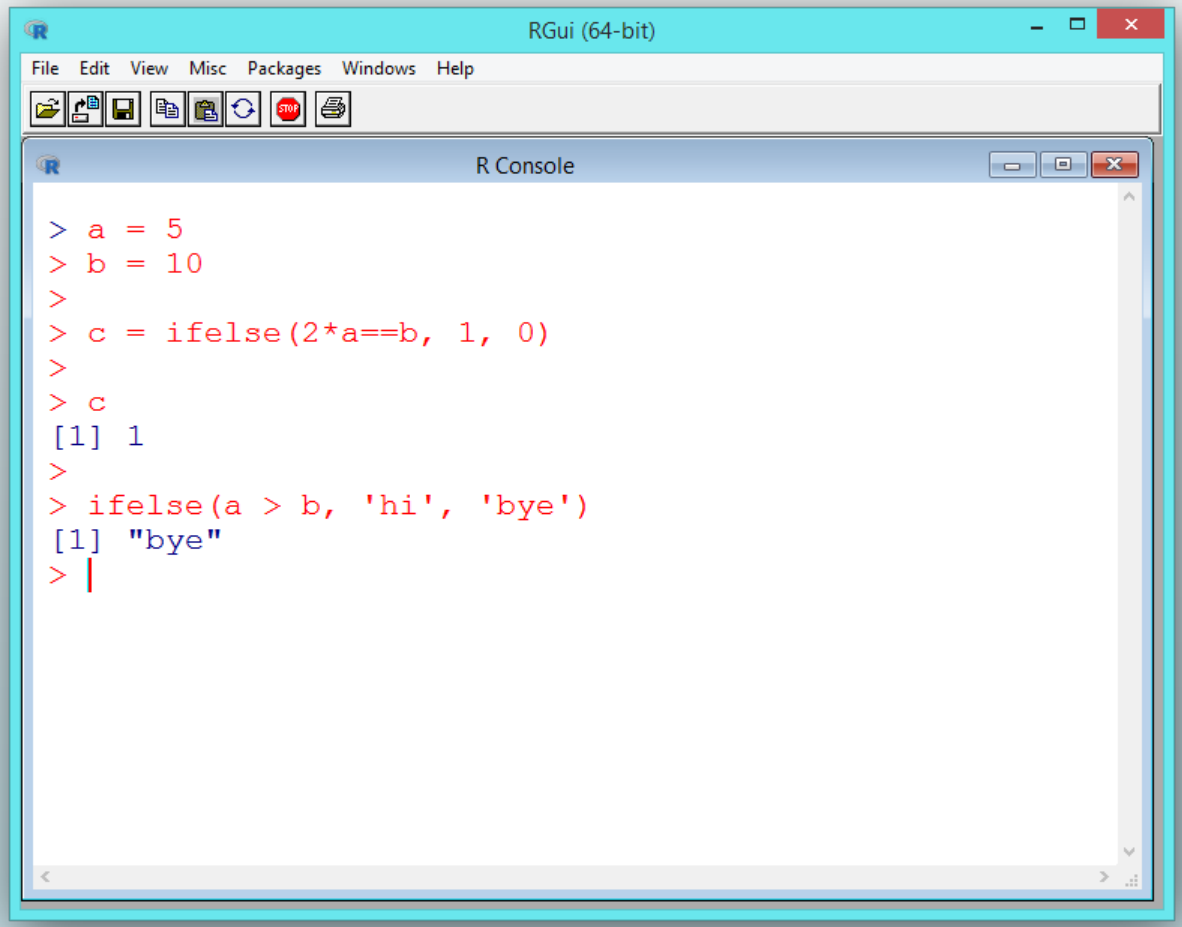
Conditional Statements

- `if … else` Statements (2)



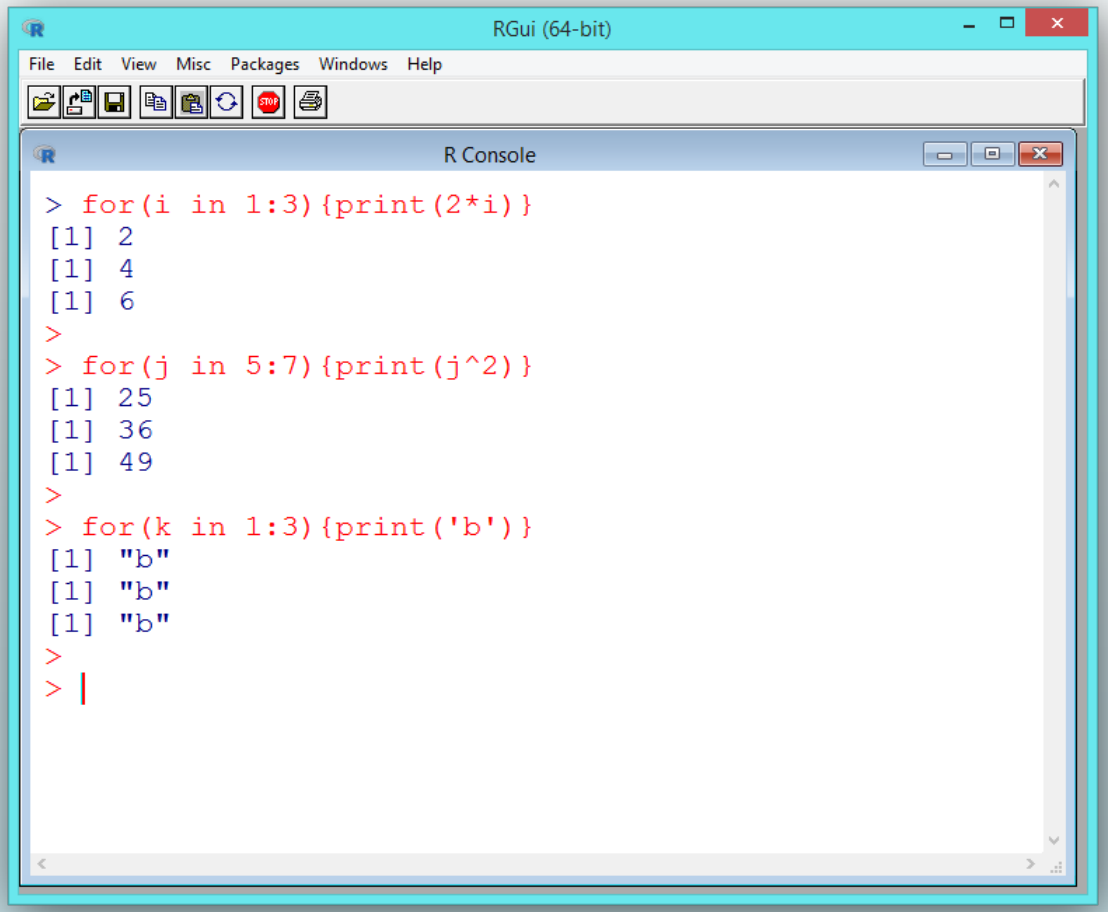
Conditional Statements

- `ifelse` Statements



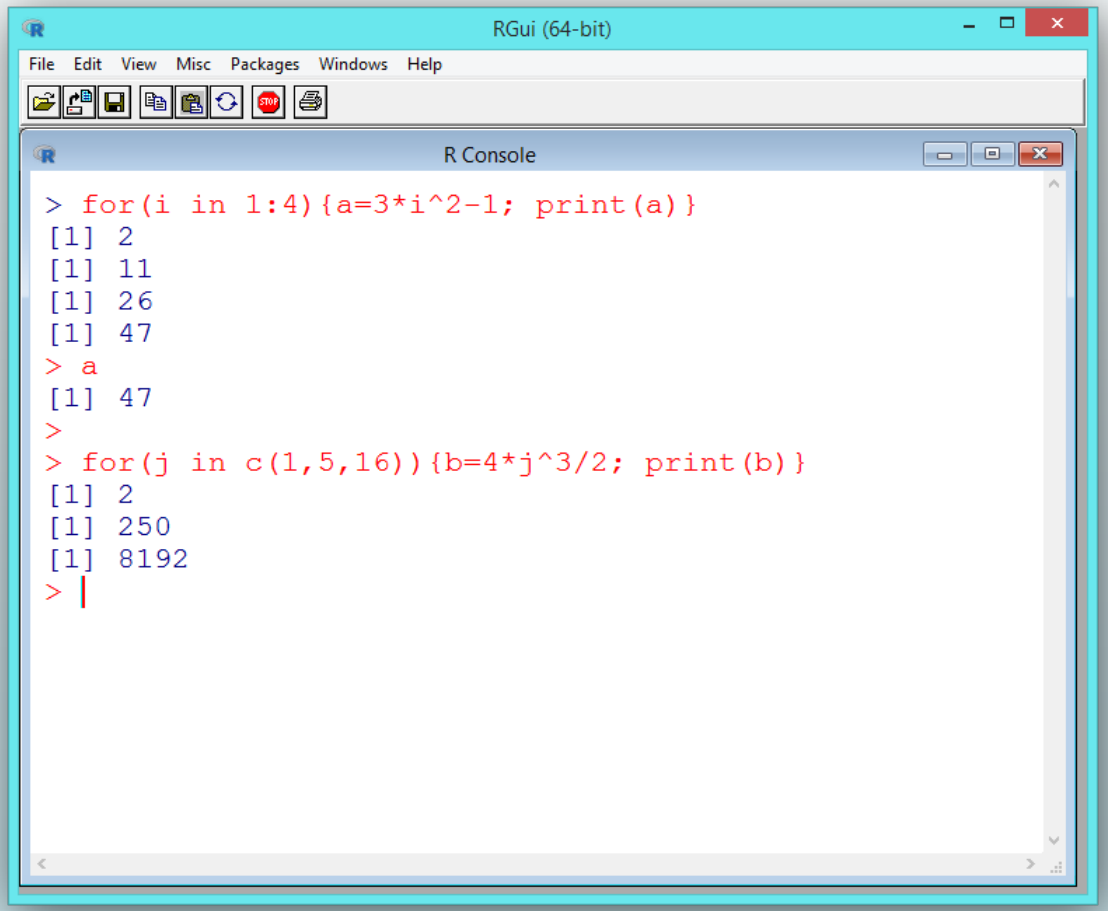
Loop

- `for` Loops (1)



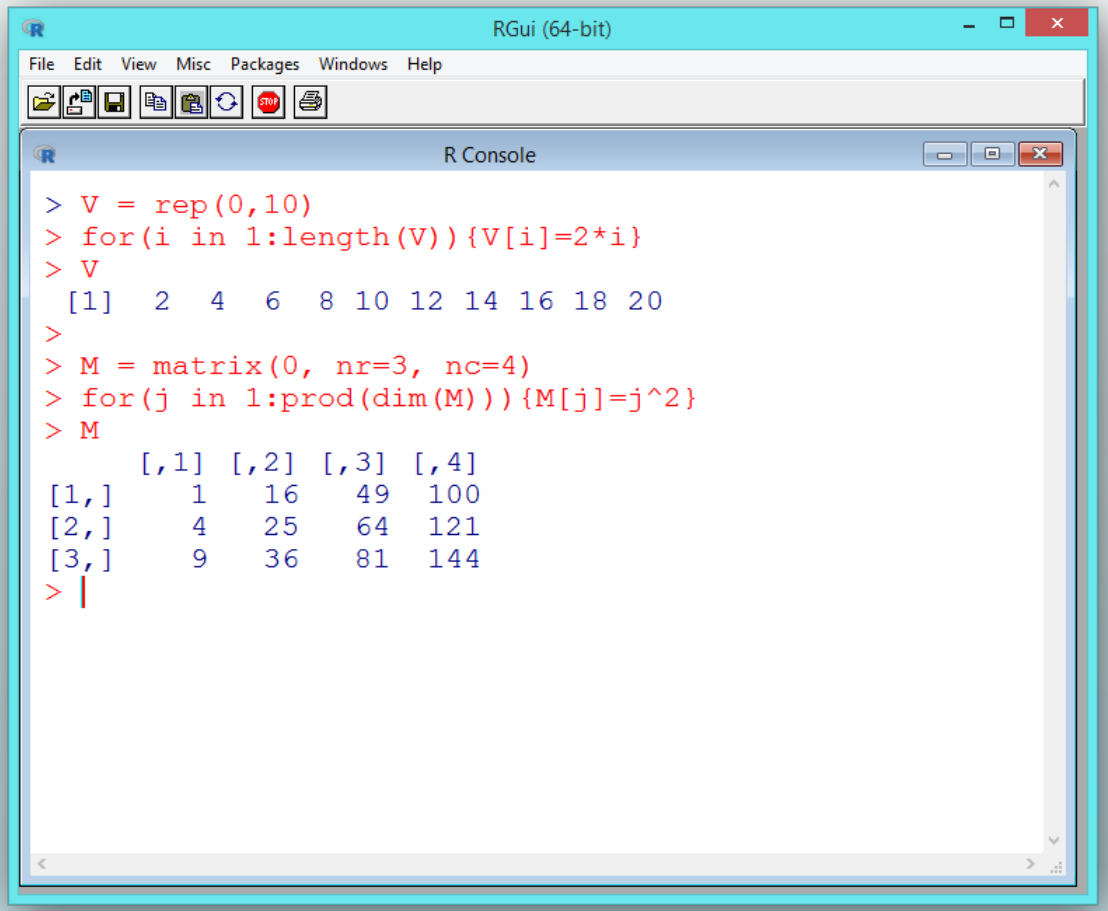
Loop

- `for` Loops (2)



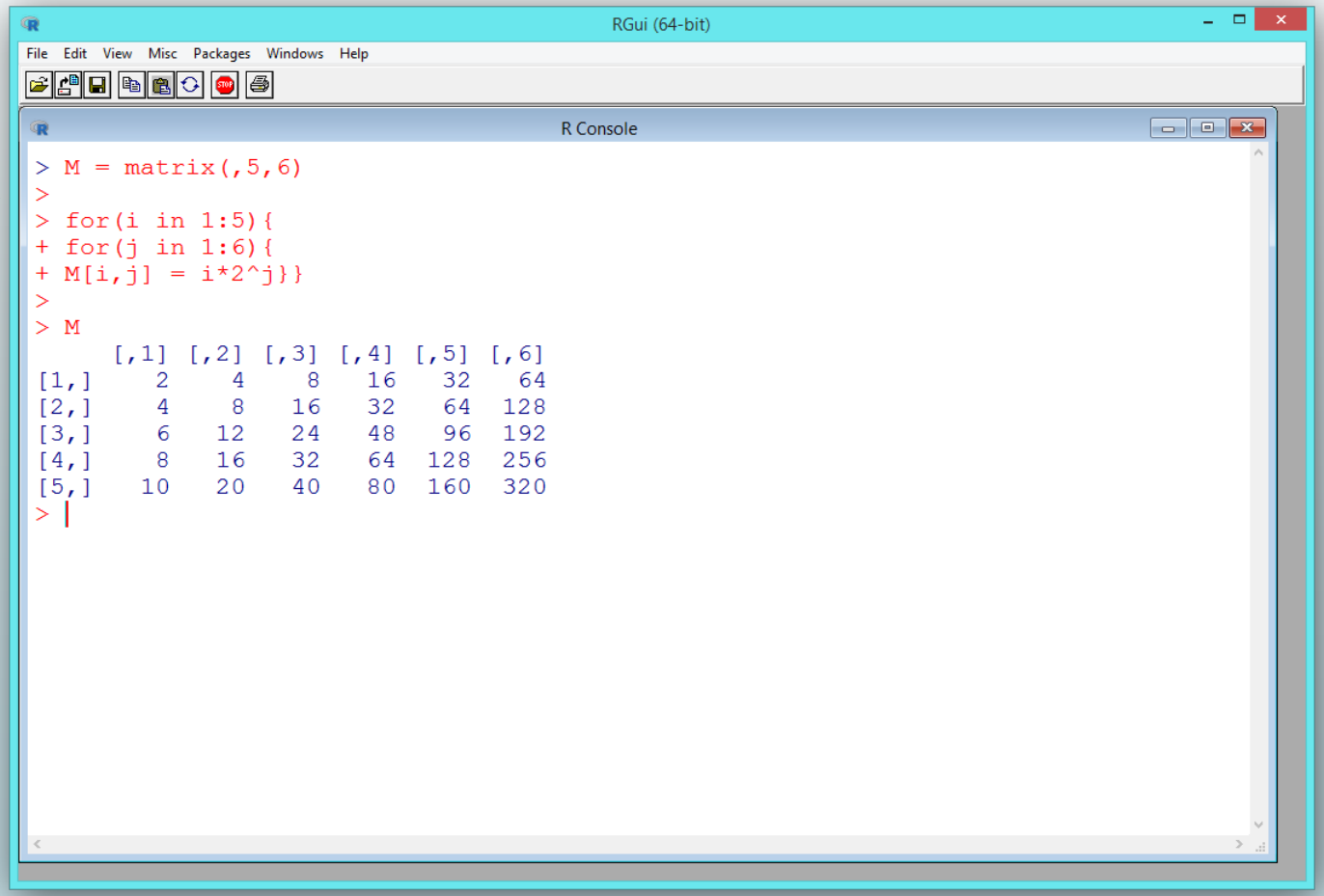
Loop

- `for` Loops (3)



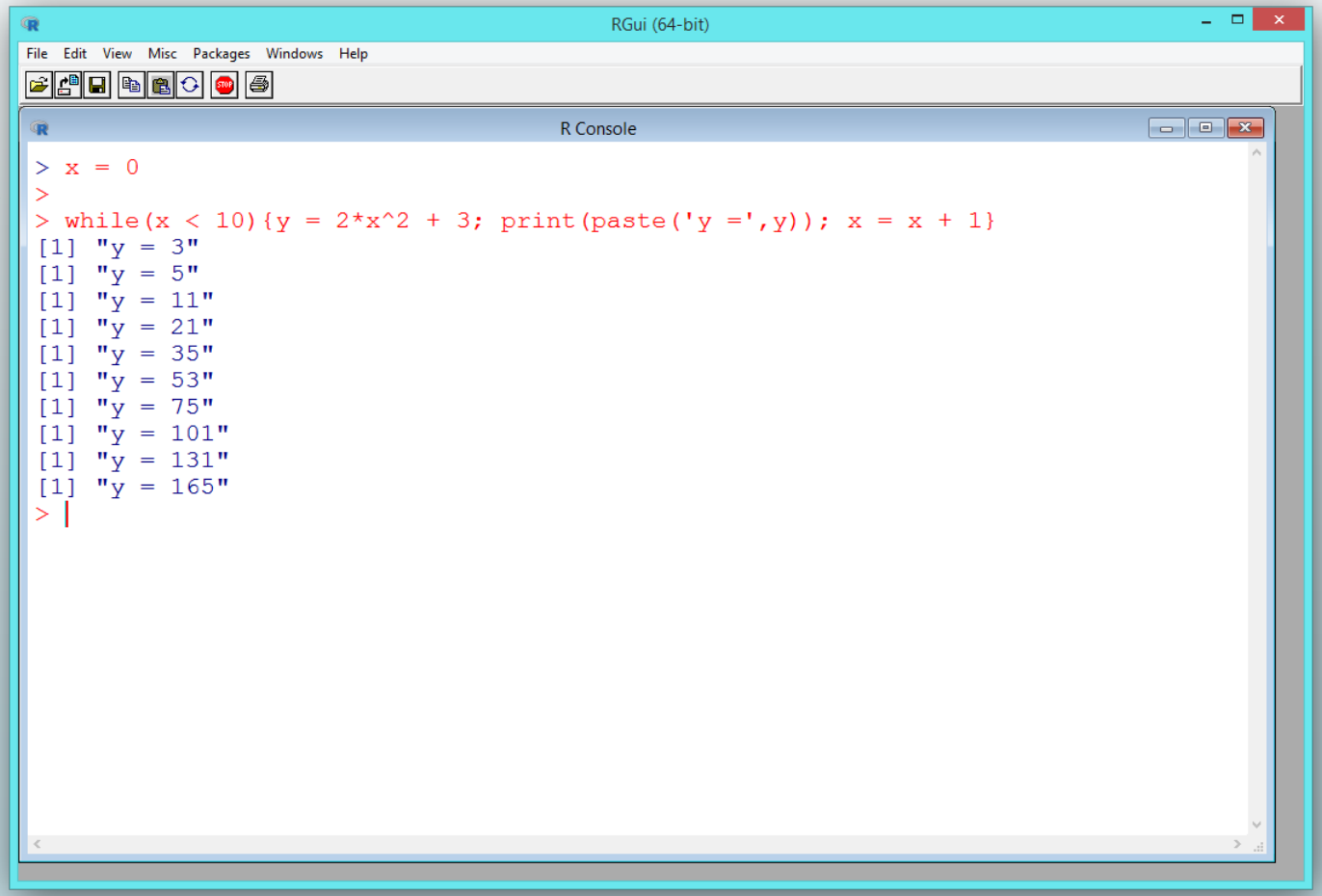
Loop

- Nested `for` Loops



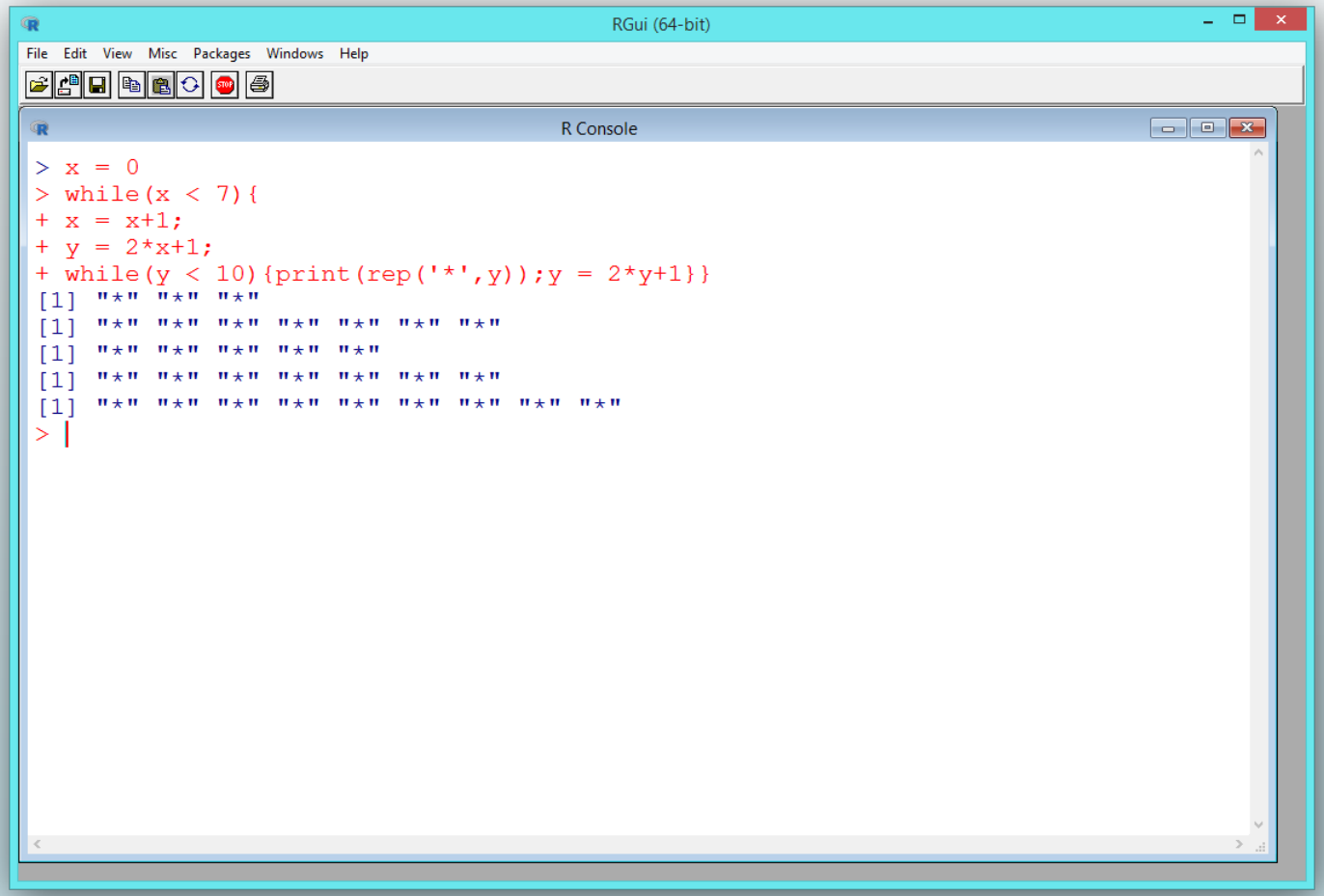
Loop

- `while` Loops



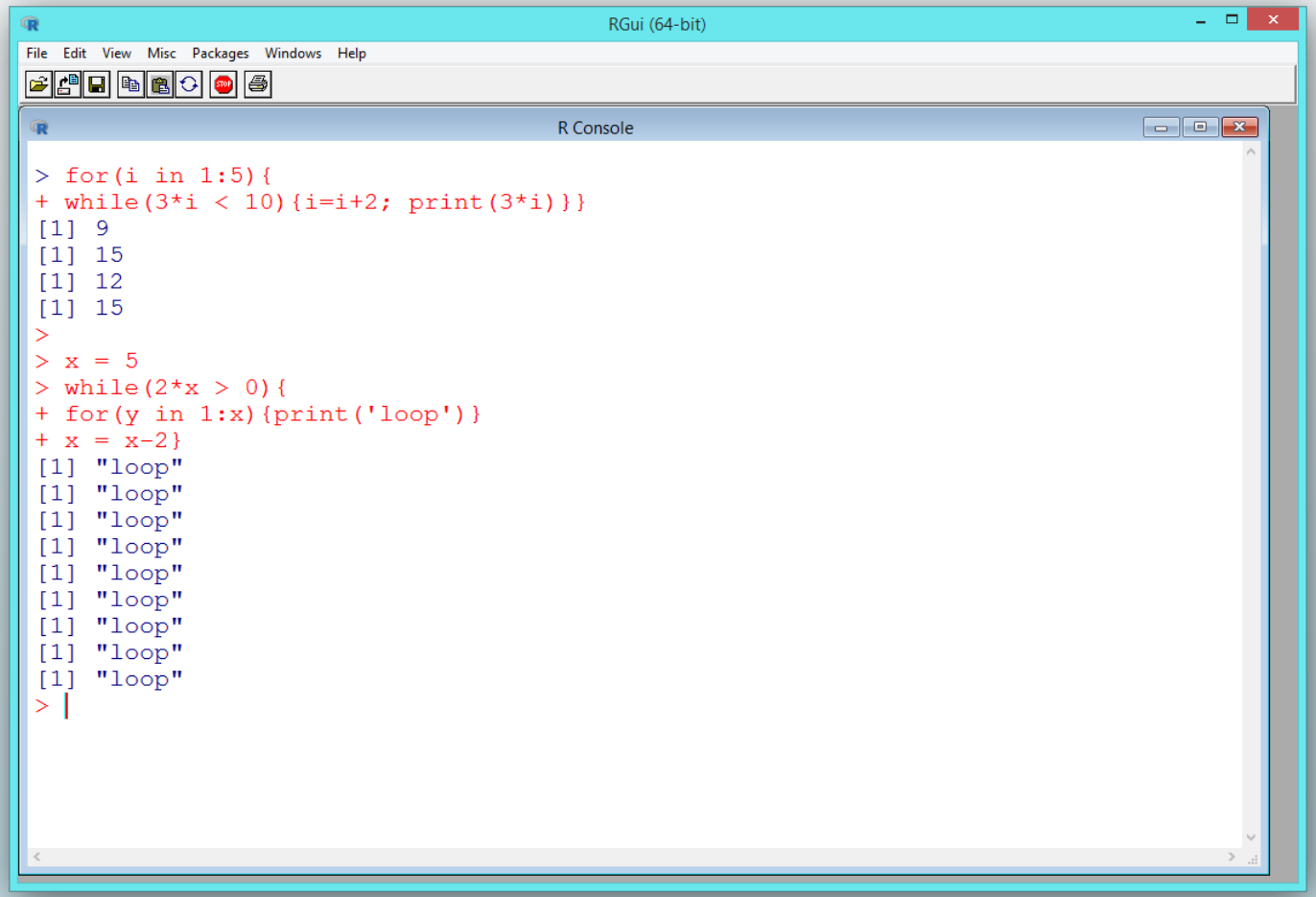
Loop

- Nested `while` Loops



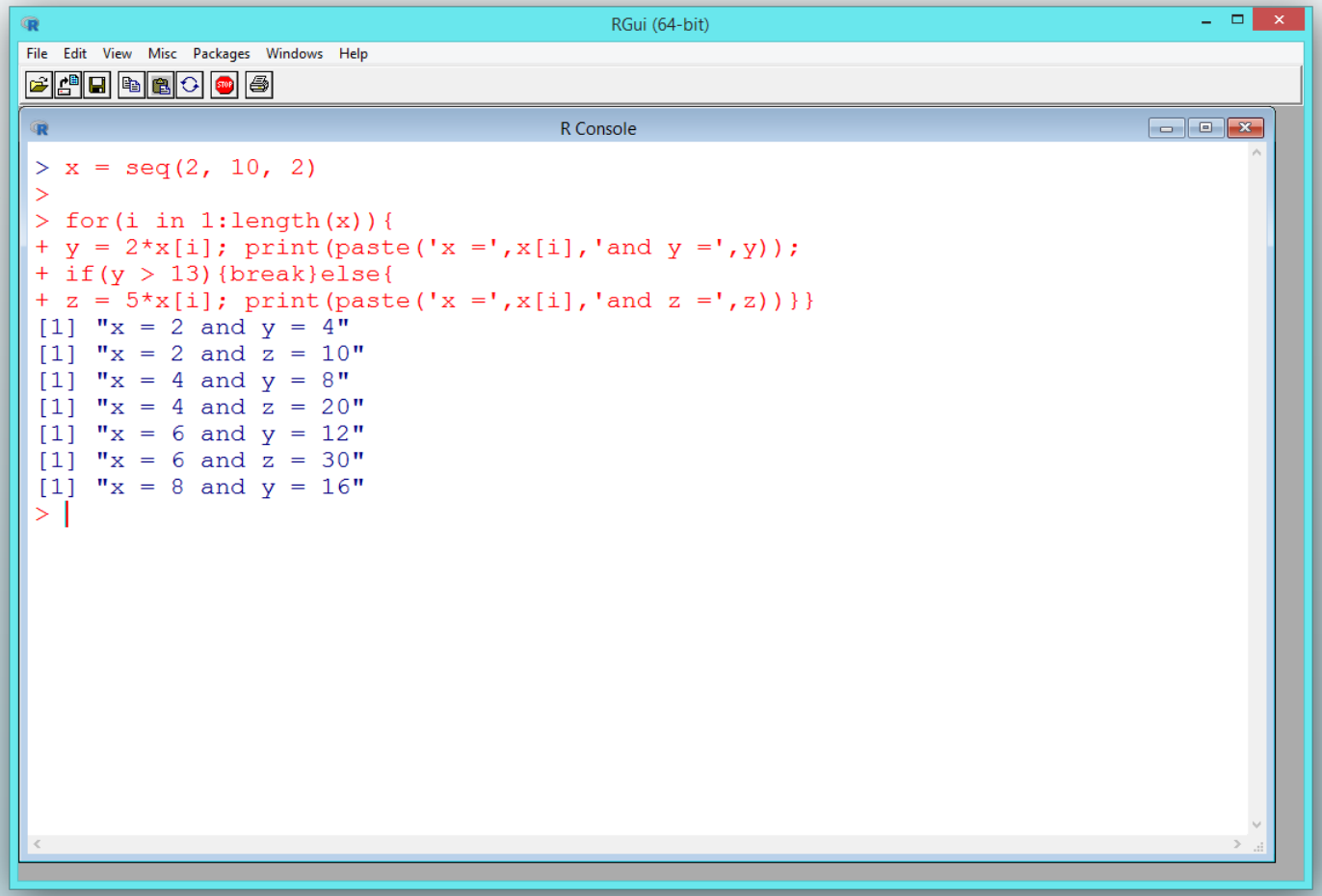
Loop

- Nested `for` and `while` Loops



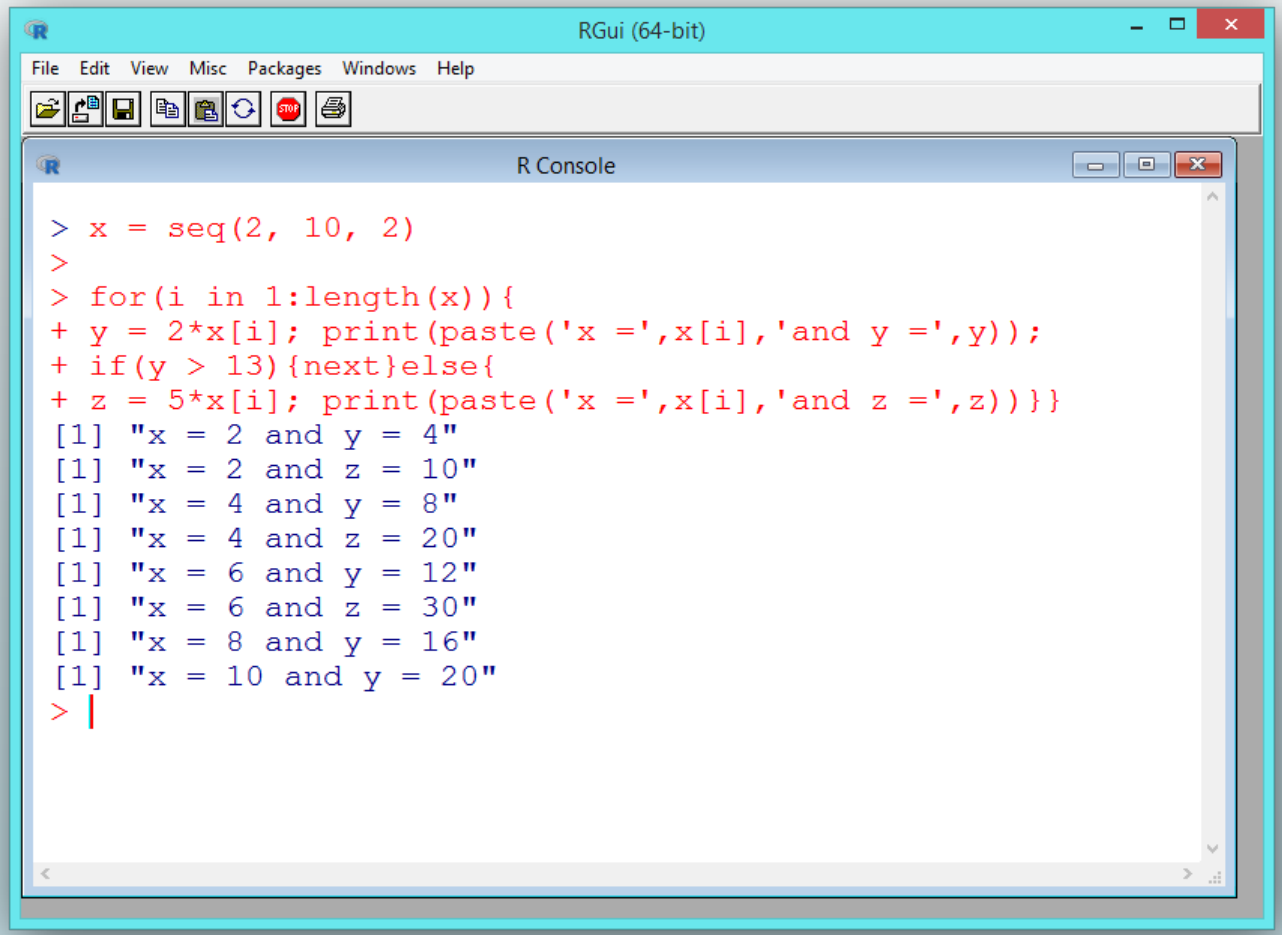
Loop

`break` Control Command



Loop

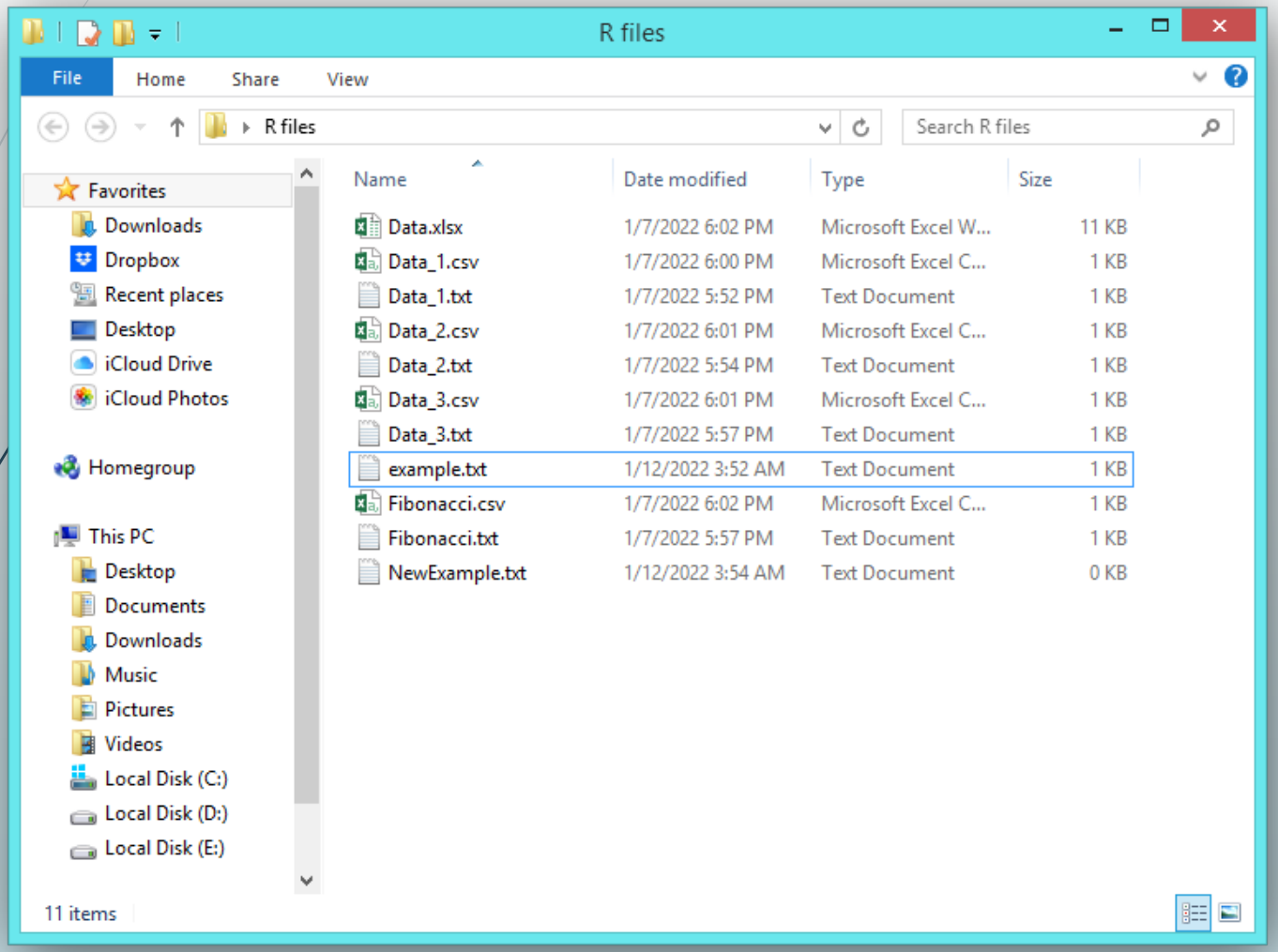
- `next` Control Command



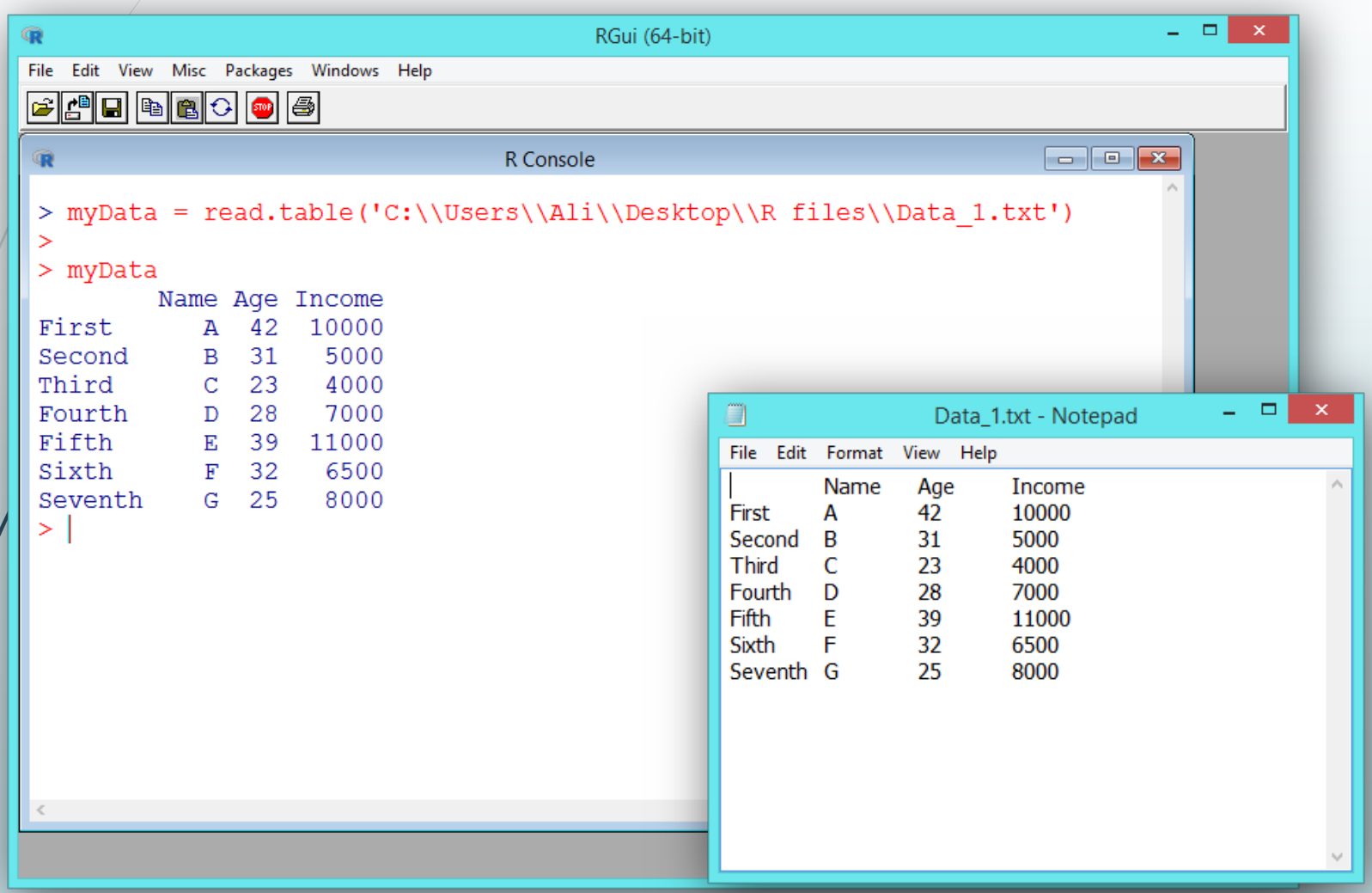
Reading and Writing

Working with data files

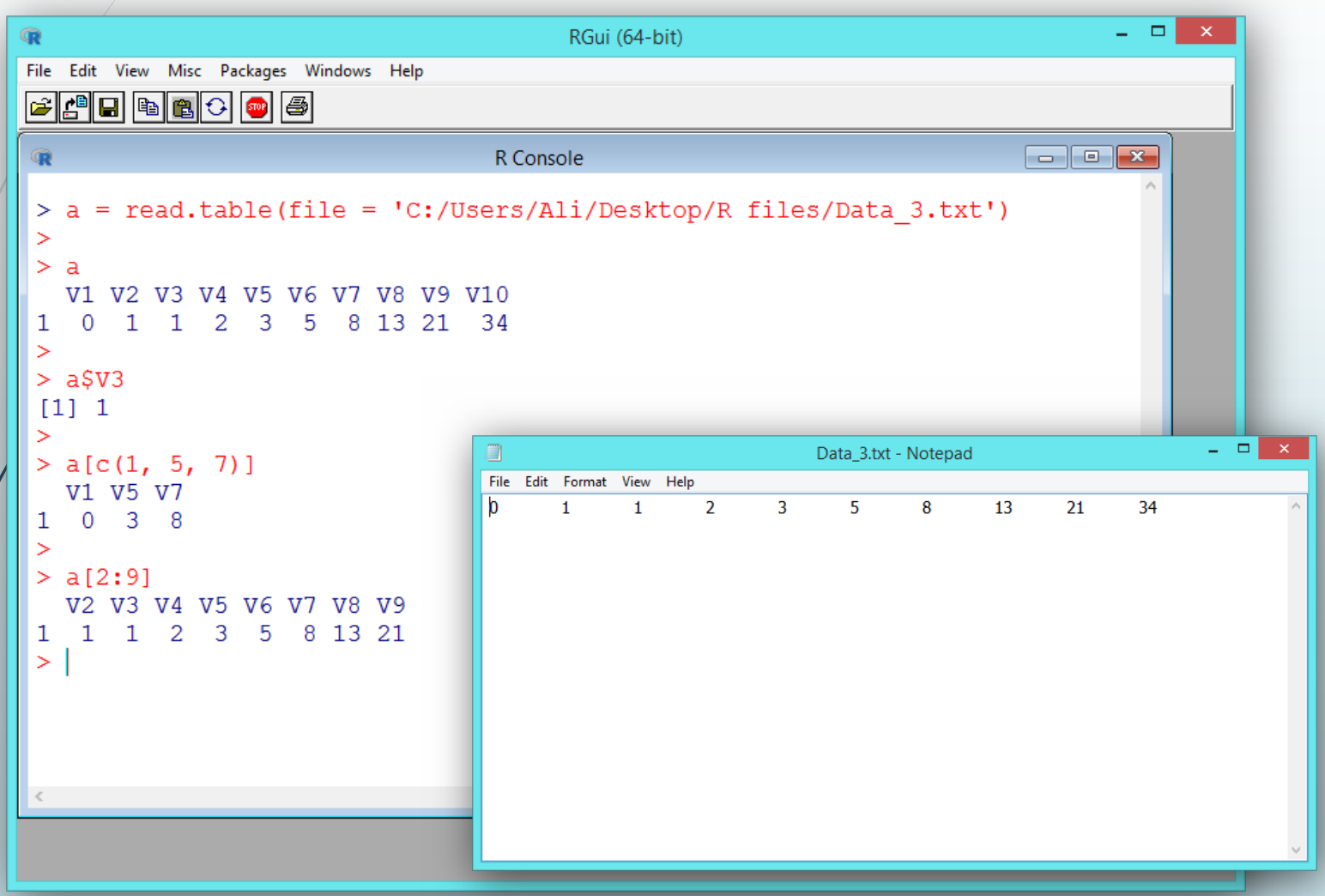
read.table()


R files
File
Home
Share
View
R files
Search R files
Favorites
Downloads
Dropbox
Recent places
Desktop
iCloud Drive
iCloud Photos
Homegroup
This PC
Desktop
Documents
Downloads
Music
Pictures
Videos
Local Disk (C:)
Local Disk (D:)
Local Disk (E:)
Name
Date modified
Type
Size
Data.xlsx 1/7/2022 6:02 PM Microsoft Excel W... 11 KB
Data_1.csv 1/7/2022 6:00 PM Microsoft Excel C... 1 KB
Data_1.txt 1/7/2022 5:52 PM Text Document 1 KB
Data_2.csv 1/7/2022 6:01 PM Microsoft Excel C... 1 KB
Data_2.txt 1/7/2022 5:54 PM Text Document 1 KB
Data_3.csv 1/7/2022 6:01 PM Microsoft Excel C... 1 KB
Data_3.txt 1/7/2022 5:57 PM Text Document 1 KB
example.txt 1/12/2022 3:52 AM Text Document 1 KB
Fibonacci.csv 1/7/2022 6:02 PM Microsoft Excel C... 1 KB
Fibonacci.txt 1/7/2022 5:57 PM Text Document 1 KB
NewExample.txt 1/12/2022 3:54 AM Text Document 0 KB
11 items

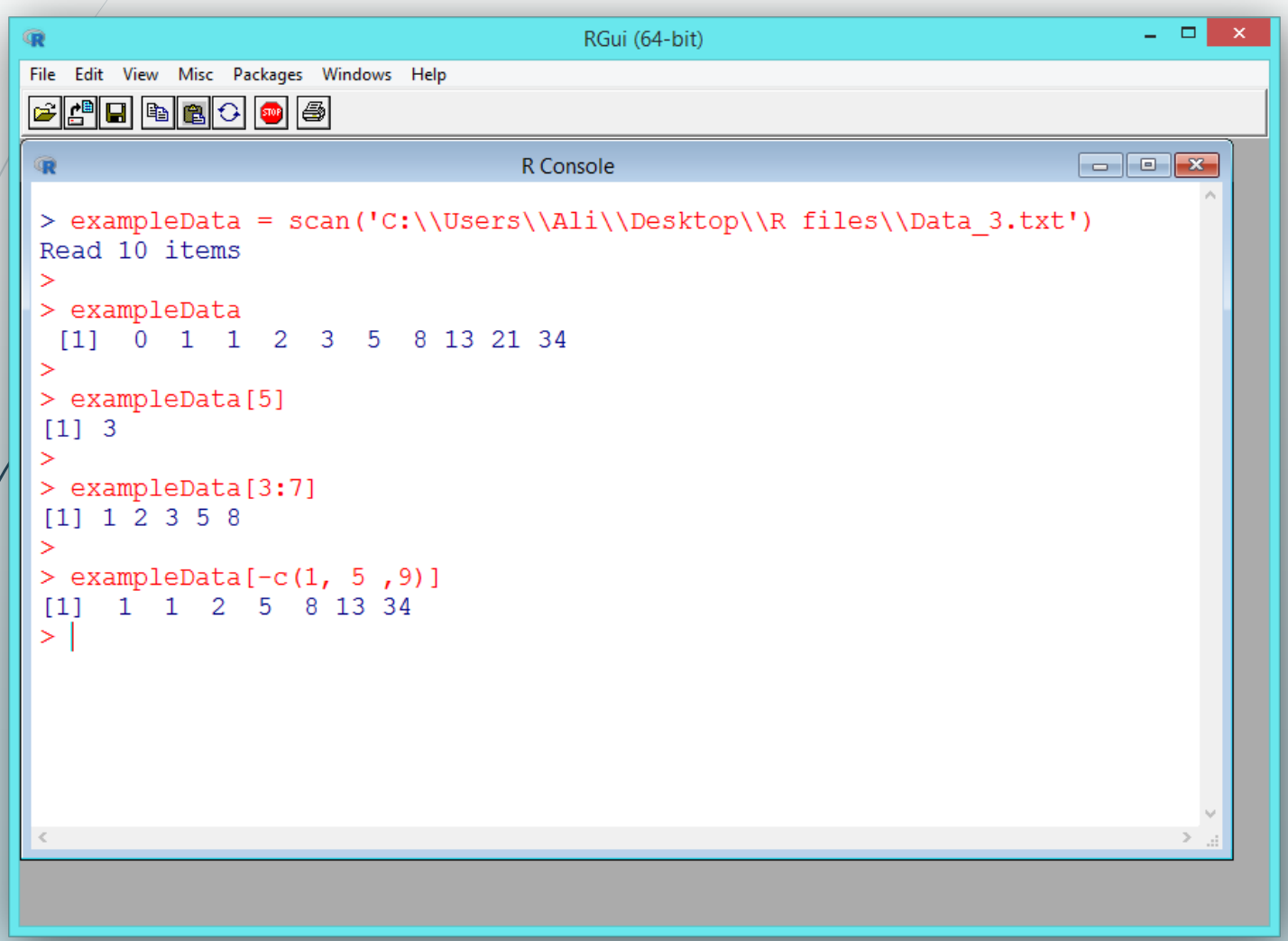
read.table


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> myData = read.table('C:\\Users\\Ali\\Desktop\\R files\\Data_1.txt')
>
> myData
Name Age Income
First A 42 10000
Second B 31 5000
Third C 23 4000
Fourth D 28 7000
Fifth E 39 11000
Sixth F 32 6500
Seventh G 25 8000
>
Data_1.txt - Notepad
File Edit Format View Help
Name Age Income
First A 42 10000
Second B 31 5000
Third C 23 4000
Fourth D 28 7000
Fifth E 39 11000
Sixth F 32 6500
Seventh G 25 8000

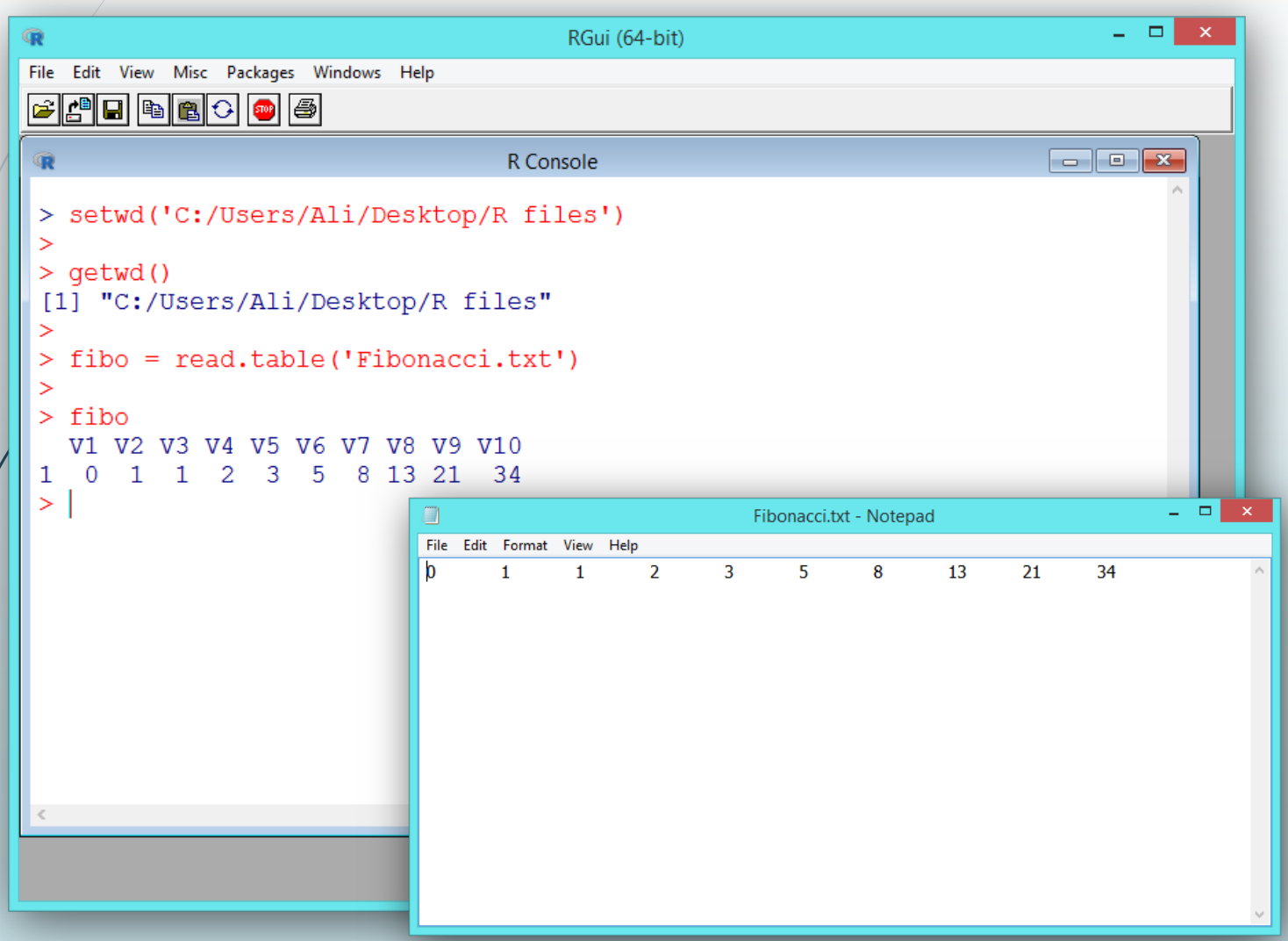
read.table()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> a = read.table(file = 'C:/Users/Ali/Desktop/R files/Data_3.txt')
>
> a
V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
1 0 1 1 2 3 5 8 13 21 34
>
> a$V3
[1] 1
>
> a[c(1, 5, 7)]
V1 V5 V7
1 0 3 8
>
> a[2:9]
V2 V3 V4 V5 V6 V7 V8 V9
1 1 1 2 3 5 8 13 21
>
Data_3.txt - Notepad
File Edit Format View Help
0 1 1 2 3 5 8 13 21 34

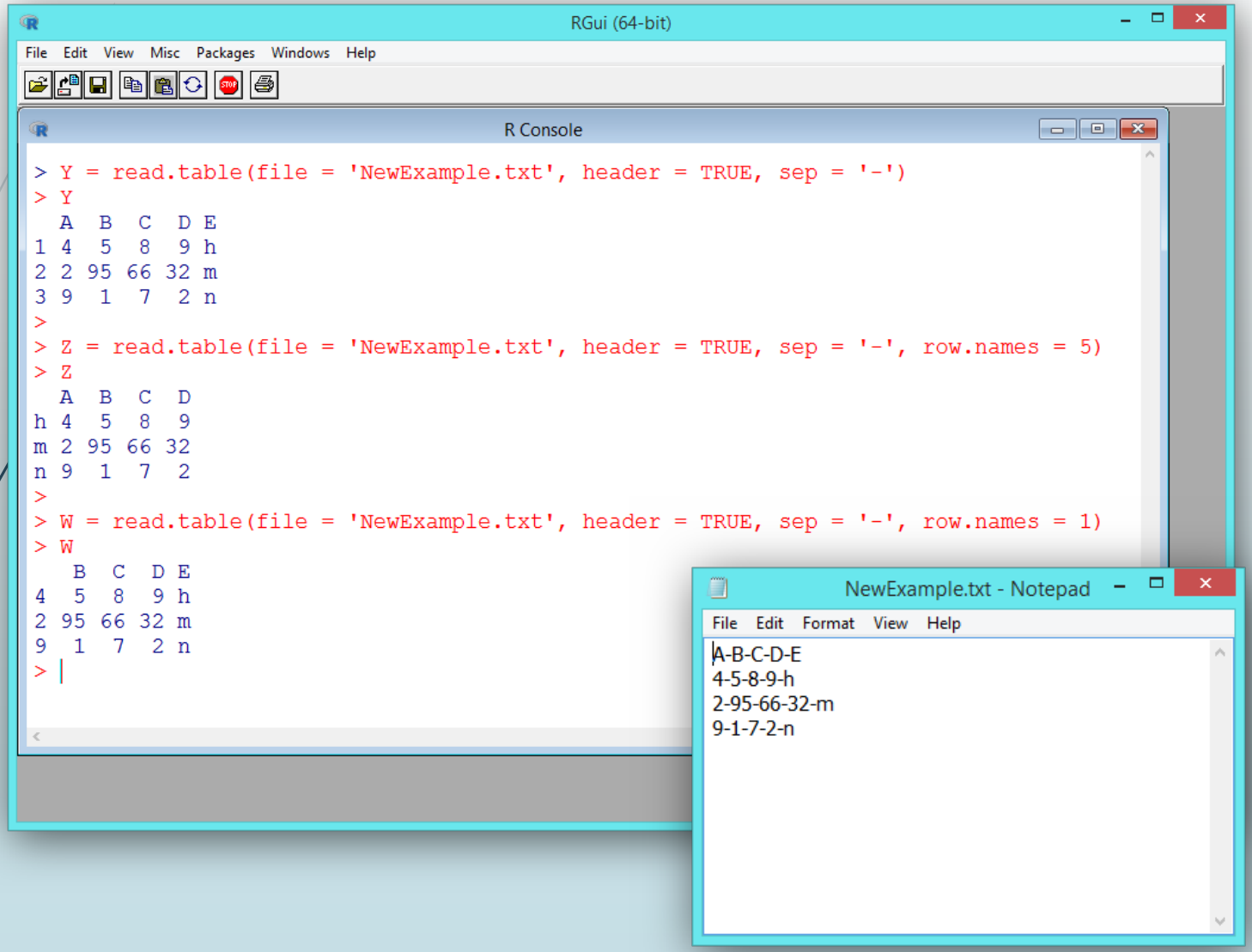
Scan()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> exampleData = scan('C:\\Users\\Ali\\Desktop\\R files\\Data_3.txt')
Read 10 items
>
> exampleData
 [1] 0 1 1 2 3 5 8 13 21 34
>
> exampleData[5]
[1] 3
>
> exampleData[3:7]
[1] 1 2 3 5 8
>
> exampleData[-c(1, 5 ,9)]
[1] 1 1 2 5 8 13 34
>

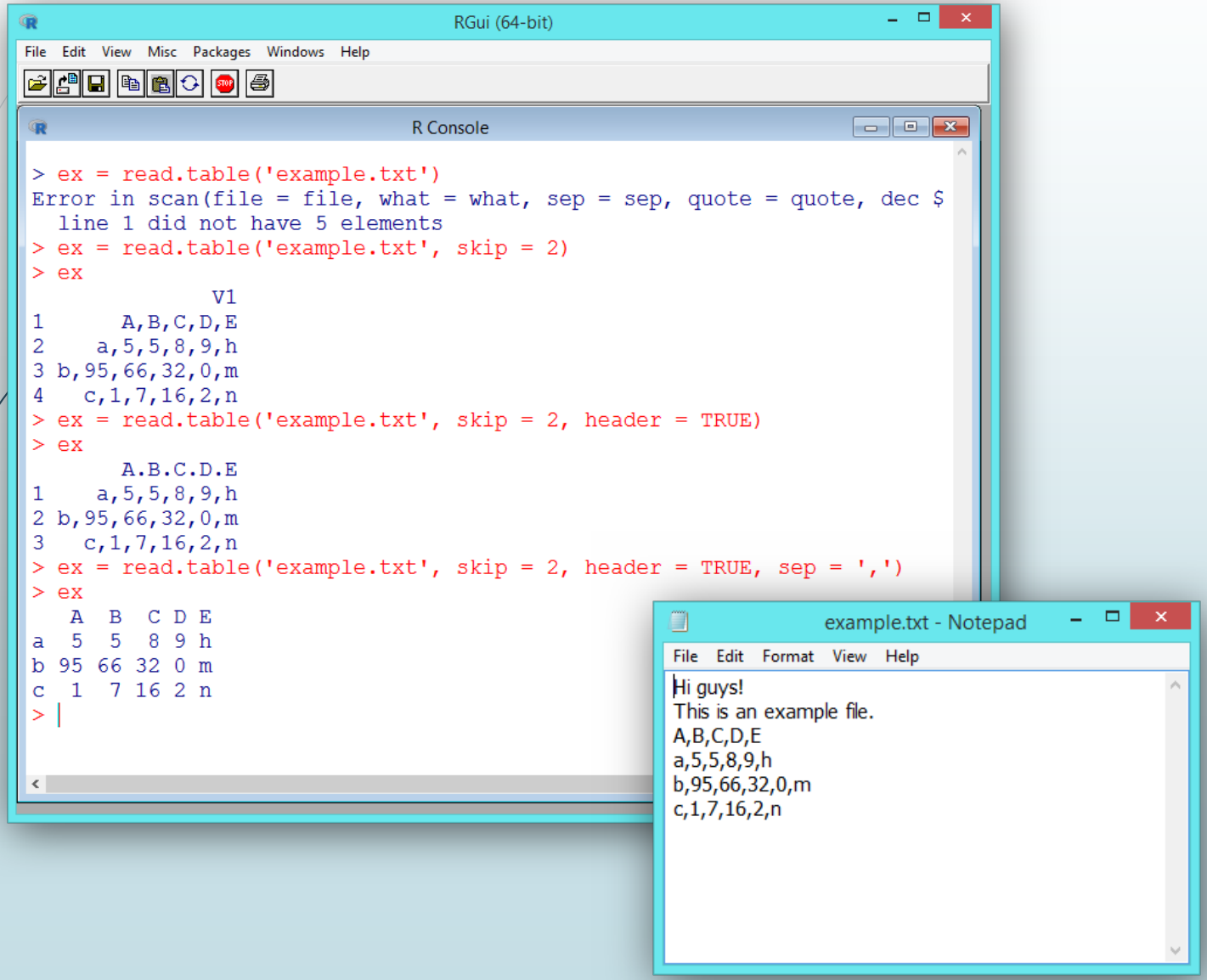
Setwd() & getwd()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> setwd('C:/Users/Ali/Desktop/R files')
>
> getwd()
[1] "C:/Users/Ali/Desktop/R files"
>
> fibo = read.table('Fibonacci.txt')
>
> fibo
V1 V2 V3 V4 V5 V6 V7 V8 V9 V10
1 0 1 1 2 3 5 8 13 21 34
>
Fibonacci.txt - Notepad
File Edit Format View Help
0 1 1 2 3 5 8 13 21 34

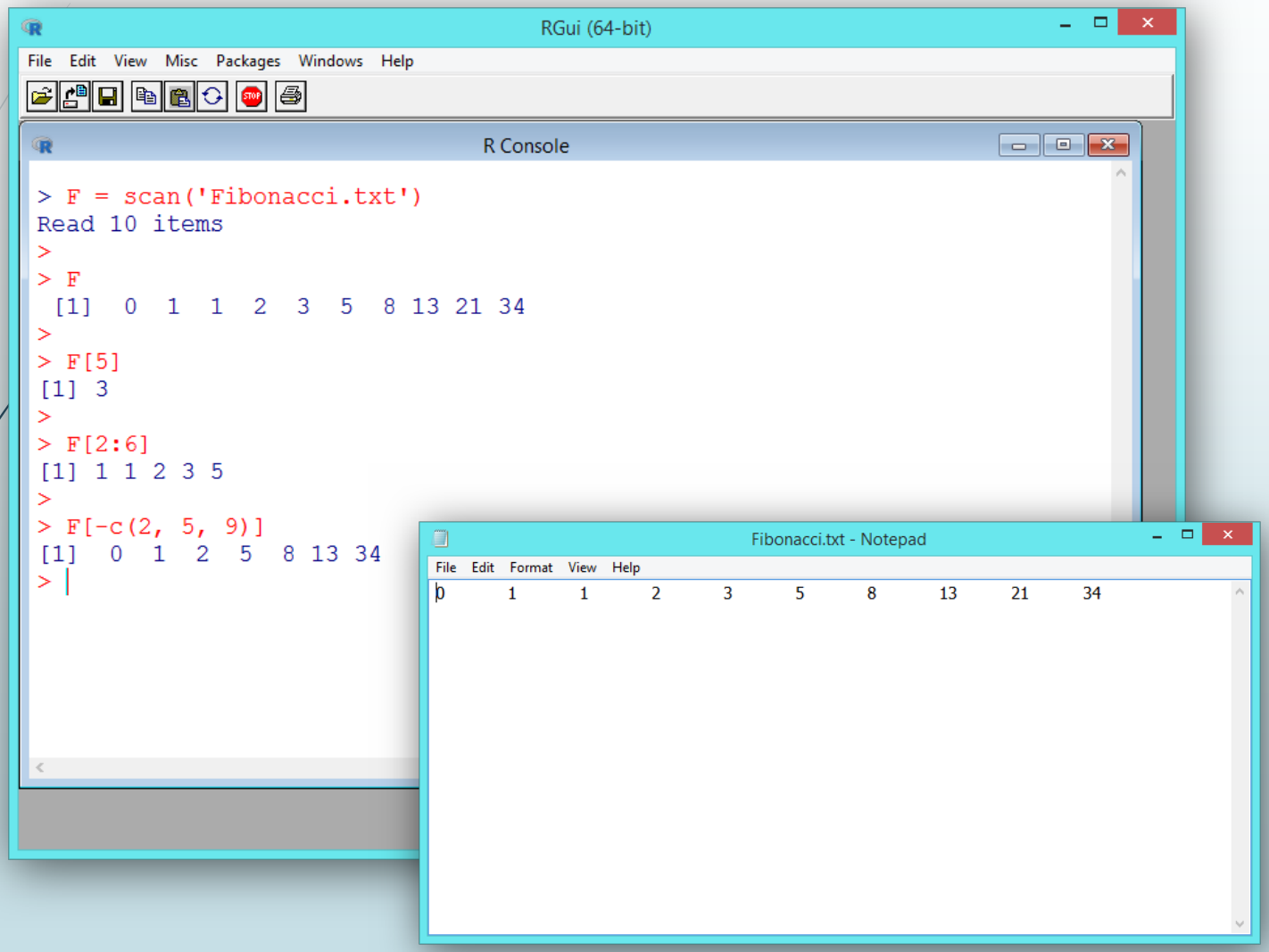
read.table()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> Y = read.table(file = 'NewExample.txt', header = TRUE, sep = '-')
> Y
A B C D E
1 4 5 8 9 h
2 2 95 66 32 m
3 9 1 7 2 n
> Z = read.table(file = 'NewExample.txt', header = TRUE, sep = '-', row.names = 5)
> Z
A B C D
h 4 5 8 9
m 2 95 66 32
n 9 1 7 2
> W = read.table(file = 'NewExample.txt', header = TRUE, sep = '-', row.names = 1)
> W
B C D E
4 5 8 9 h
2 95 66 32 m
9 1 7 2 n
NewExample.txt - Notepad
File Edit Format View Help
A-B-C-D-E
4-5-8-9-h
2-95-66-32-m
9-1-7-2-n

read.table()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> ex = read.table('example.txt')
Error in scan(file = file, what = what, sep = sep, quote = quote, dec $
line 1 did not have 5 elements
> ex = read.table('example.txt', skip = 2)
> ex
V1
1 A,B,C,D,E
2 a,5,5,8,9,h
3 b,95,66,32,0,m
4 c,1,7,16,2,n
> ex = read.table('example.txt', skip = 2, header = TRUE)
> ex
A.B.C.D.E
1 a,5,5,8,9,h
2 b,95,66,32,0,m
3 c,1,7,16,2,n
> ex = read.table('example.txt', skip = 2, header = TRUE, sep = ',')
> ex
A B C D E
a 5 5 8 9 h
b 95 66 32 0 m
c 1 7 16 2 n
>
example.txt - Notepad
File Edit Format View Help
Hi guys!
This is an example file.
A,B,C,D,E
a,5,5,8,9,h
b,95,66,32,0,m
c,1,7,16,2,n

Scan()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> F = scan('Fibonacci.txt')
Read 10 items
>
> F
 [1] 0 1 1 2 3 5 8 13 21 34
>
> F[5]
[1] 3
>
> F[2:6]
[1] 1 1 2 3 5
>
> F[-c(2, 5, 9)]
[1] 0 1 2 5 8 13 34
>
Fibonacci.txt - Notepad
File Edit Format View Help
0 1 1 2 3 5 8 13 21 34

read.csv()

RGui (64-bit)

File Edit View Misc Packages Windows Help

R Console

```
> csvdata = read.csv(file = 'Data_1.csv')
> csvdata
  Name Age Income
1    A  42  10000
2    B  31   5000
3    C  23   4000
4    D  28   7000
5    E  39  11000
6    F  32   6500
7    G  25   8000
>
> CSVDATA = read.csv(file = 'Data_2.csv')
> CSVDATA
       X Name Age Income
1  First    A  42  10000
2 Second    B  31   5000
3  Third    C  23   4000
4 Fourth    D  28   7000
5  Fifth    E  39  11000
6  Sixth    F  32   6500
7 Seventh    G  25   8000
>
```

Data_1.csv - Excel

	A	B	C	D	E	F	G	H	I
1	Name	Age	Income						
2	A	42	10000						
3	B	31	5000						
4	C	23	4000						
5	D	28	7000						
6	E	39	11000						
7	F	32	6500						
8	G	25	8000						
9									
10									

Data_1 Ready 100%

Data_2.csv - Excel

	A	B	C	D	E	F	G	H	I
1		Name	Age	Income					
2	First	A	42	10000					
3	Second	B	31	5000					
4	Third	C	23	4000					
5	Fourth	D	28	7000					
6	Fifth	E	39	11000					
7	Sixth	F	32	6500					
8	Seventh	G	25	8000					
9									
10									

Data_2 Ready 100%

read.csv()

RGui (64-bit)

File Edit View Misc Packages Windows Help

R Console

```
> CSVDATA = read.csv(file = 'Data_2.csv')
> CSVDATA
        X Name Age Income
1   First    A  42  10000
2  Second    B  31   5000
3   Third    C  23   4000
4  Fourth    D  28   7000
5   Fifth    E  39  11000
6   Sixth    F  32   6500
7 Seventh    G  25   8000
>
> CSVDATA_2 = read.csv(file = 'Data_2.csv', row.names = 1)
> CSVDATA_2
        Name Age Income
First      A  42  10000
Second     B  31   5000
Third      C  23   4000
Fourth     D  28   7000
Fifth      E  39  11000
Sixth      F  32   6500
Seventh    G  25   8000
>
```

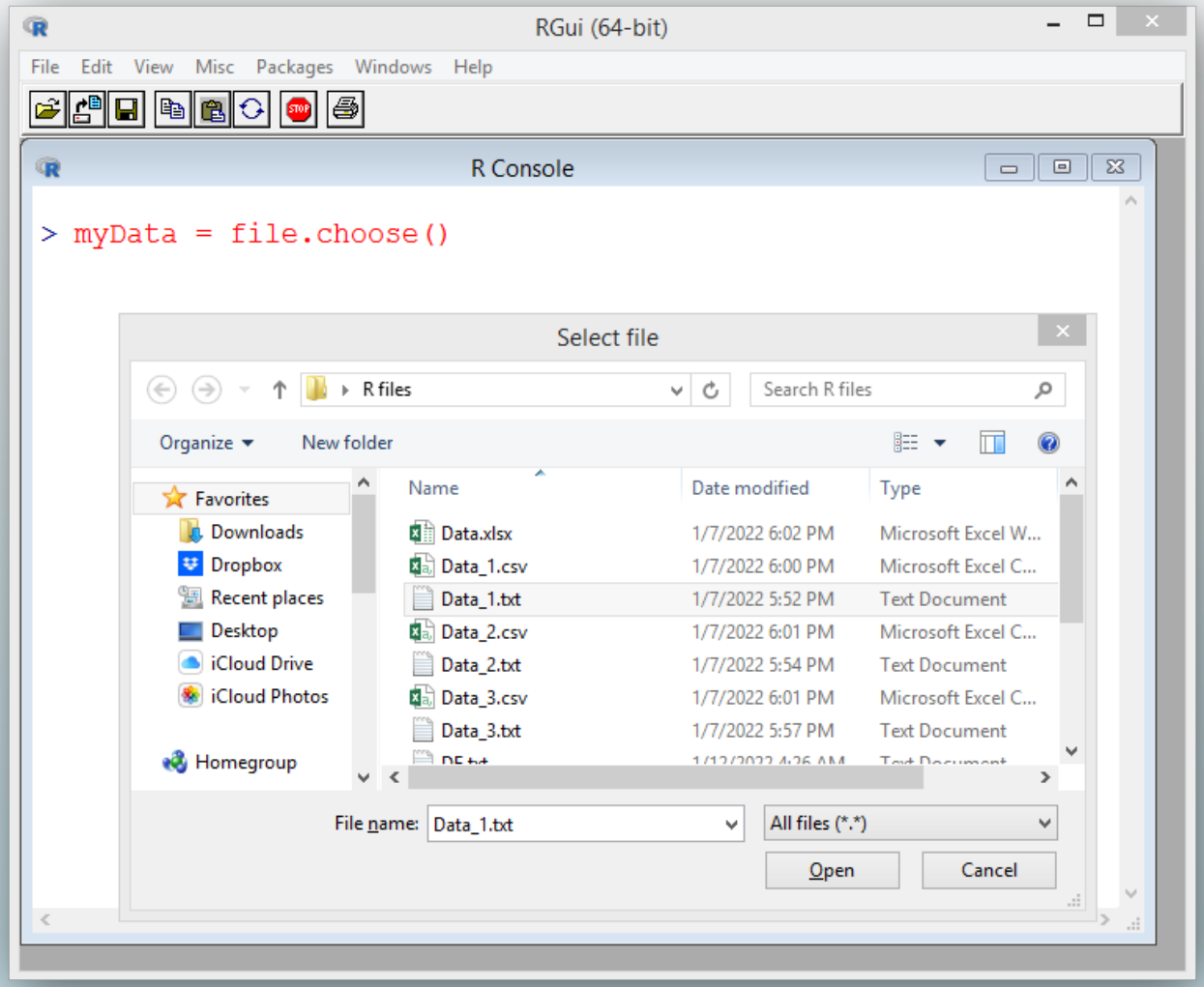
Data_2.csv - Excel

	A	B	C	D
1		Name	Age	Income
2	First	A	42	10000
3	Second	B	31	5000
4	Third	C	23	4000
5	Fourth	D	28	7000
6	Fifth	E	39	11000
7	Sixth	F	32	6500
8	Seventh	G	25	8000
9				
10				

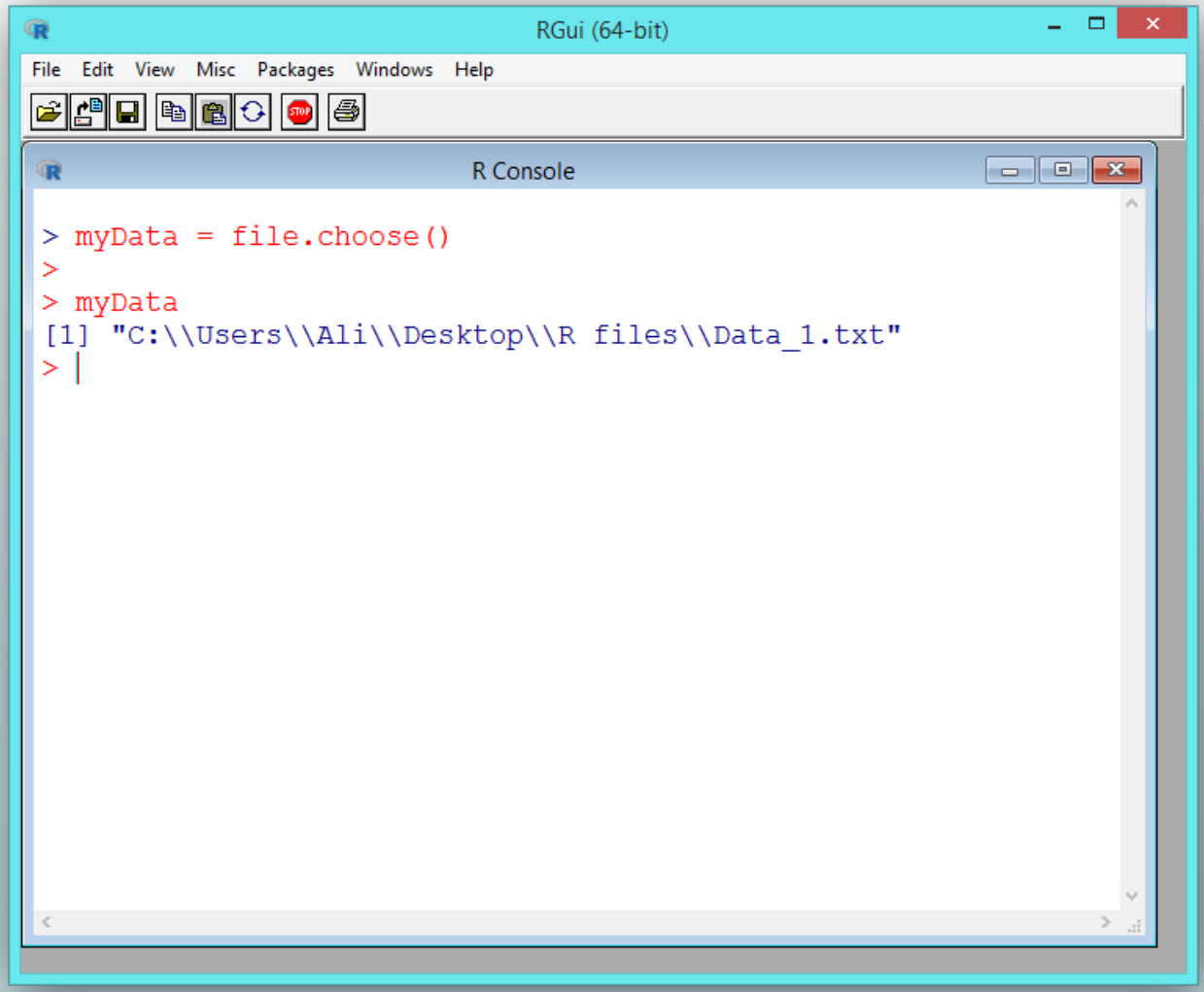
Data_2

Ready

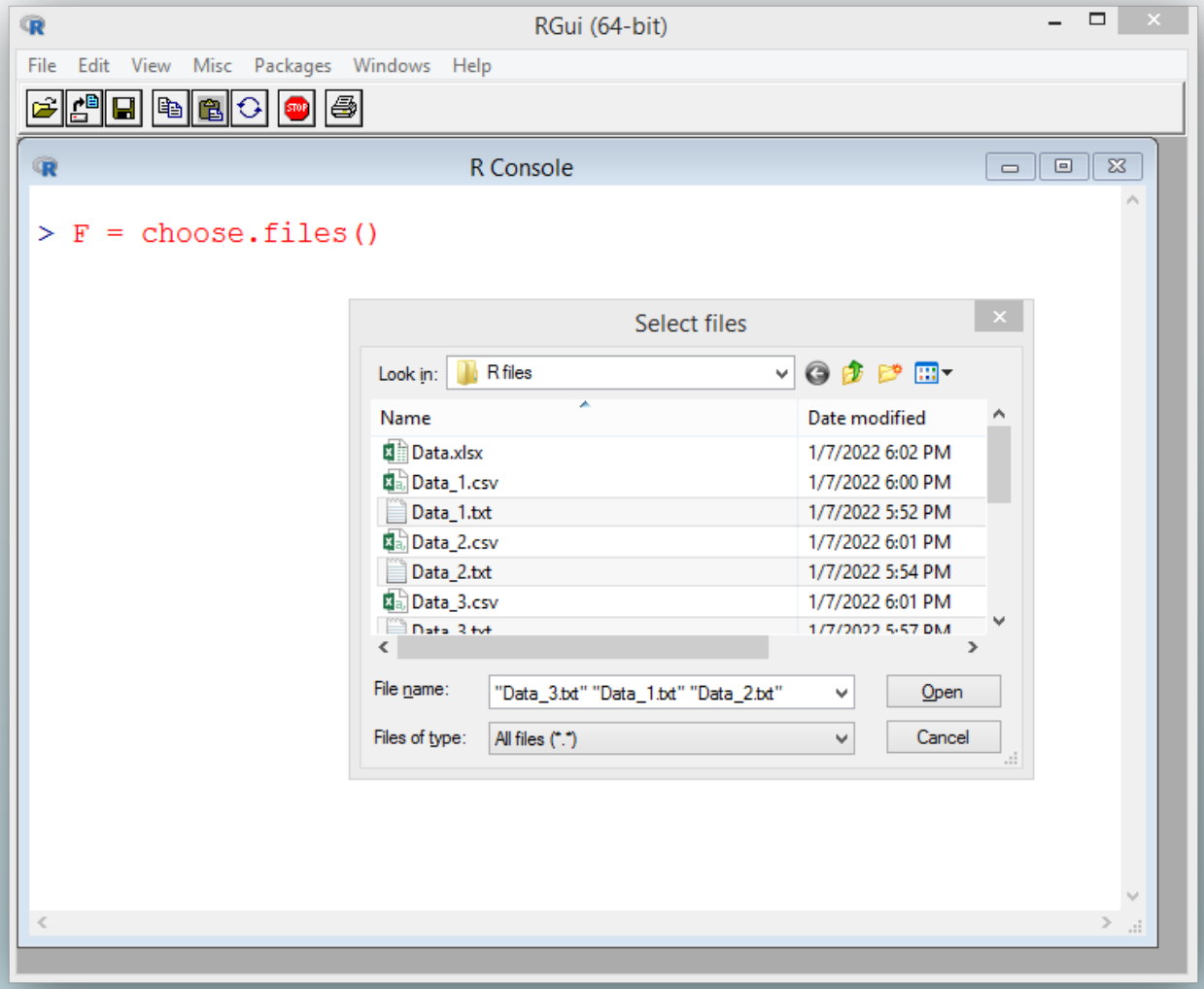
file.choose()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> myData = file.choose()
Select file
R files
Search R files
Organize
New folder
Favorites
Downloads
Dropbox
Recent places
Desktop
iCloud Drive
iCloud Photos
Homegroup
Name
Date modified
Type
Data.xlsx 1/7/2022 6:02 PM Microsoft Excel W...
Data_1.csv 1/7/2022 6:00 PM Microsoft Excel C...
Data_1.txt 1/7/2022 5:52 PM Text Document
Data_2.csv 1/7/2022 6:01 PM Microsoft Excel C...
Data_2.txt 1/7/2022 5:54 PM Text Document
Data_3.csv 1/7/2022 6:01 PM Microsoft Excel C...
Data_3.txt 1/7/2022 5:57 PM Text Document
File name: Data_1.txt
All files (*.*)
Open
Cancel

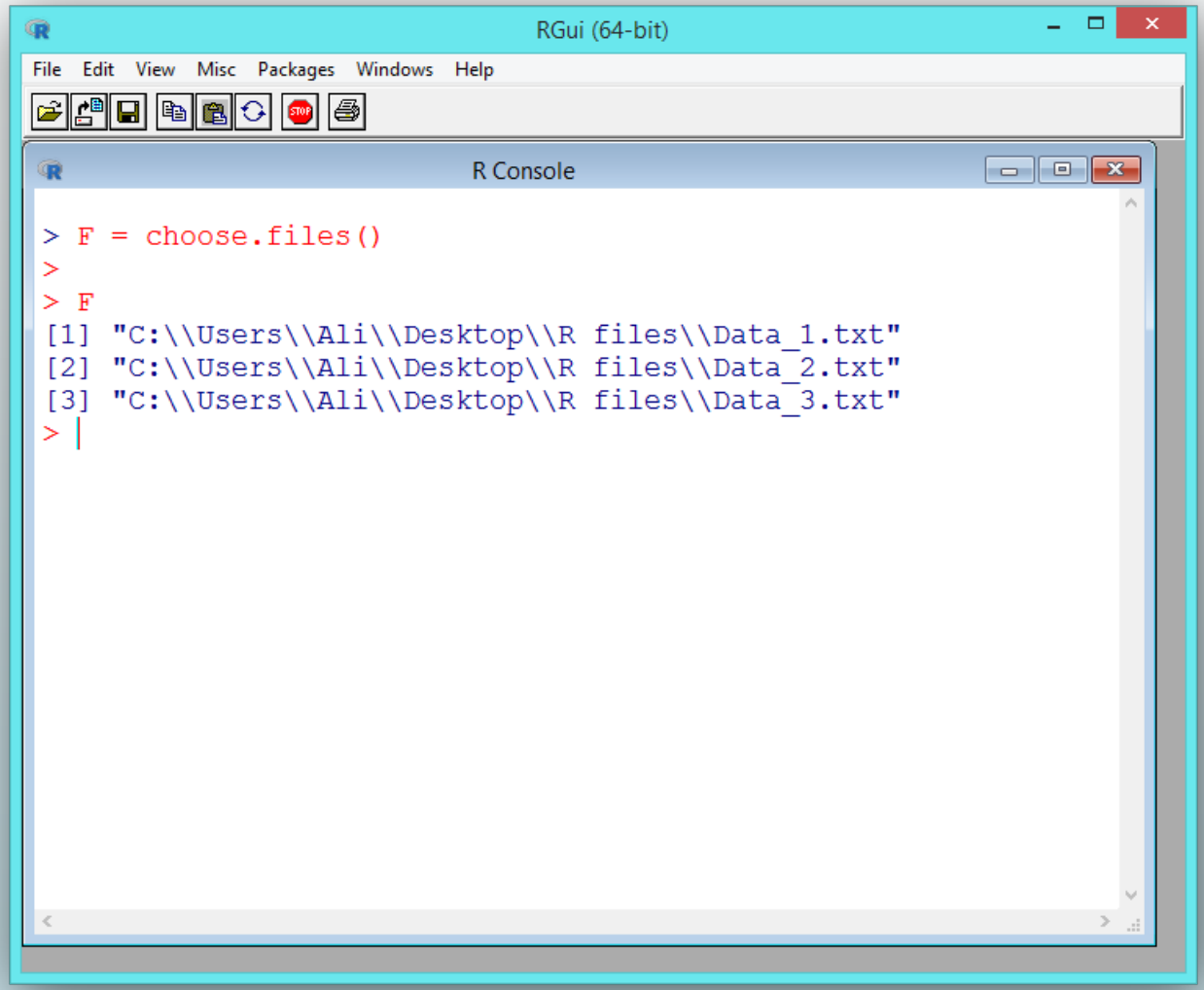
file.choose()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> myData = file.choose()
>
> myData
[1] "C:\\Users\\Ali\\Desktop\\R files\\Data_1.txt"
>

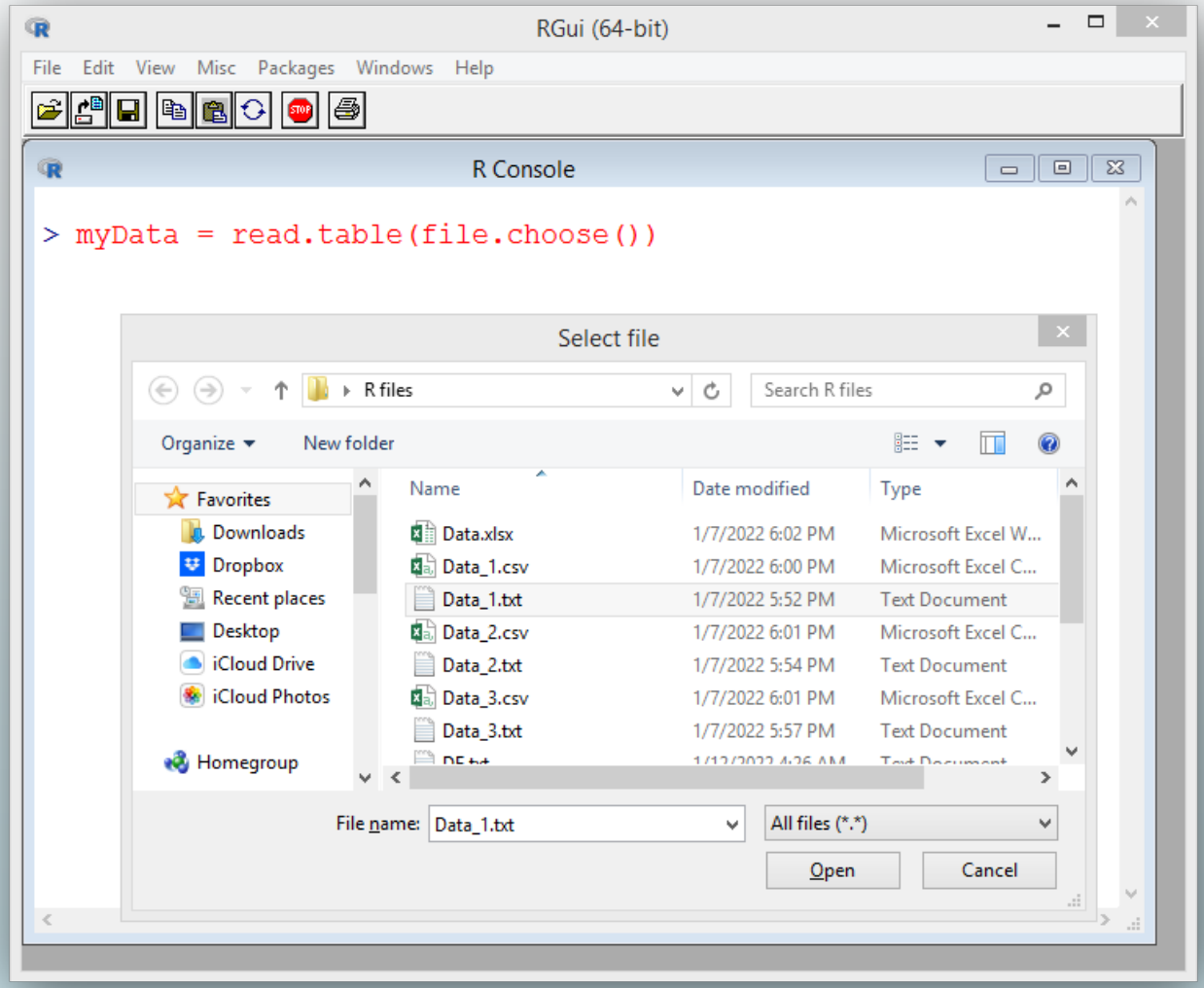
choose.files()



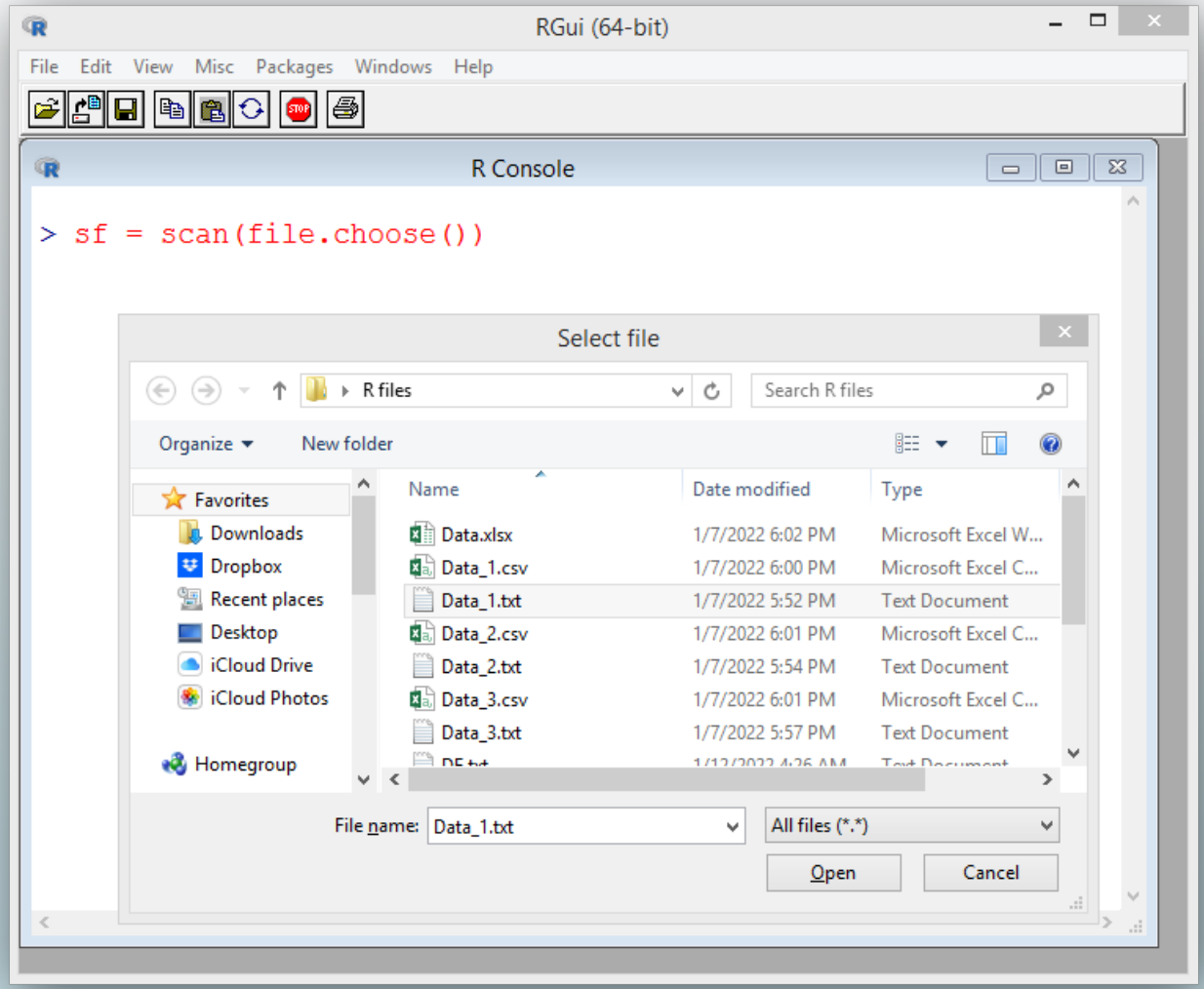
choose.files()



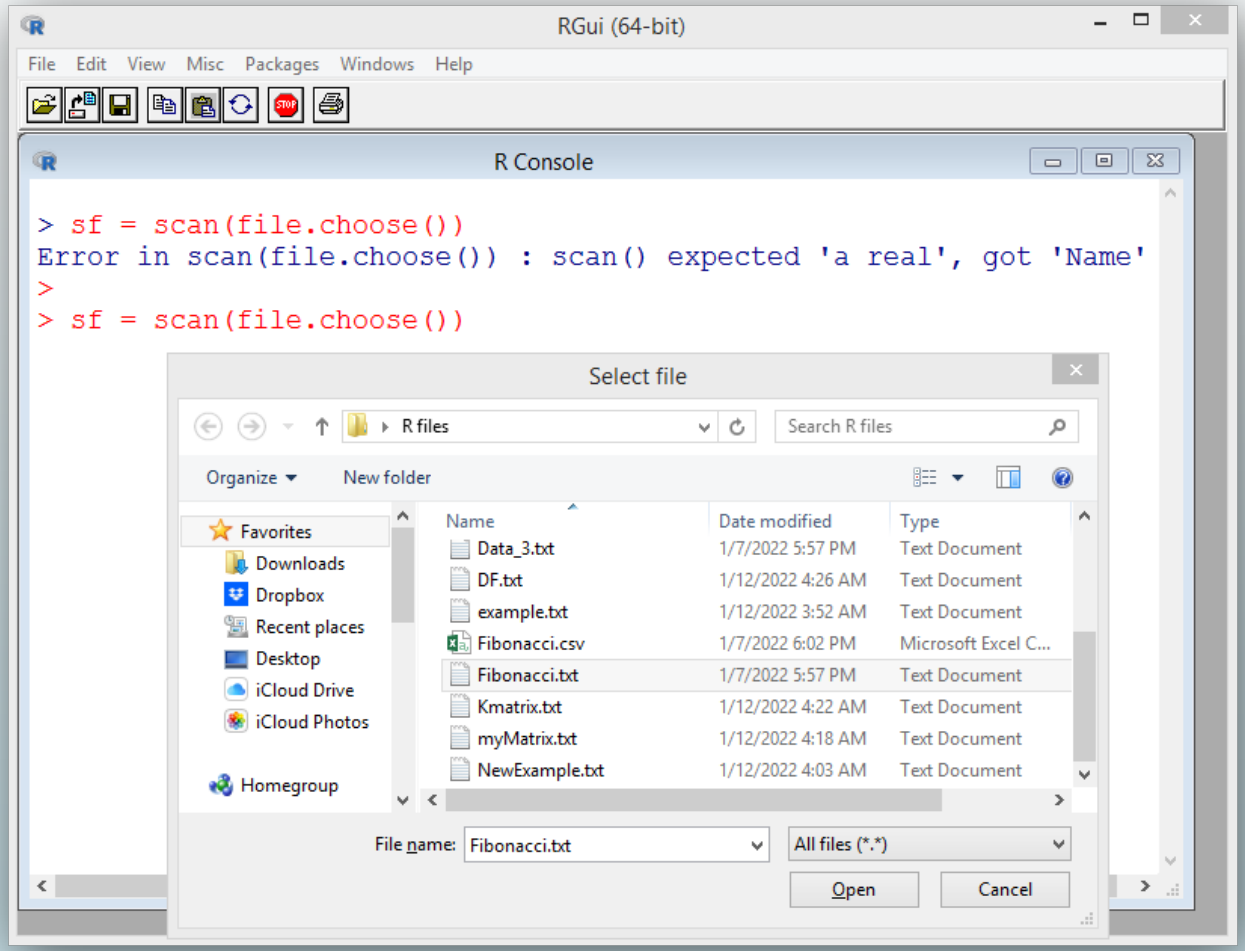
read.table(file.choose())



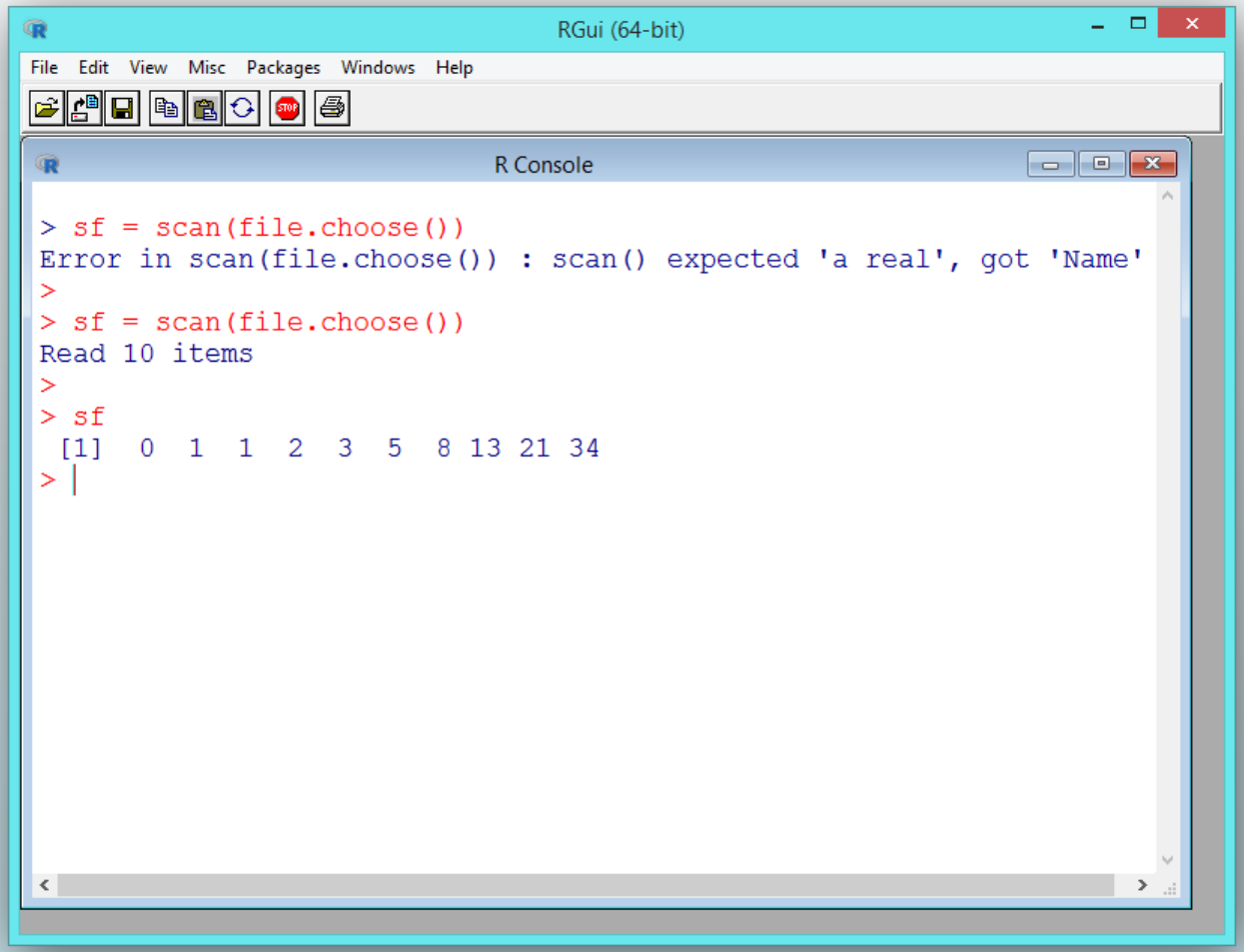
scan(file.choose())



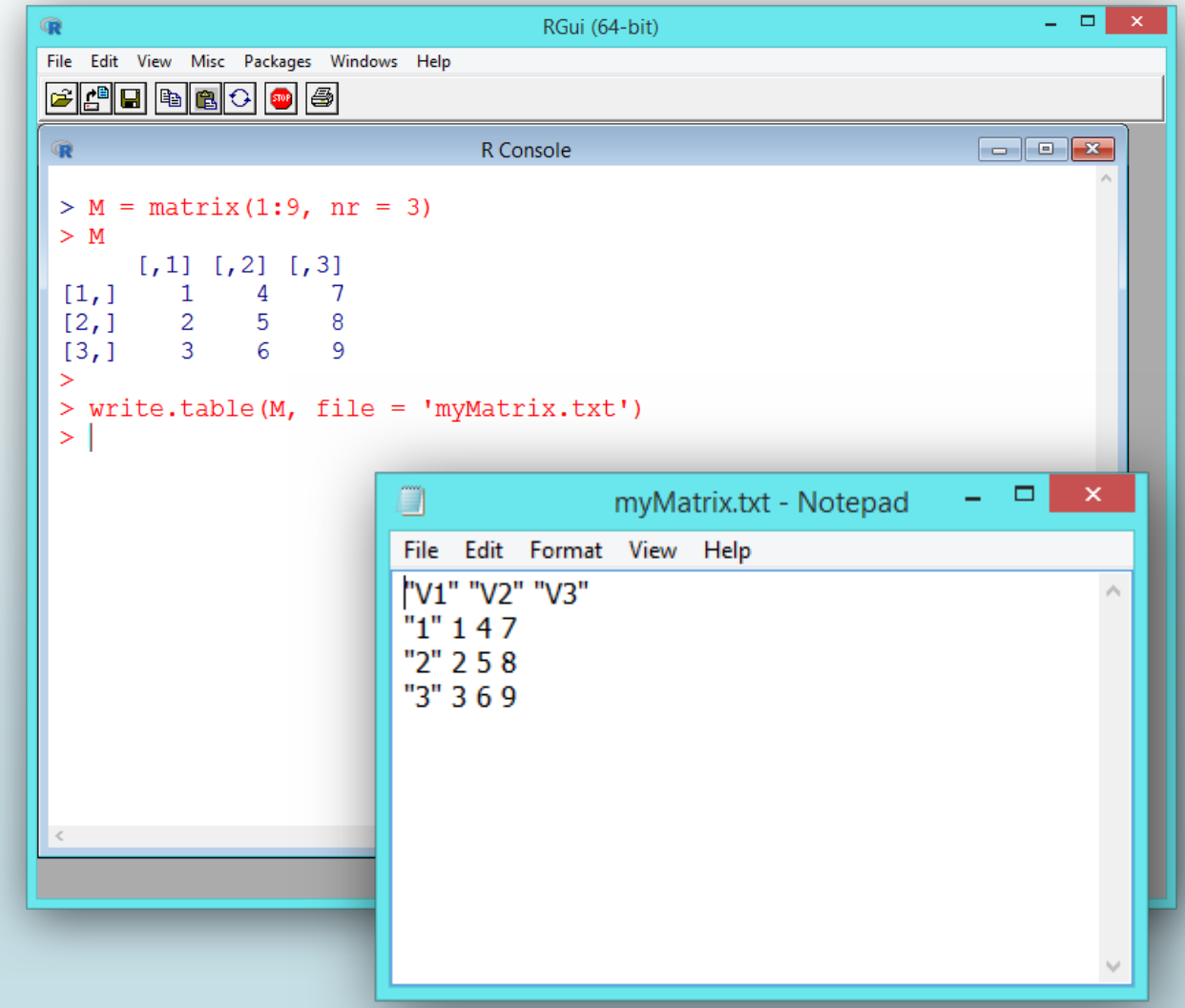
scan(file.choose())



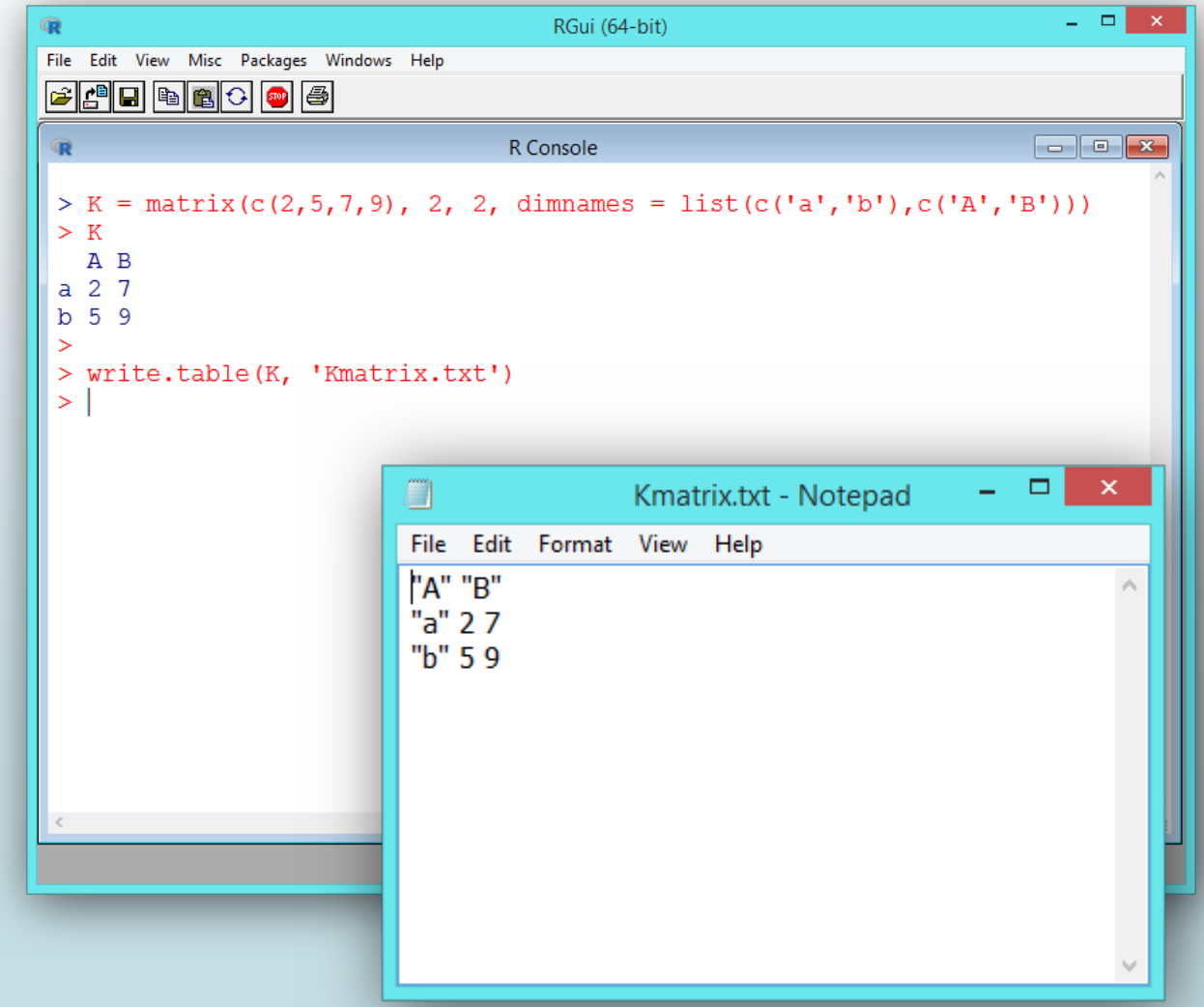
scan(file.choose())



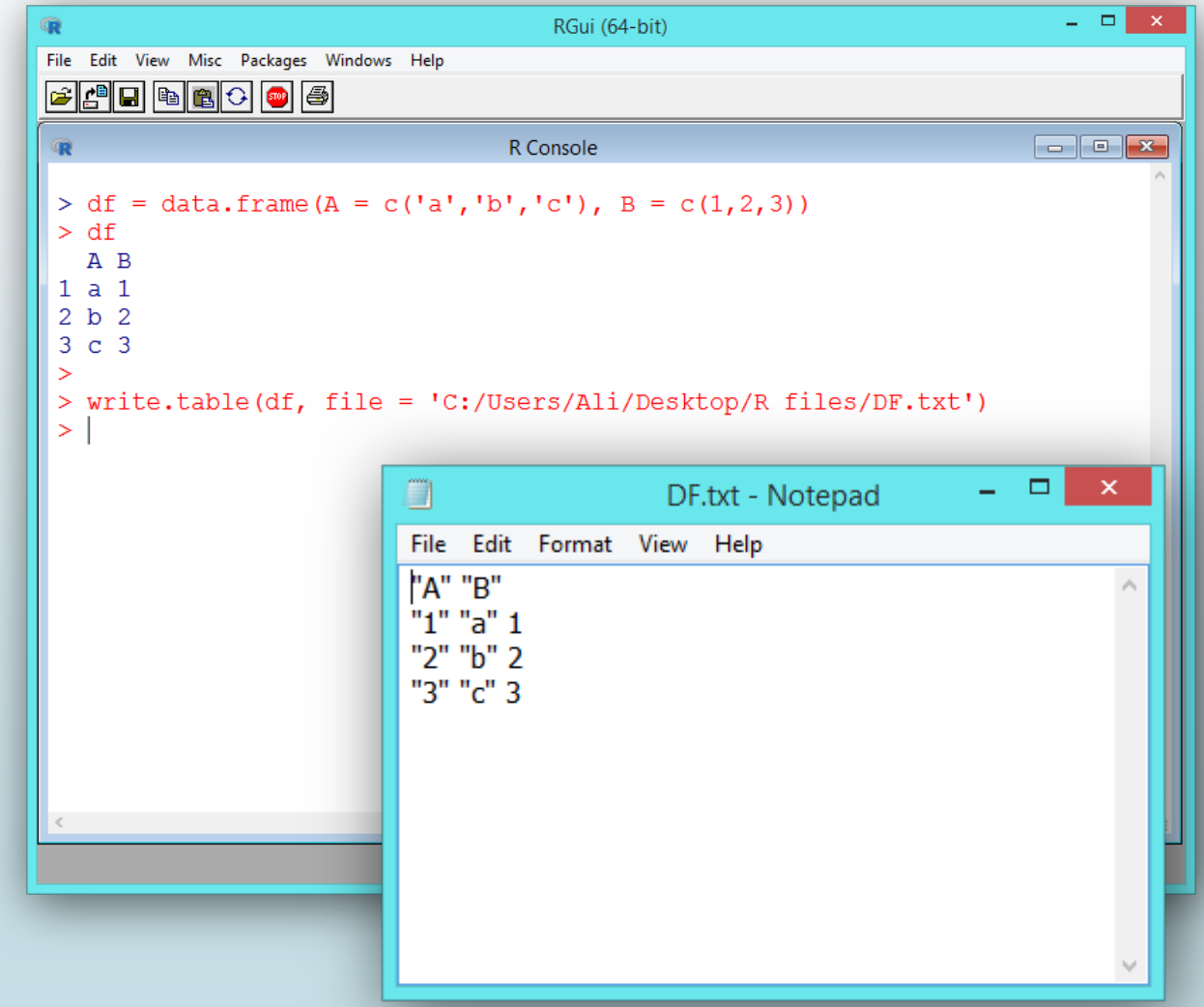
write.table()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> M = matrix(1:9, nr = 3)
> M
[,1] [,2] [,3]
[1,] 1 4 7
[2,] 2 5 8
[3,] 3 6 9
>
> write.table(M, file = 'myMatrix.txt')
>
myMatrix.txt - Notepad
File Edit Format View Help
"V1" "V2" "V3"
"1" 1 4 7
"2" 2 5 8
"3" 3 6 9

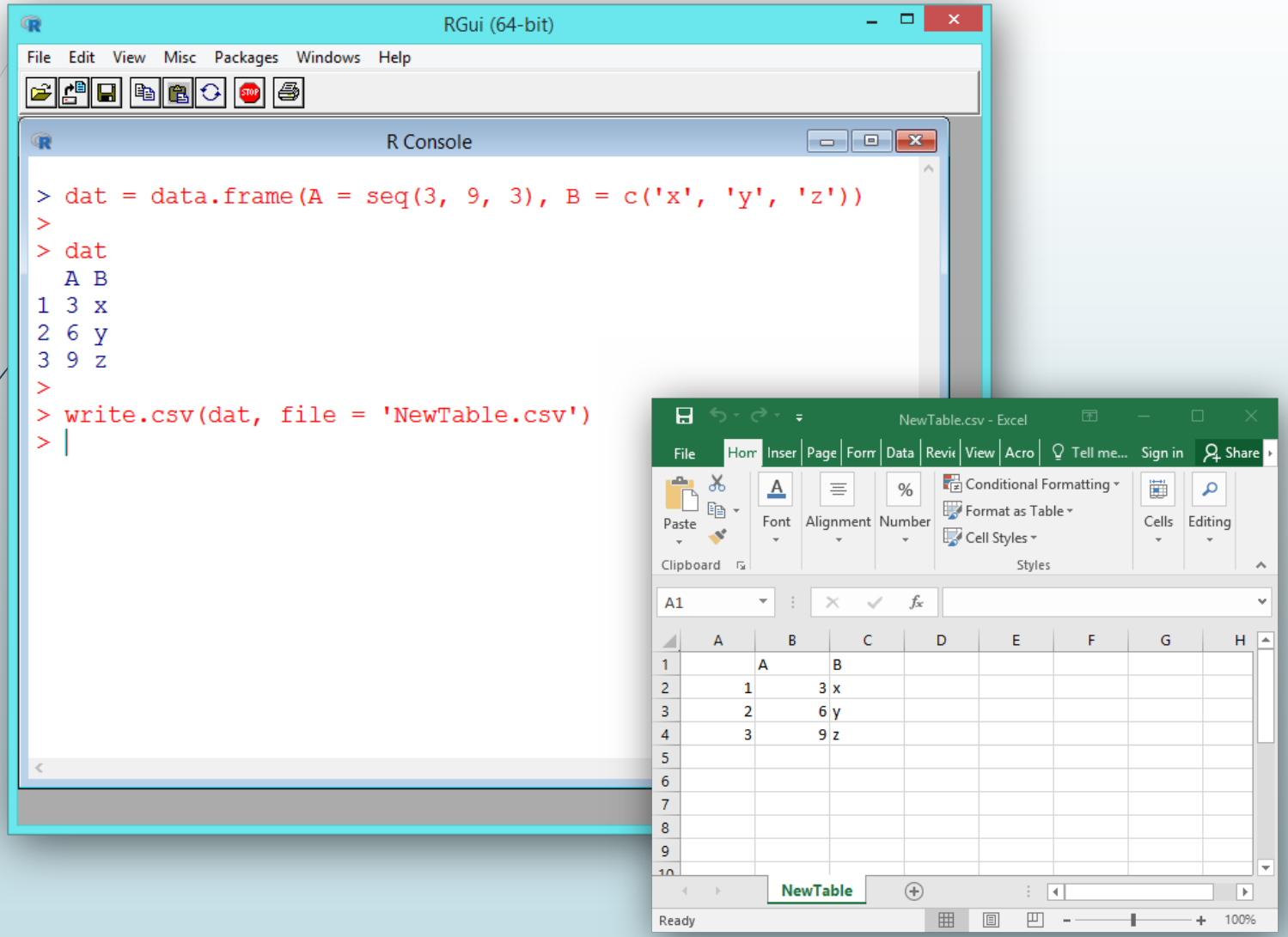
write.table()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> K = matrix(c(2,5,7,9), 2, 2, dimnames = list(c('a','b'),c('A','B')))
> K
A B
a 2 7
b 5 9
>
> write.table(K, 'Kmatrix.txt')
>
Kmatrix.txt - Notepad
File Edit Format View Help
"A" "B"
"a" 2 7
"b" 5 9

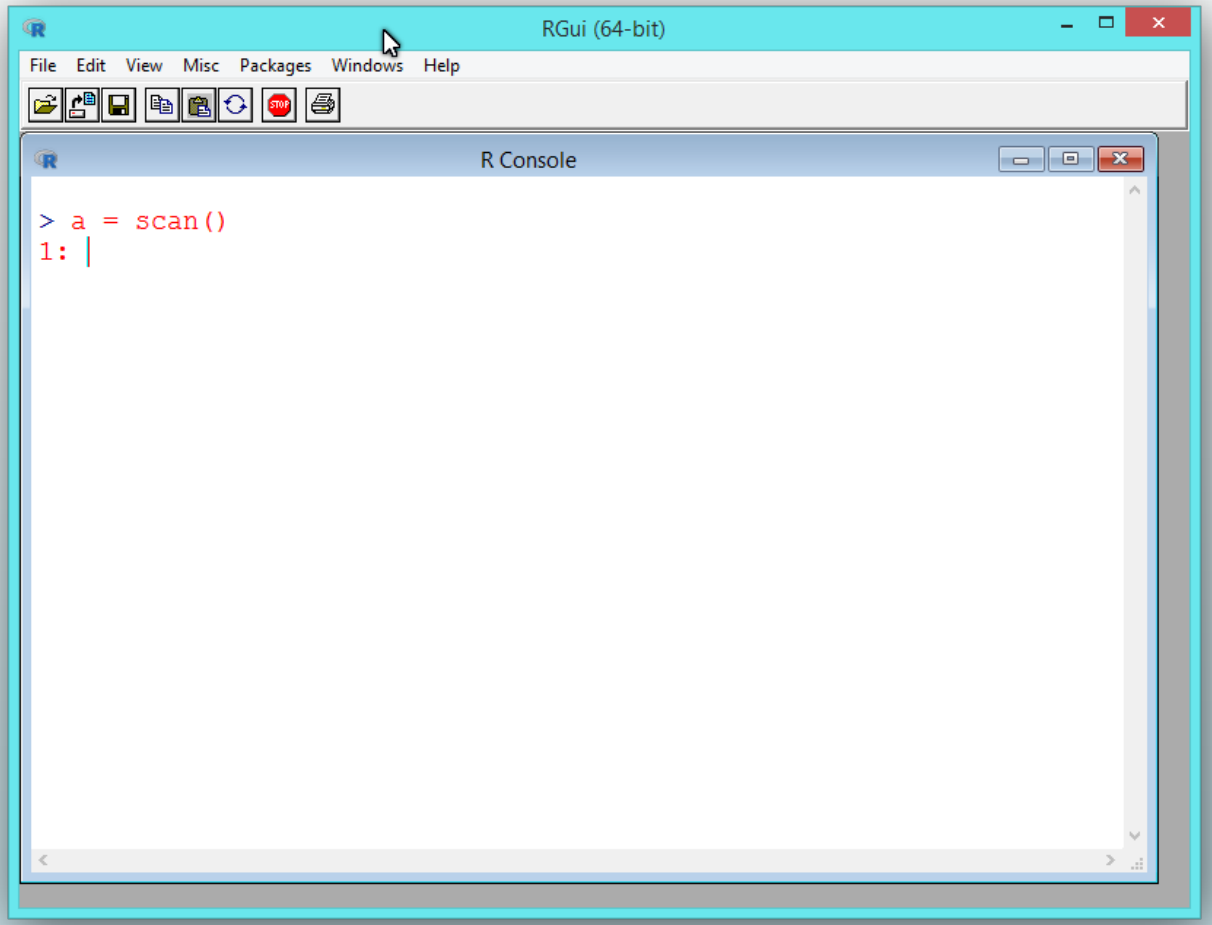
write.table()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> df = data.frame(A = c('a','b','c'), B = c(1,2,3))
> df
A B
1 a 1
2 b 2
3 c 3
>
> write.table(df, file = 'C:/Users/Ali/Desktop/R files/DF.txt')
>
DF.txt - Notepad
File Edit Format View Help
"A" "B"
"1" "a" 1
"2" "b" 2
"3" "c" 3

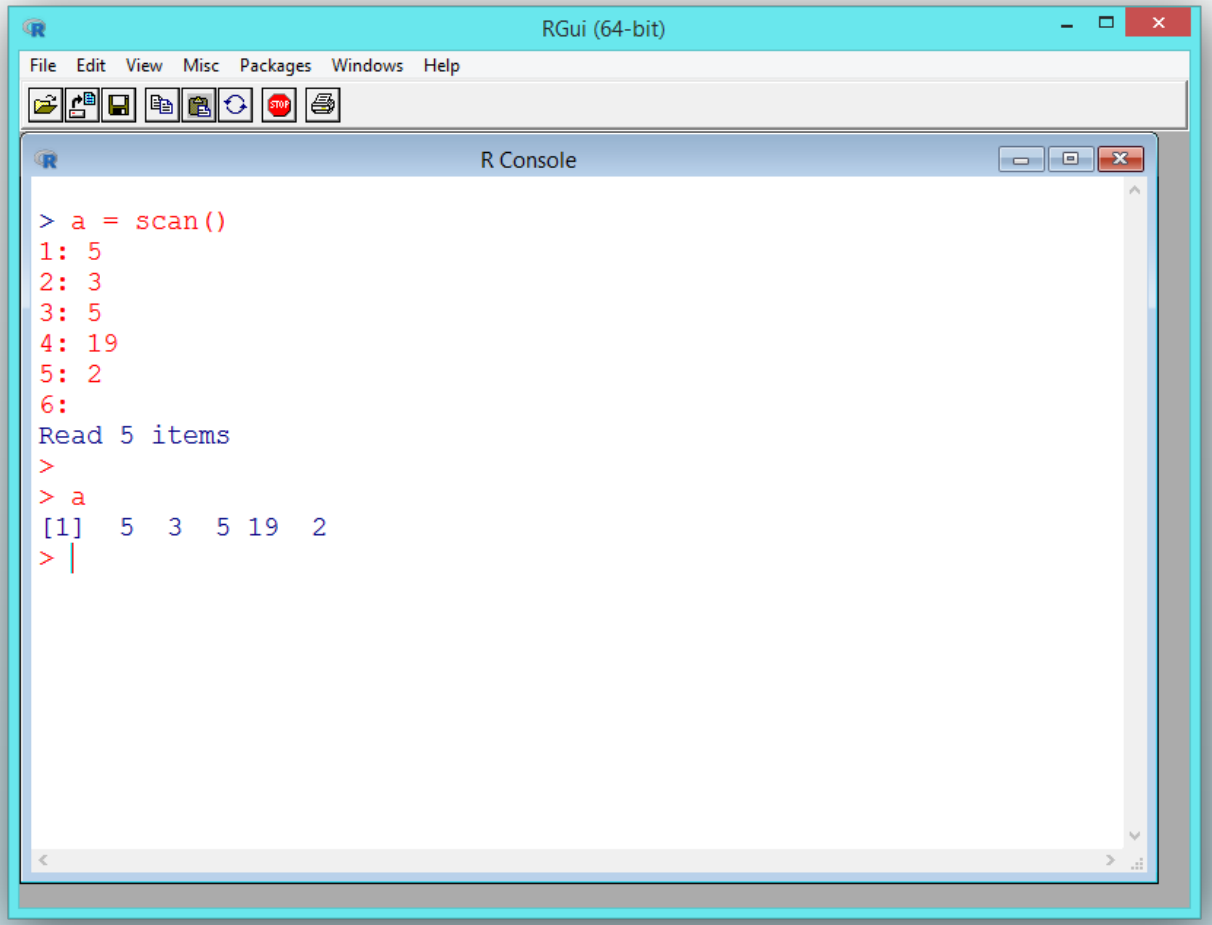
write.csv()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> dat = data.frame(A = seq(3, 9, 3), B = c('x', 'y', 'z'))
>
> dat
A B
1 3 x
2 6 y
3 9 z
>
> write.csv(dat, file = 'NewTable.csv')
>
NewTable.csv - Excel
File Hom Inser Page Form Data Revie View Acro Tell me... Sign in Share
Paste Font Alignment Number Conditional Formatting Format as Table Cell Styles Cells Editing
Clipboard Styles
A1
A B C D E F G H
1 A B
2 1 3 x
3 2 6 y
4 3 9 z
5
6
7
8
9
10
NewTable
Ready 100%

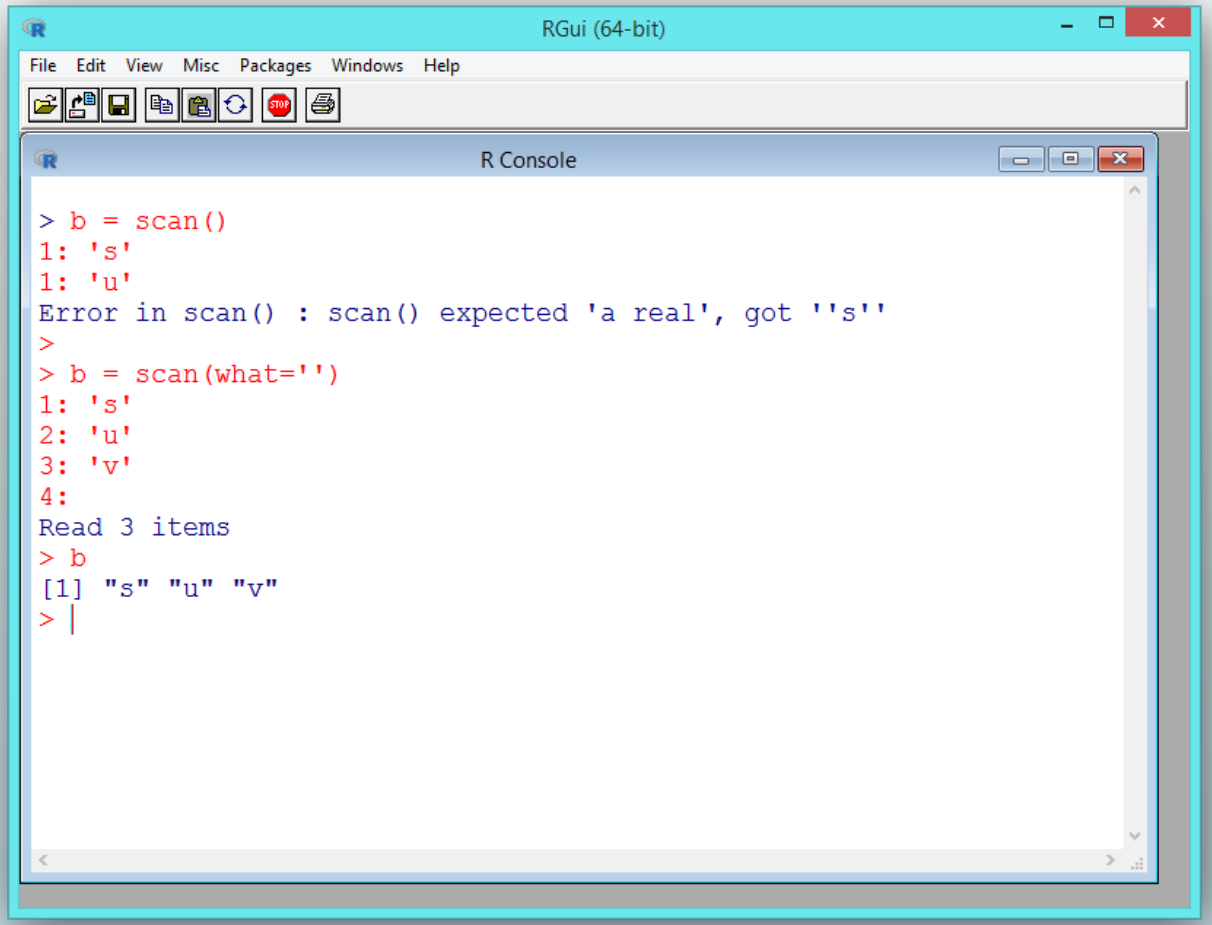
scan()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> a = scan()
1:

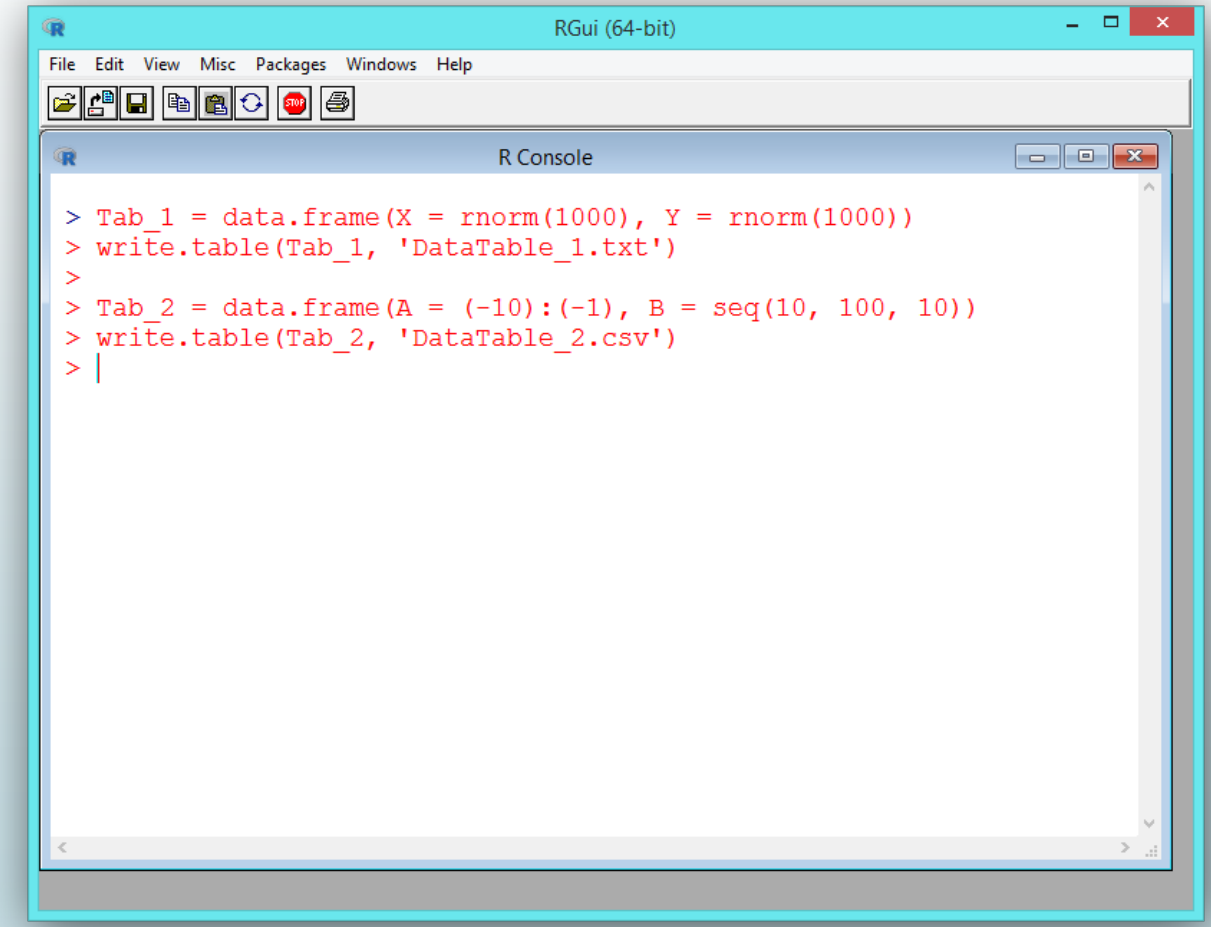
scan()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> a = scan()
1: 5
2: 3
3: 5
4: 19
5: 2
6:
Read 5 items
>
> a
[1] 5 3 5 19 2
>

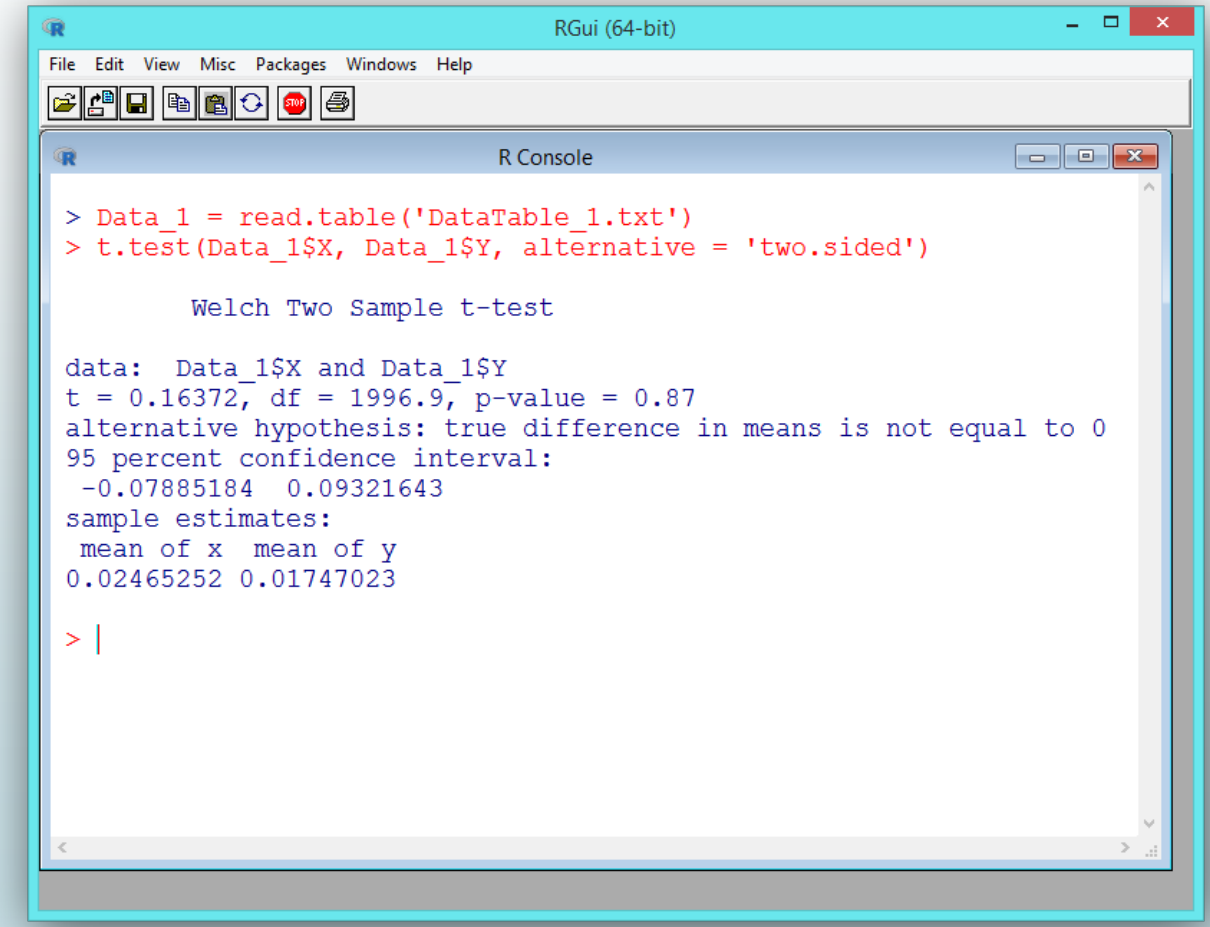
scan()


RGui (64-bit)
File Edit View Misc Packages Windows Help
R Console
> b = scan()
1: 's'
1: 'u'
Error in scan() : scan() expected 'a real', got ''s''
>
> b = scan(what='')
1: 's'
2: 'u'
3: 'v'
4:
Read 3 items
> b
[1] "s" "u" "v"
>

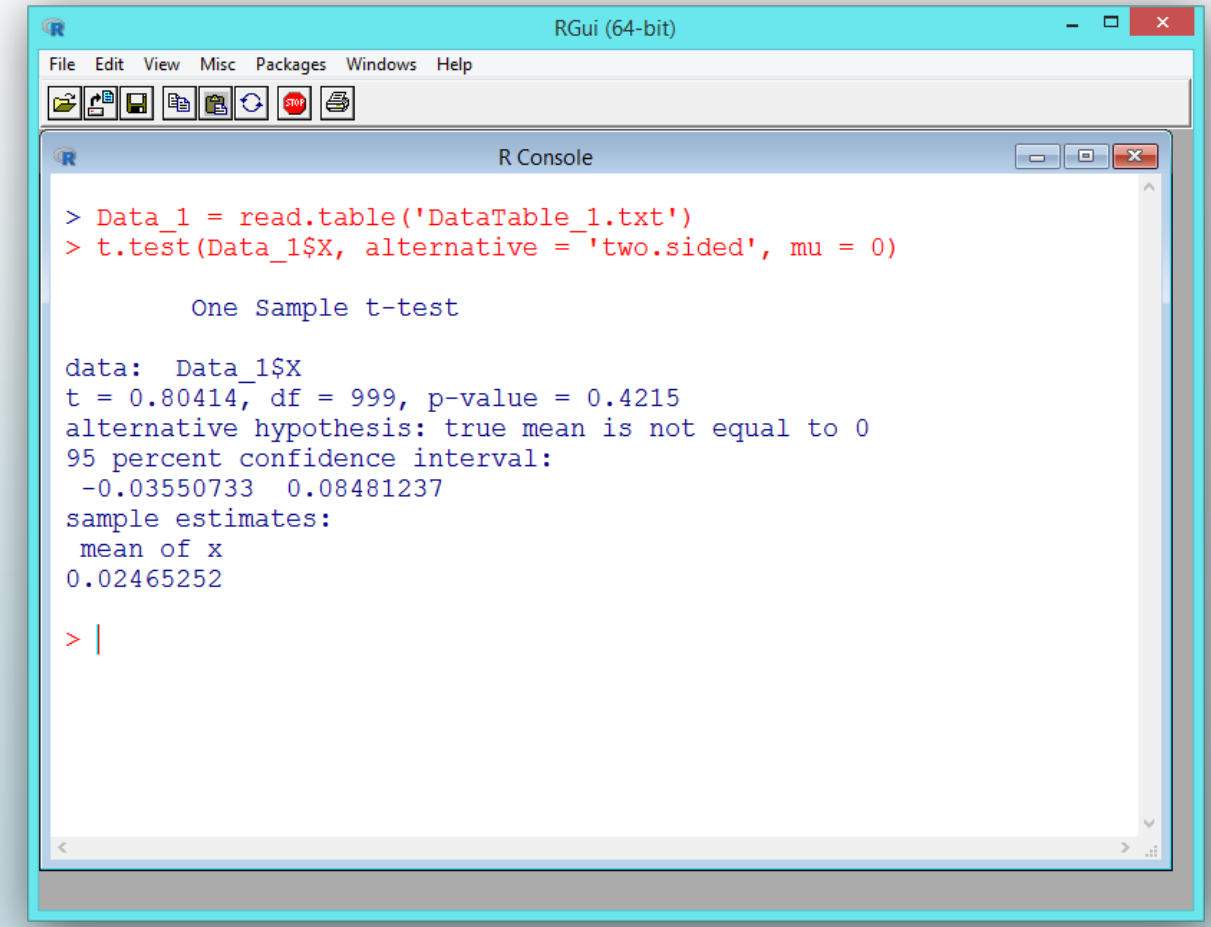
Read and Write Data - T-test Example



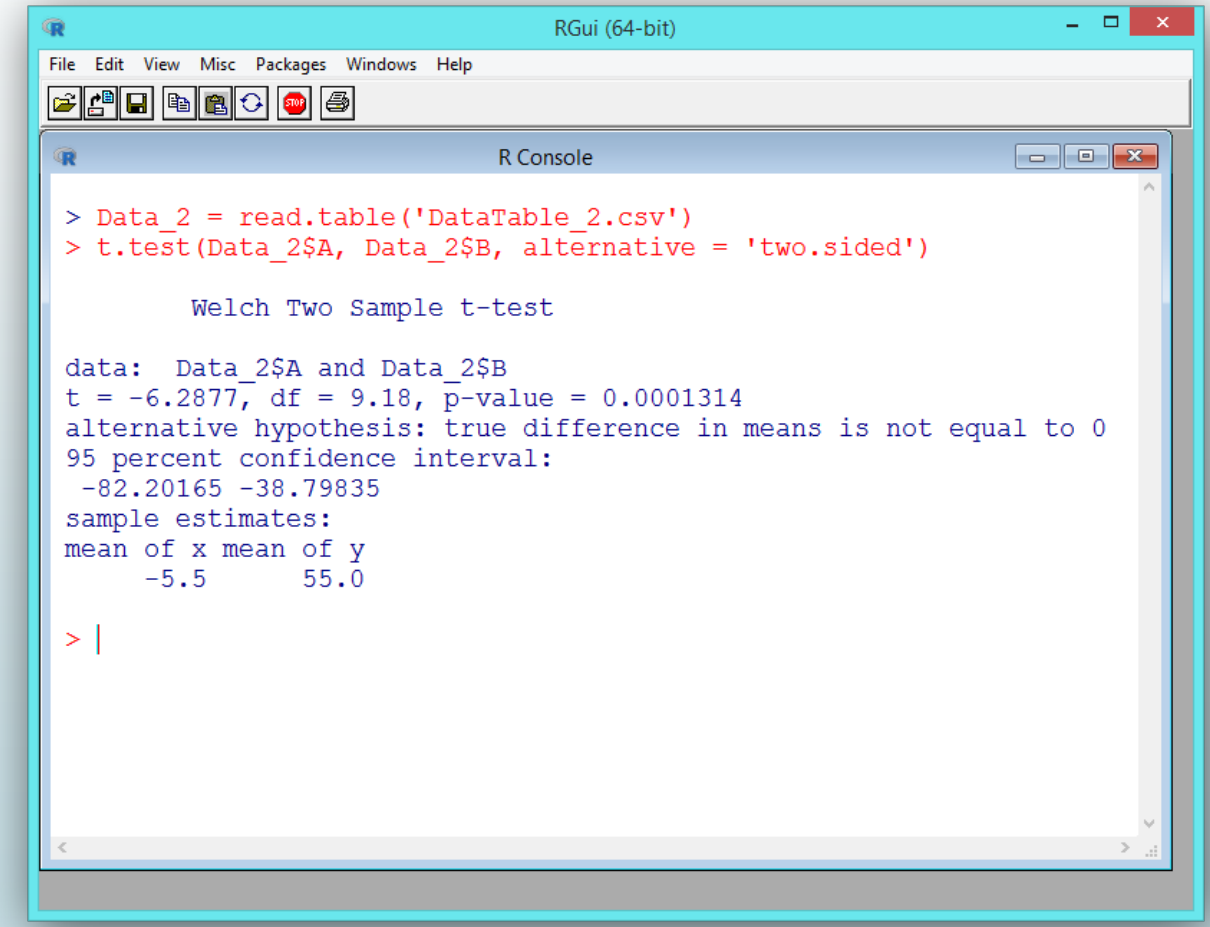
Read and Write Data - T-test Example



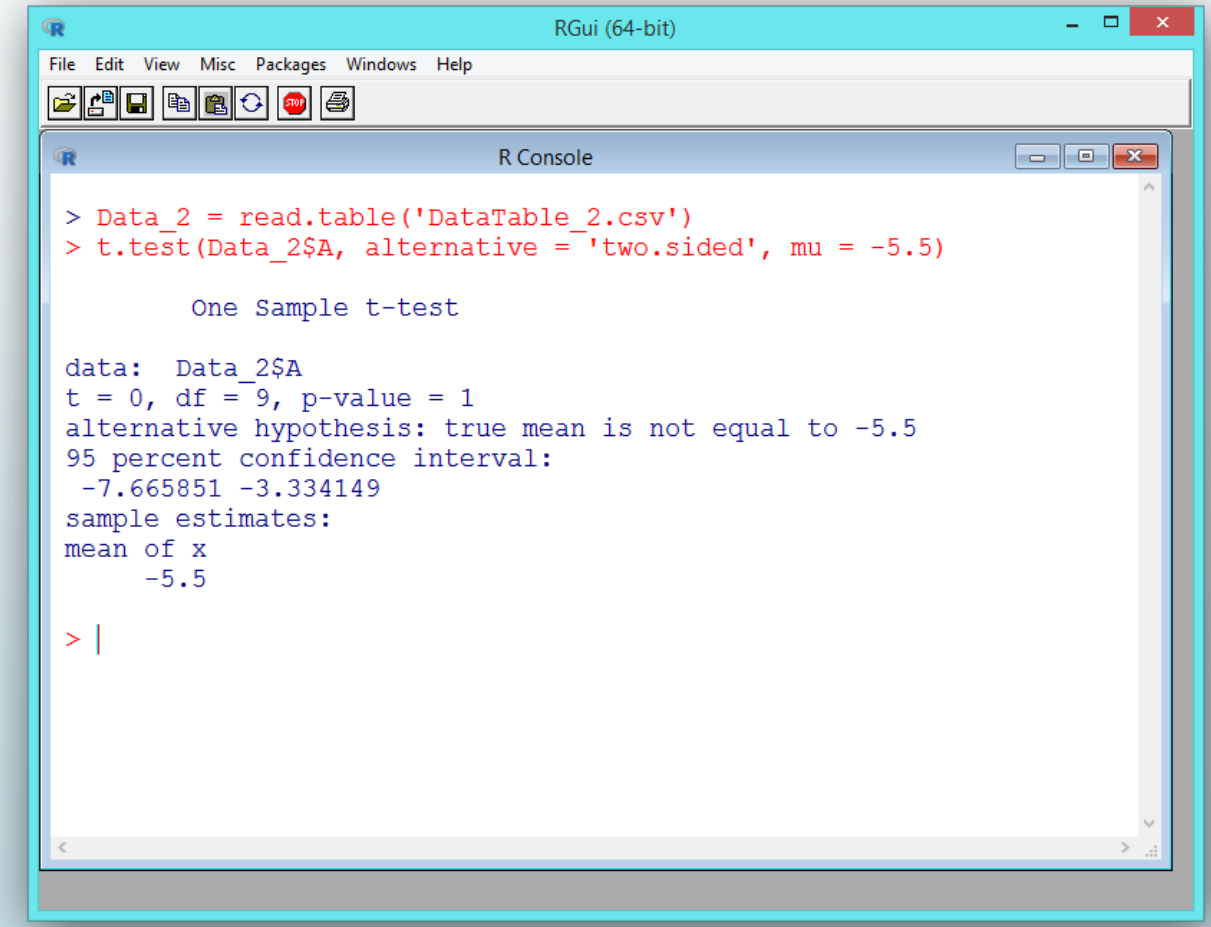
Read and Write Data - T-test Example



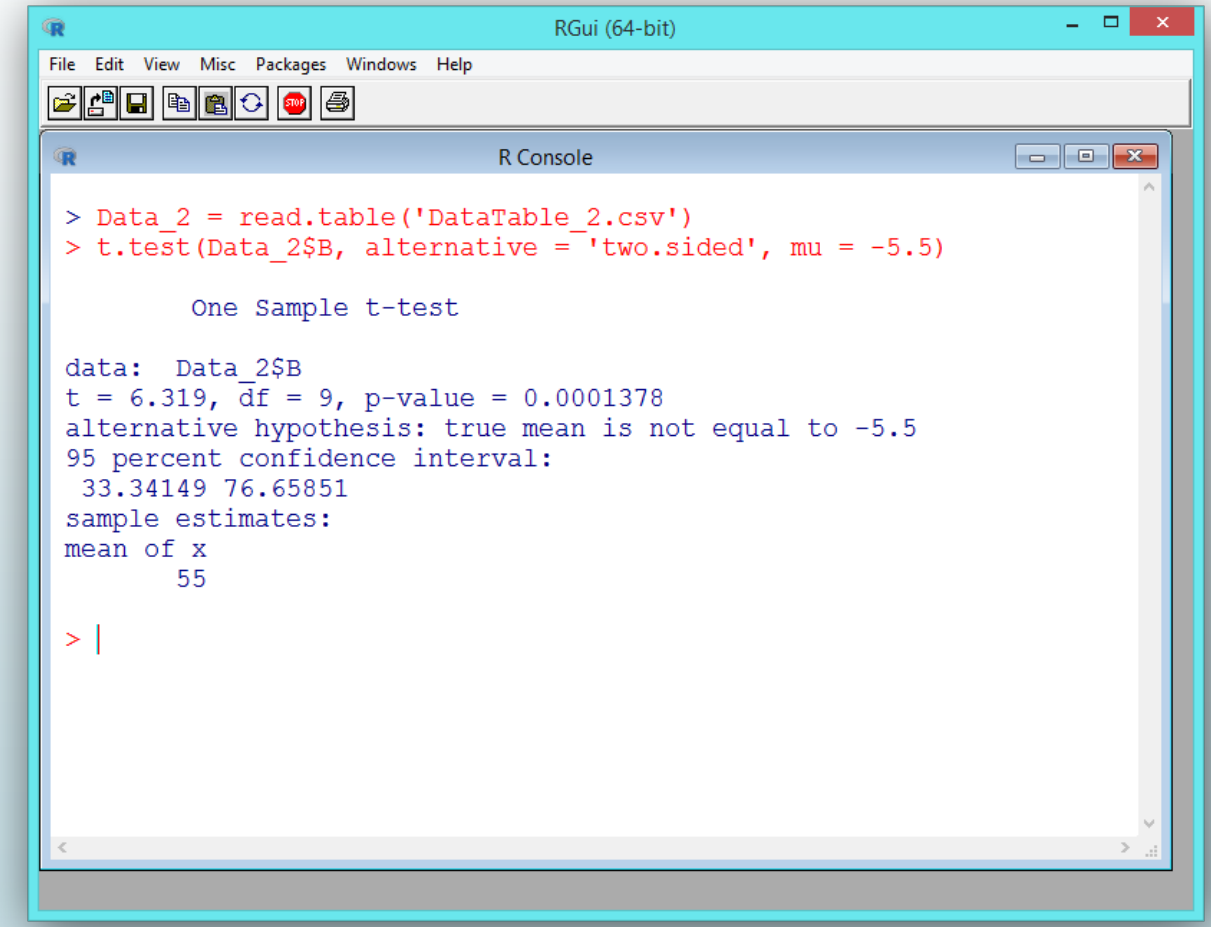
Read and Write Data - T-test Example



Read and Write Data - T-test Example



Read and Write Data - T-test Example

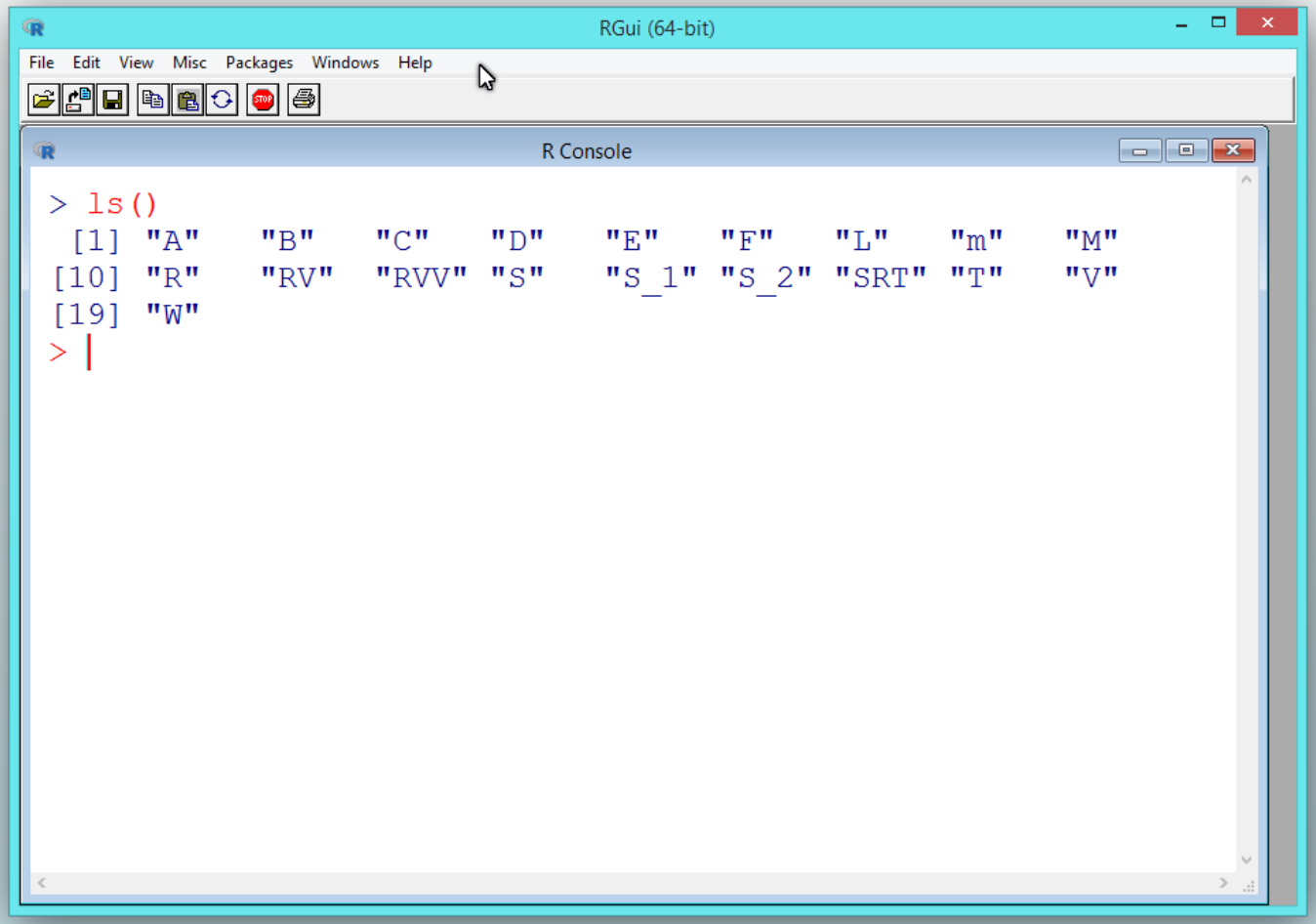


Workspace

Workspace and Objects

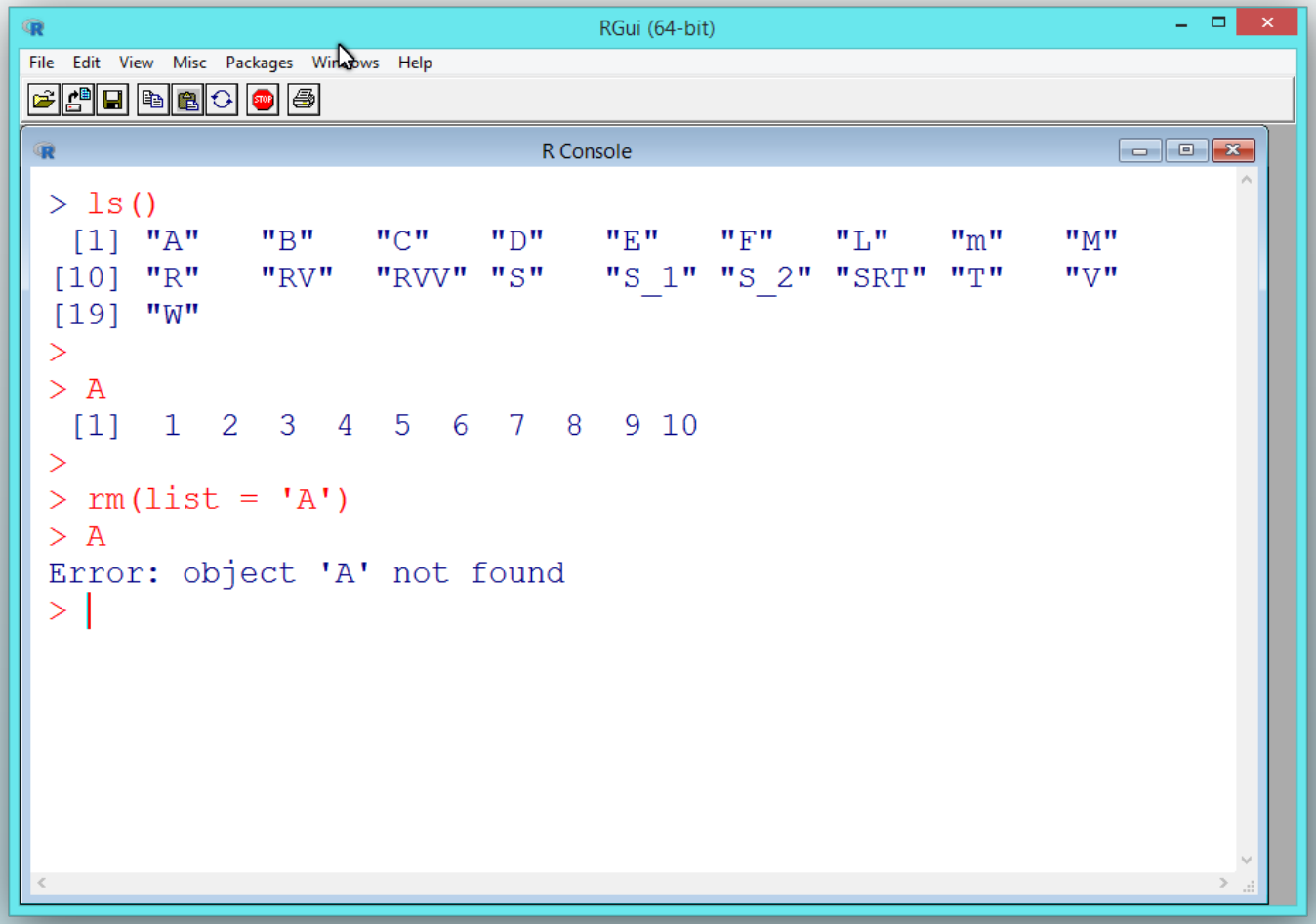
Workspace

- List of the Saved Objects



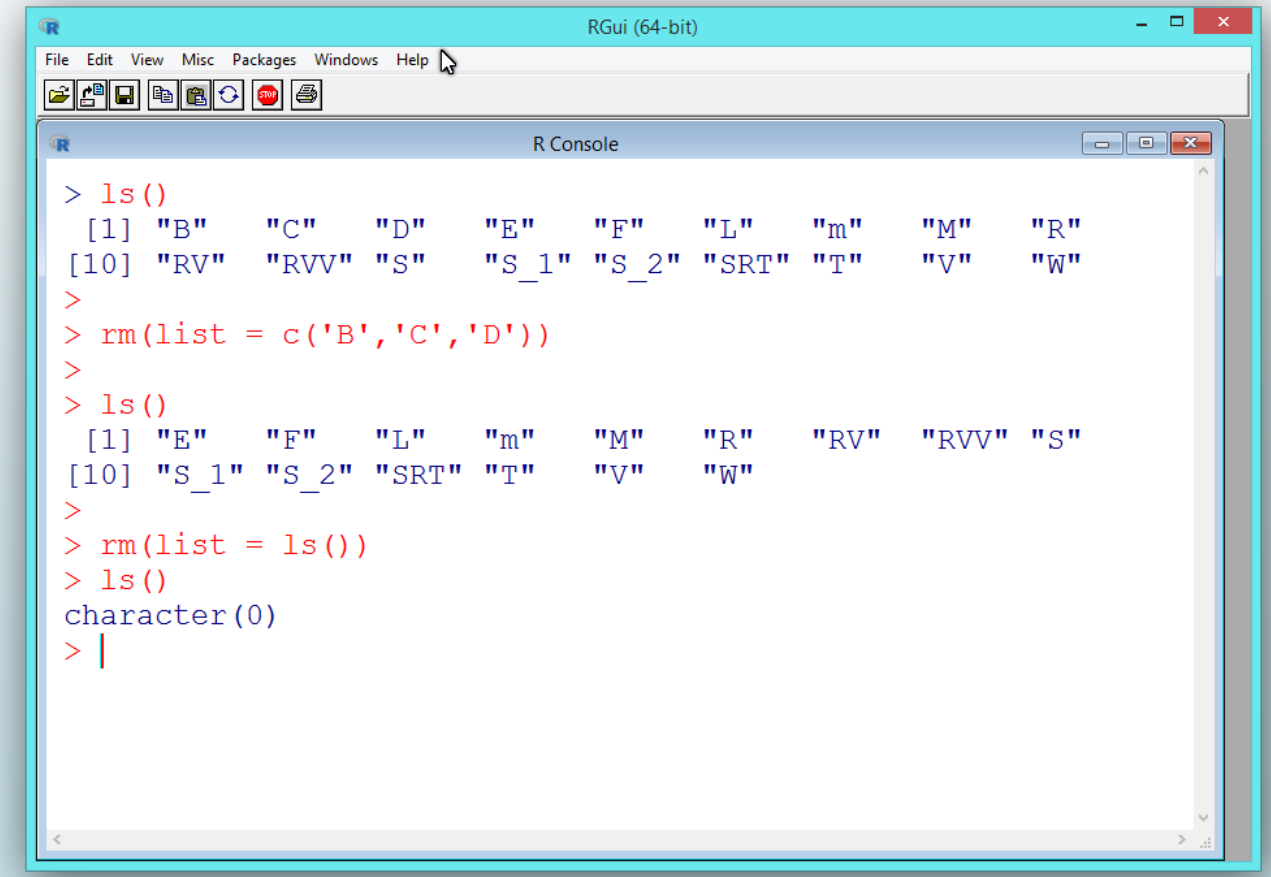
Workspace

- Removing an Object from the Workspace



Workspace

- Removing a List of the Objects from the Workspace

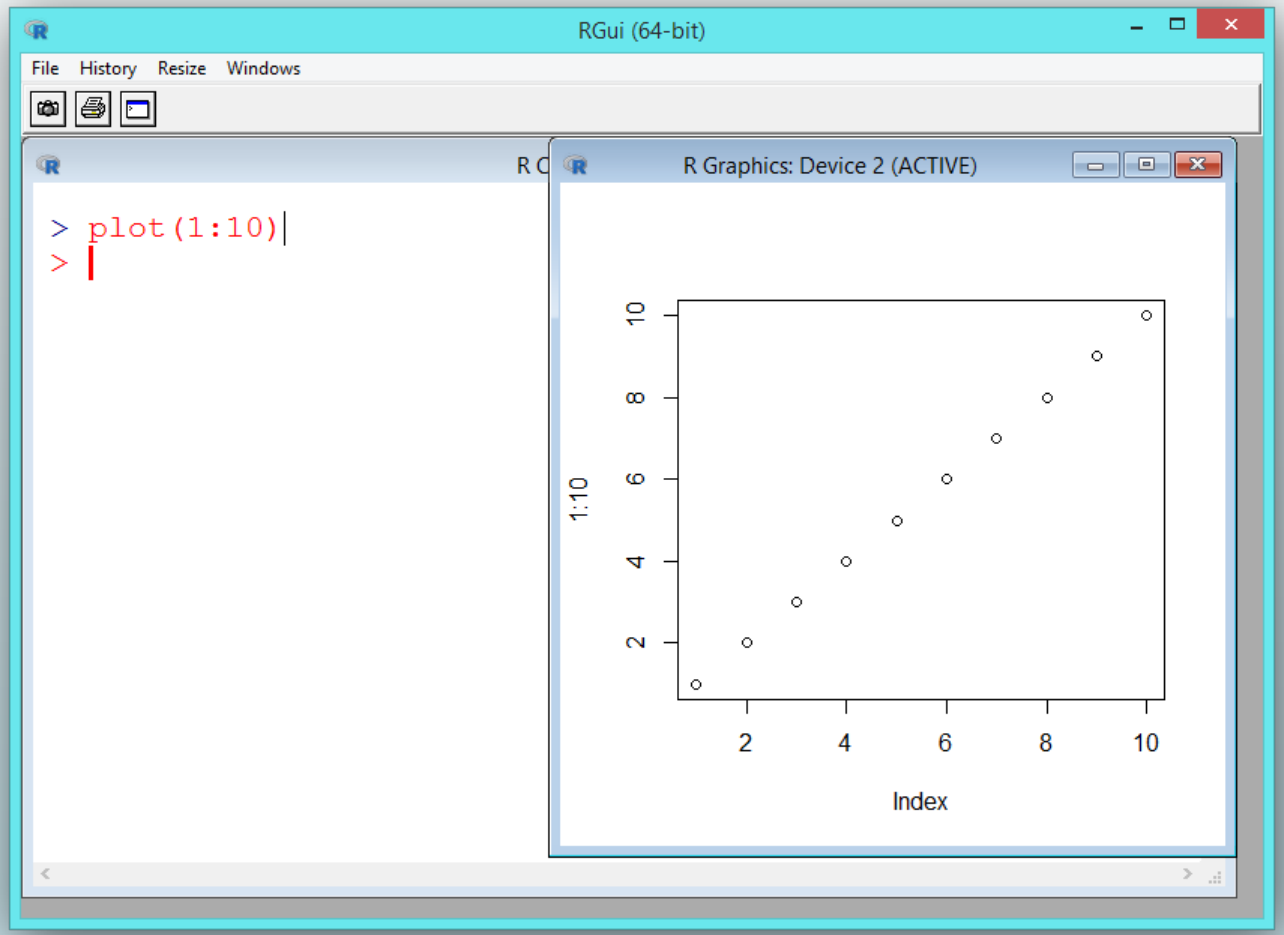


Plots

Two-Dimensional Plots

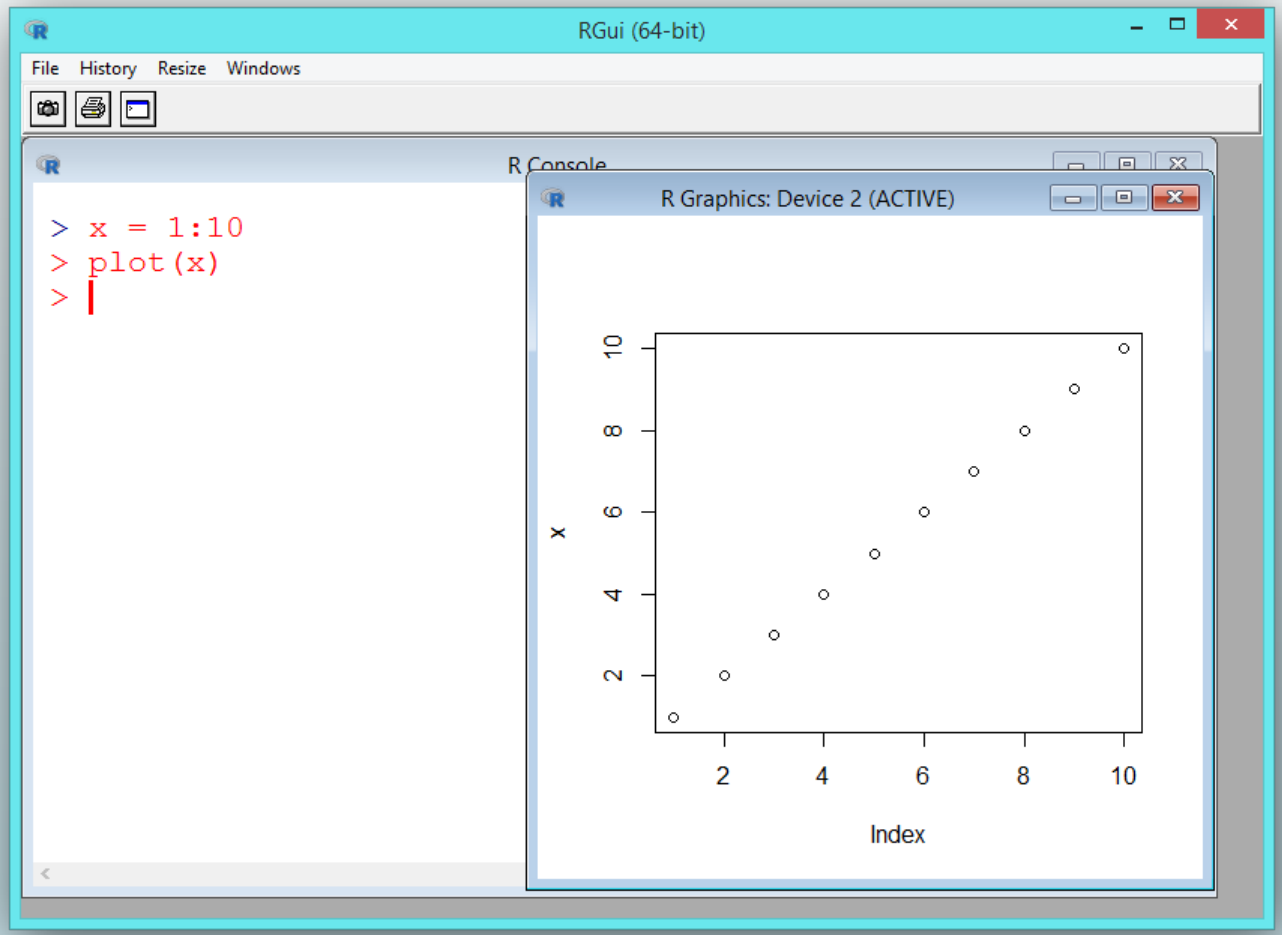
Plot

- `plot` Function (1)



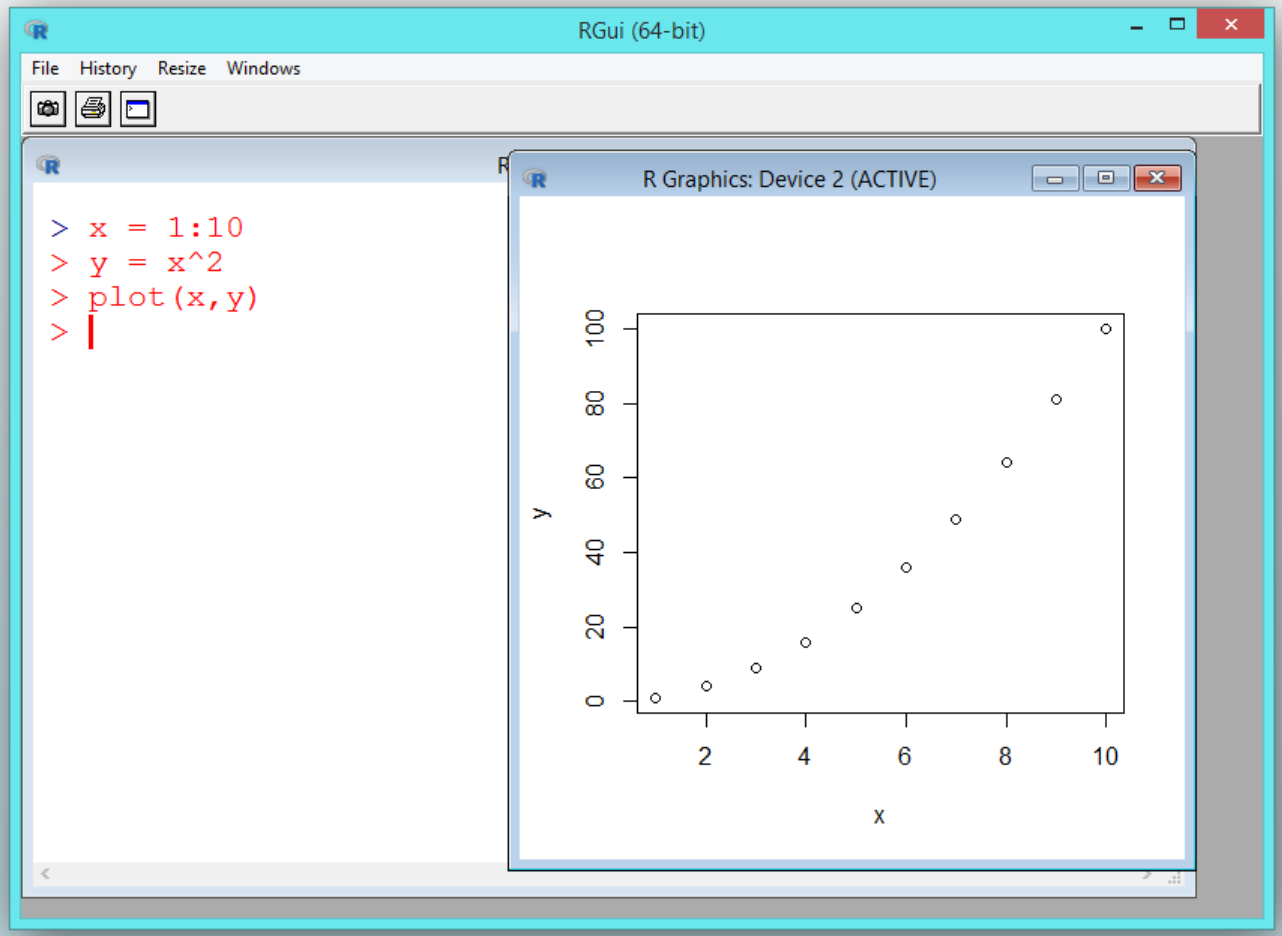
Plot

- `plot` Function (2)



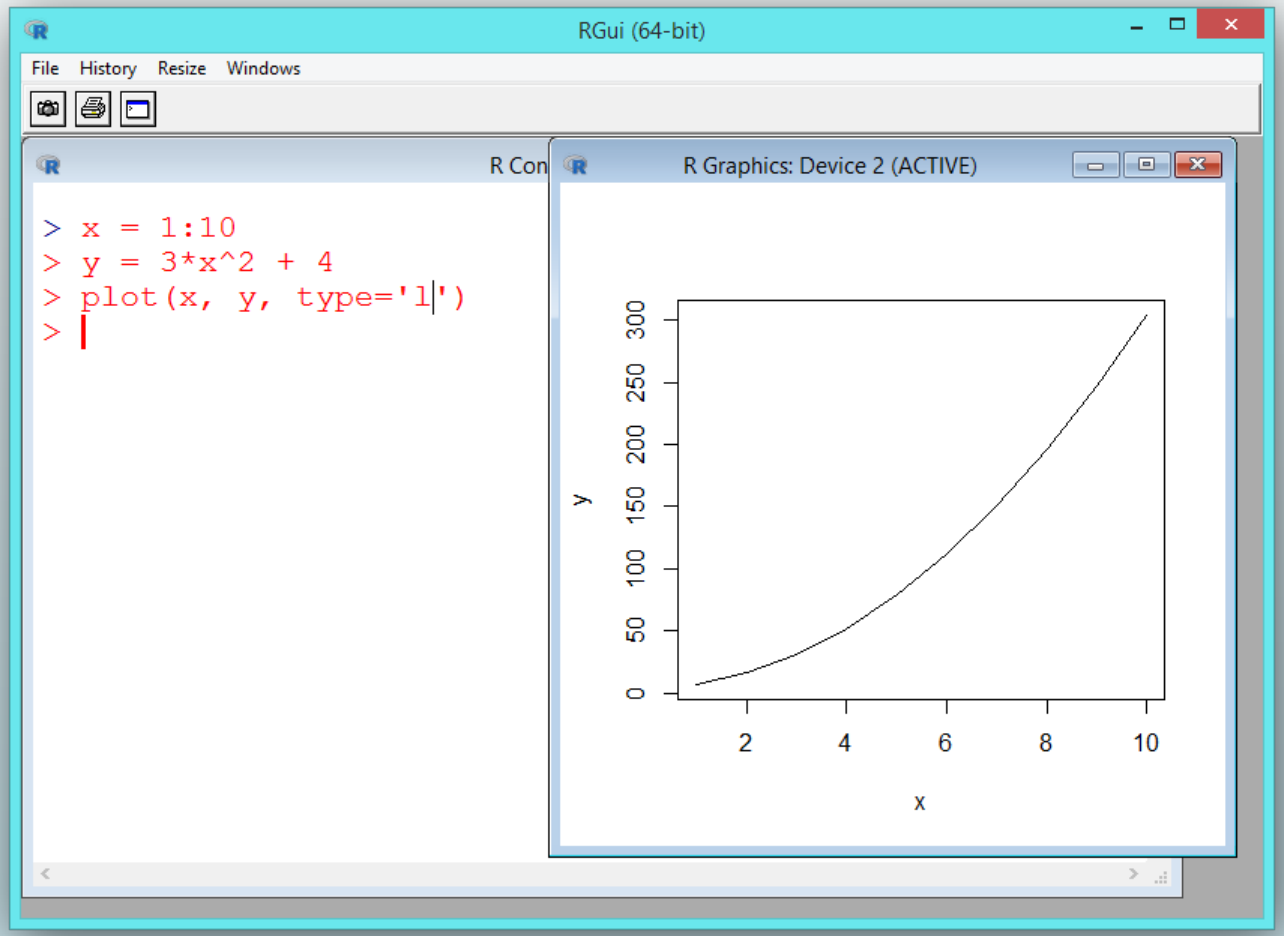
Plot

- `plot` Function (3)



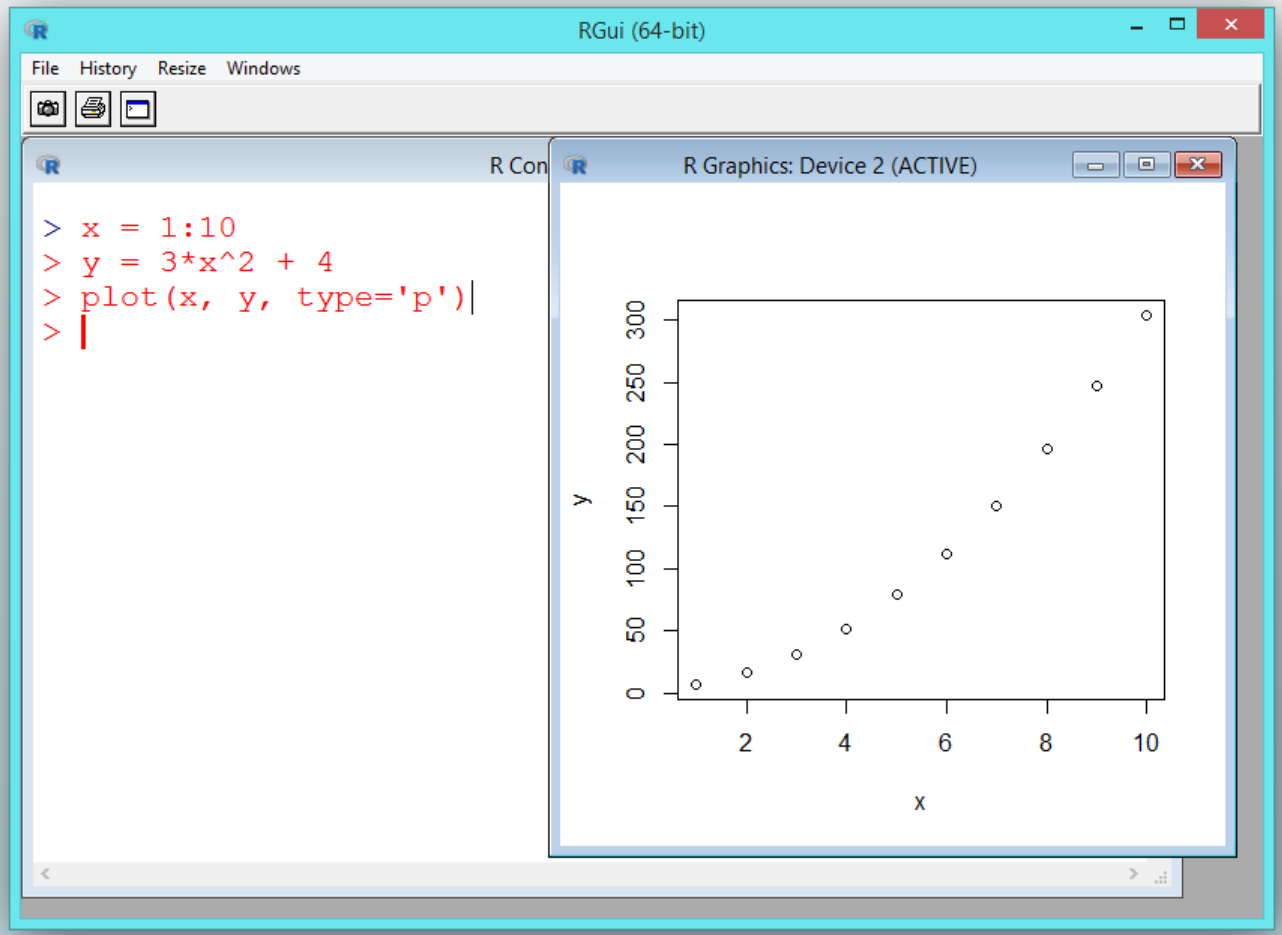
Plot

- `type='l'` (lines)



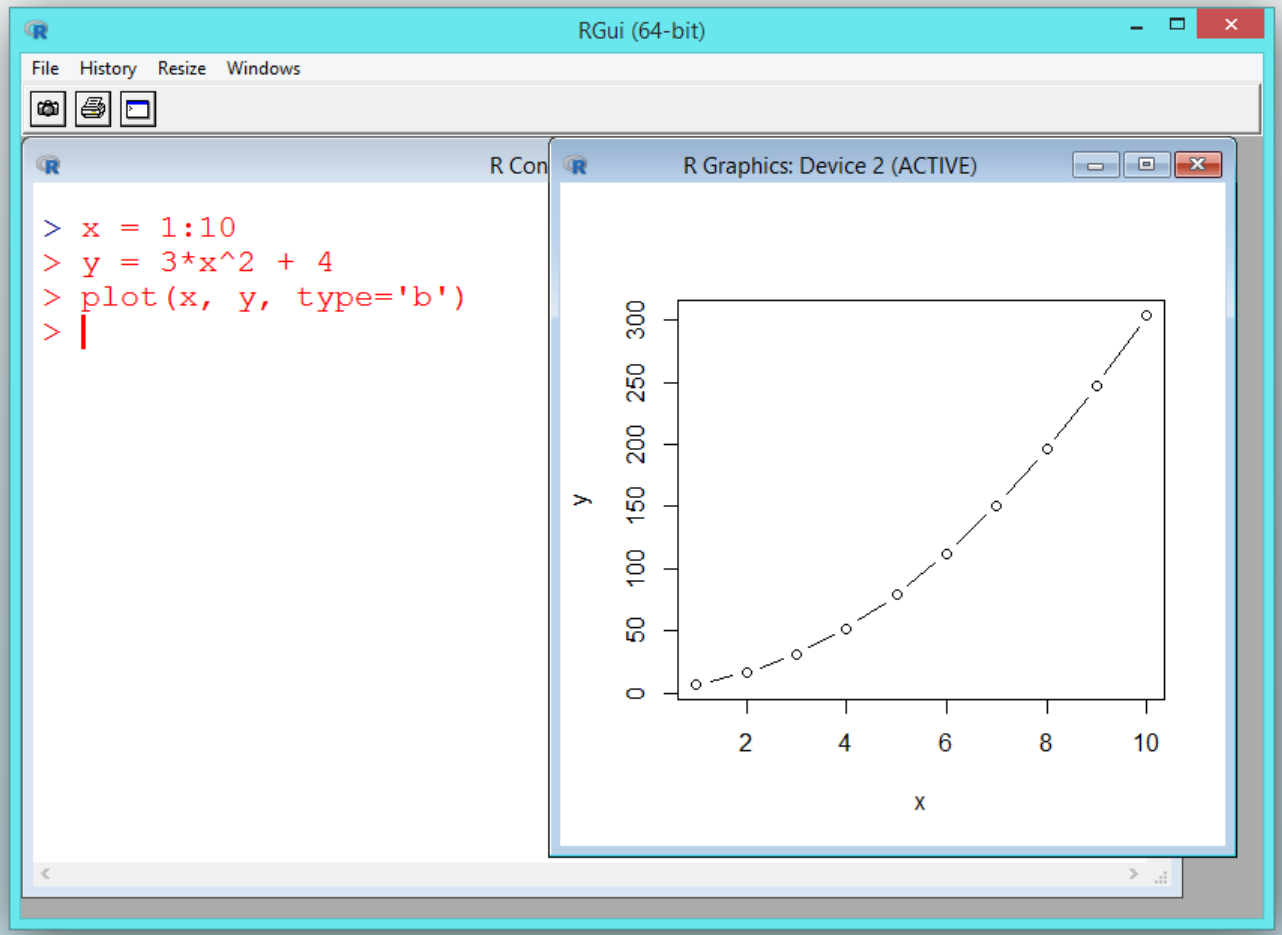
Plot

- `type='p'` (points)



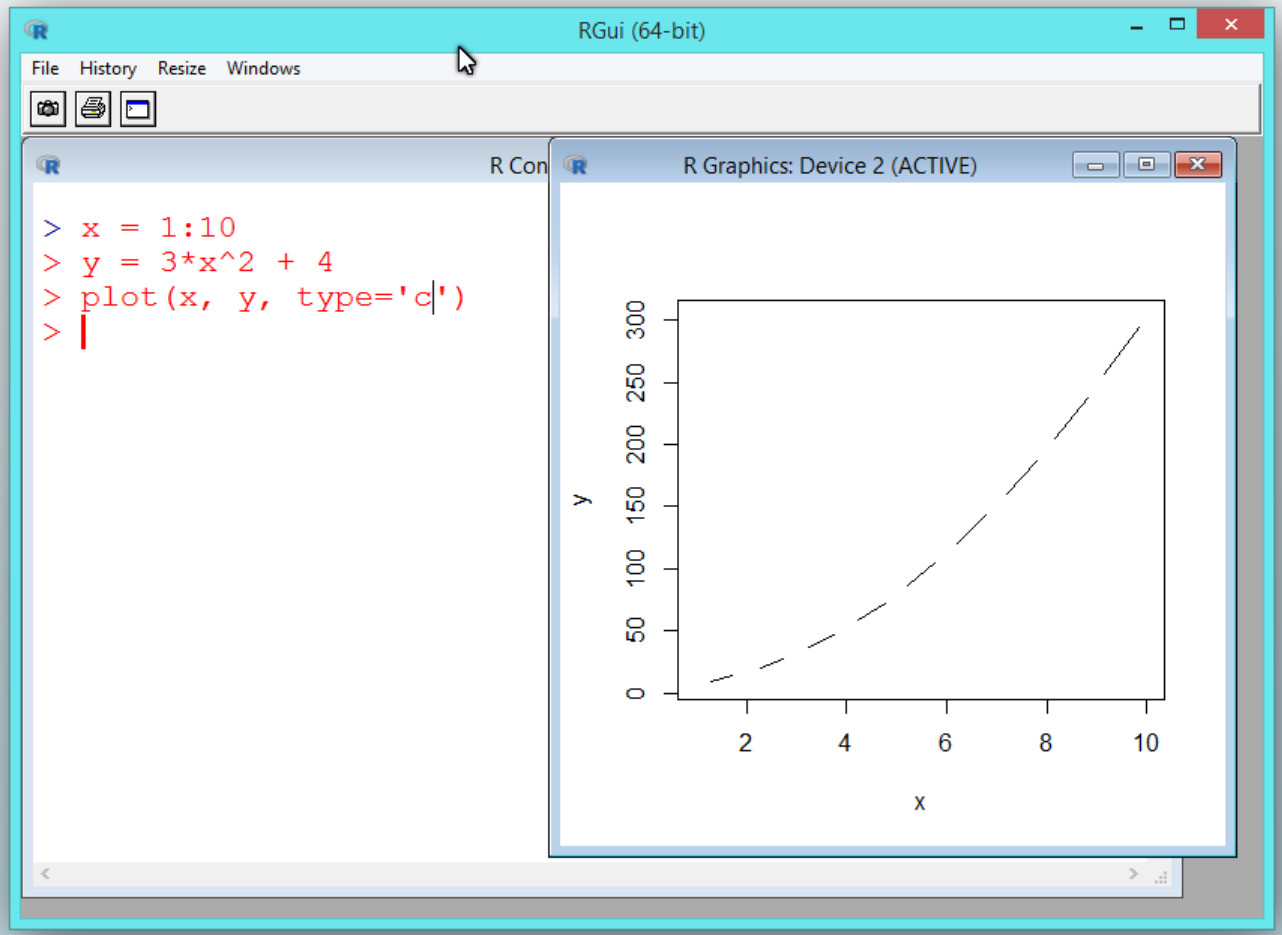
Plot

- `type='b'` (both)



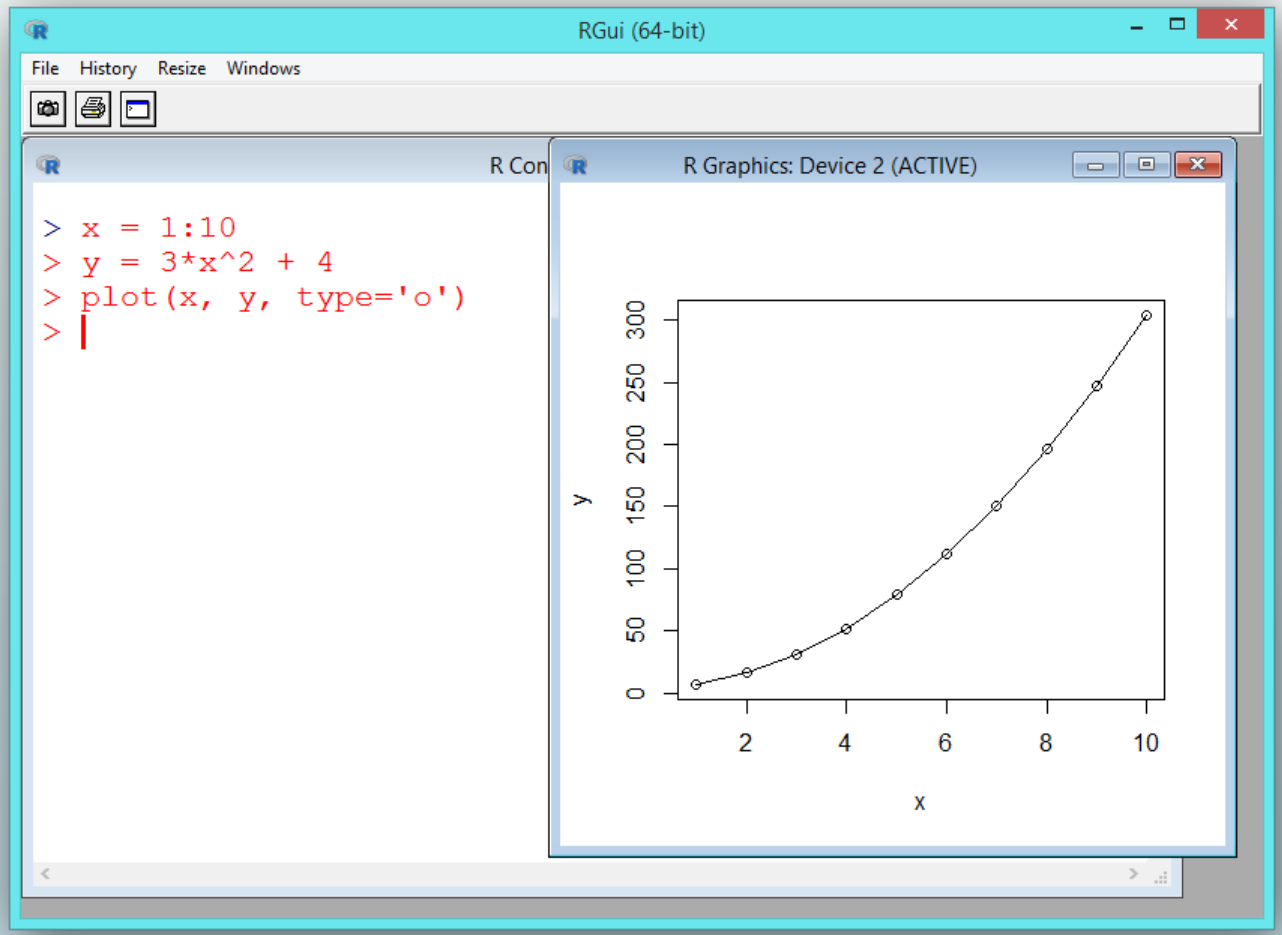
Plot

- `type='c'` (the lines part alone of 'b')



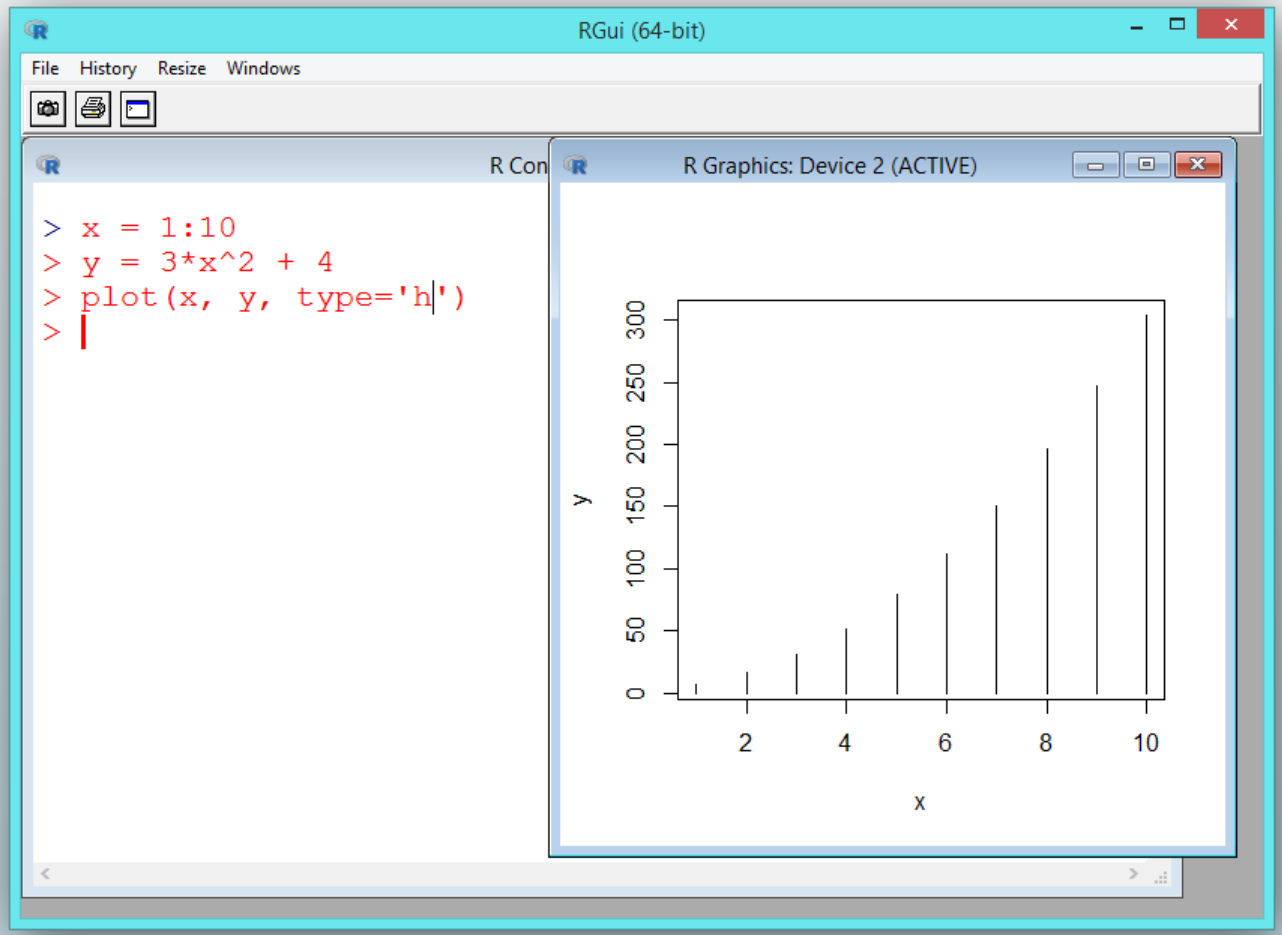
Plot

- `type='o'` (overplotted)



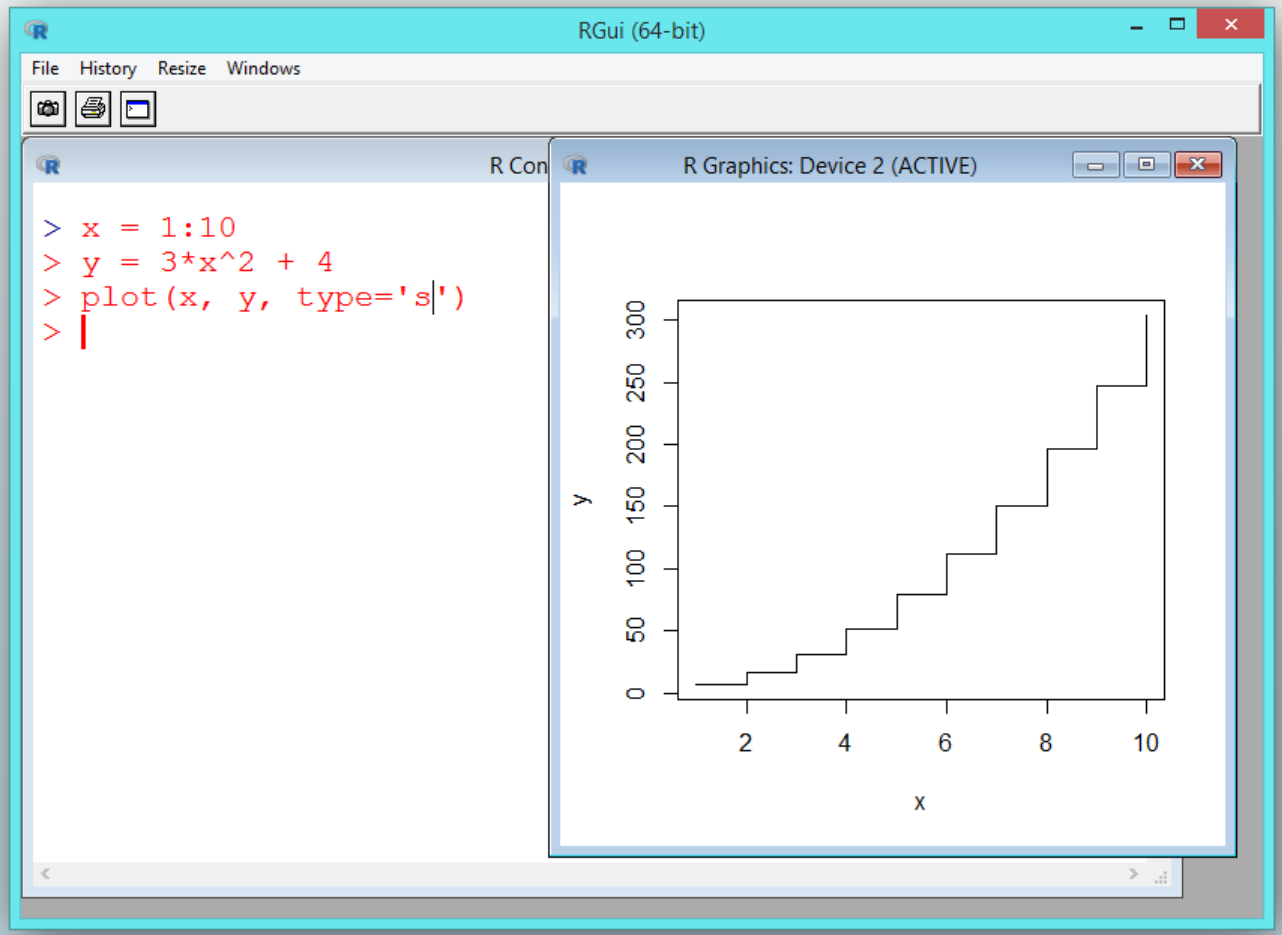
Plot

- `type='h'` ('histogram' like)



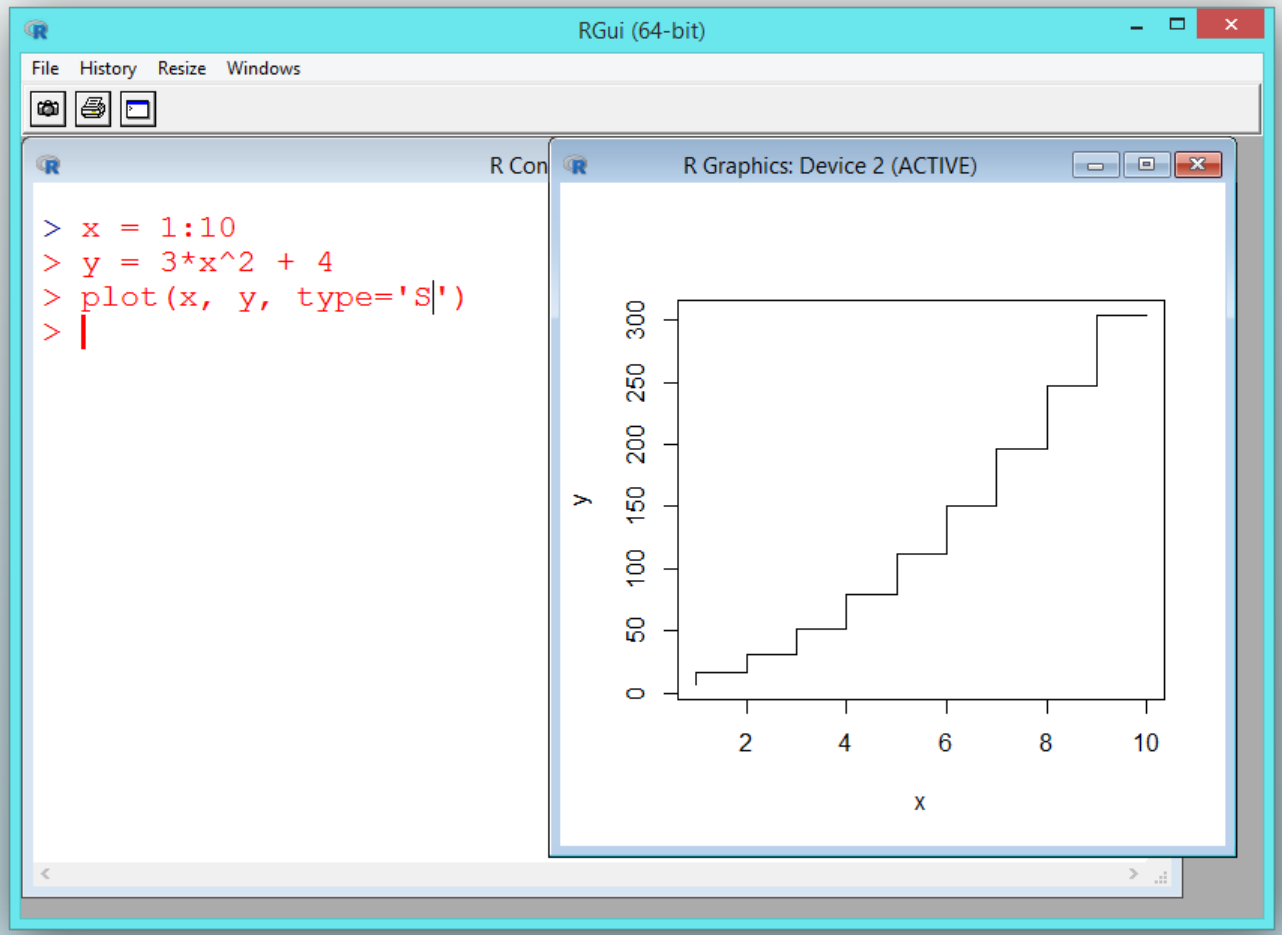
Plot

- `type='s'` (stair steps)



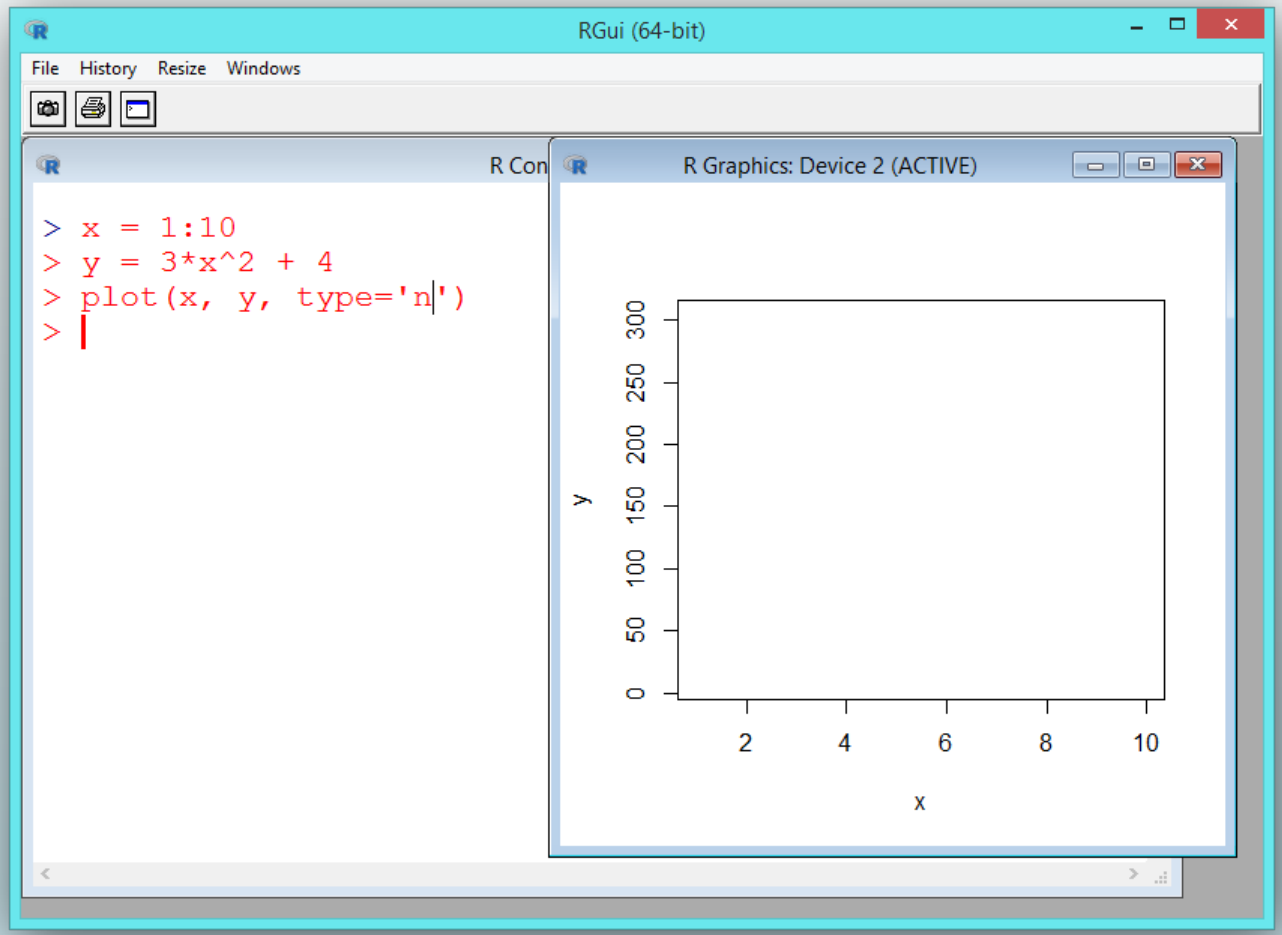
Plot

- `type='S'` (other steps)



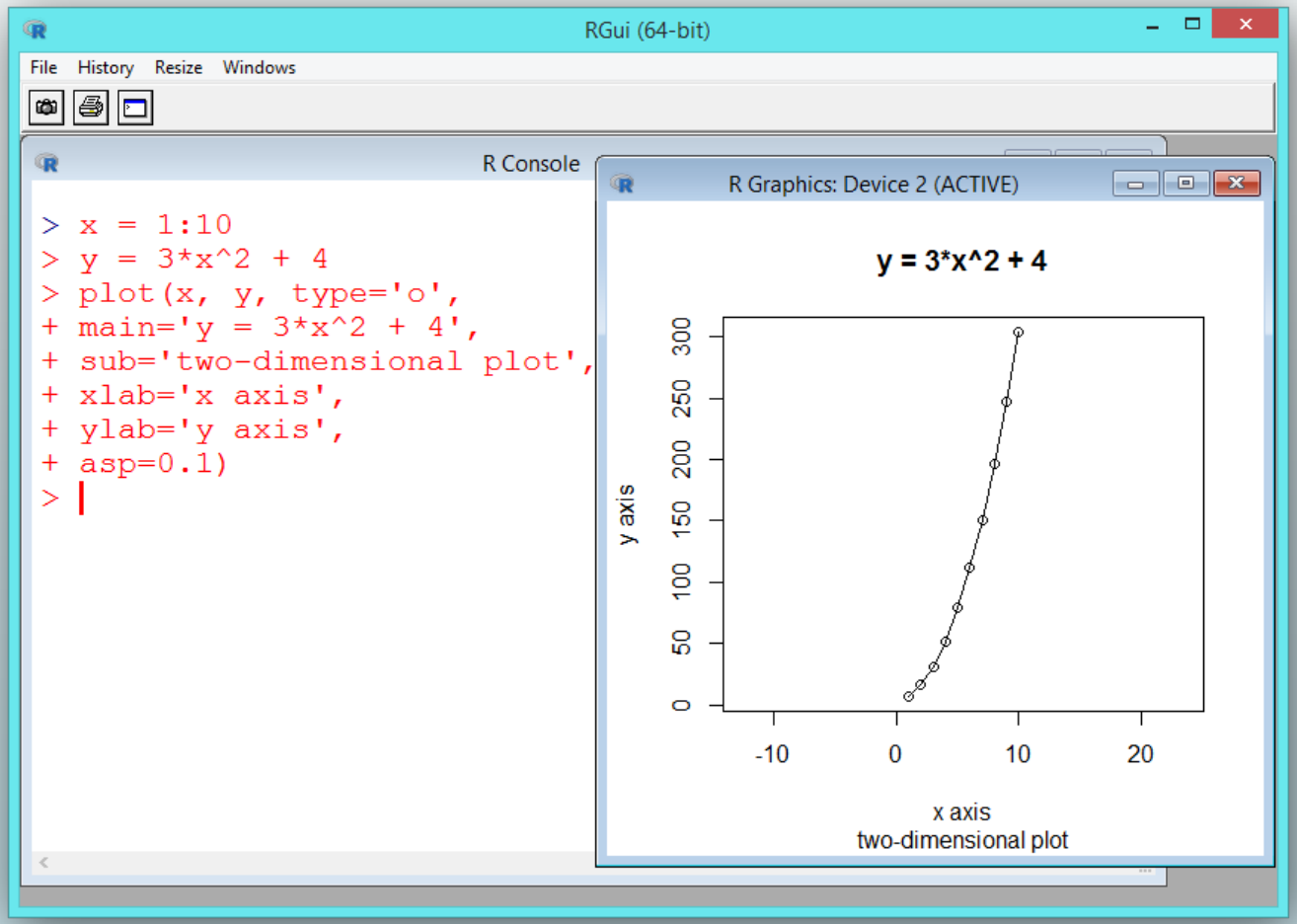
Plot

- `type='n'` (no plotting)



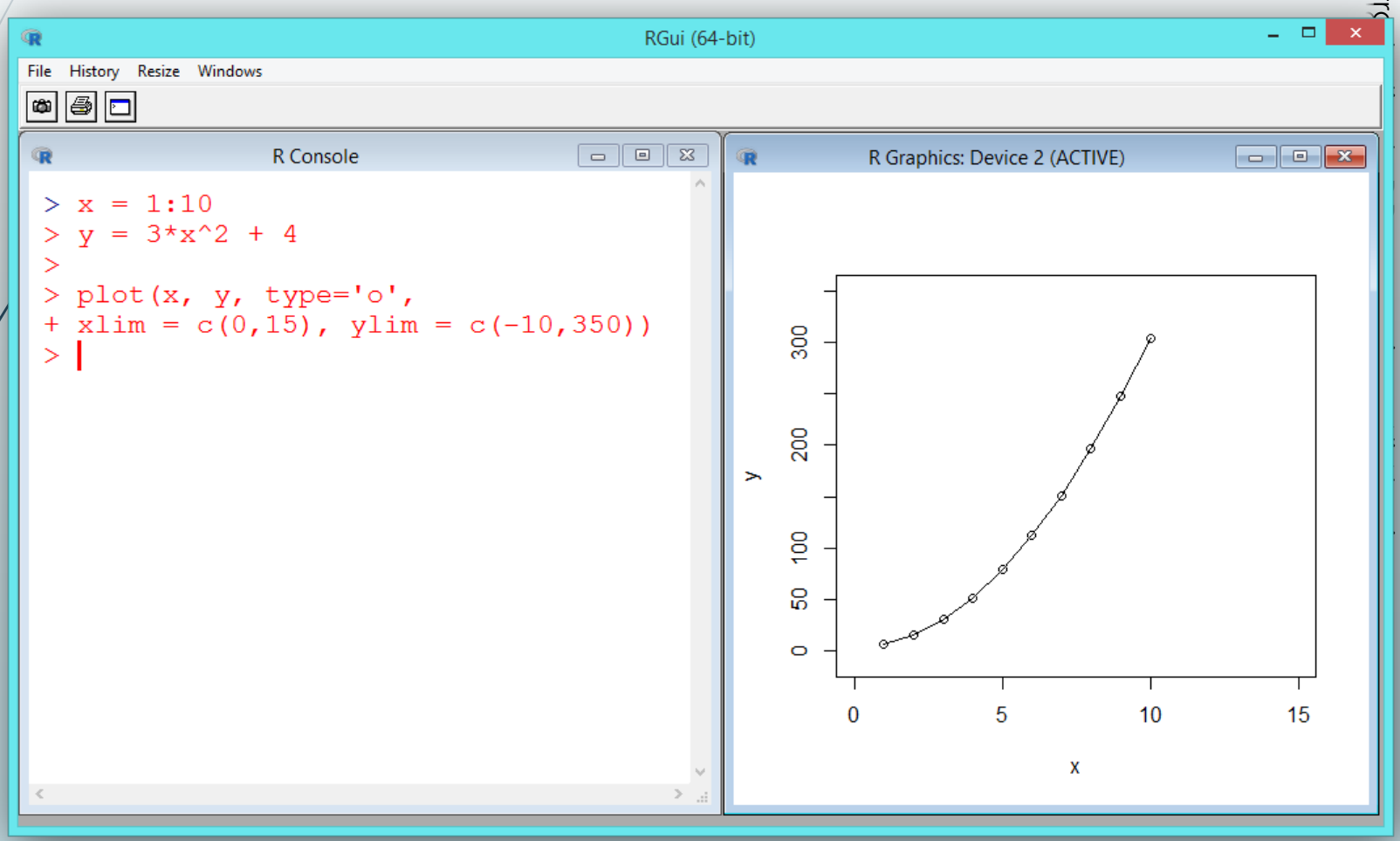
Plot

- `plot` Arguments (1)



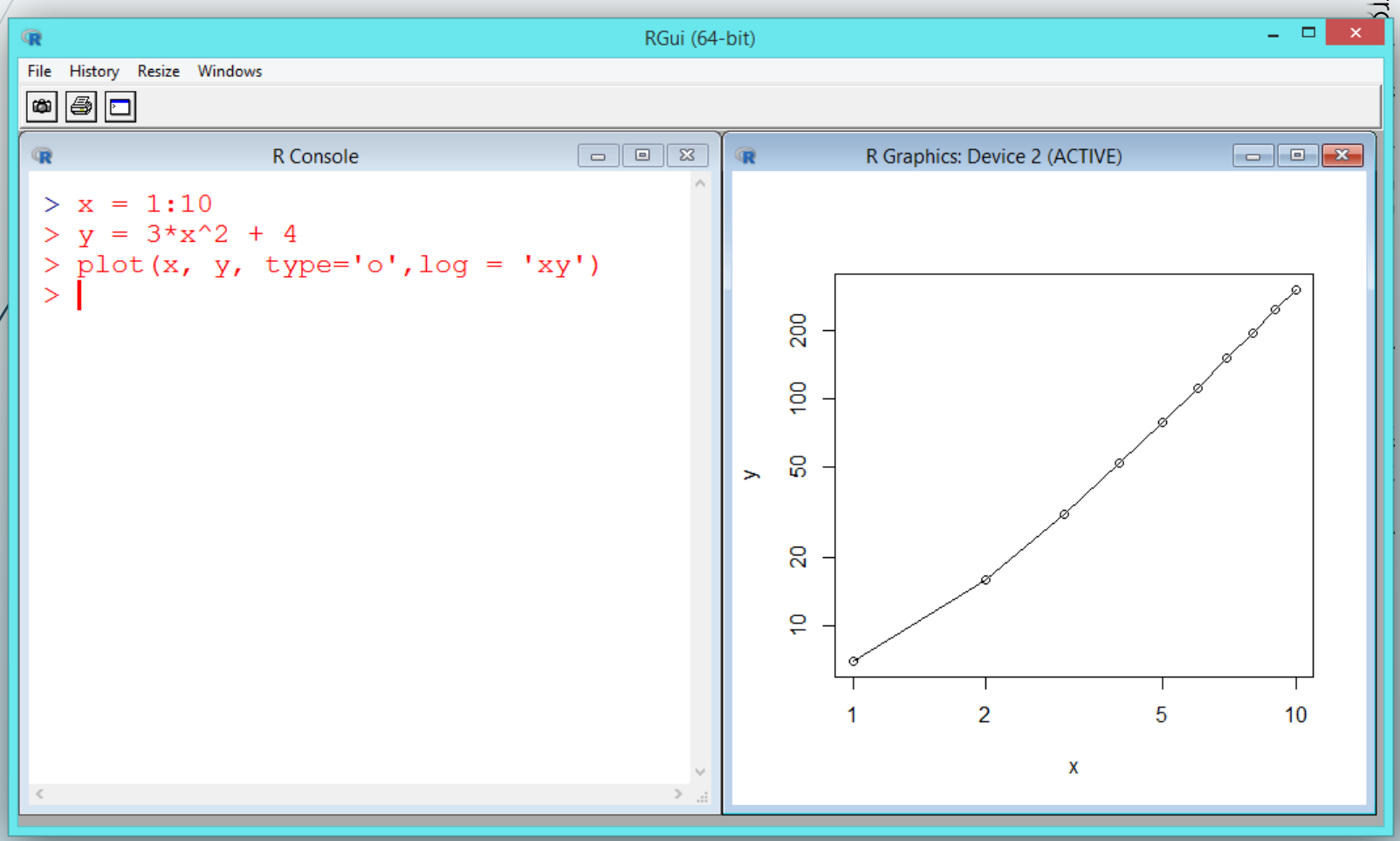
Plot

- `plot` Arguments (2)



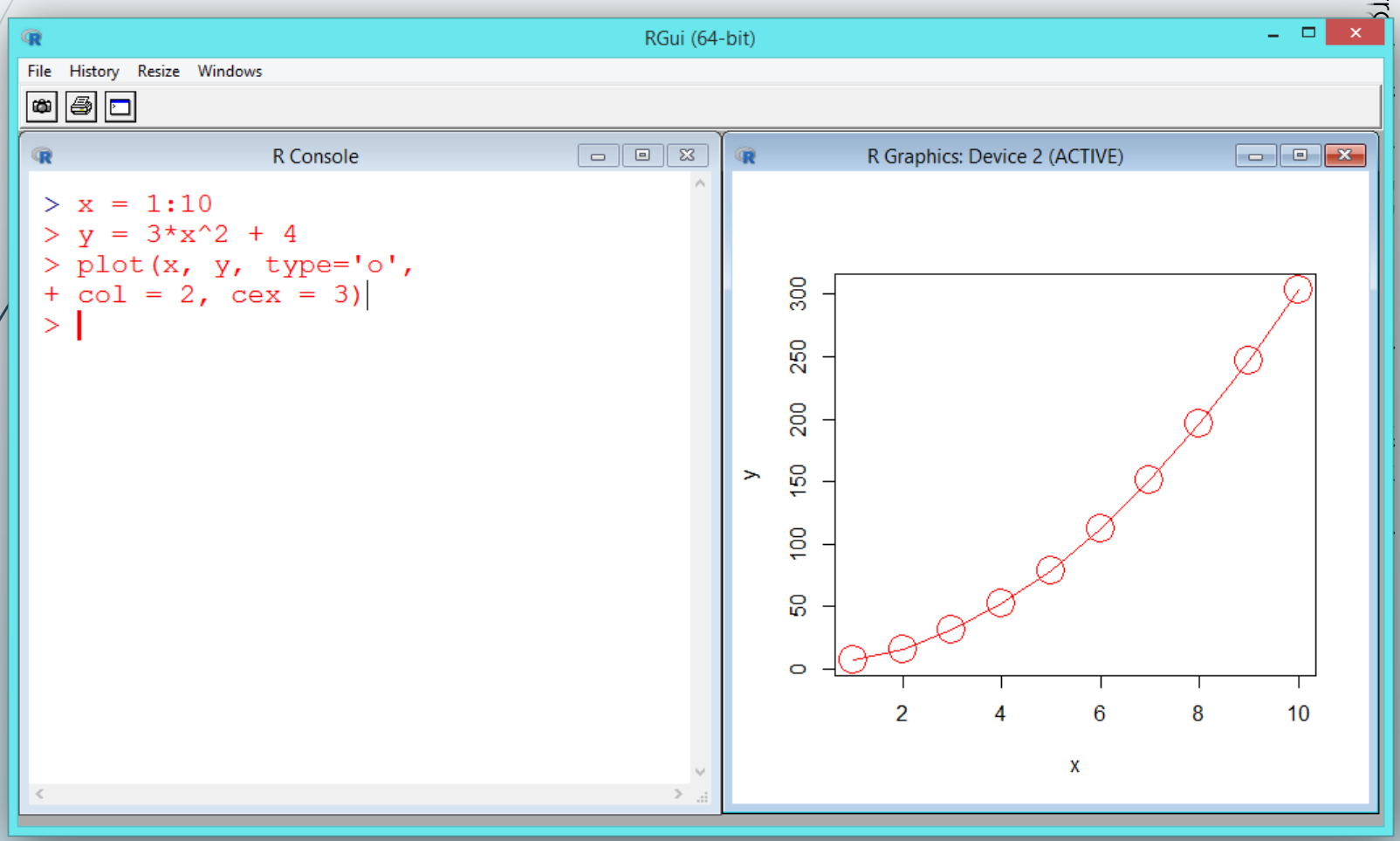
Plot

- `plot` Arguments (3)



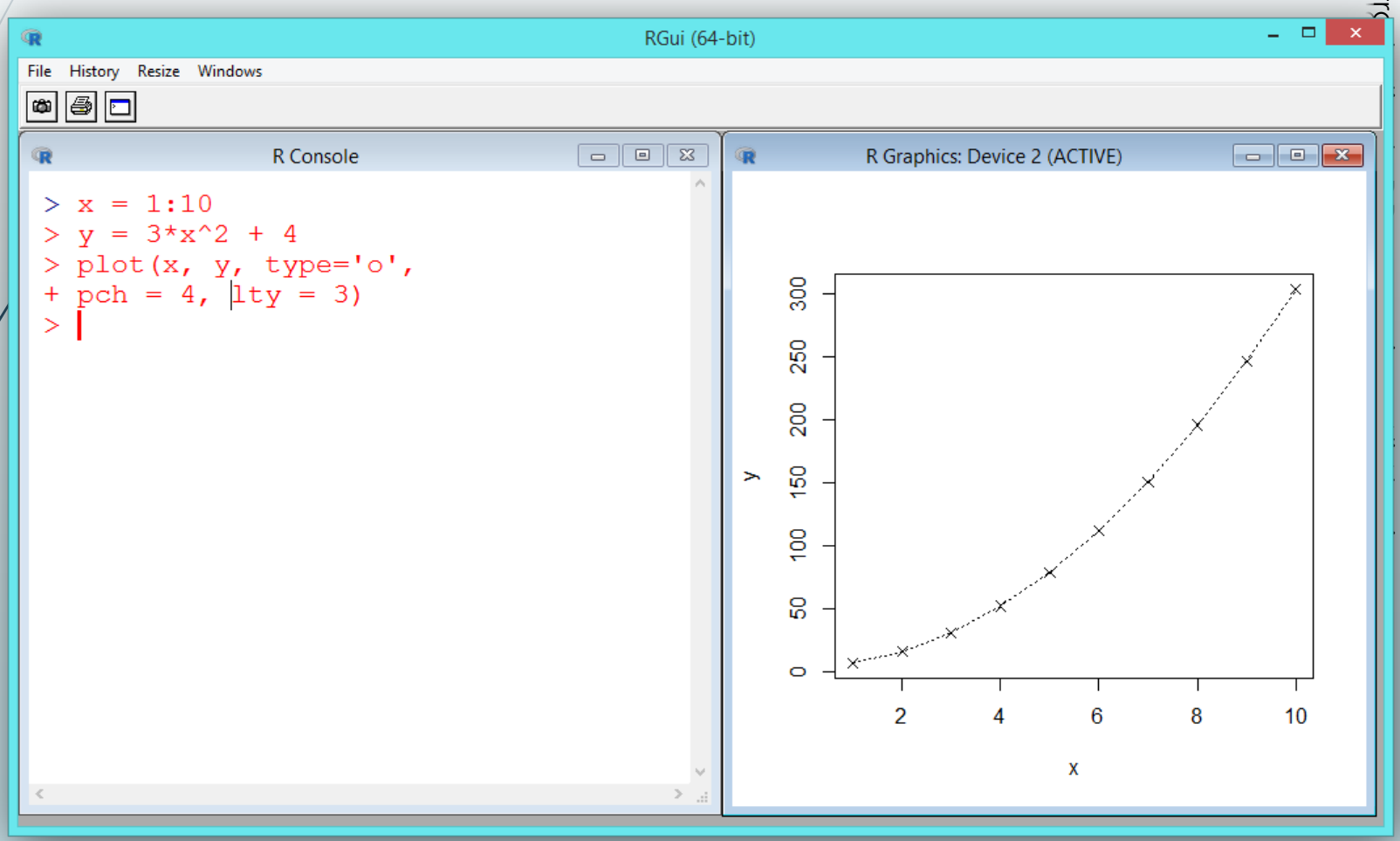
Plot

- `plot` Arguments (4)



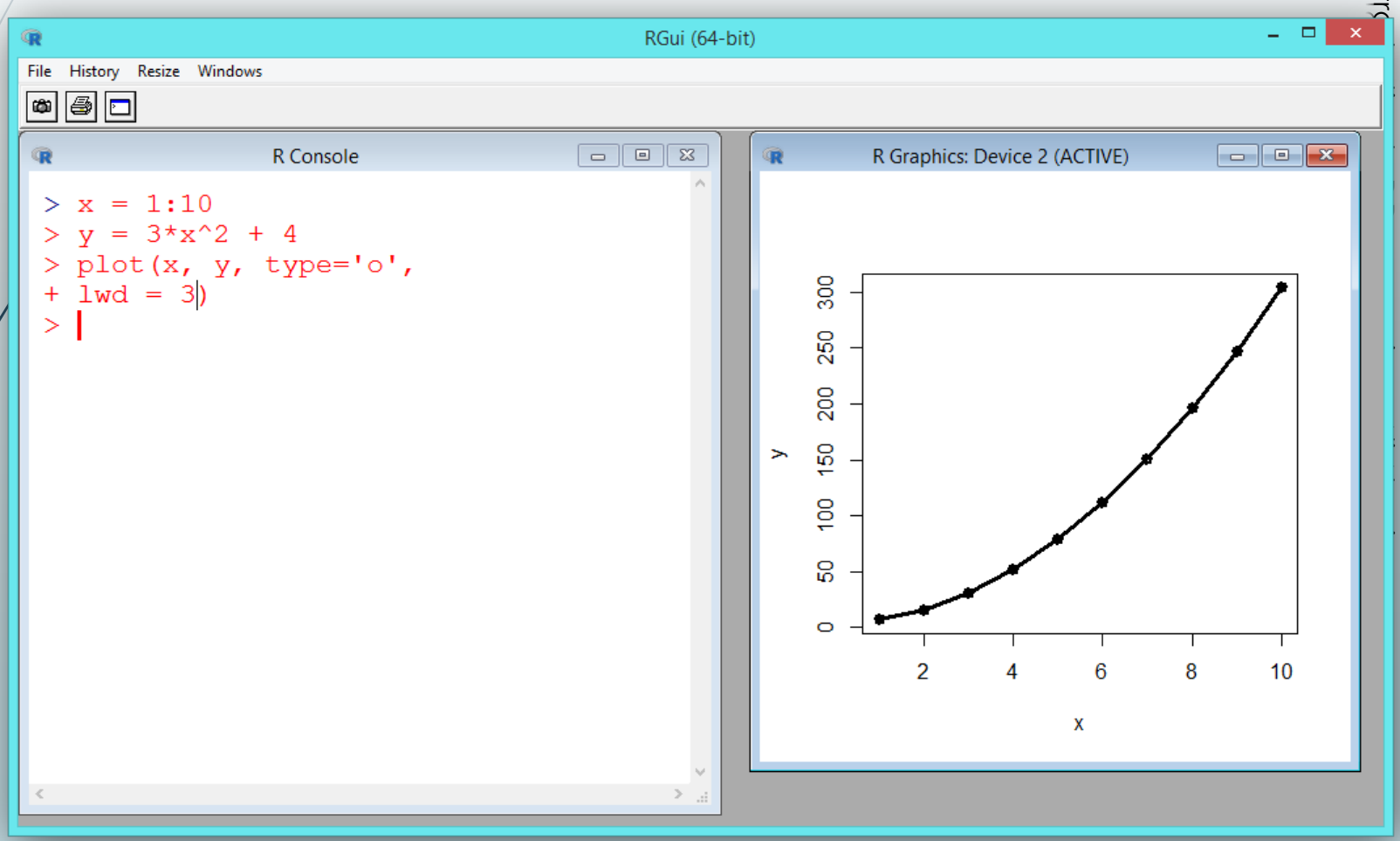
Plot

- `plot` Arguments (5)



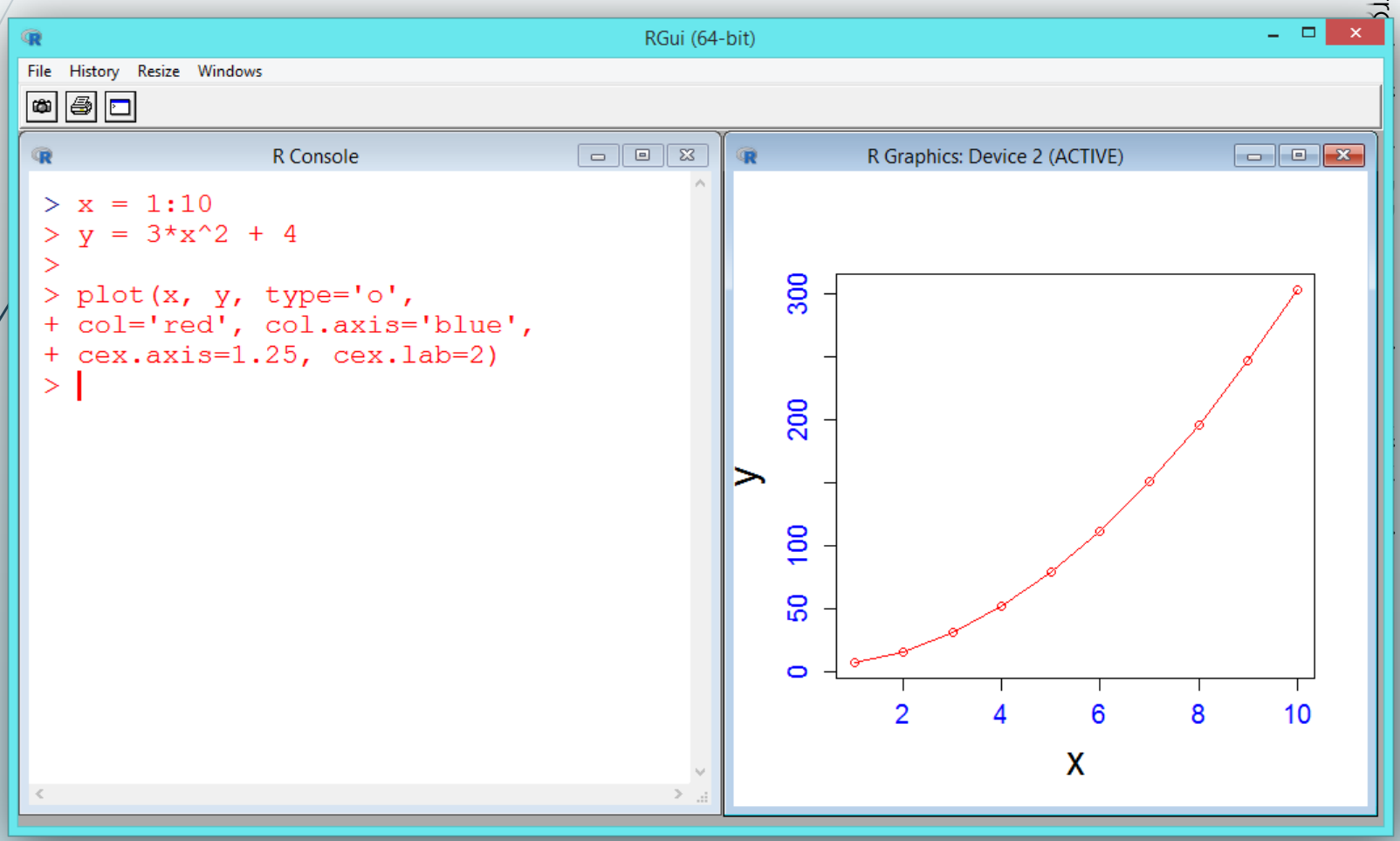
Plot

- `plot` Arguments (6)



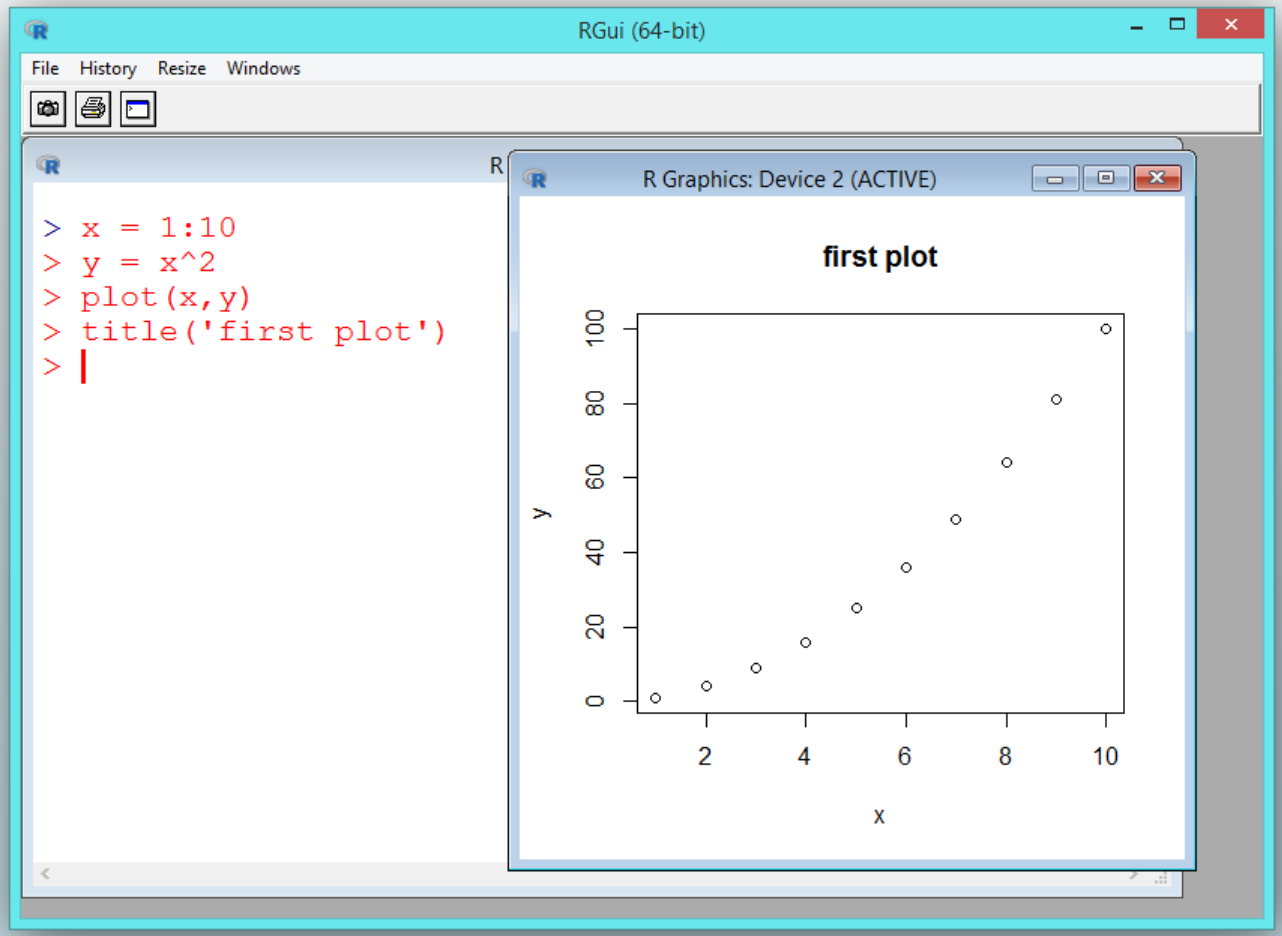
Plot

- `plot` Arguments (7)



Plot

- `title` Function



Plot

legend Function

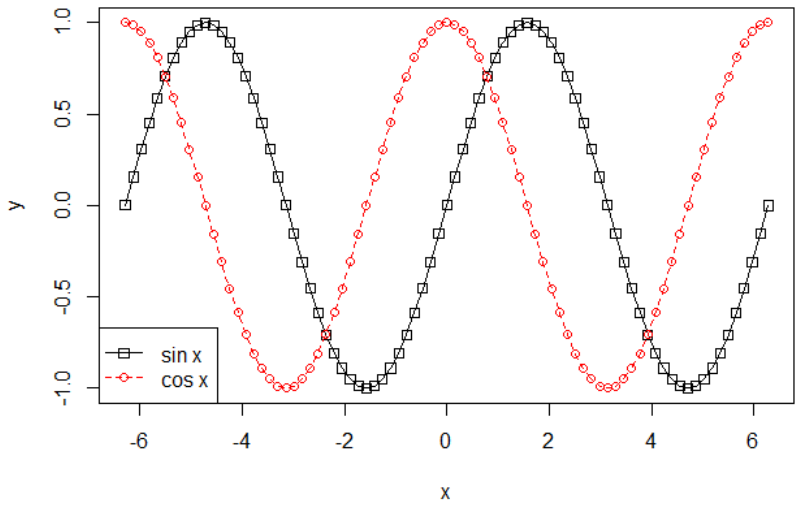
RGui (64-bit)

File Edit View Misc Packages Windows Help

R Console

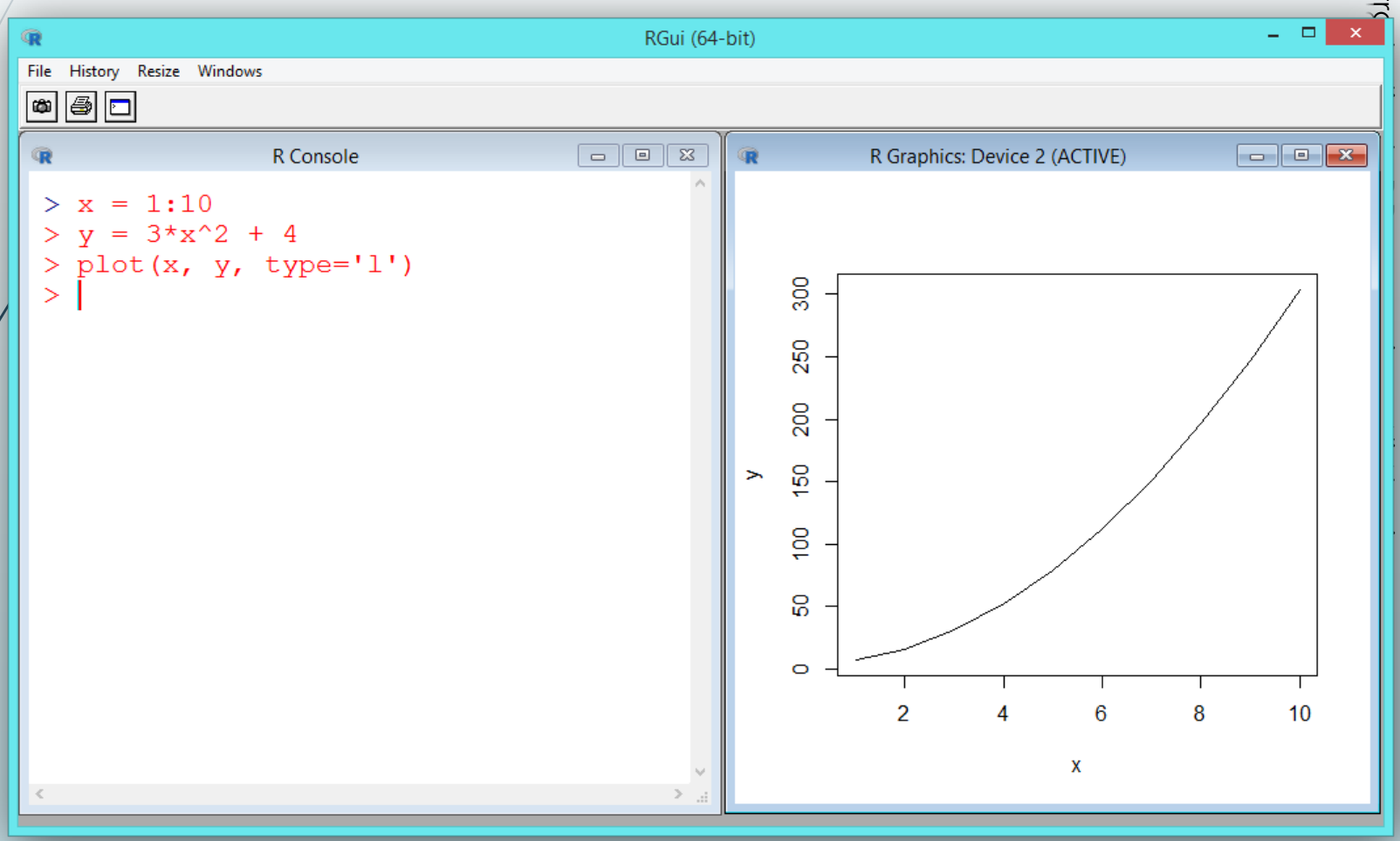
```
> x = seq(-2*pi,2*pi,pi/20)
> y = sin(x)
> z = cos(x)
>
> plot(x,y,type='o',pch=0,lty=1,col=1)
> lines(x,z,type='o',pch=1,lty=2,col=2)
>
> legend('bottomleft',
+ legend=c('sin x','cos x'),
+ col=1:2,lty=1:2,pch=c(0,1))
>
```

R Graphics: Device 2 (ACTIVE)



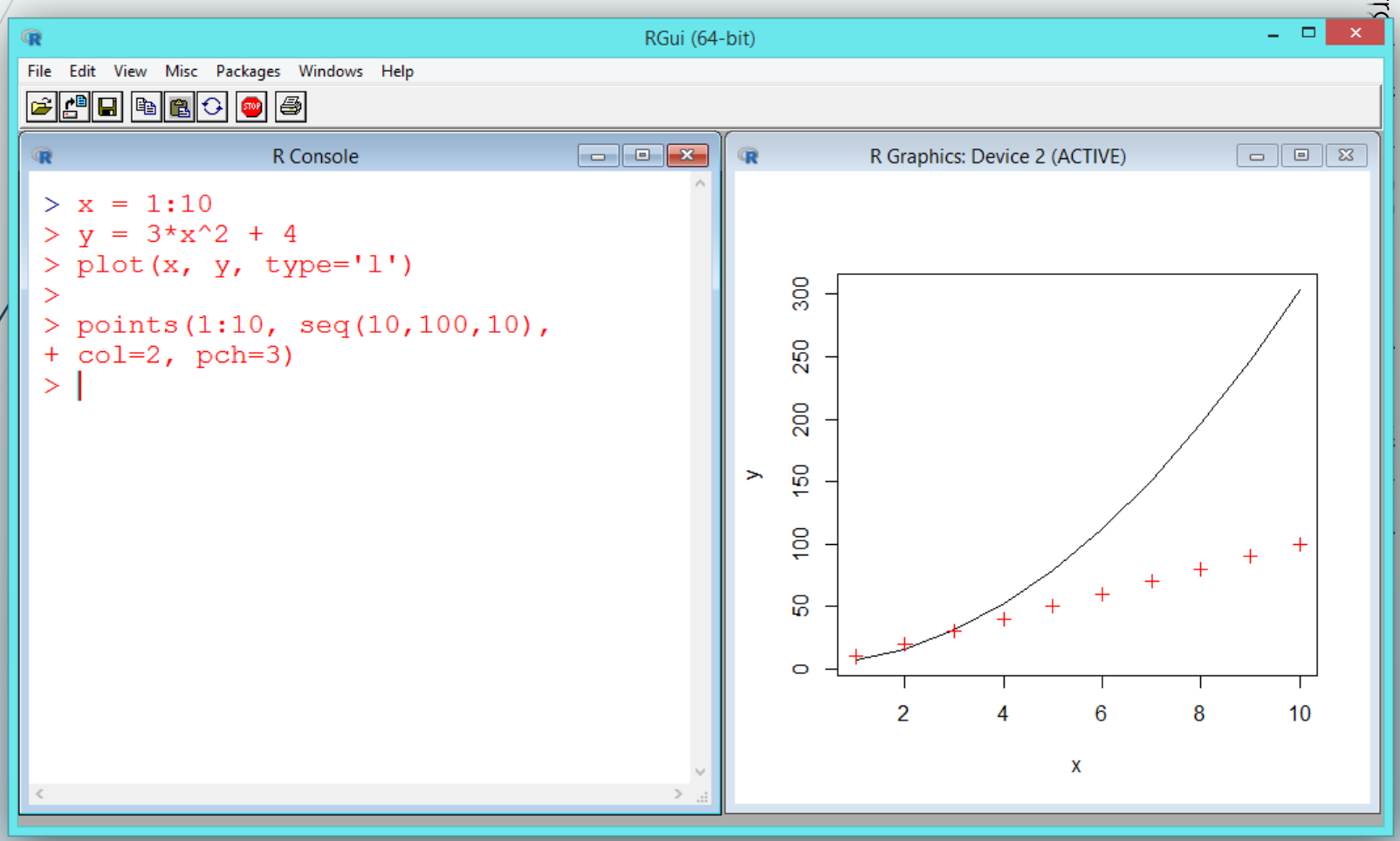
Plot

- `points` Function



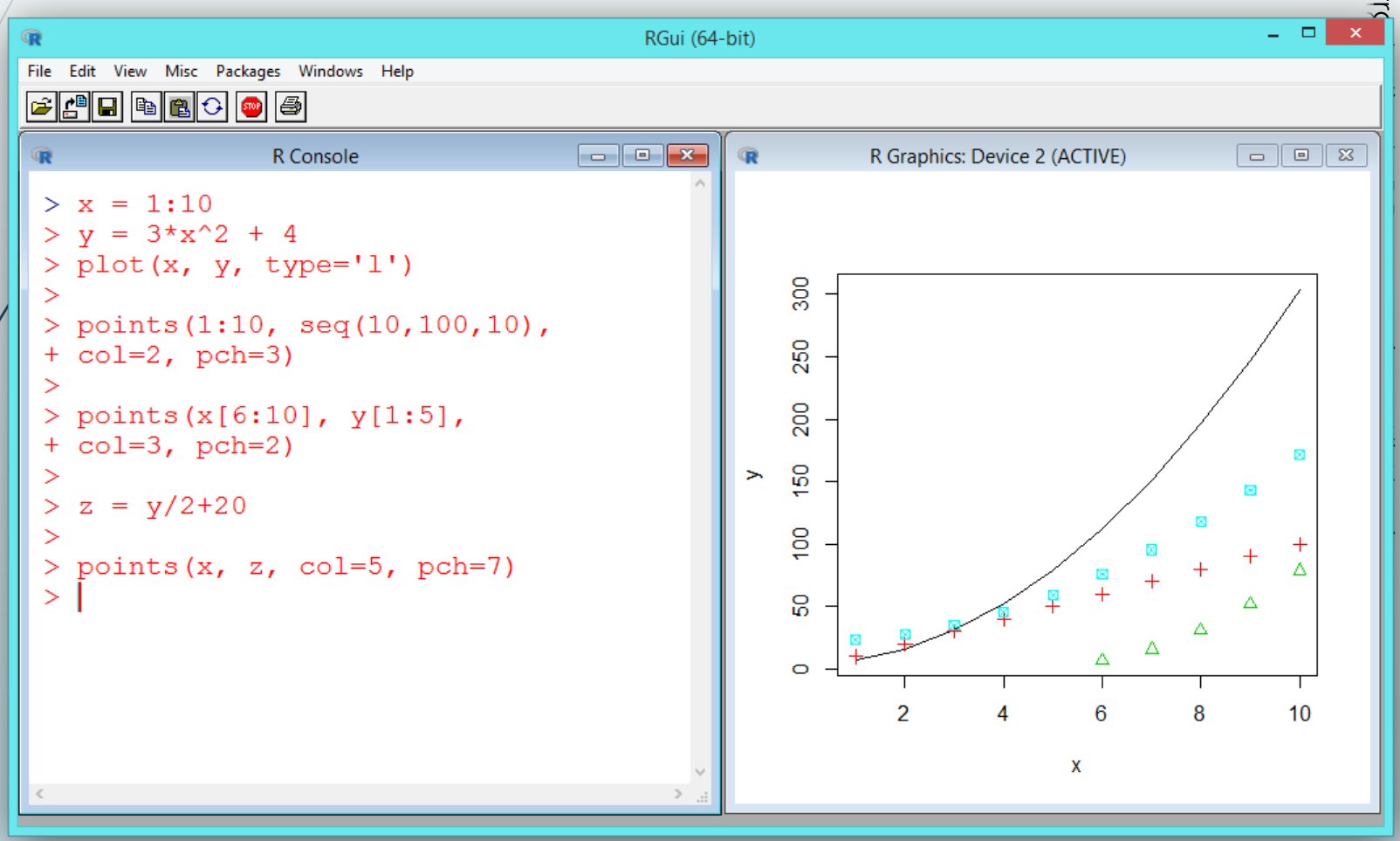
Plot

- `points` Function



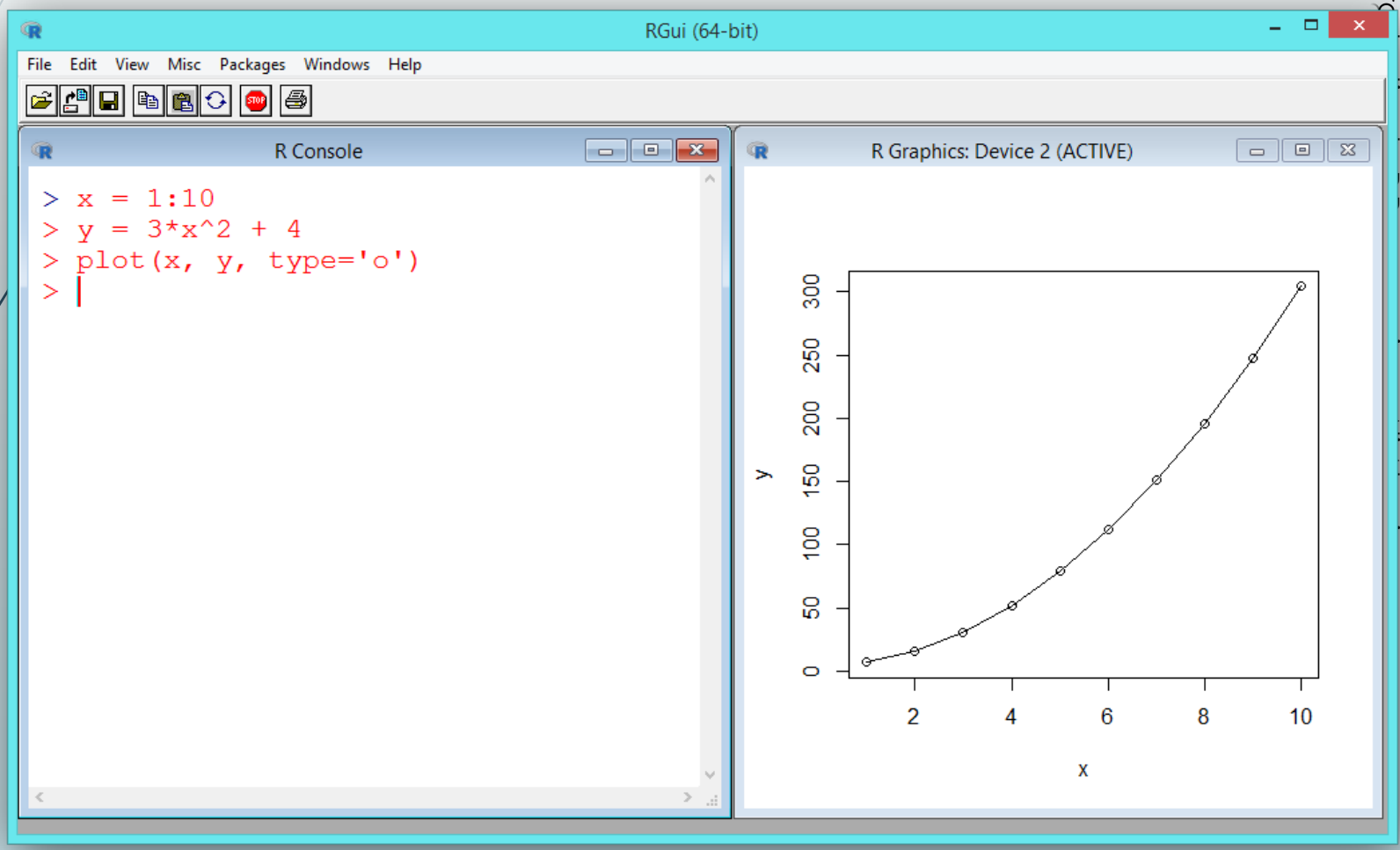
Plot

- `points` Function



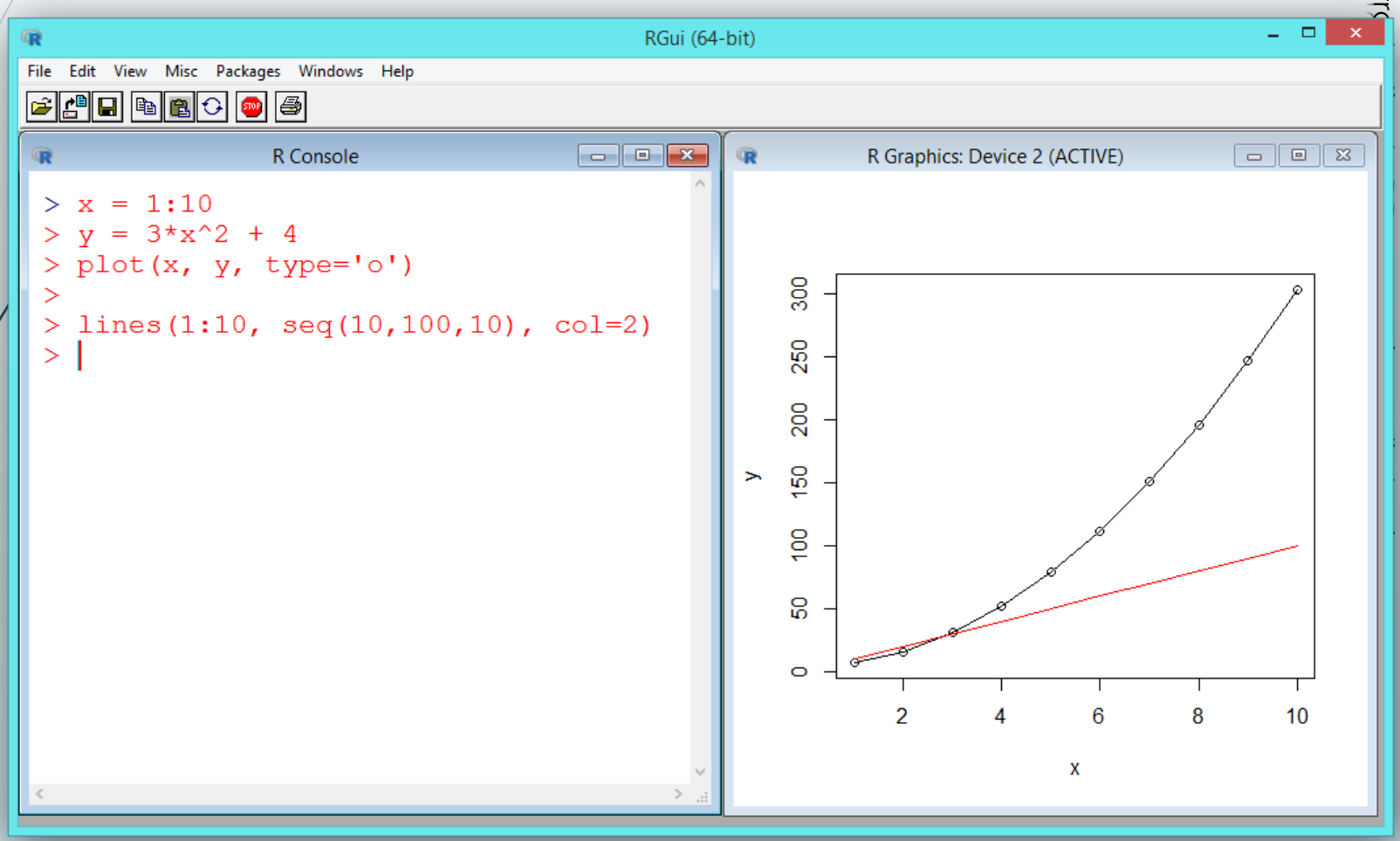
Plot

- `lines` Function



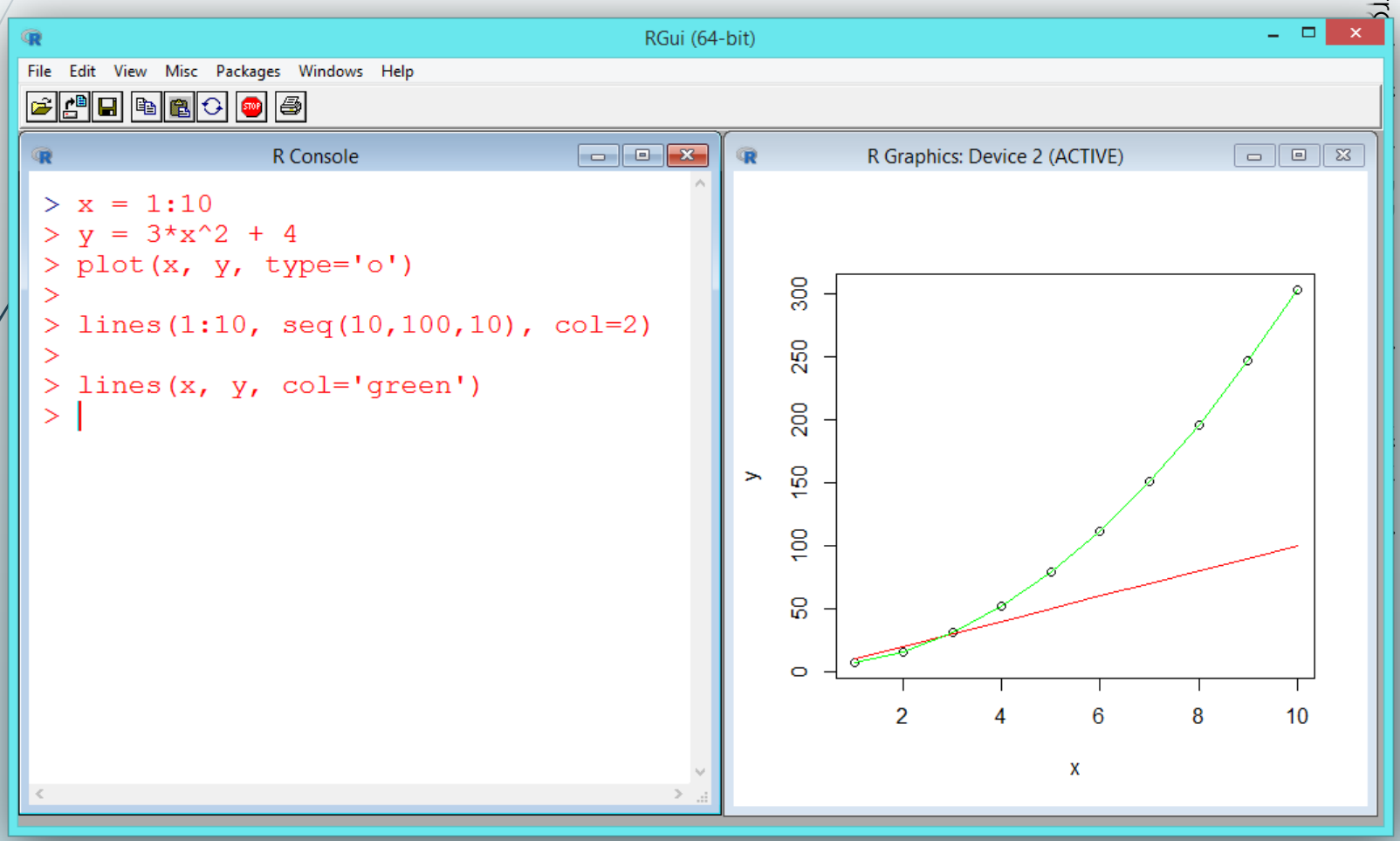
Plot

- `lines` Function



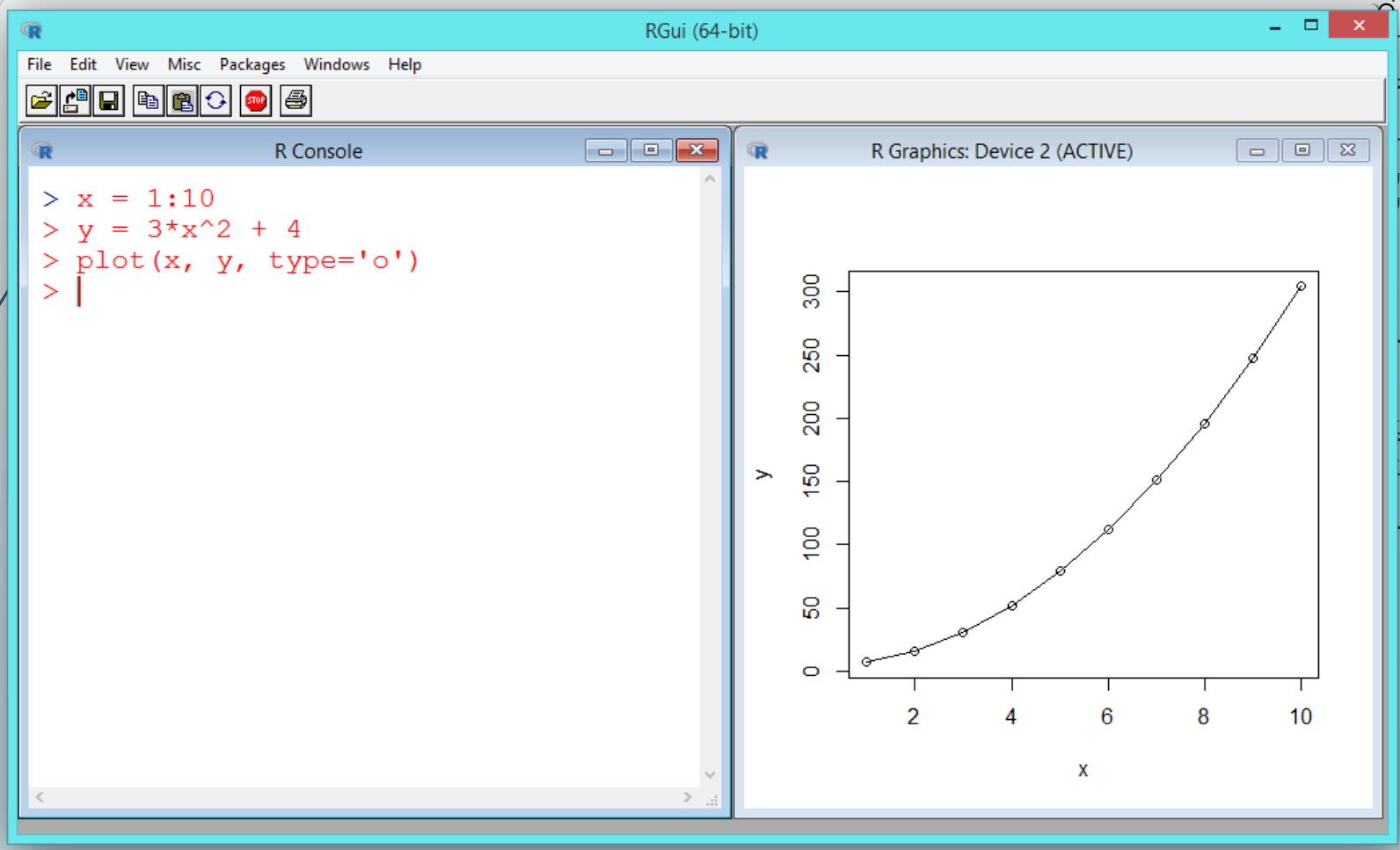
Plot

- `lines` Function



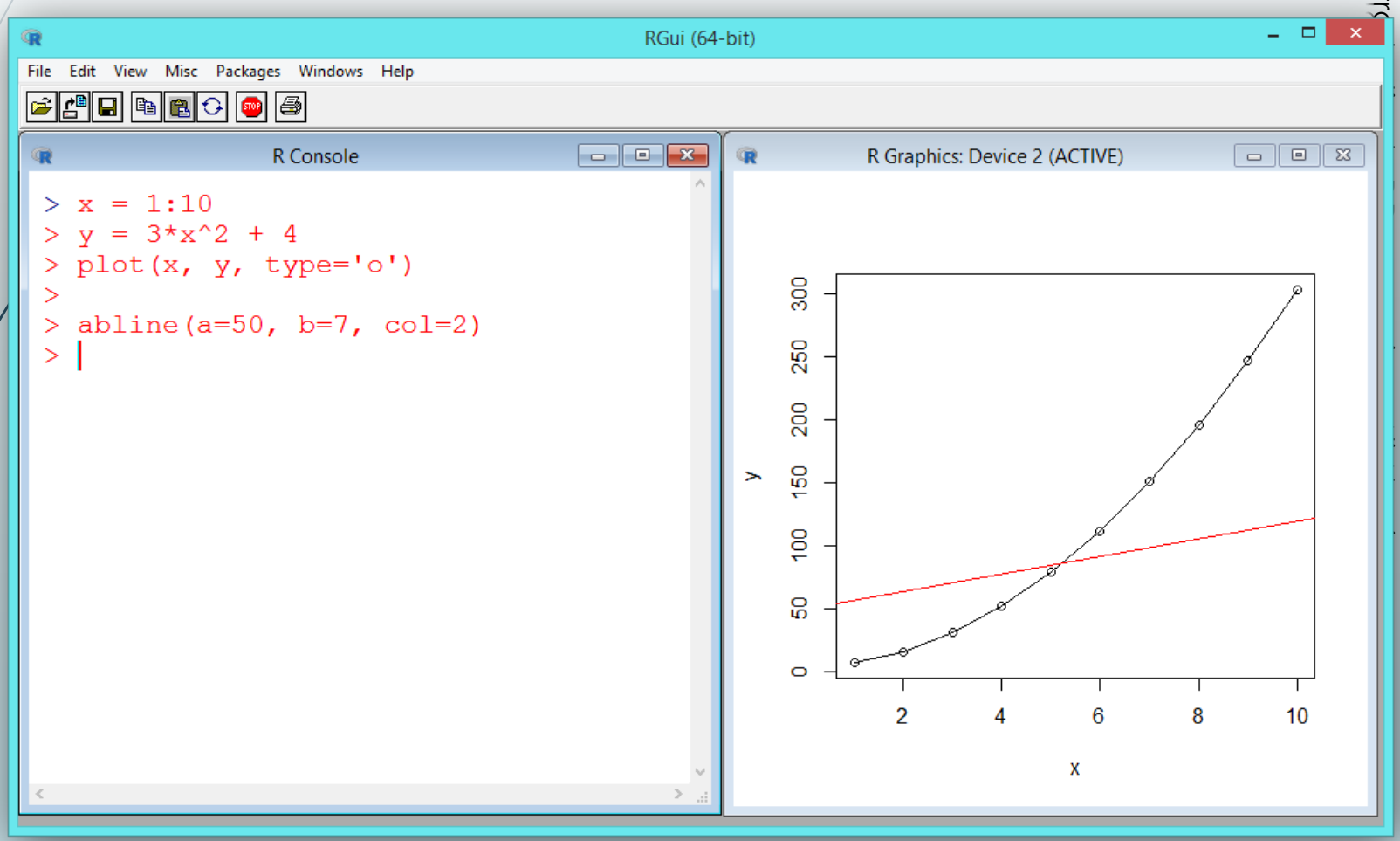
Plot

- `abline` Function



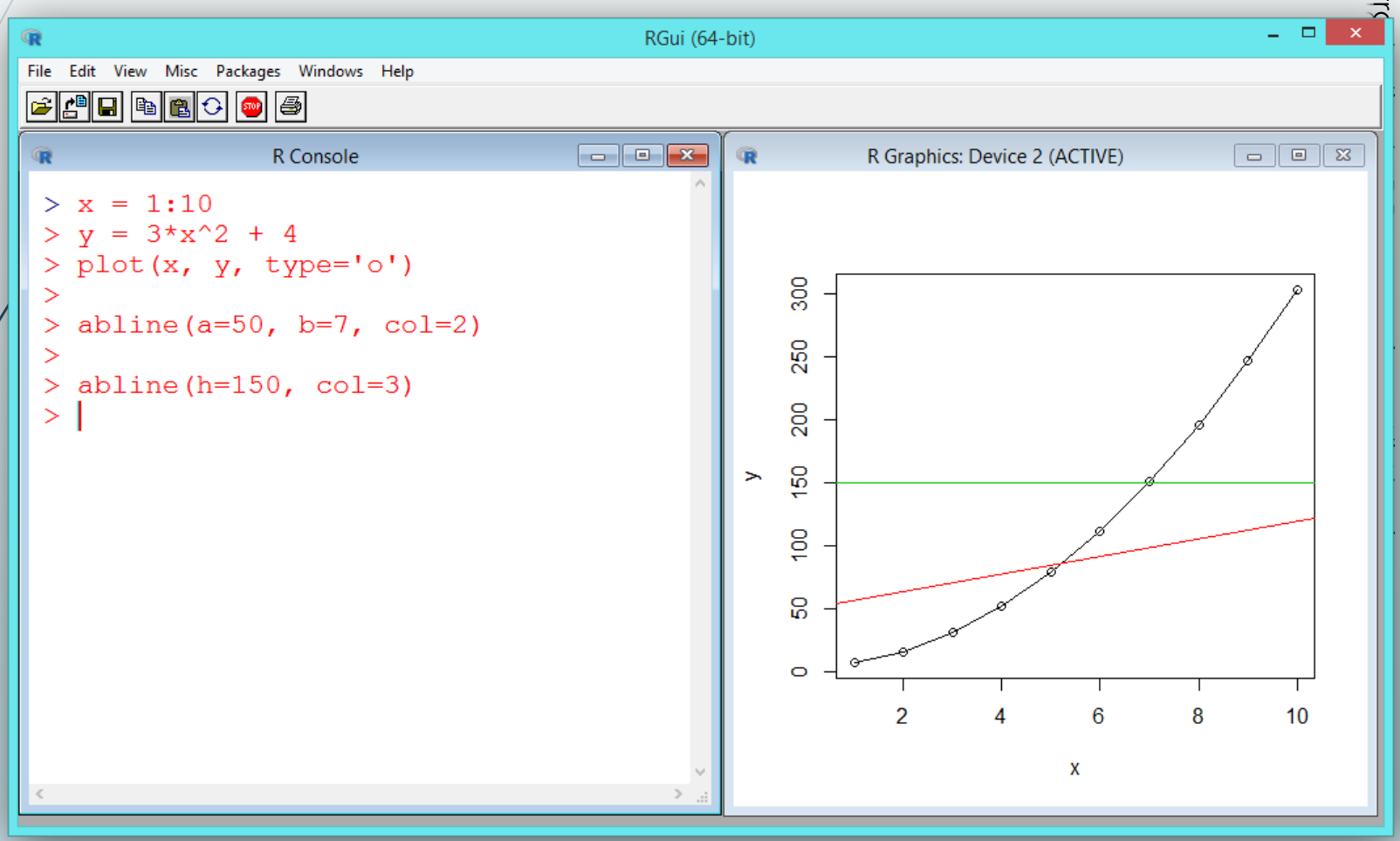
Plot

- `abline` Function



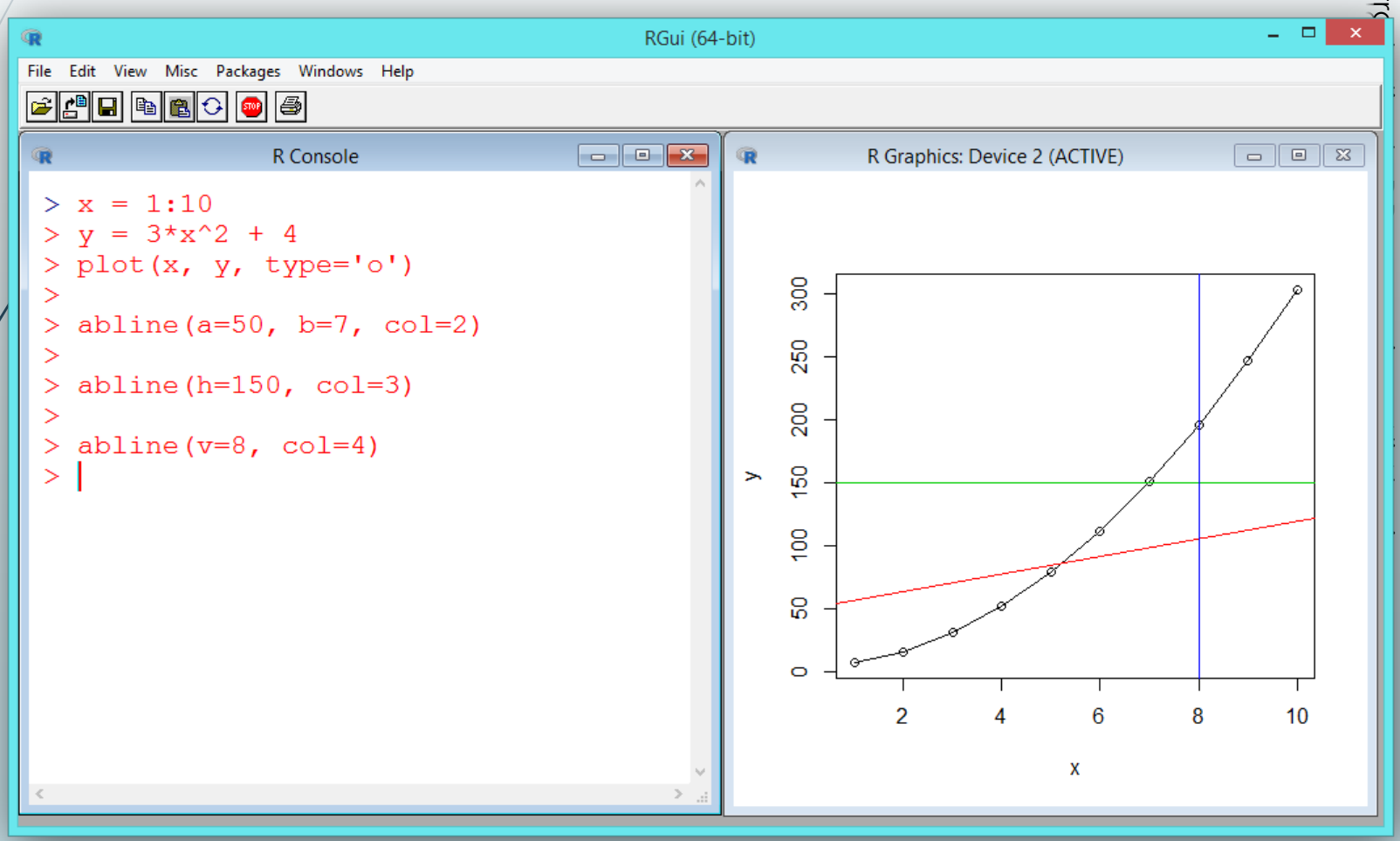
Plot

- `abline` Function



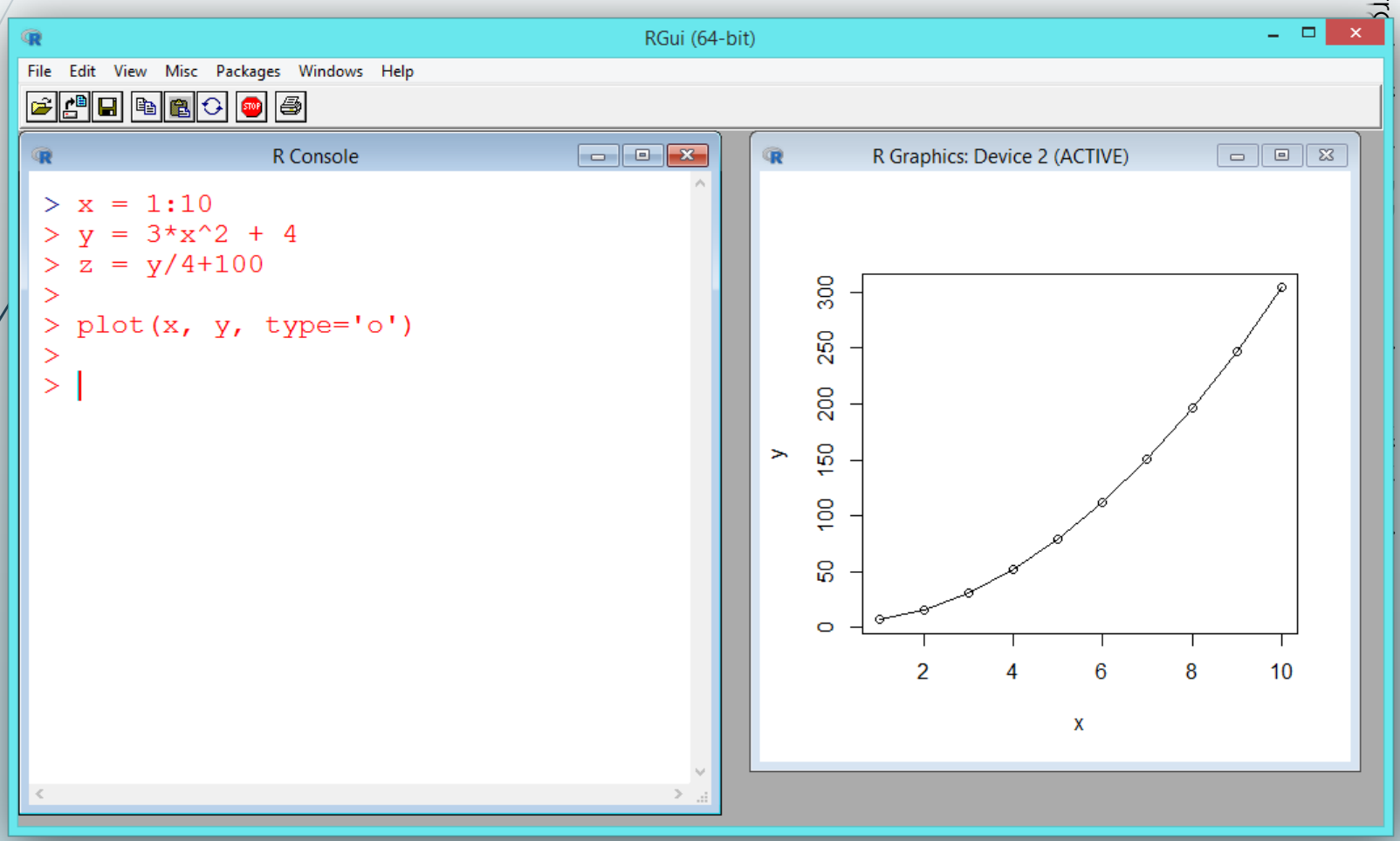
Plot

- `abline` Function



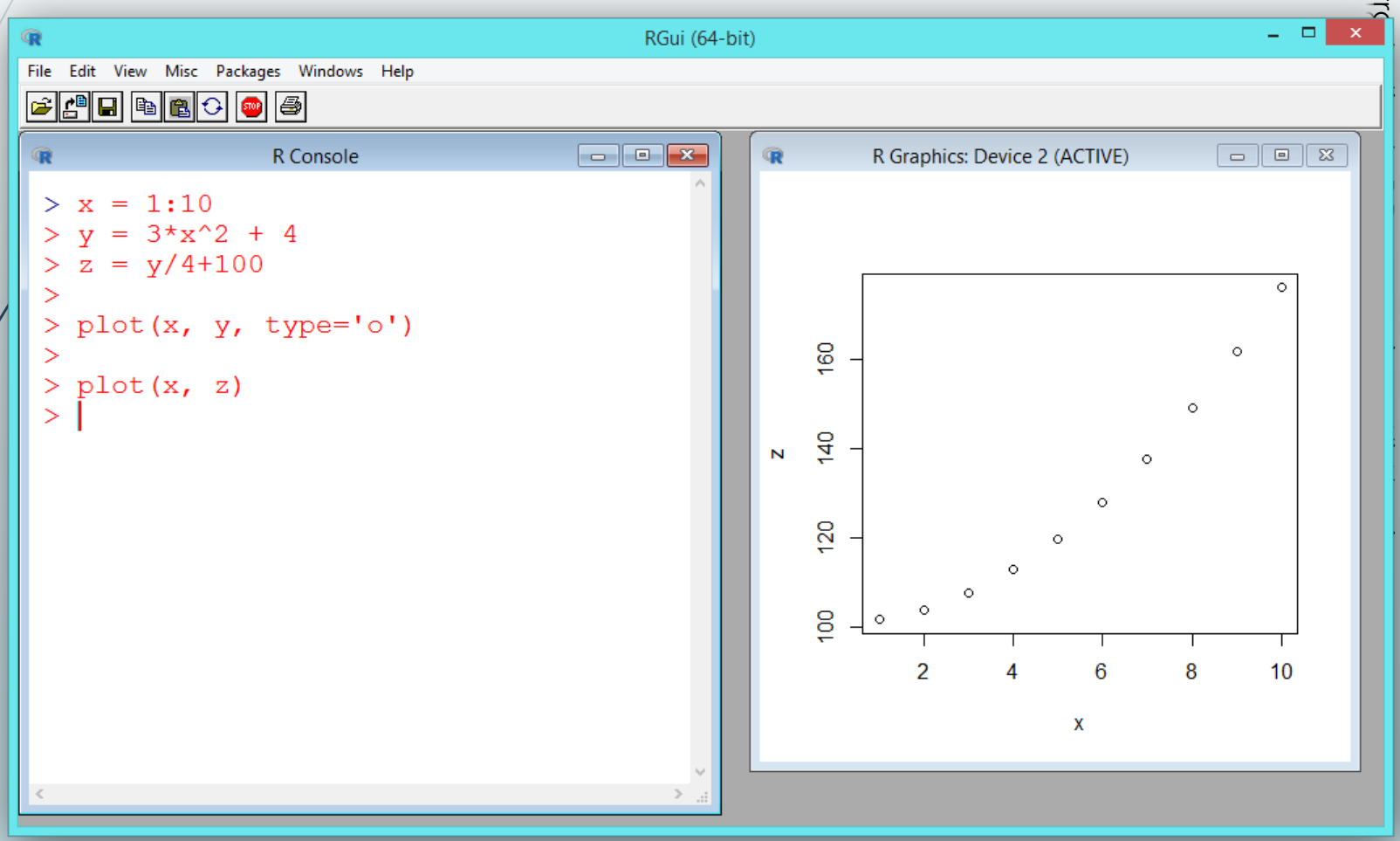
Plot

- `windows` Function



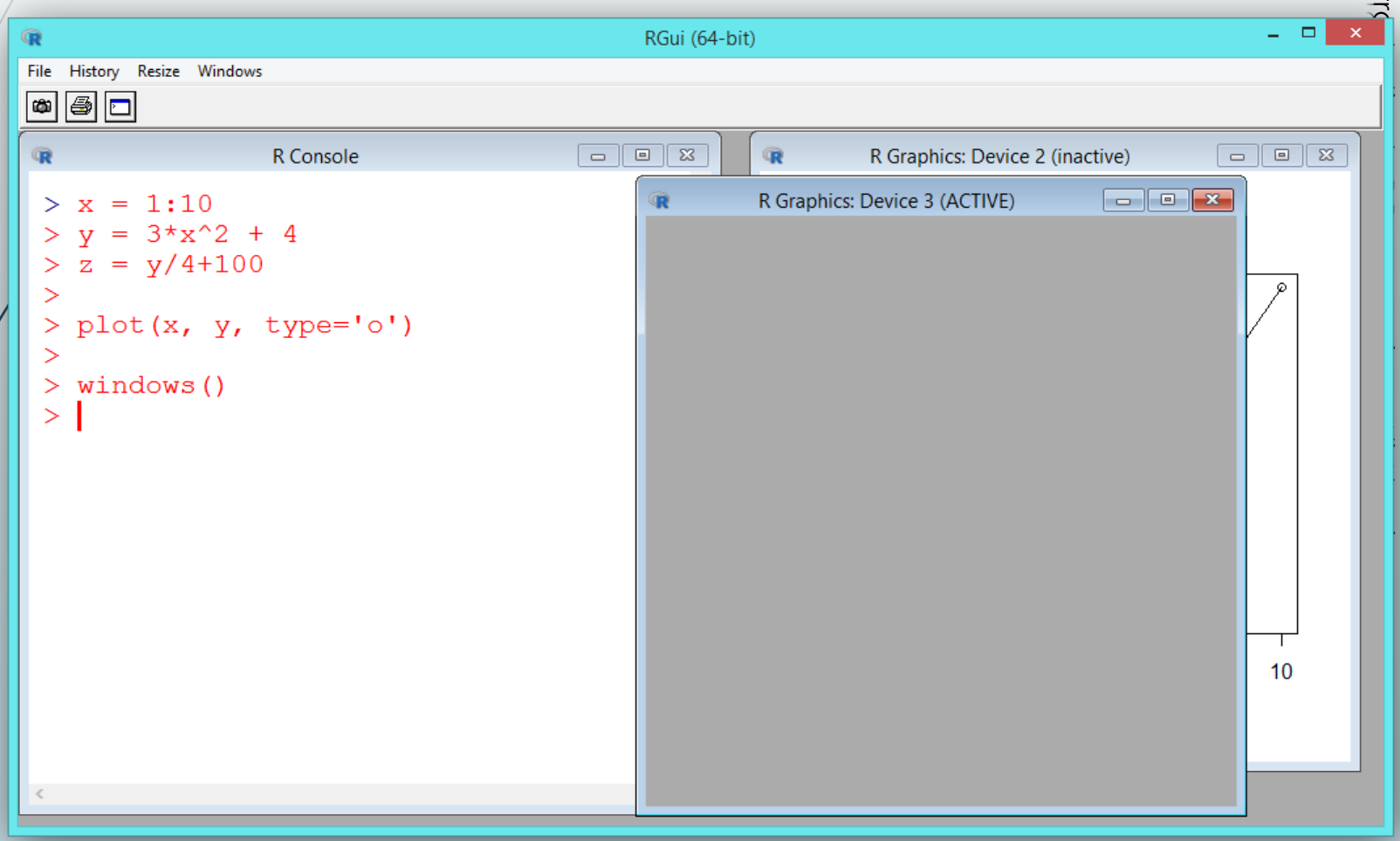
Plot

- `windows` Function



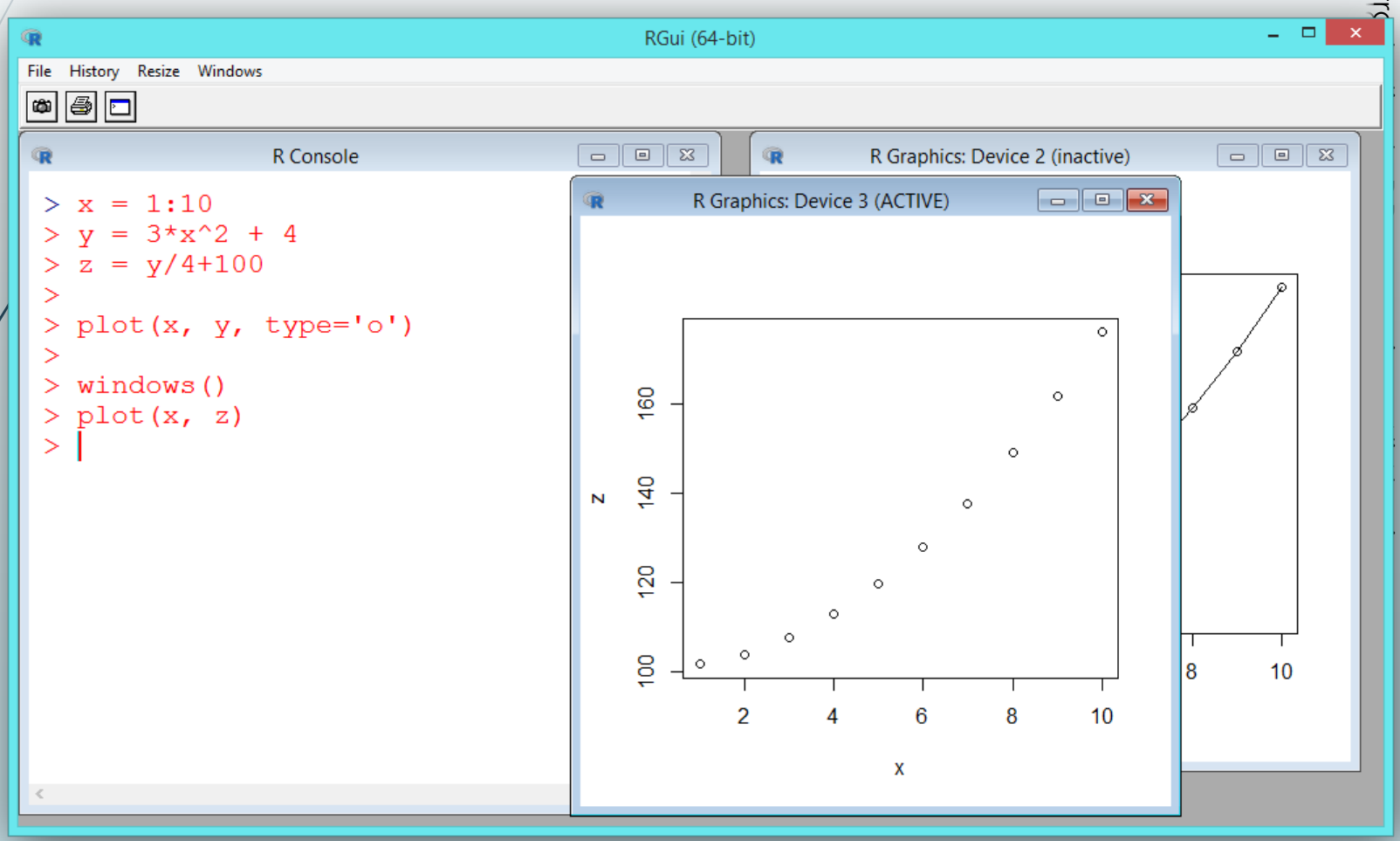
Plot

- `windows` Function



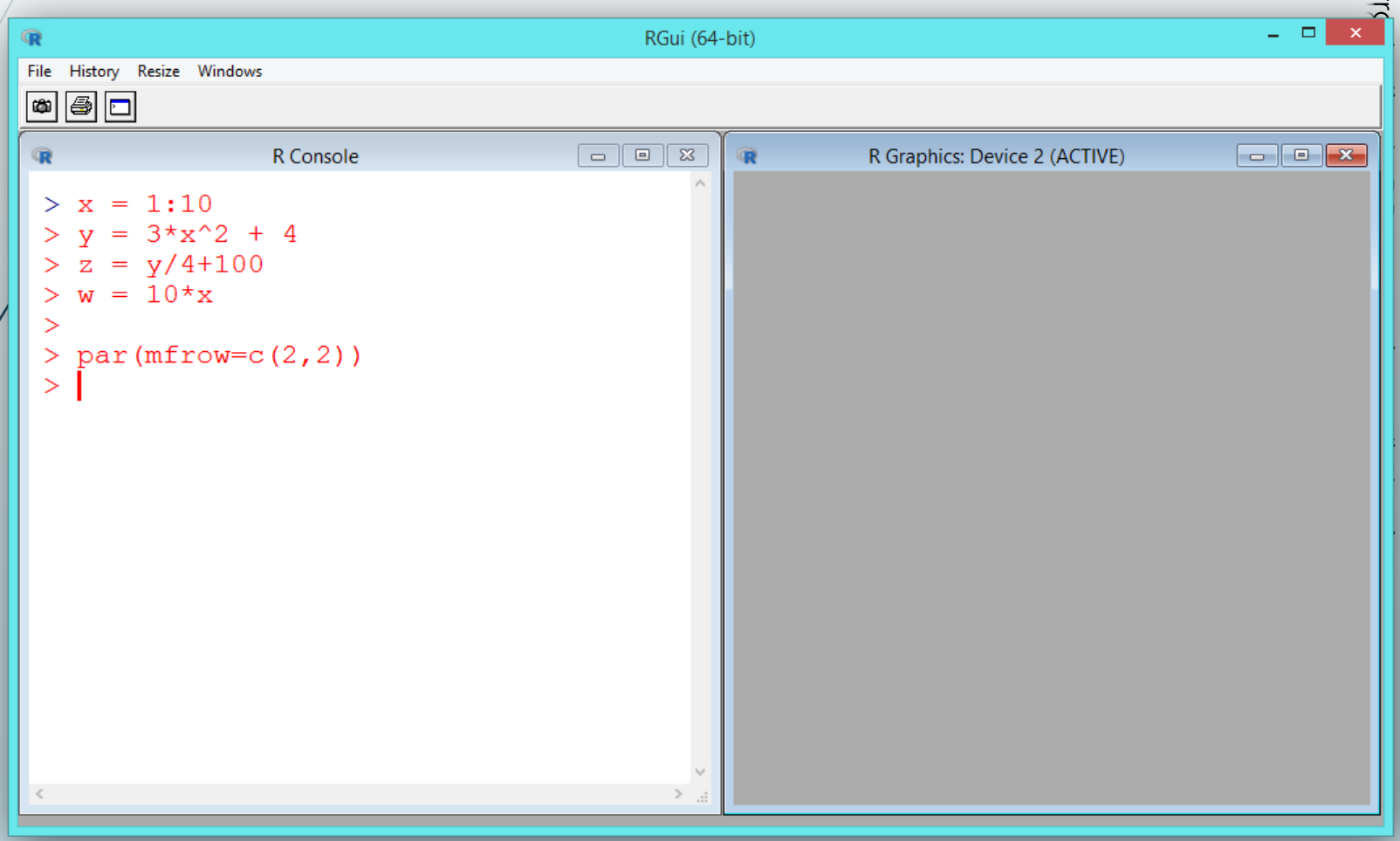
Plot

- `windows` Function



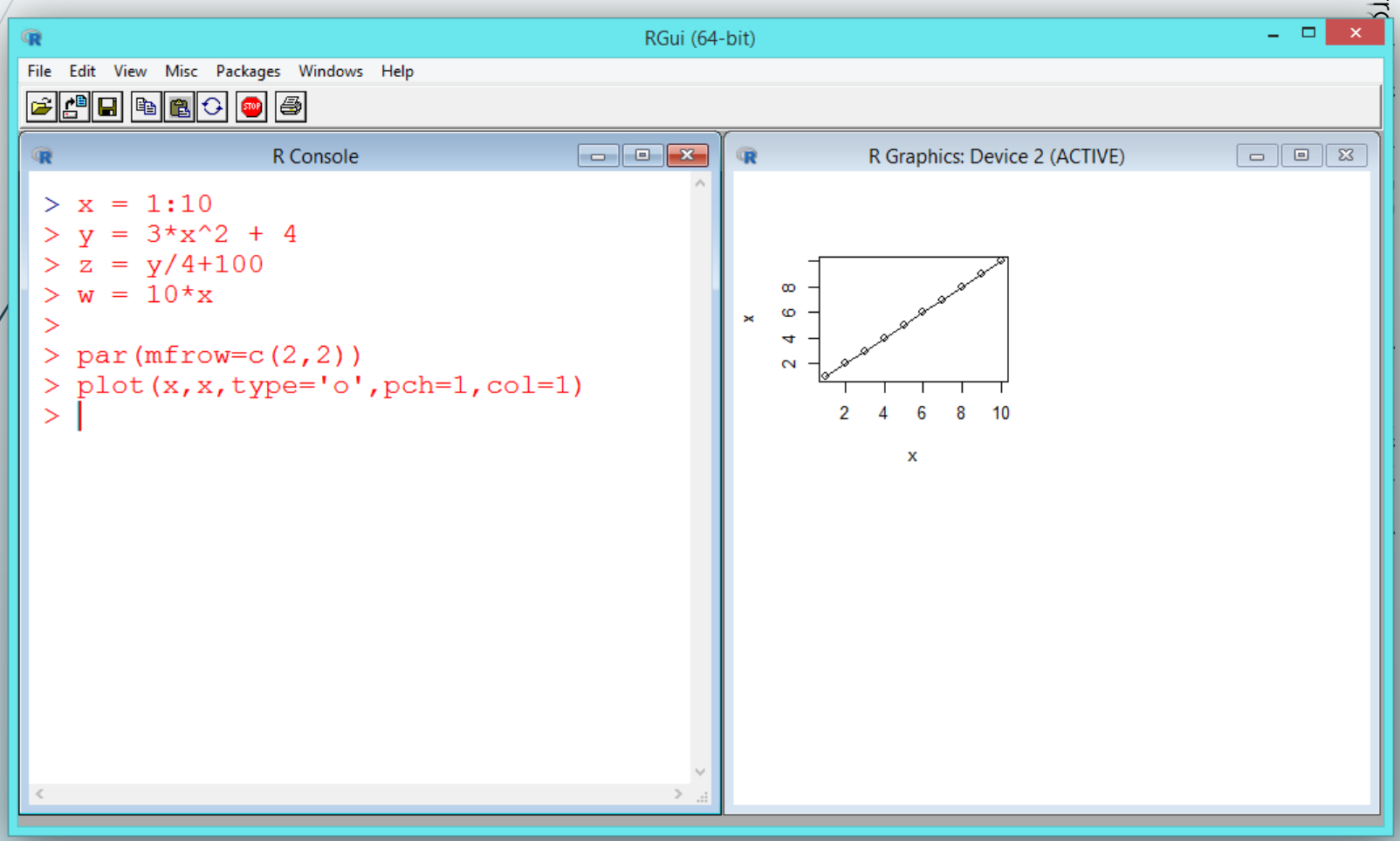
Plot

- Multiple Plots



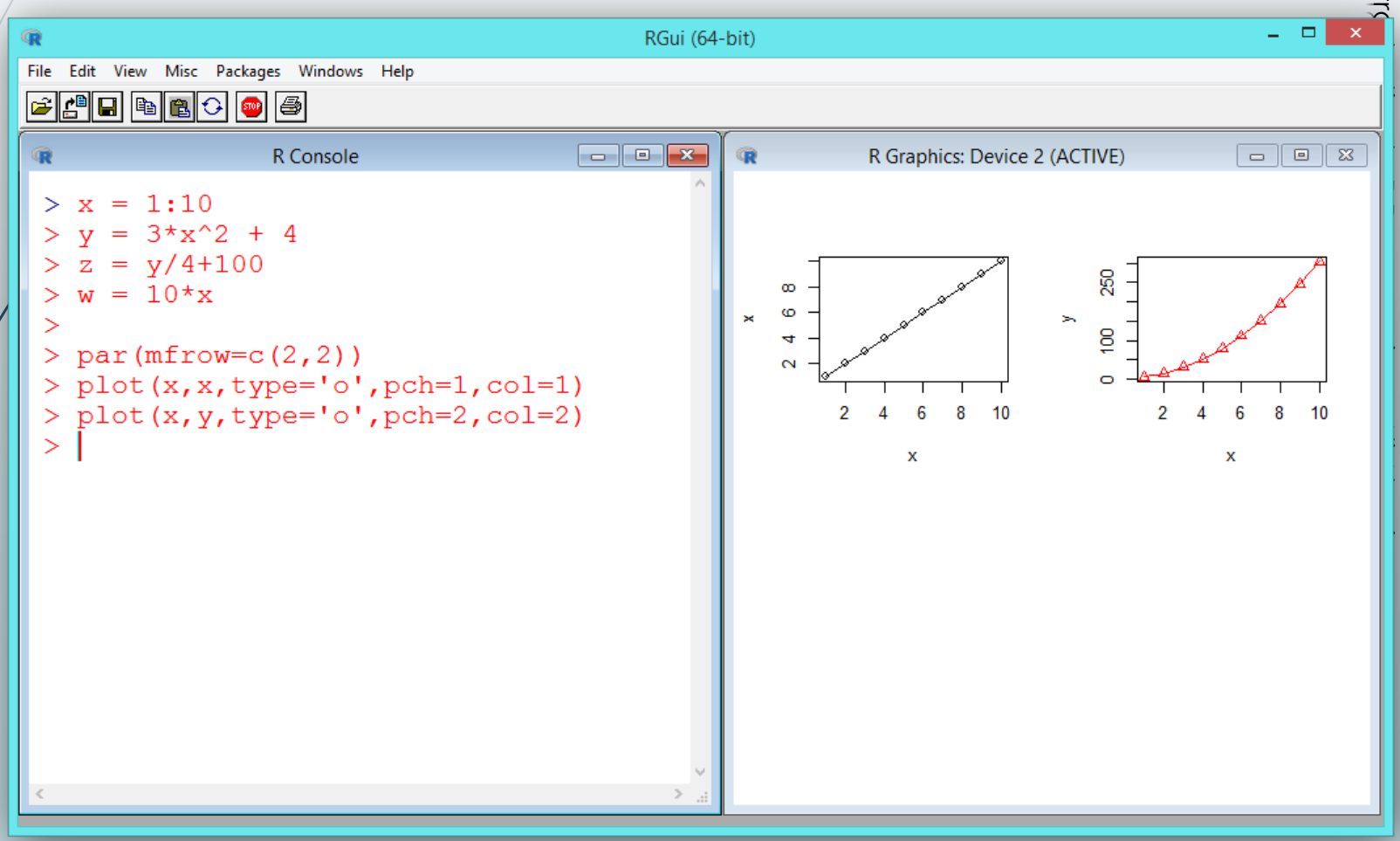
Plot

- Multiple Plots: `par(mfrow=...)`



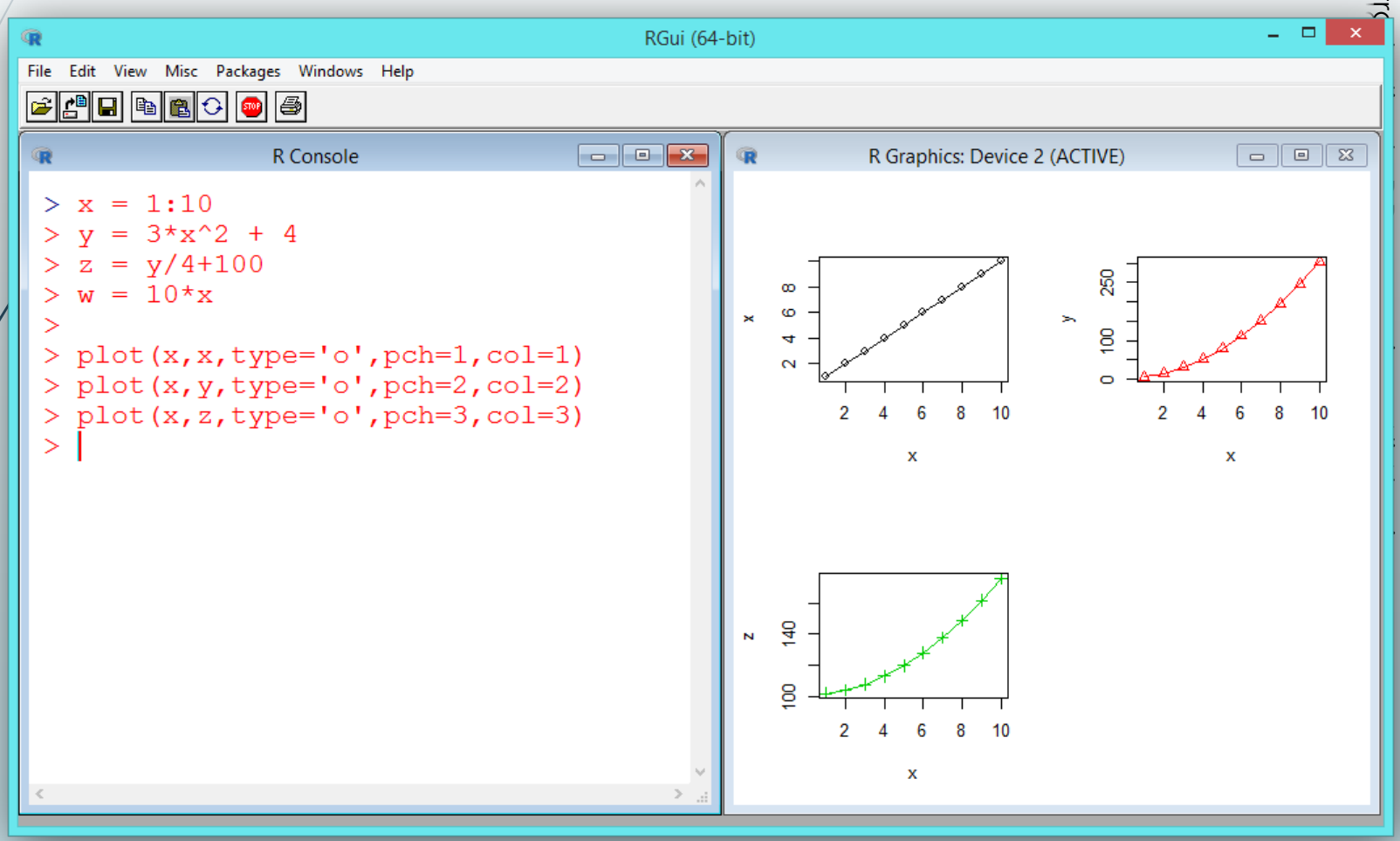
Plot

- Multiple Plots: `par(mfrow=...)`



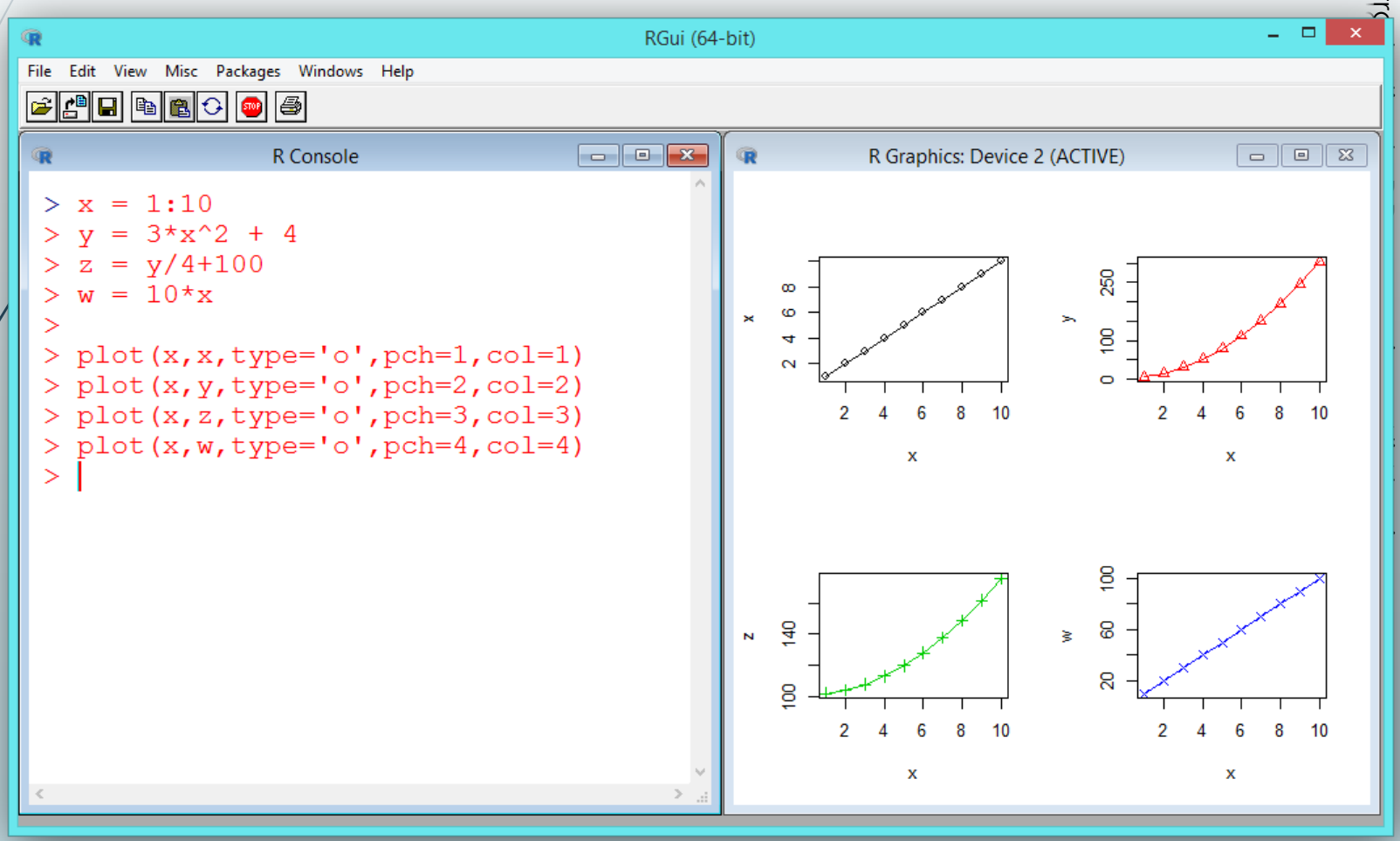
Plot

- Multiple Plots: `par(mfrow=...)`



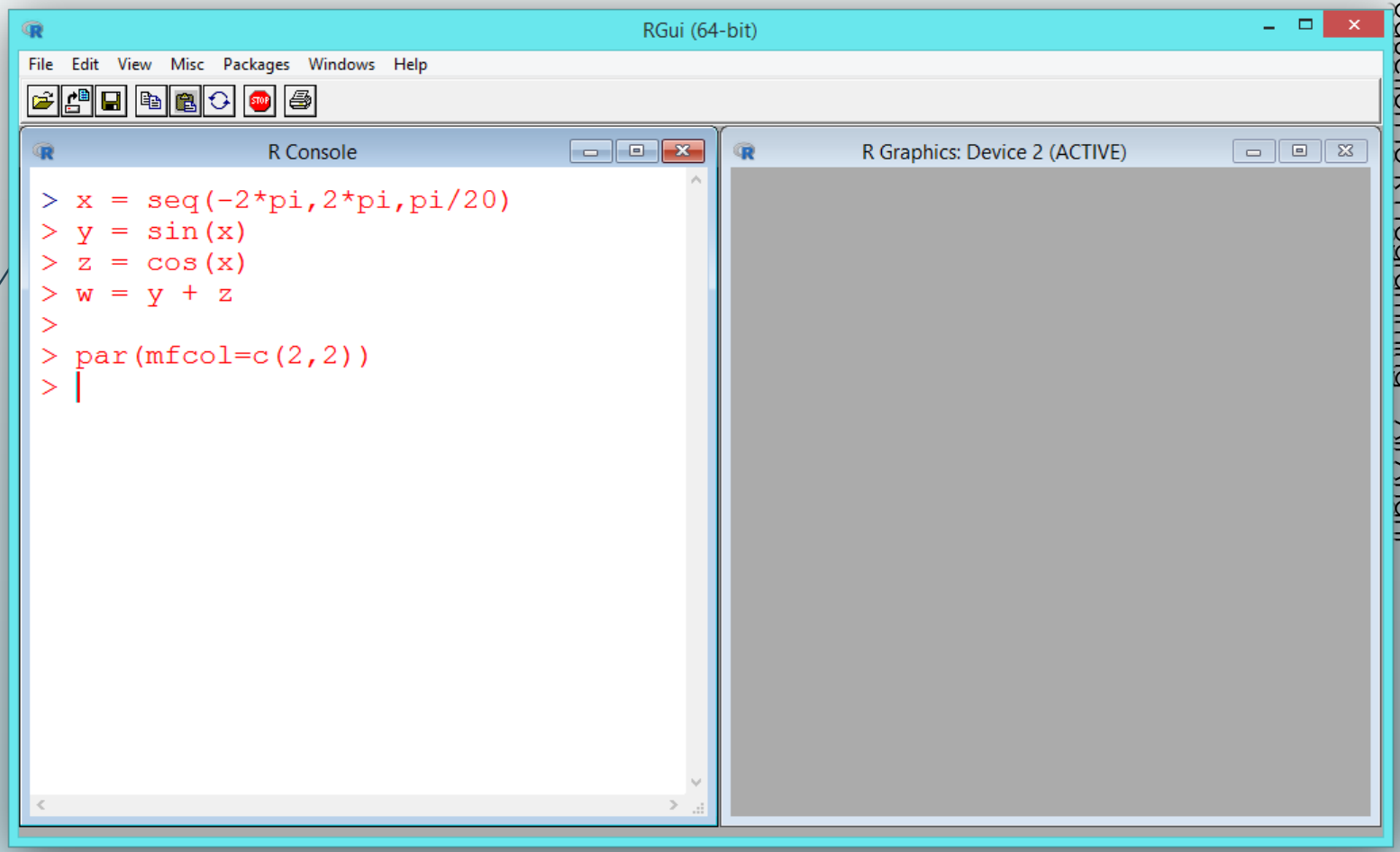
Plot

- Multiple Plots: `par(mfrow=...)`



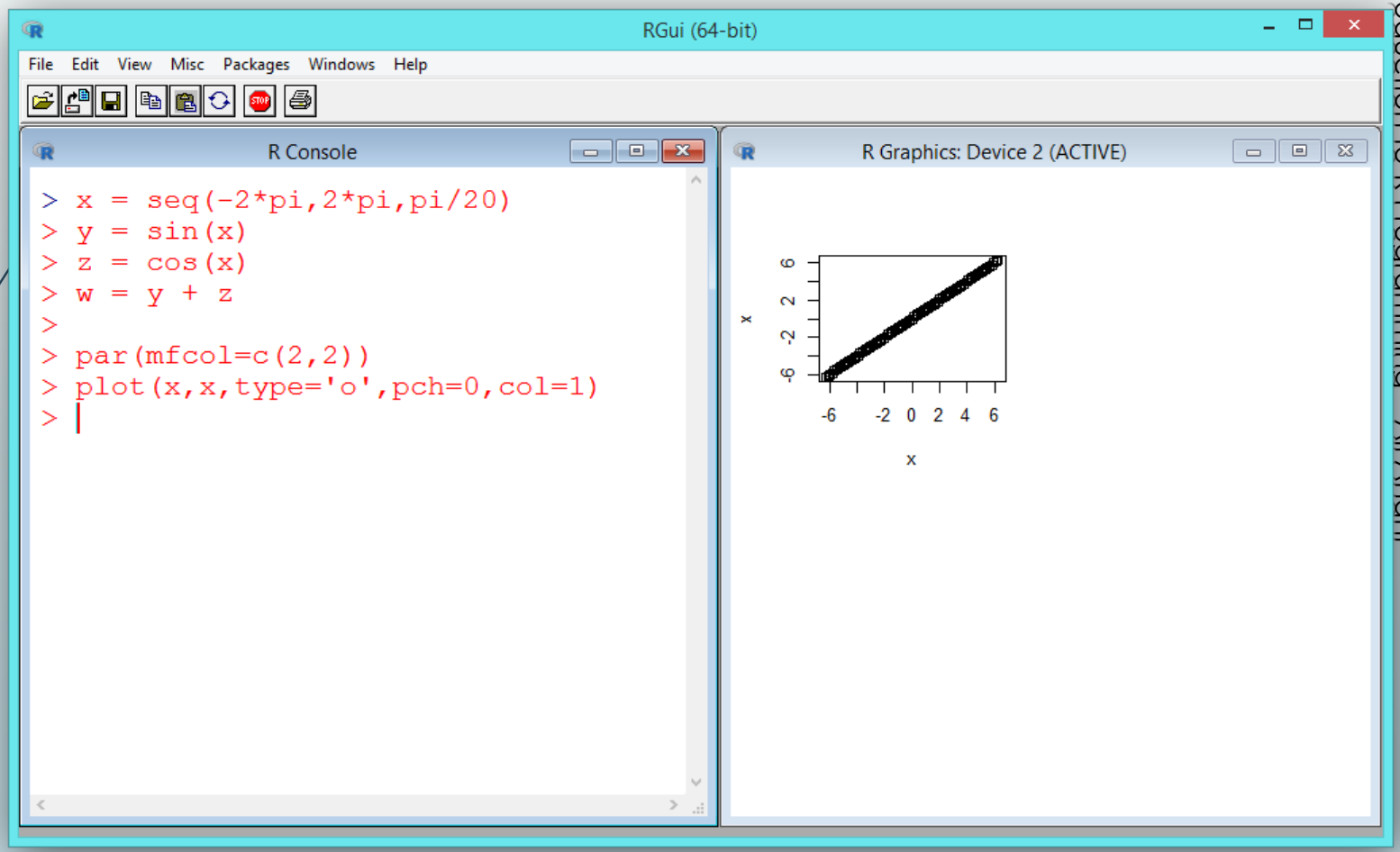
Plot

- Multiple Plots: `par(mfcol=...)`



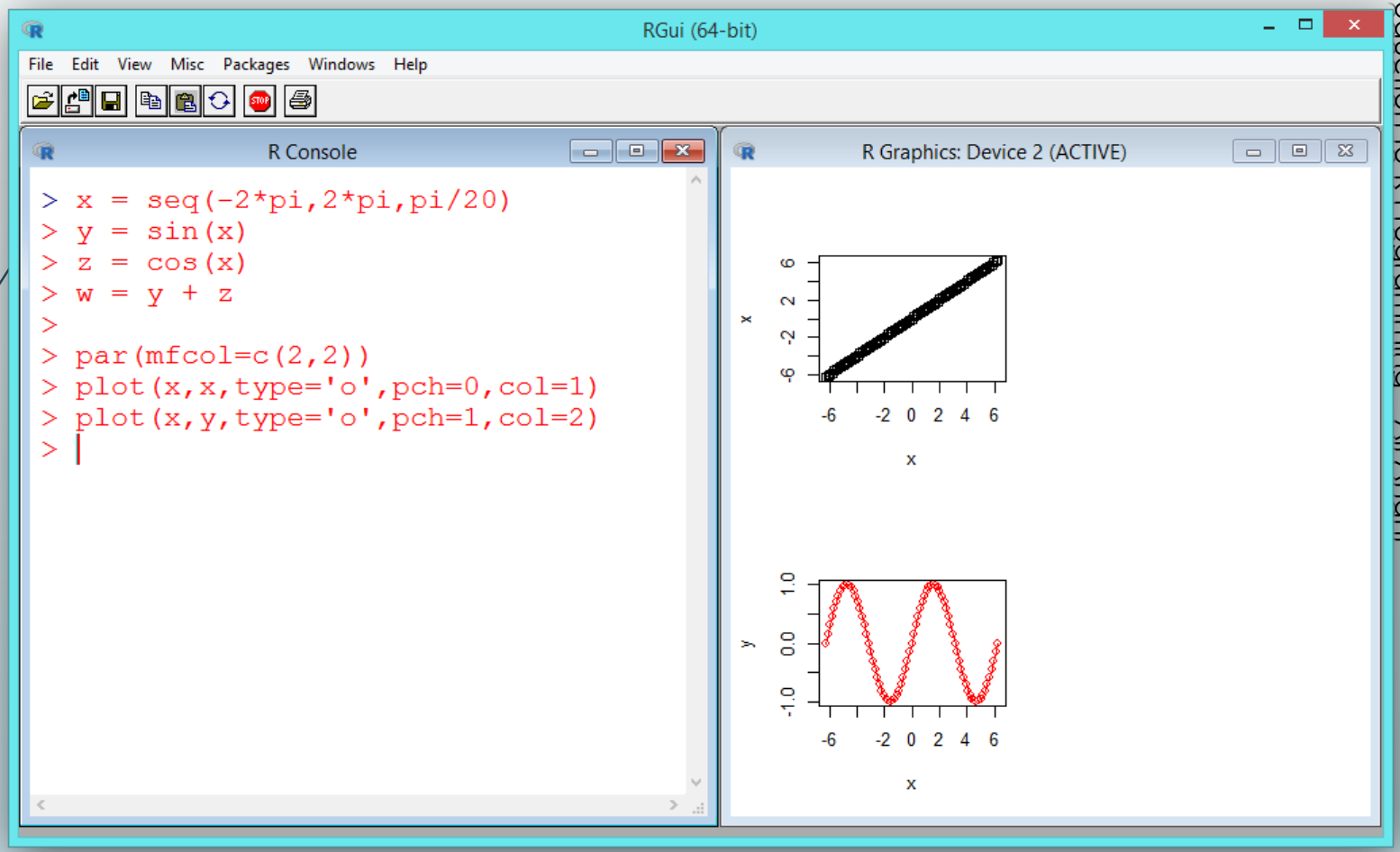
Plot

- Multiple Plots: `par(mfcol=...)`



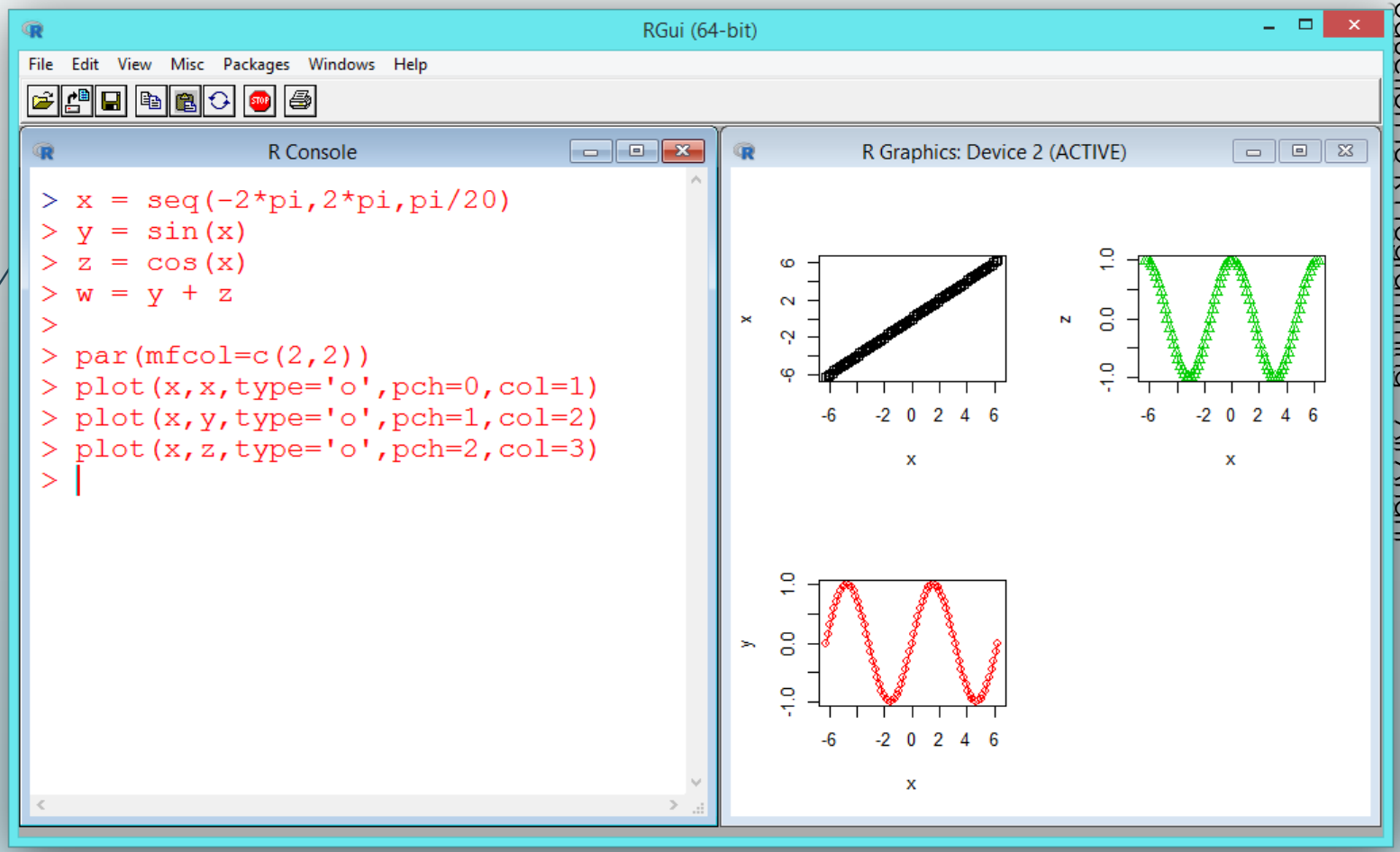
Plot

- Multiple Plots: `par(mfcol=...)`



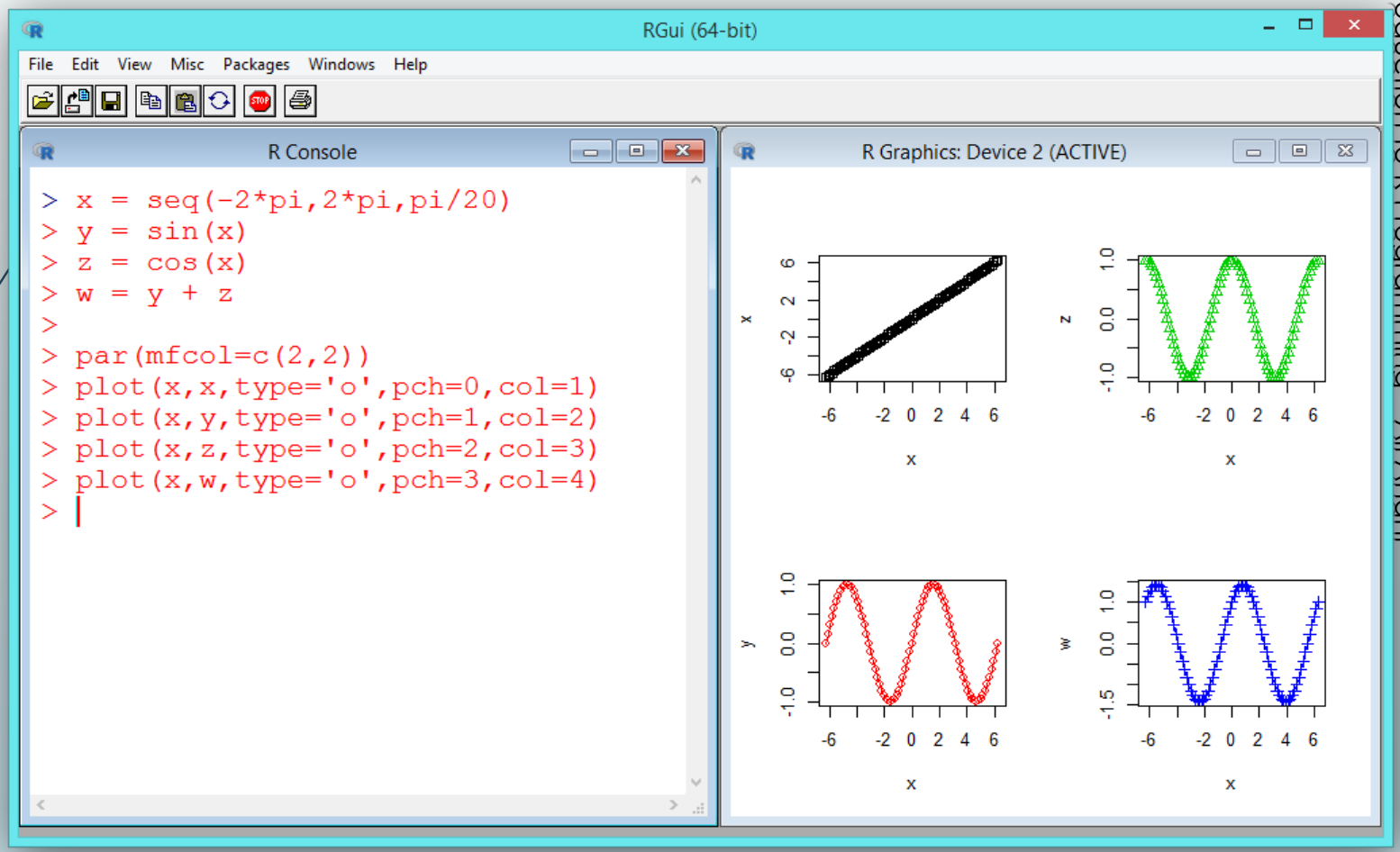
Plot

- Multiple Plots: `par(mfcol=...)`



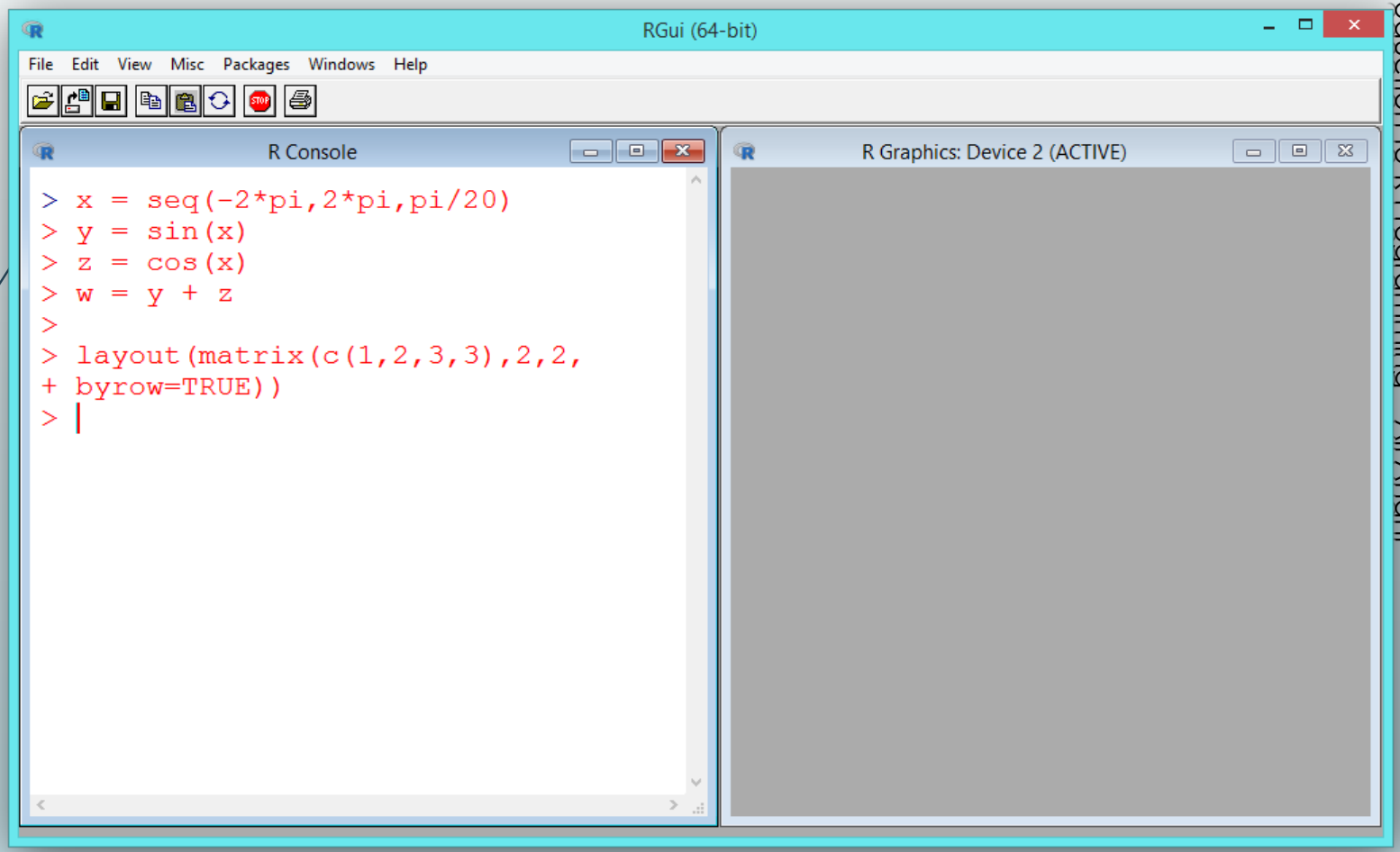
Plot

- Multiple Plots: `par(mfcol=...)`



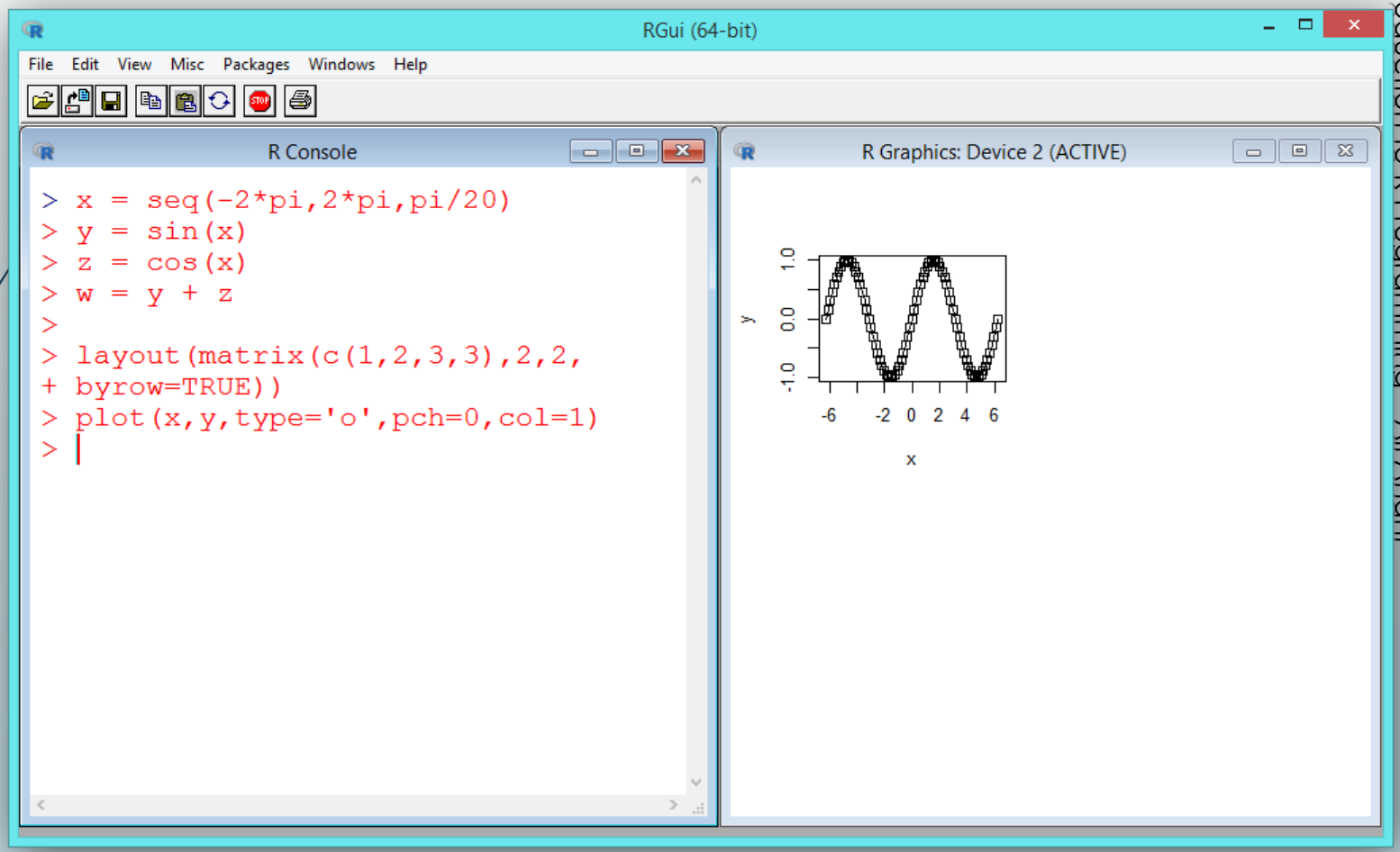
Plot

- Multiple Plots: `layout` Function



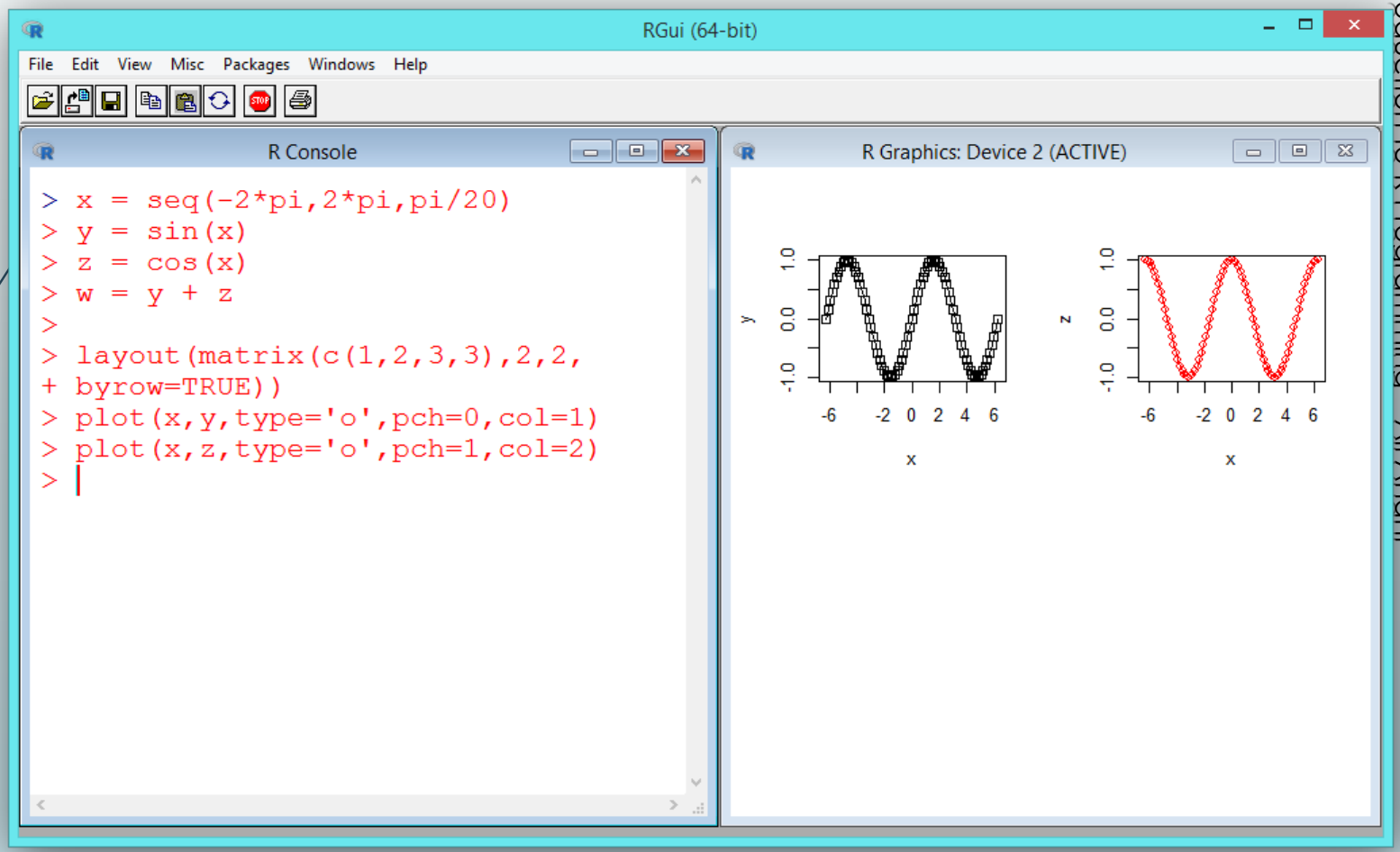
Plot

- Multiple Plots: `layout` Function



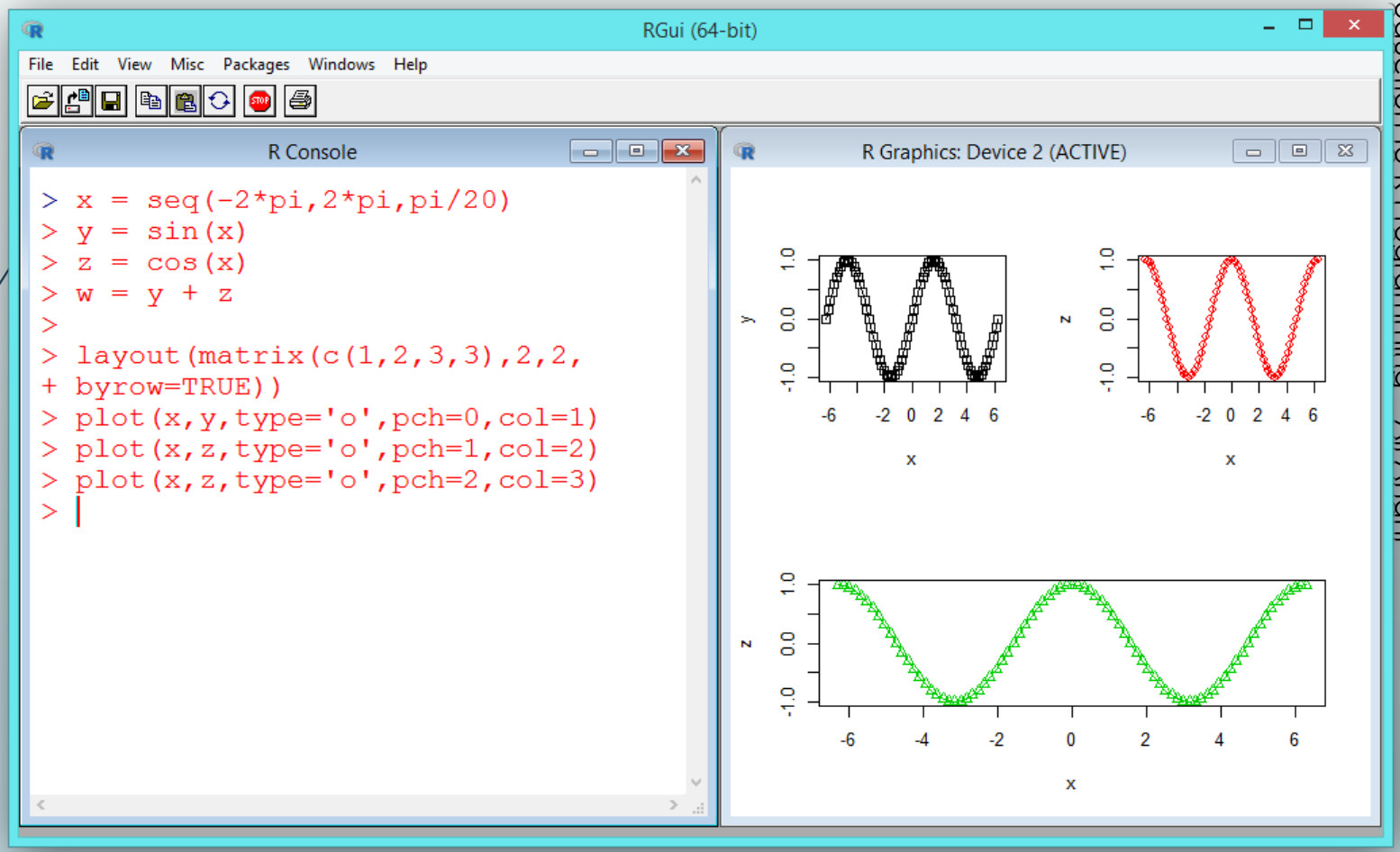
Plot

- Multiple Plots: `layout` Function

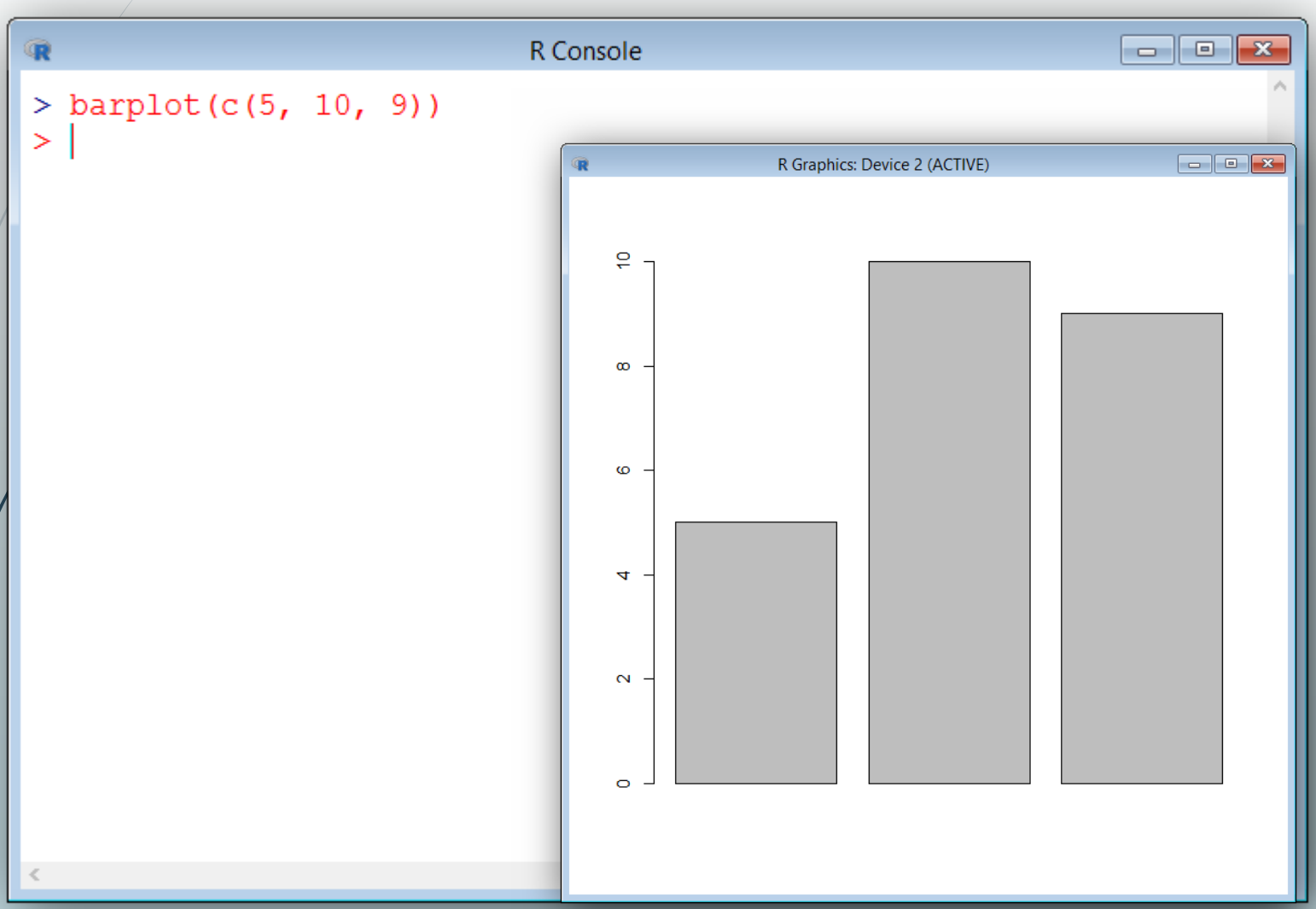


Plot

Multiple Plots: `layout` Function



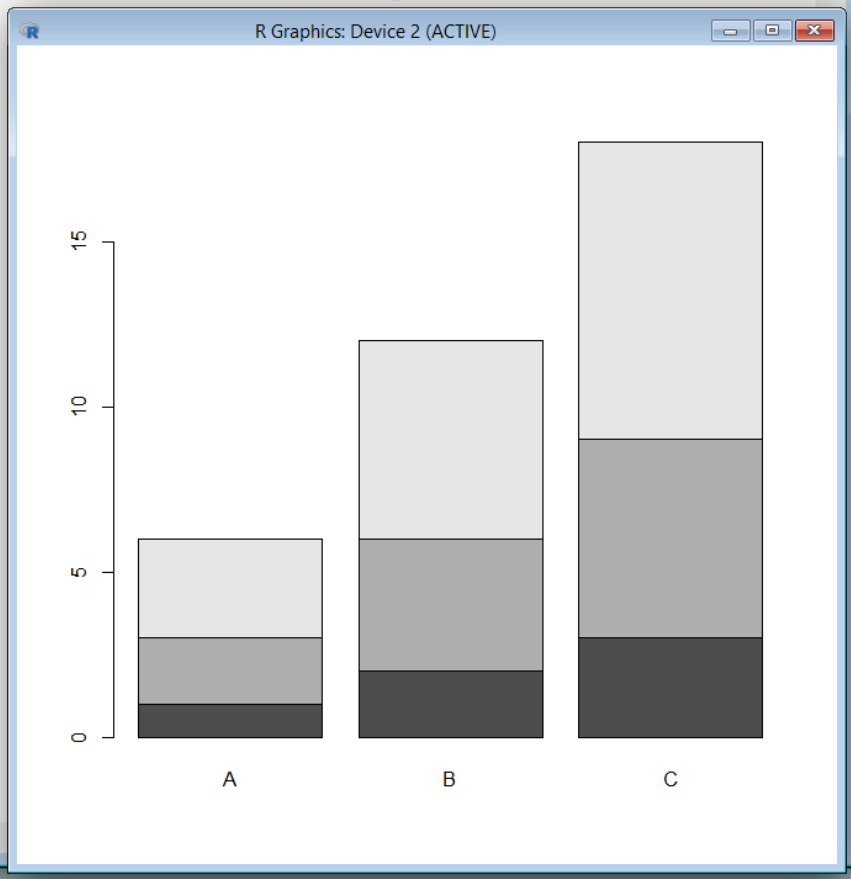
barplot()



barplot()

R Console

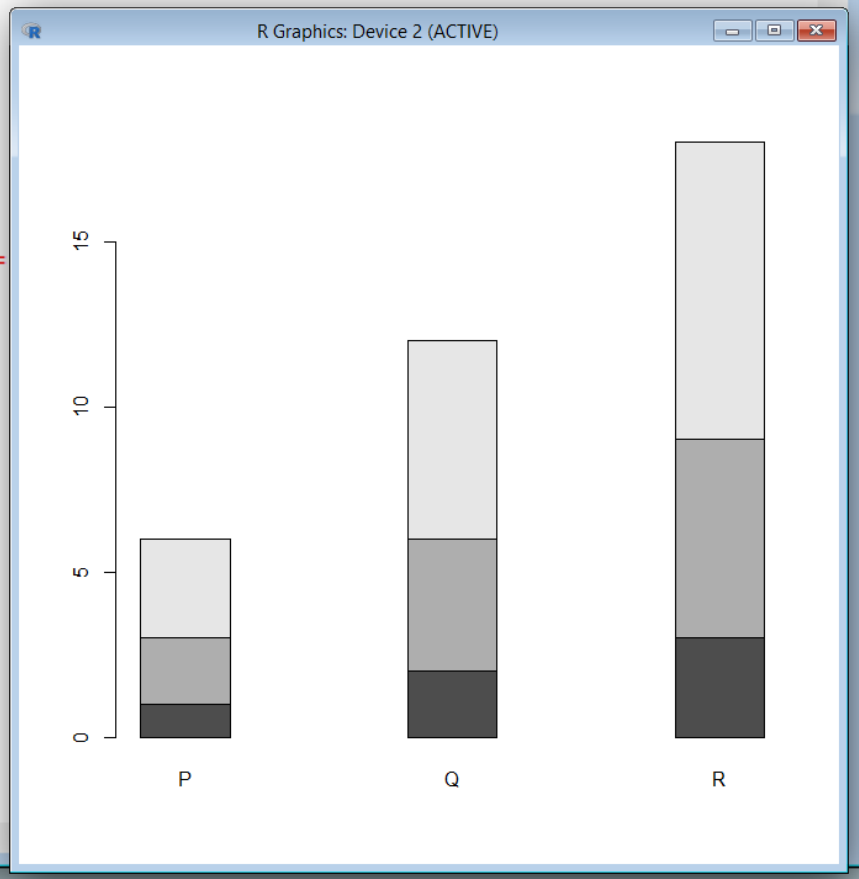
```
> DF = data.frame(A = 1:3, B = c(2, 4, 6), C = seq(3, 9, 3))
> DF
  A B C
1 1 2 3
2 2 4 6
3 3 6 9
>
> barplot(DF)
Error in barplot.default(DF) :
>
> barplot(as.matrix(DF))
>
```



barplot()

R Console

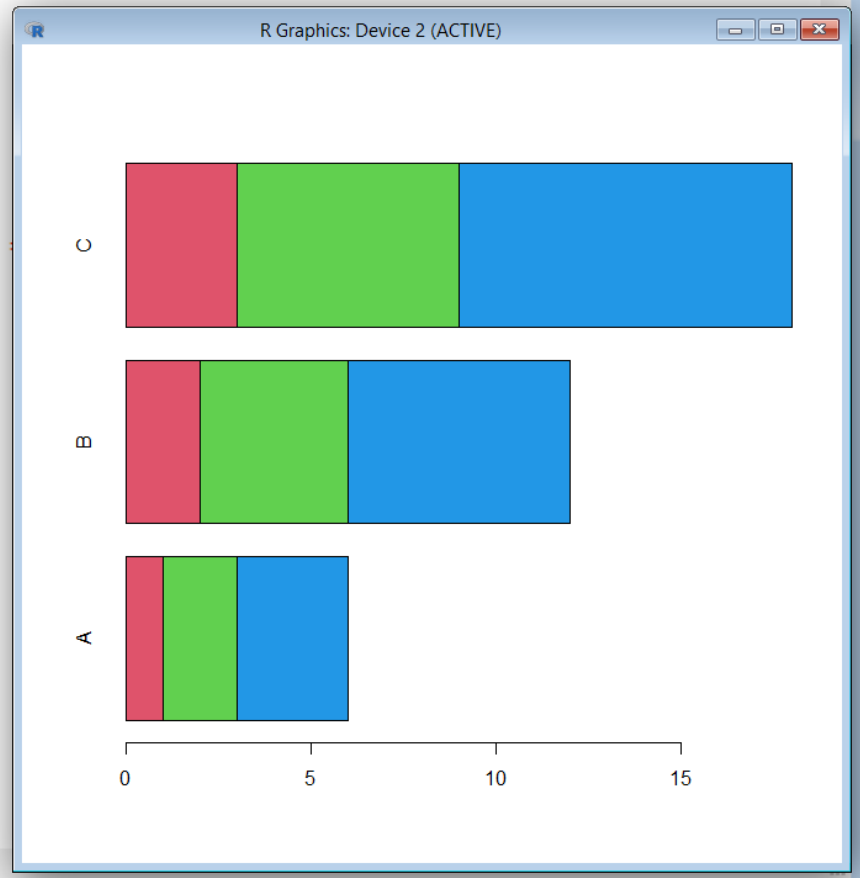
```
> DF
  A B C
1 1 2 3
2 2 4 6
3 3 6 9
> M = as.matrix(DF)
>
> barplot(M, width = 1, space =
>
```



barplot()

R Console

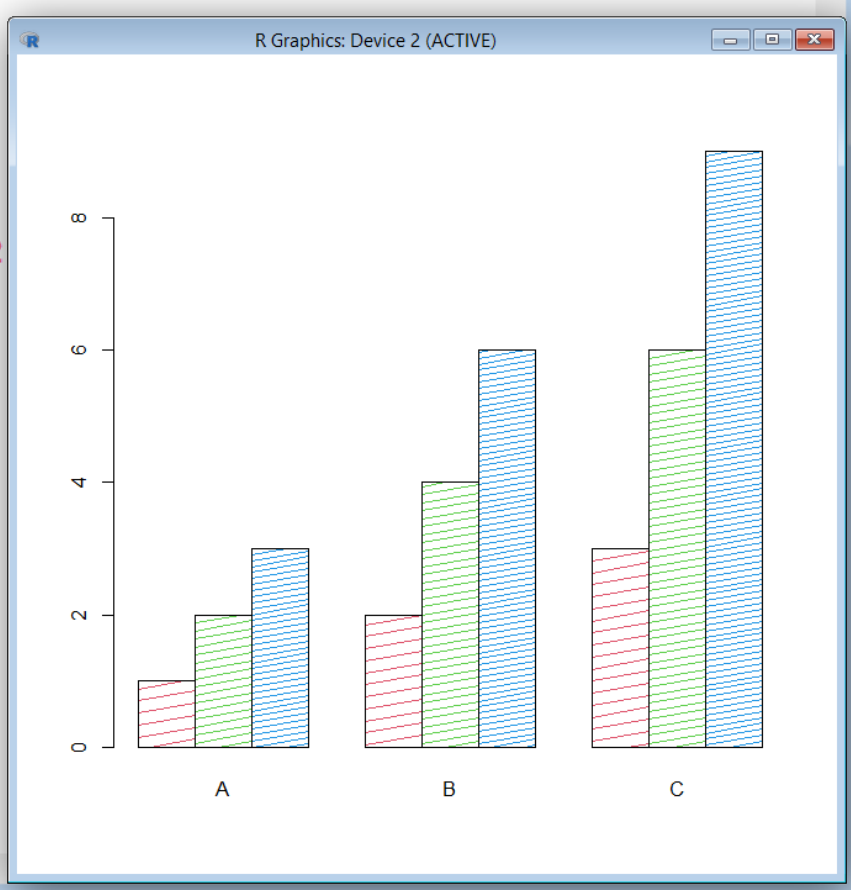
```
> M
     A B C
[1,] 1 2 3
[2,] 2 4 6
[3,] 3 6 9
>
> barplot(M, horiz = TRUE, col
>
```



barplot()

R Console

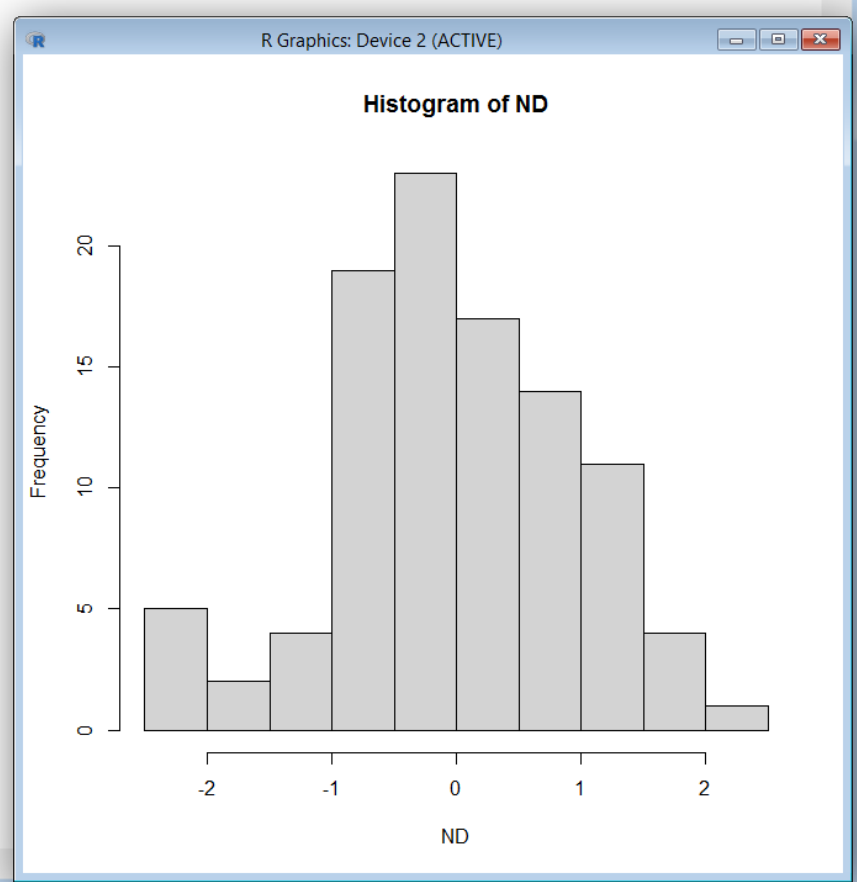
```
> M
     A B C
[1,] 1 2 3
[2,] 2 4 6
[3,] 3 6 9
>
> barplot(M, beside=TRUE, col=2
>
```



hist()

R Console

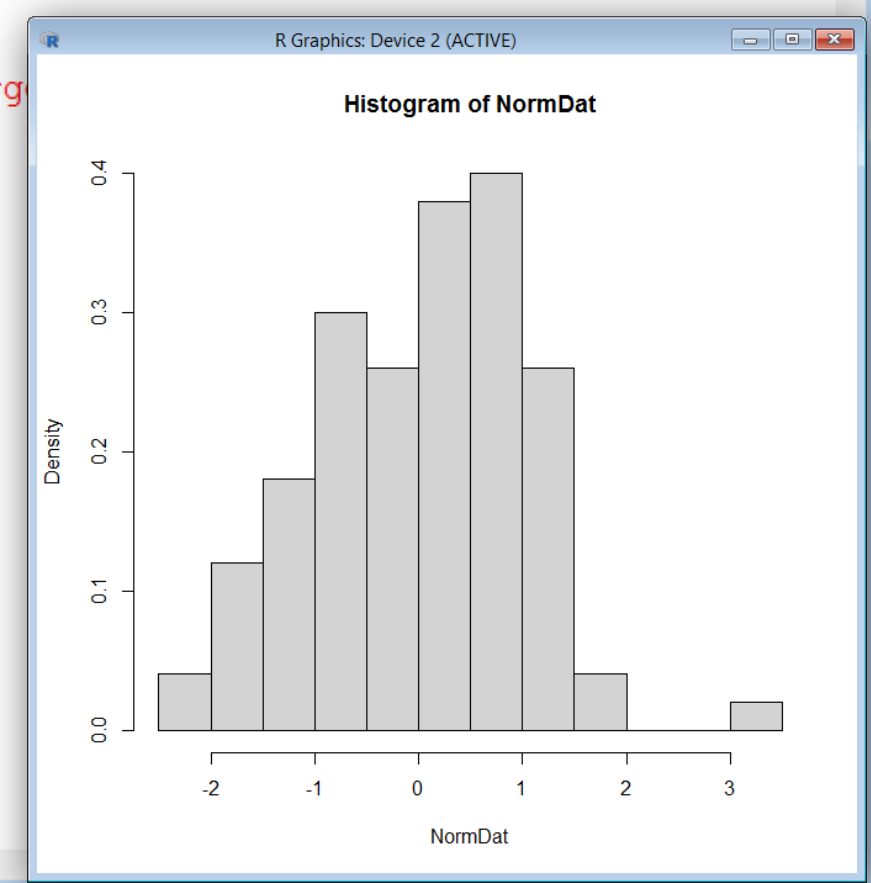
```
> ND = rnorm(100)
>
> hist(ND, breaks = 10)
>
```



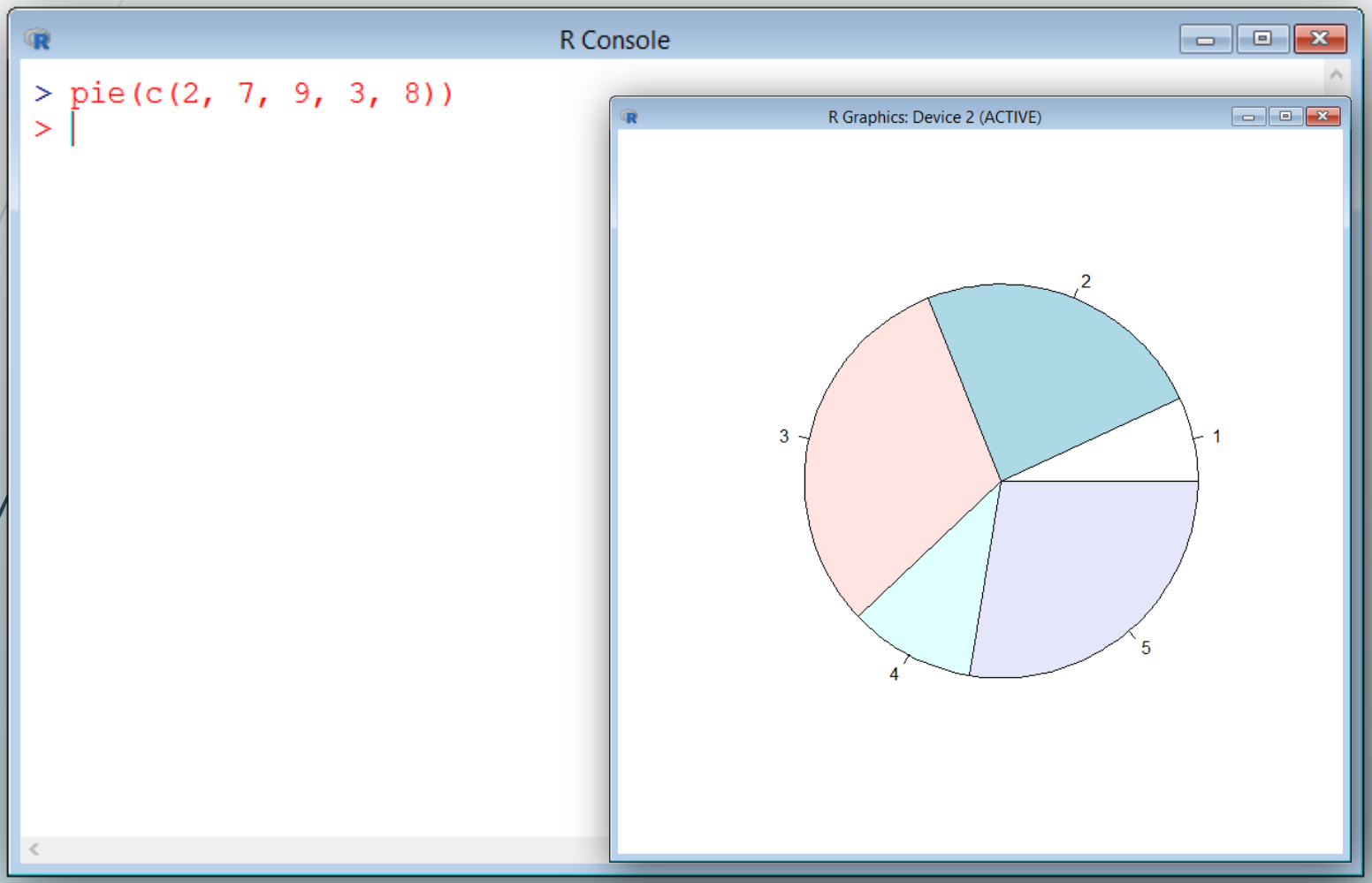
hist()

R Console

```
> NormDat = rnorm(100)
>
> hist(NormDat, breaks = 'Sturg
>
```



pie()

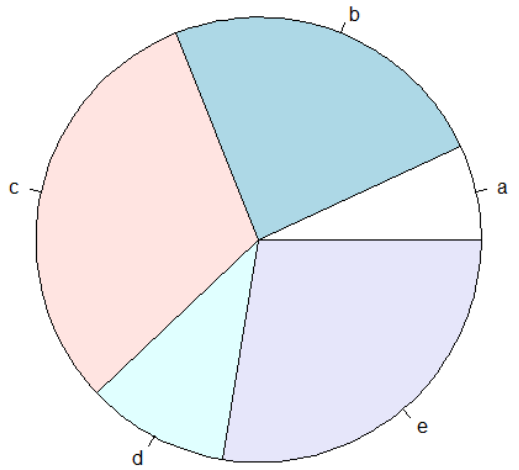


pie()

R Console

```
> pie(c(2, 7, 9, 3, 8), labels = c('a', 'b', 'c', 'd', 'e'))
>
```

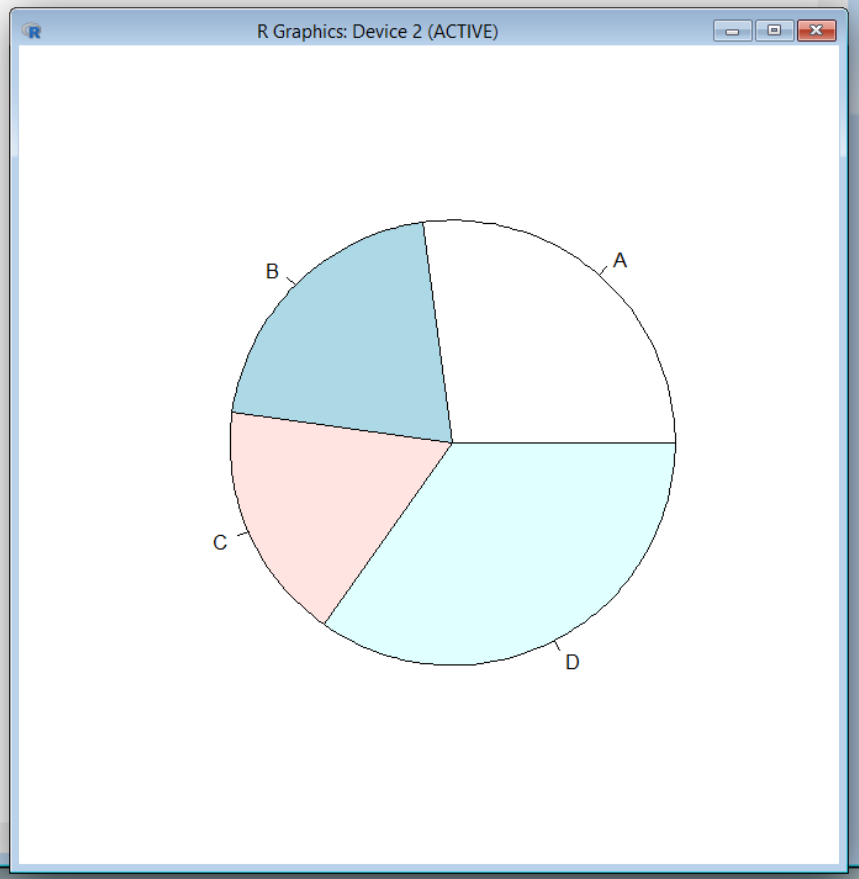
R Graphics: Device 2 (ACTIVE)



pie()

R Console

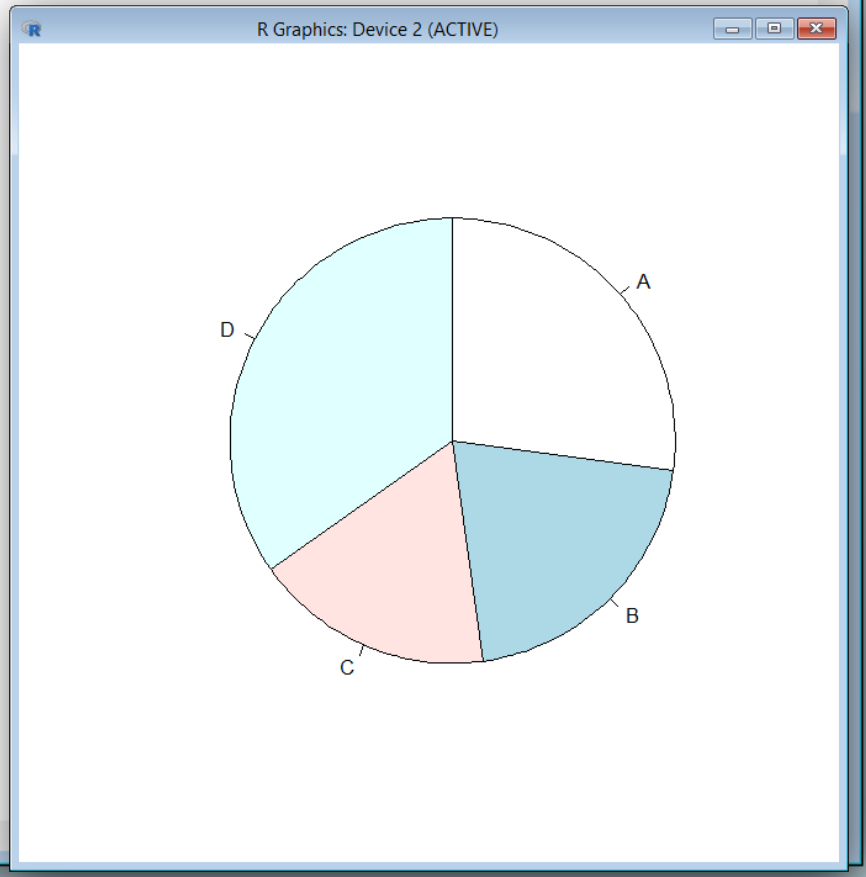
```
> DatVec = c(A=25, B=19, C=16, D=32)
> DatVec
 A  B  C  D
25 19 16 32
>
> pie(DatVec)
>
```



pie()

R Console

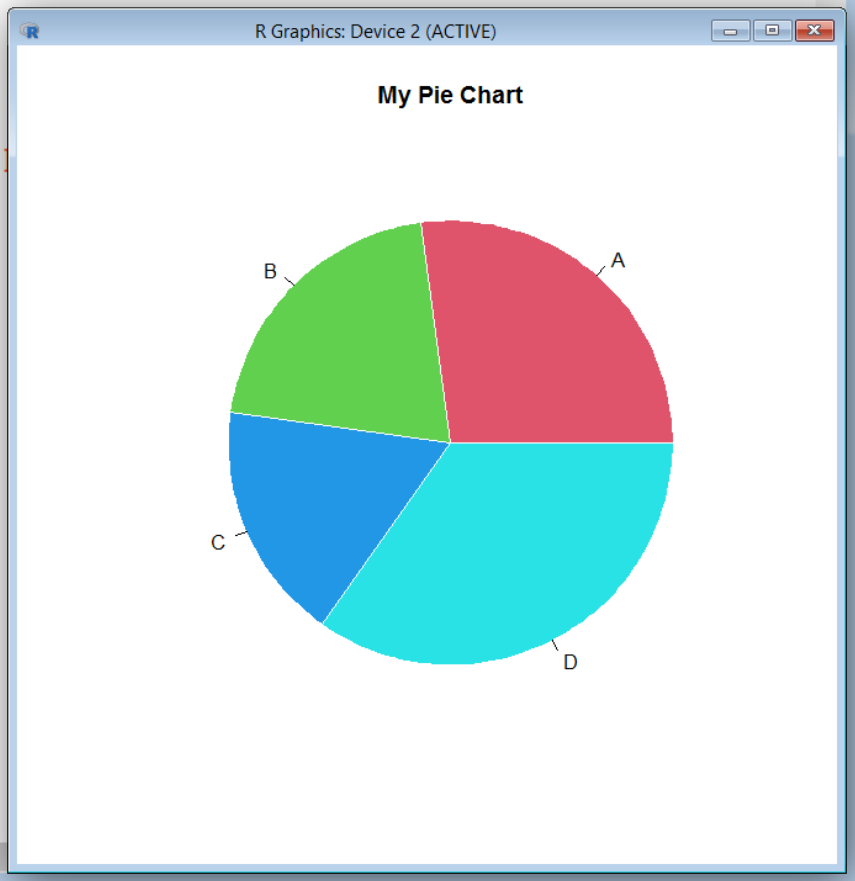
```
> DatVec = c(A=25, B=19, C=16, D=32)
> DatVec
 A  B  C  D
25 19 16 32
>
> pie(DatVec, clockwise = TRUE)
>
```



pie()

R Console

```
> DatVec
 A  B  C  D
25 19 16 32
>
> pie(DatVec, col= c(2,3,4,5), 
>
```

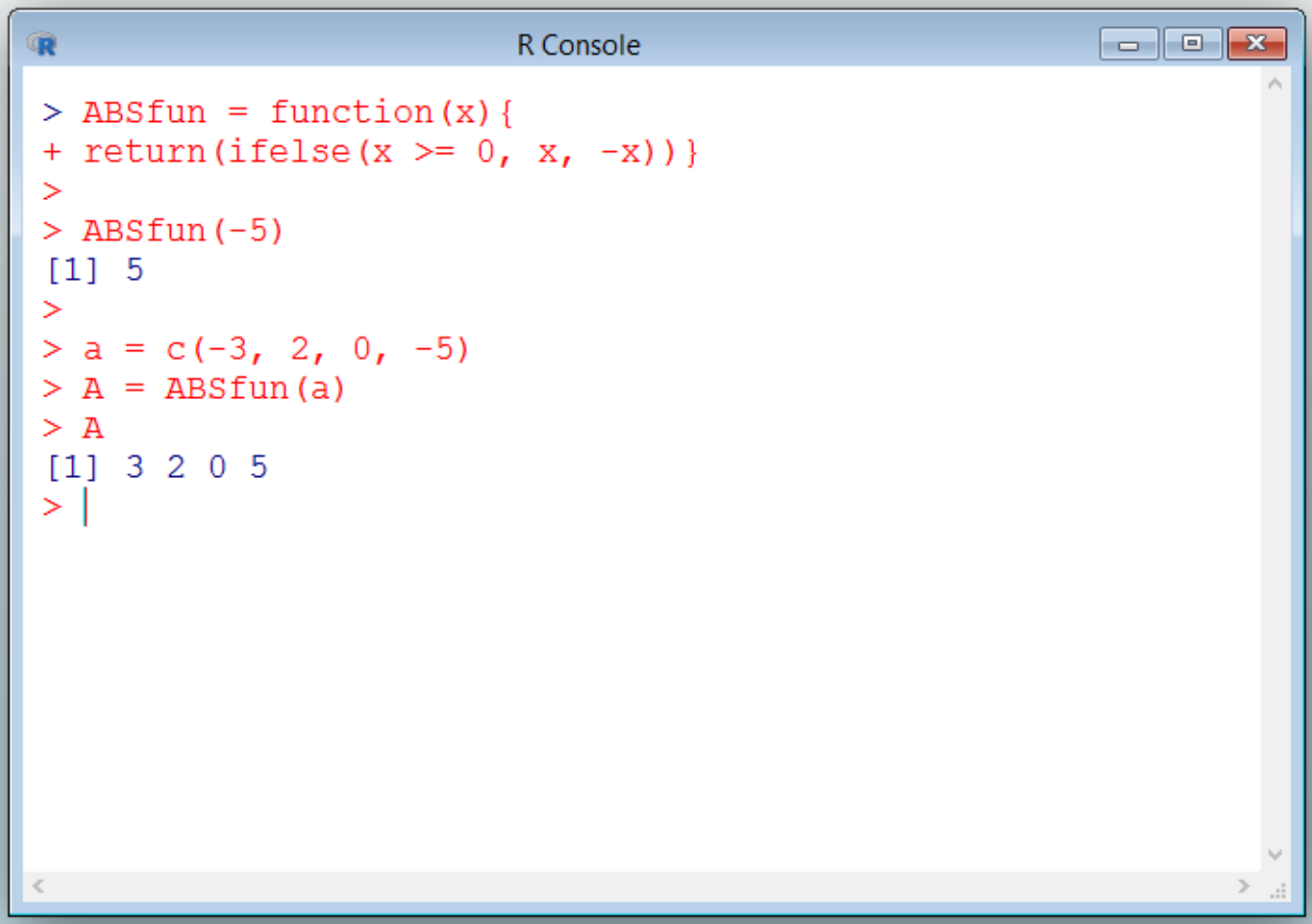


User-Defined Functions

Functional Programming

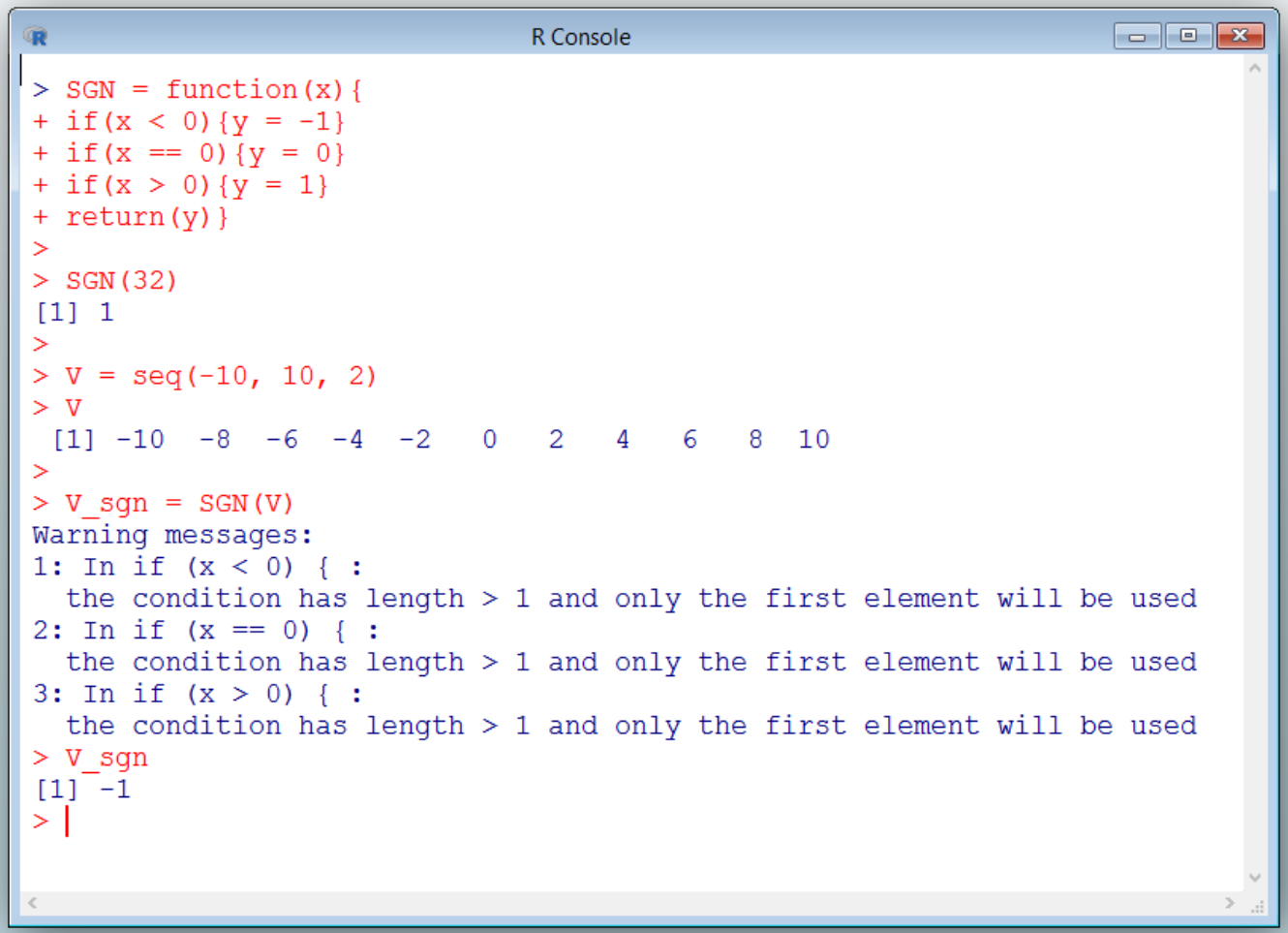
function(){}

- Example: absolute value



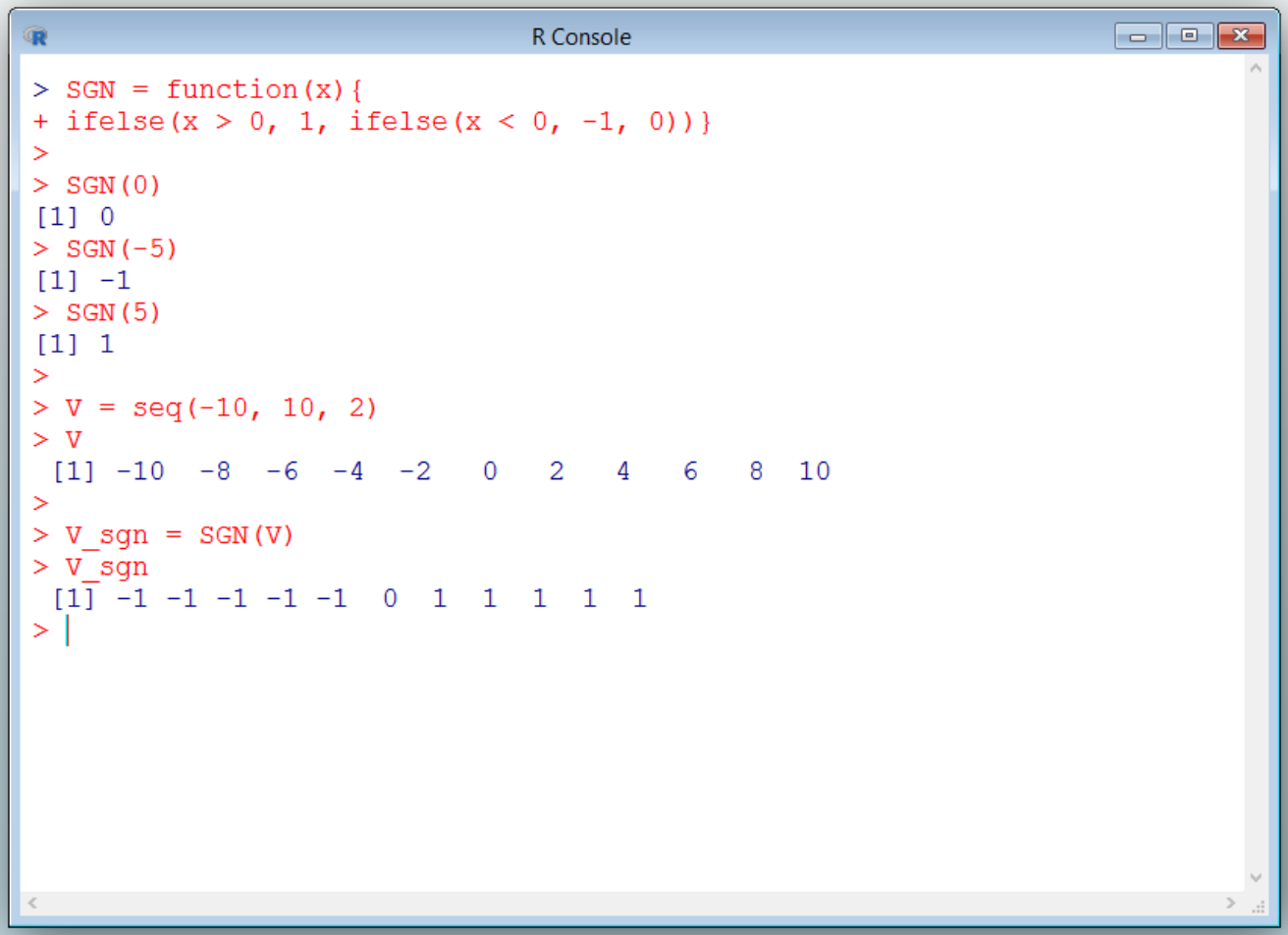
function(){}

- Example: sign function



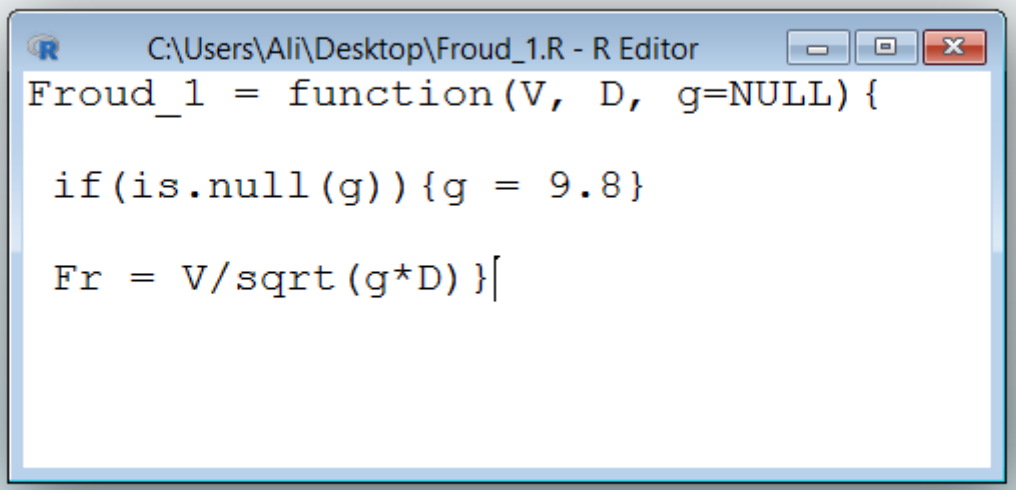
function(){}

- Example: sign function



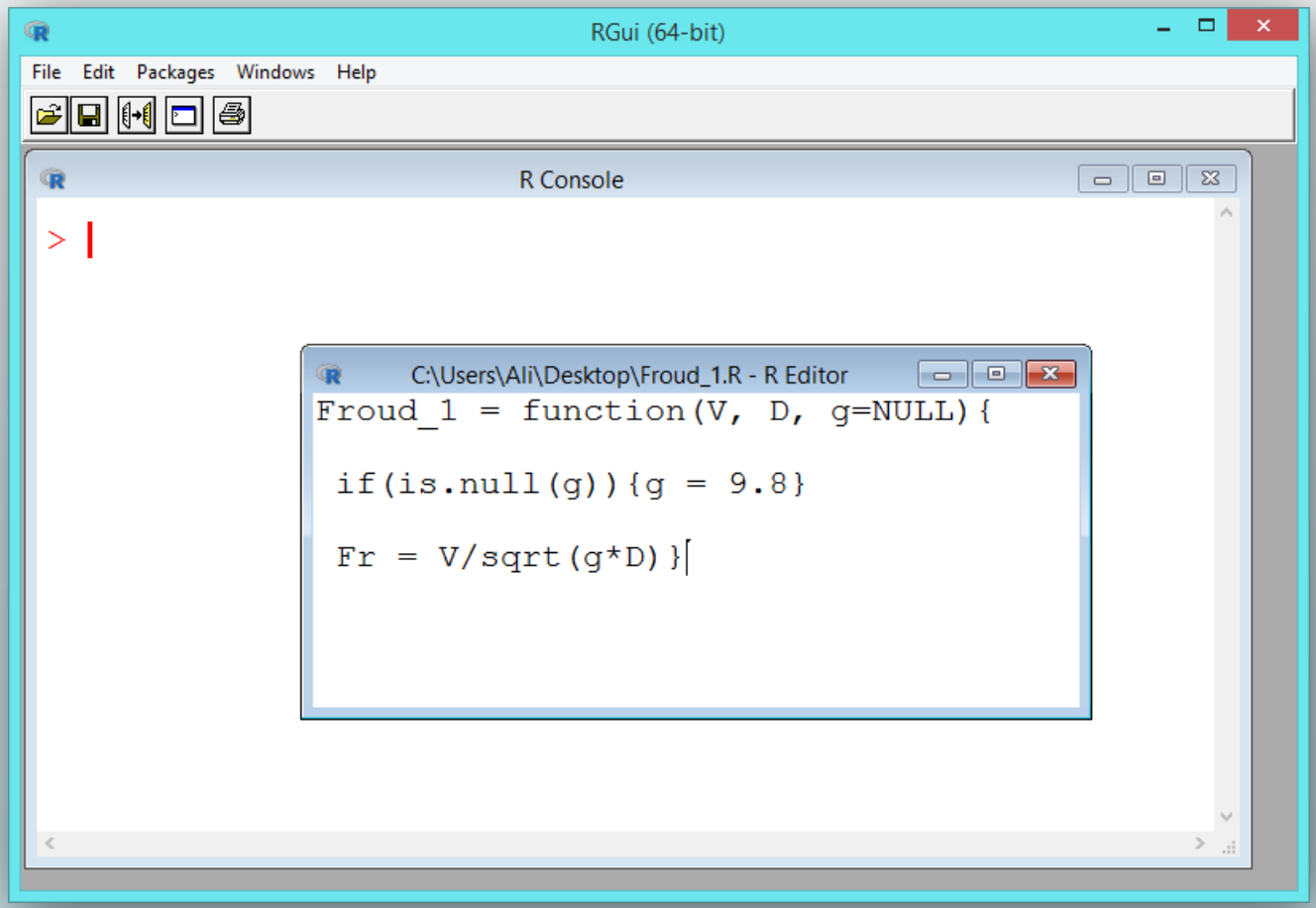
function(){}

- Example: Froud Number



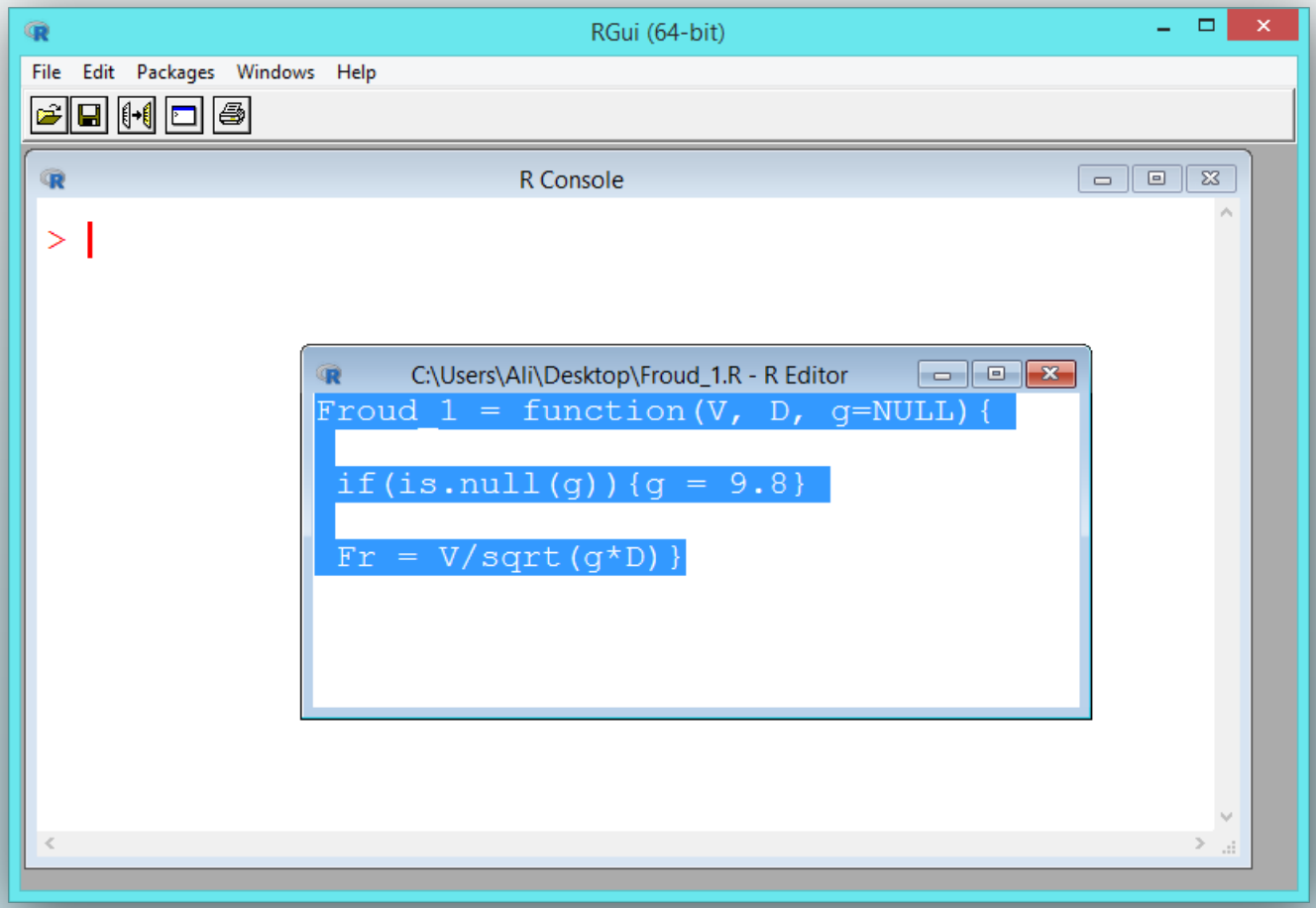
function(){}

- Example: Froud Number



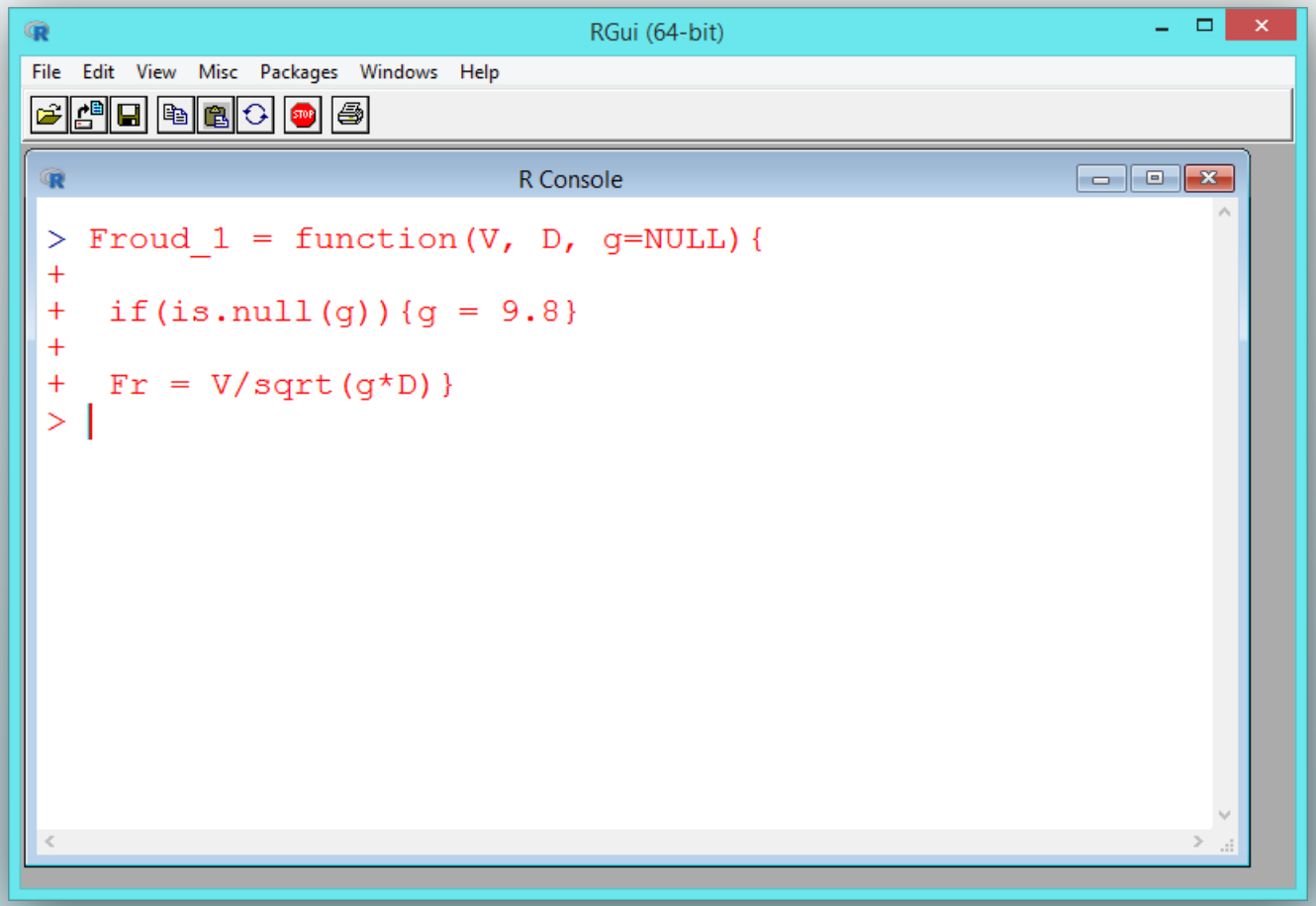
function(){}

- Example: Froud Number



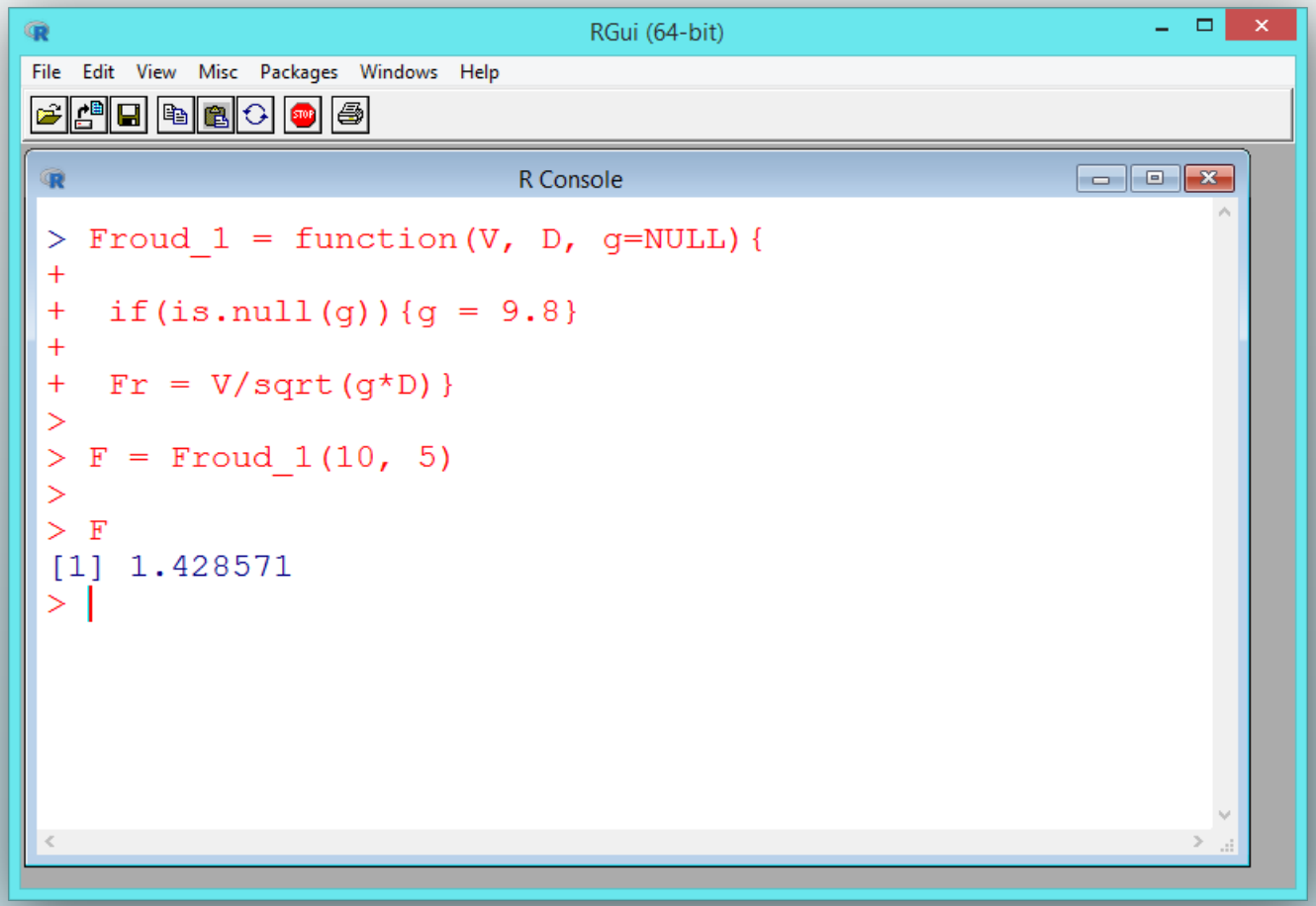
function(){}

- Example: Froud Number



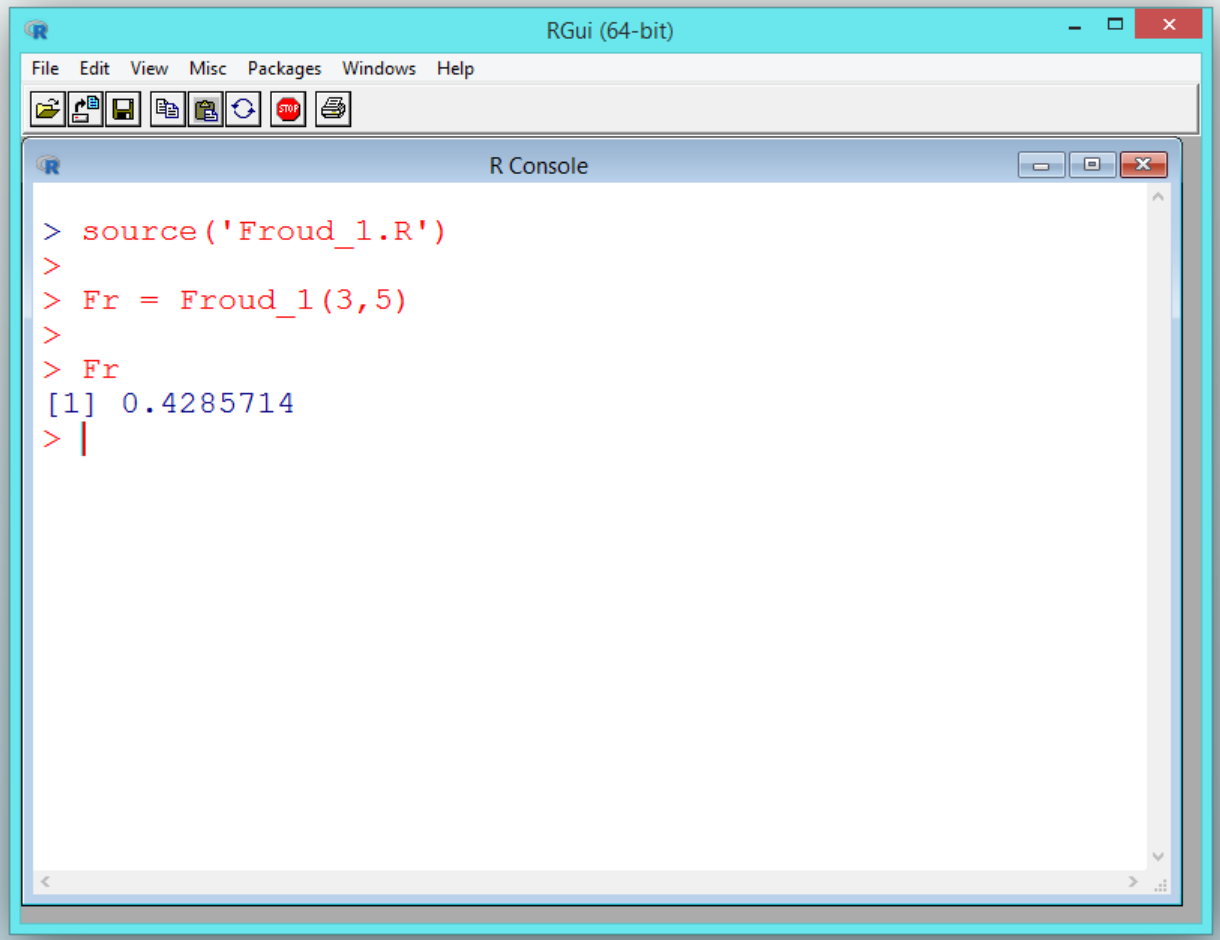
function(){}

- Example: Froud Number



function() {} and source()

- Example: Froud Number



function() {} and source()

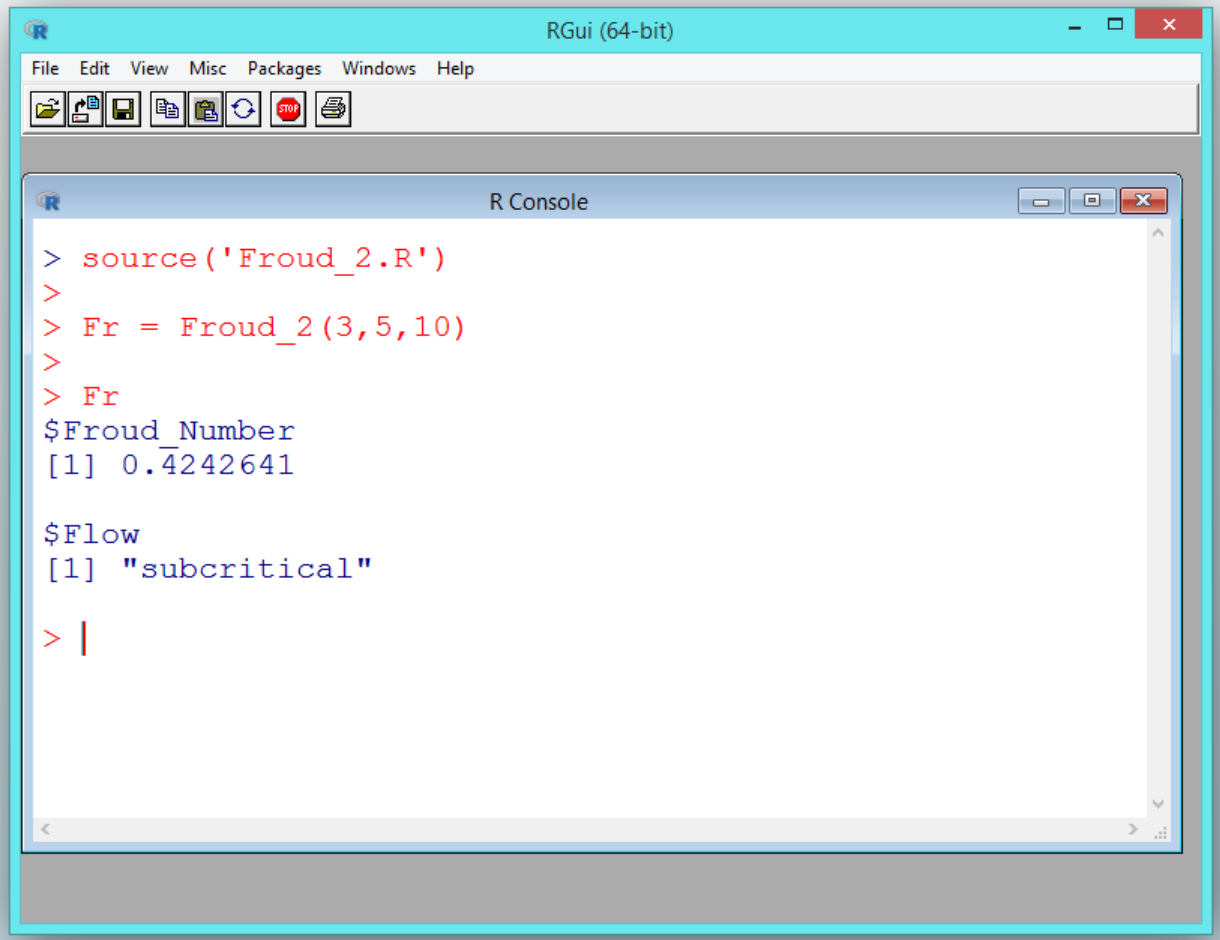
- Example: Froud Number

C:\Users\Ali\Desktop\Froud_2.R - R Editor

```
Froud_2 = function(V, D, g=NULL){

 if(is.null(g)){g = 9.8}

 Fr = V/sqrt(g*D)

 if(Fr < 1){flow = 'subcritical'}
  else if(Fr == 1){flow = 'critical'}
  else{flow = 'supercritical'}

 list(Froud_Number = Fr, Flow = flow)
}
```

function() {} and source()

- Example: Froud Number



function() {} and source()

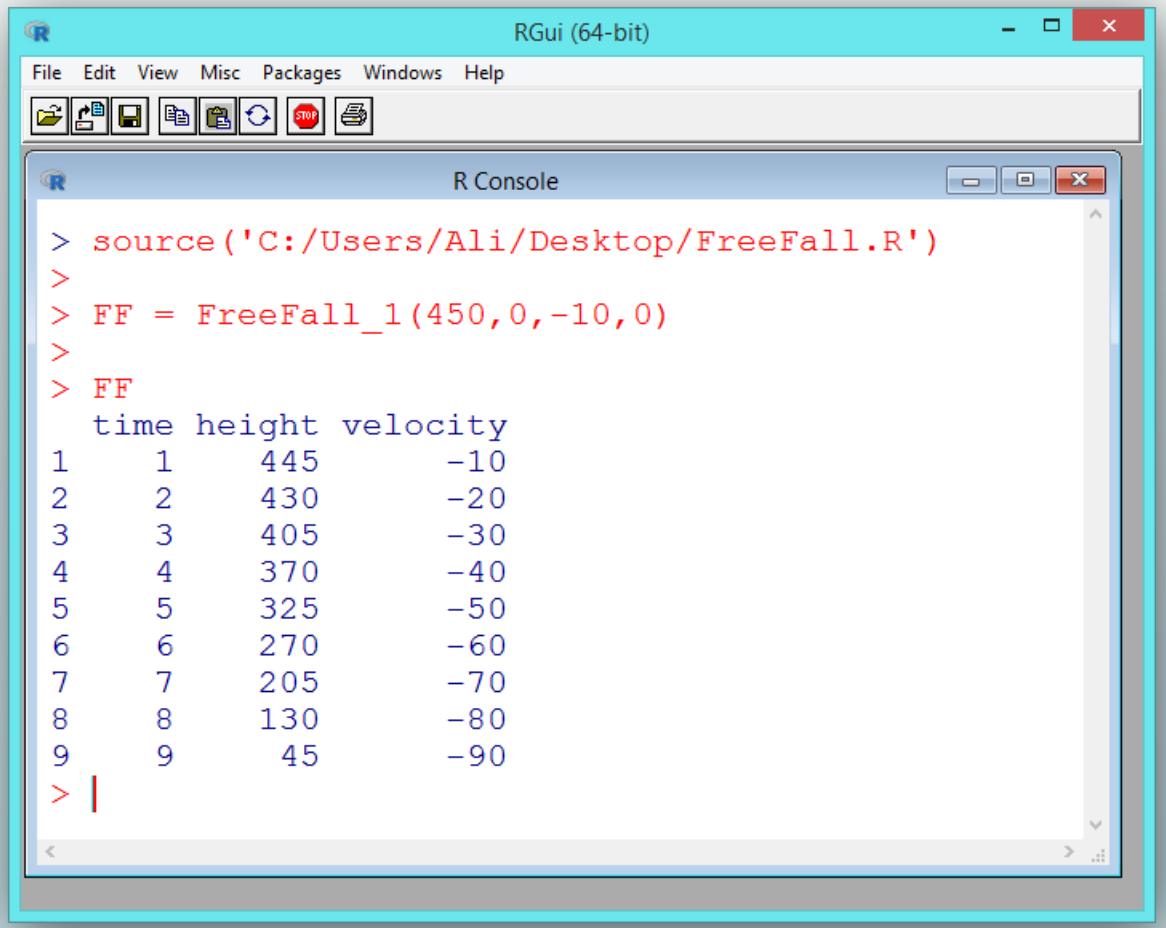
- Example: Free Fall

C:\Users\Ali\Desktop\FreeFall.R - R Editor

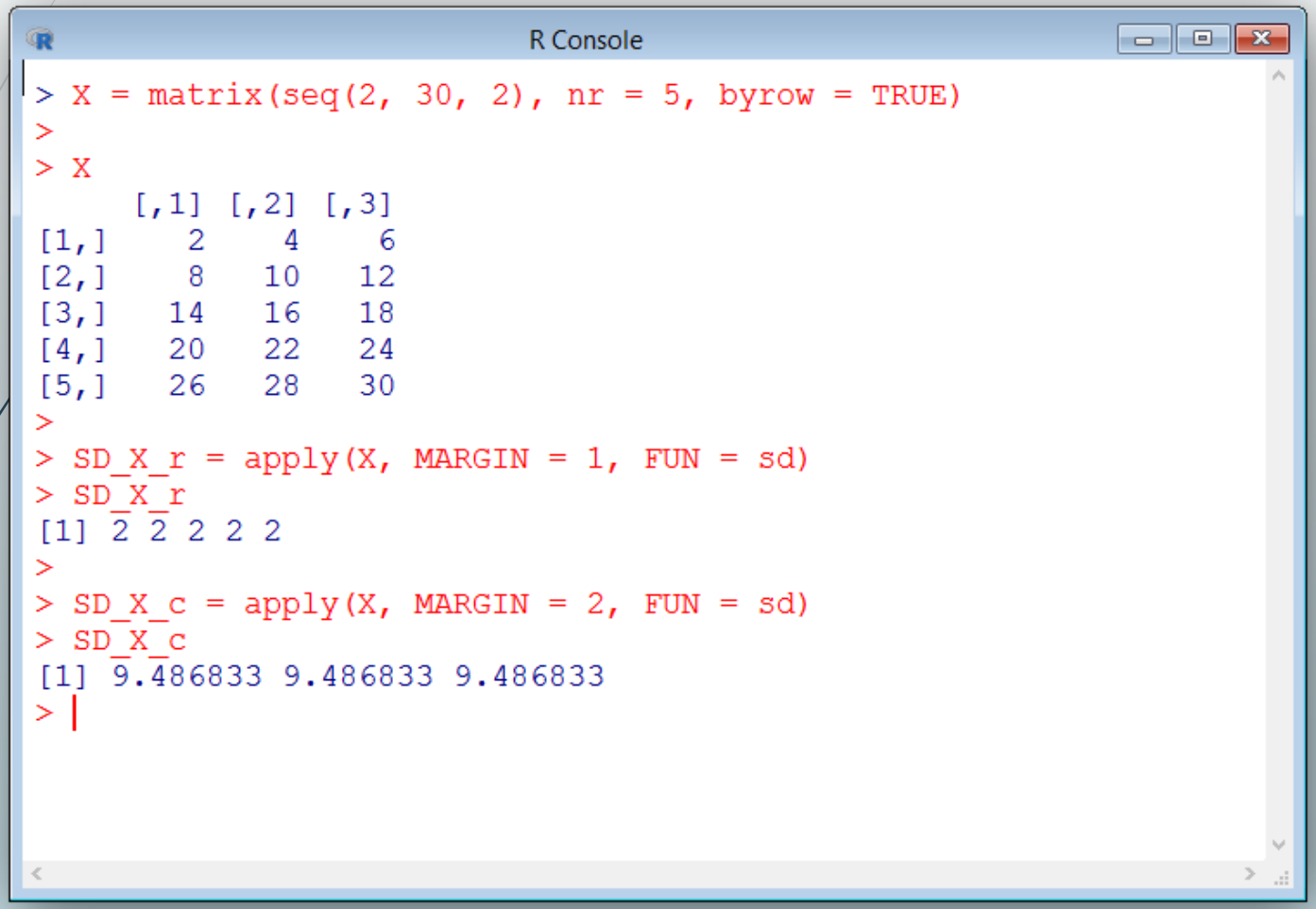
```
FreeFall_1 = function(y_0, v_0=NULL, g=NULL, y=NULL){

 if(is.null(v_0)){v_0 = 0}
 if(is.null(g)){g = -9.8}
 if(is.null(y)){y = 0}

 dy = y-y_0

 delta = v_0^2 - 4*0.5*g*(-dy)
 t_1 = (-v_0 + sqrt(delta)) / (2*0.5*g)
 t_2 = (-v_0 - sqrt(delta)) / (2*0.5*g)
 t = max(t_1, t_2)

 v_1 = c()
 y_1 = c()
 for(i in 1:t){
  v_1[i] = g*i + v_0
  y_1[i] = 0.5*g*i^2 + v_0*i + y_0}

 data.frame(time = 1:t, height = y_1, velocity = v_1)}

########################################
FreeFall_2 = function(y_0, v_0=NULL, g=NULL, y=NULL){

 if(is.null(v_0)){v_0 = 0}
 if(is.null(g)){g = -9.8}
 if(is.null(y)){y = 0}

 dy = y-y_0

 y_2 = seq(y_0, y, -10)
 v_2 = -sqrt(2*g*(y_2-y_0) + v_0^2)
 T = (v_2 - v_0)/g

 data.frame(Height = y_2, Velocity = v_2, Time = T)}
```

function() {} and source()

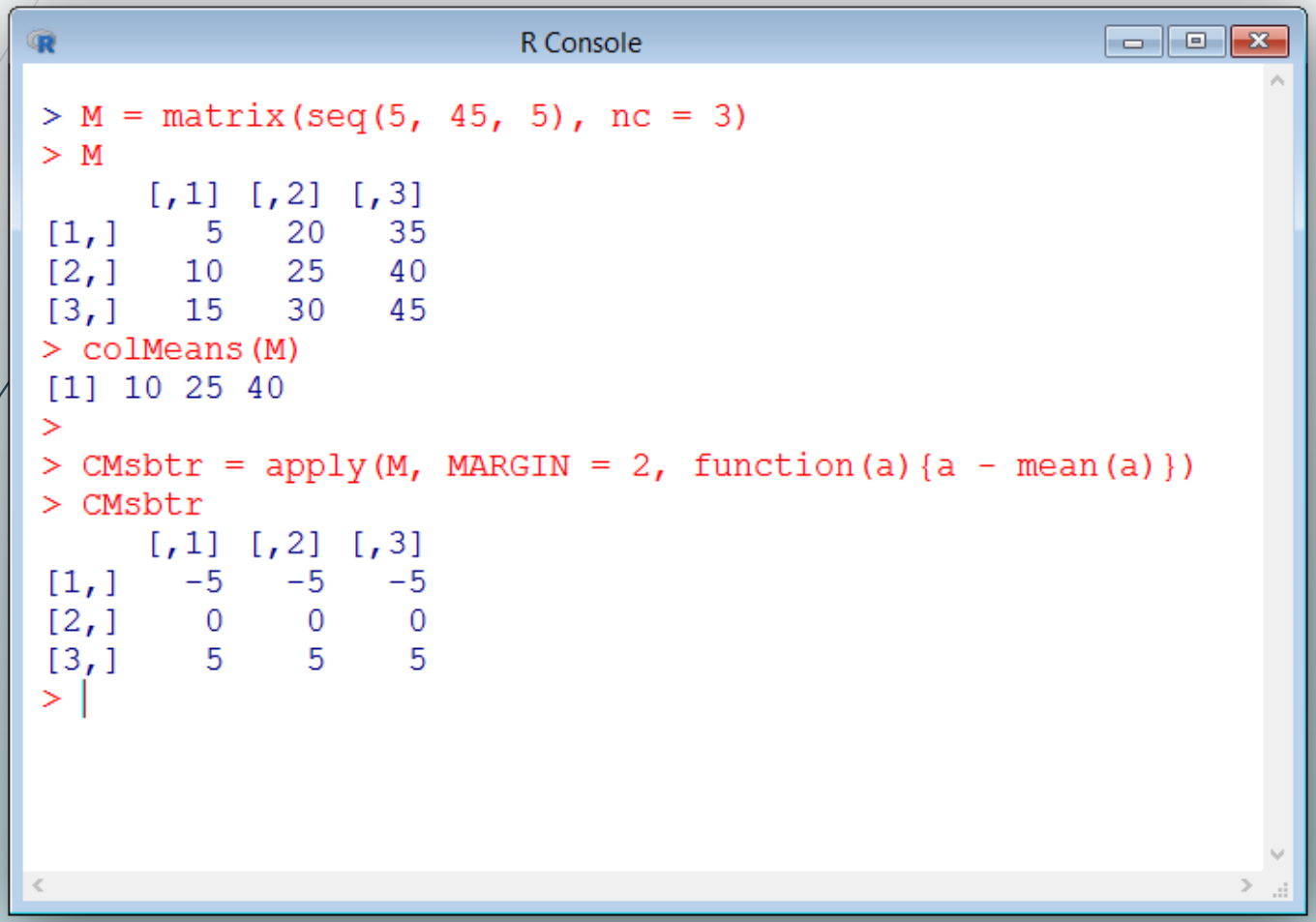
- Example: Free Fall



apply()


R Console
> X = matrix(seq(2, 30, 2), nr = 5, byrow = TRUE)
>
> X
     [,1] [,2] [,3]
[1,]   2   4   6
[2,]   8   10   12
[3,]   14   16   18
[4,]   20   22   24
[5,]   26   28   30
>
> SD_X_r = apply(X, MARGIN = 1, FUN = sd)
> SD_X_r
[1] 2 2 2 2 2
>
> SD_X_c = apply(X, MARGIN = 2, FUN = sd)
> SD_X_c
[1] 9.486833 9.486833 9.486833
>

apply()

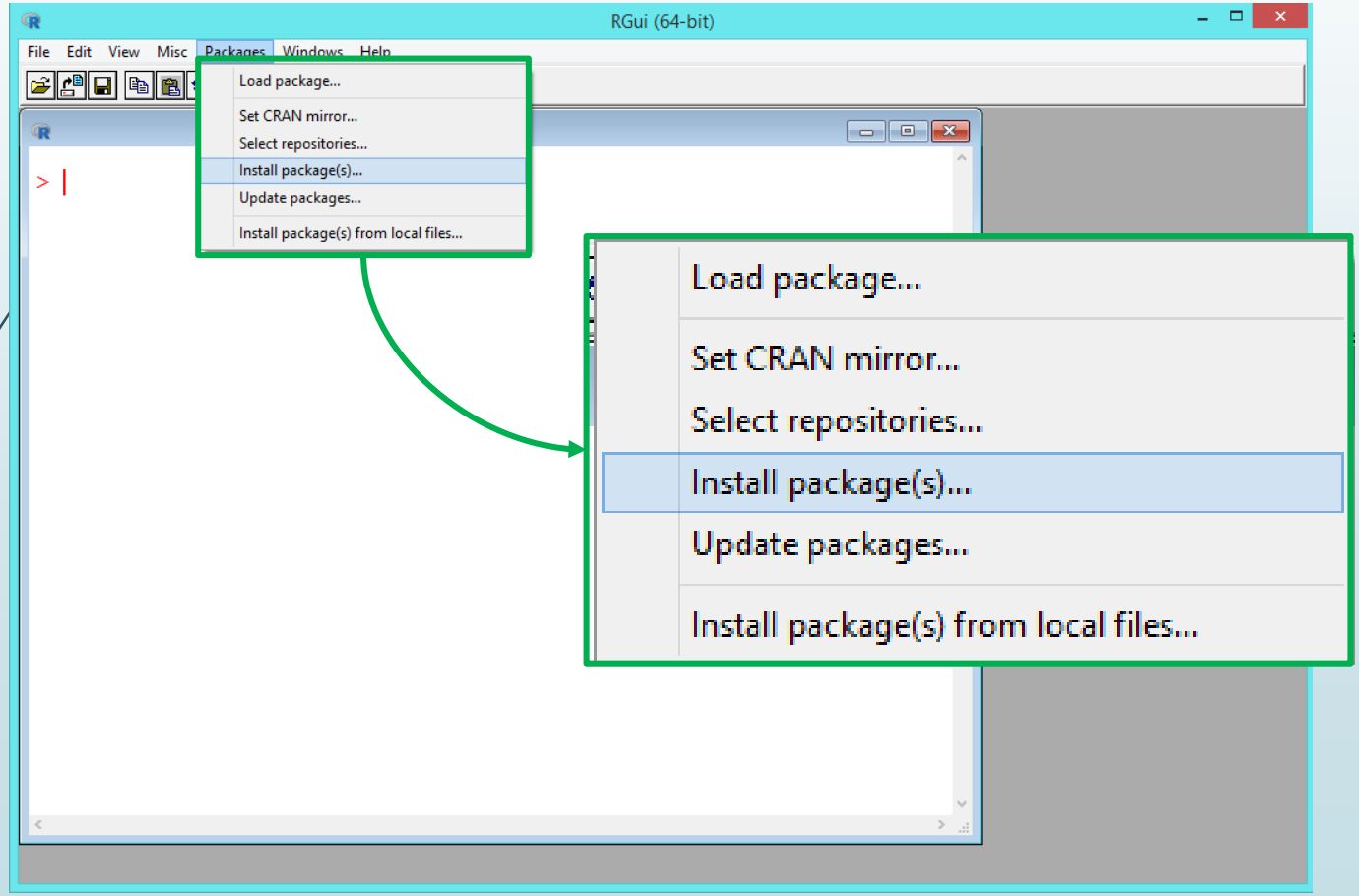

R Console
> M = matrix(seq(5, 45, 5), nc = 3)
> M
     [,1] [,2] [,3]
[1,]   5   20   35
[2,]   10   25   40
[3,]   15   30   45
> colMeans(M)
[1] 10 25 40
>
> CMsbtr = apply(M, MARGIN = 2, function(a){a - mean(a)})
> CMsbtr
     [,1] [,2] [,3]
[1,]   -5   -5   -5
[2,]   0   0   0
[3,]   5   5   5
>

Packages

Downloading and Installing R Packages

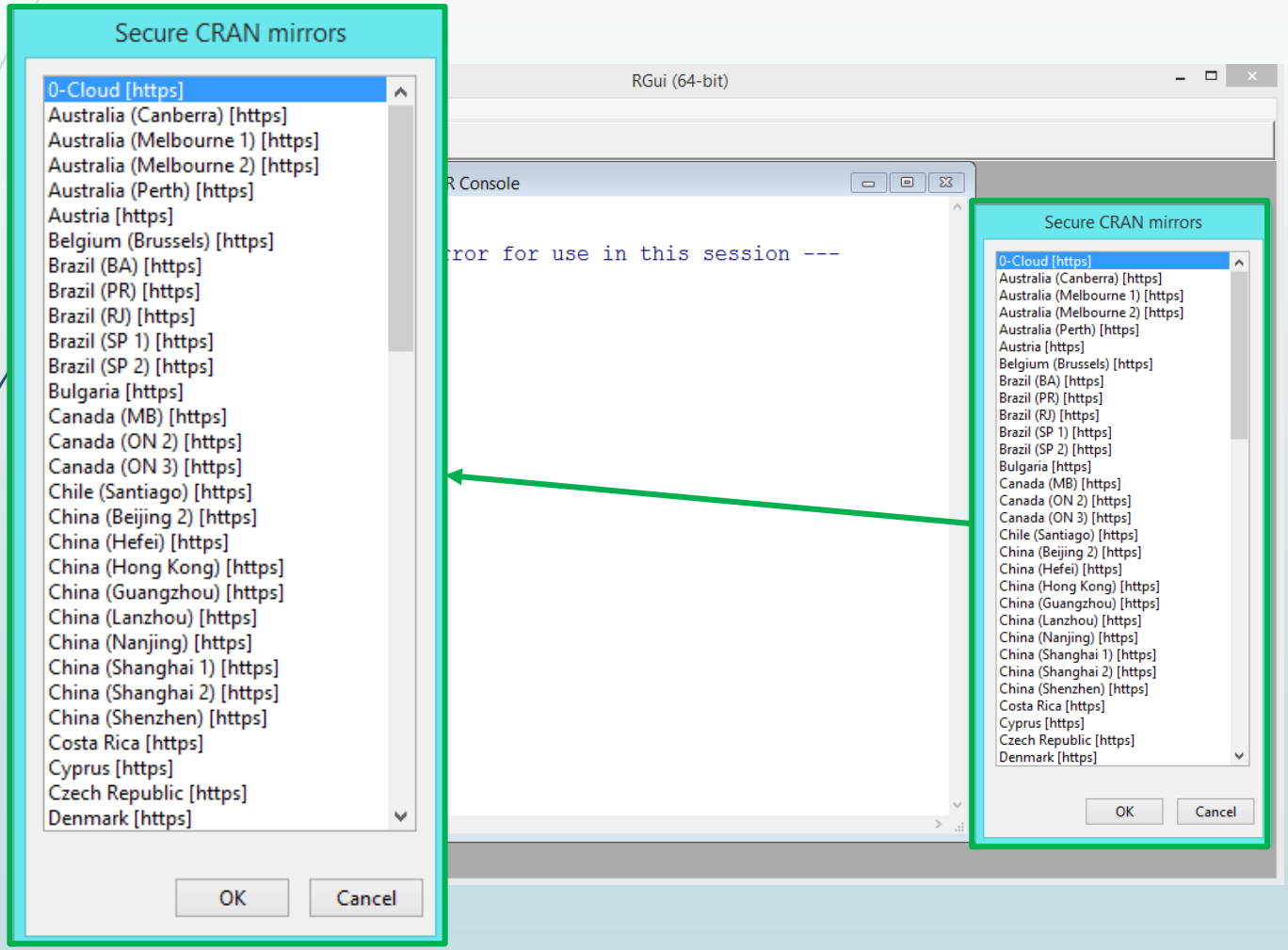
Downloading and Installing a Package

- First method (example 1)



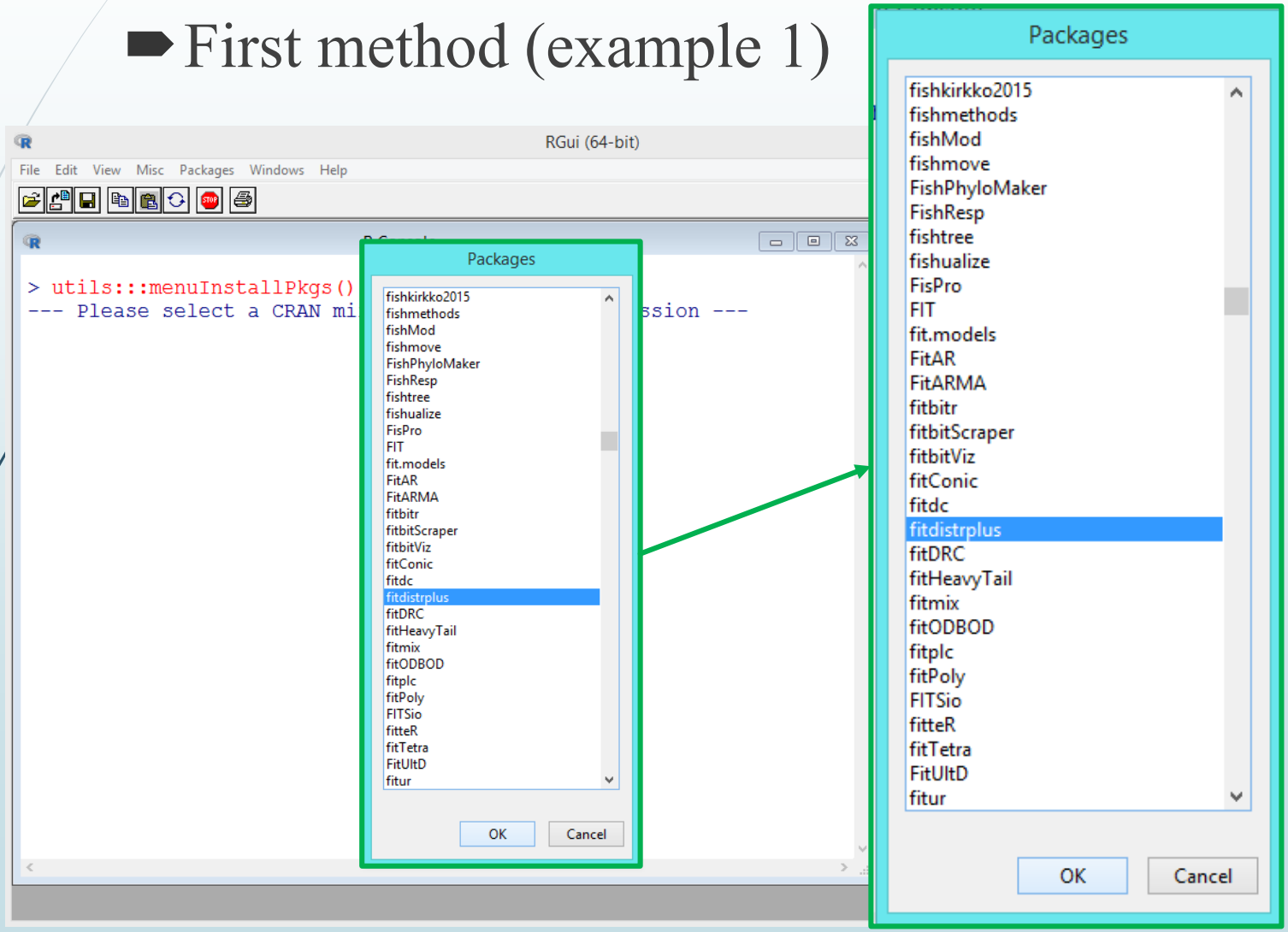
Downloading and Installing a Package

- First method (example 1)



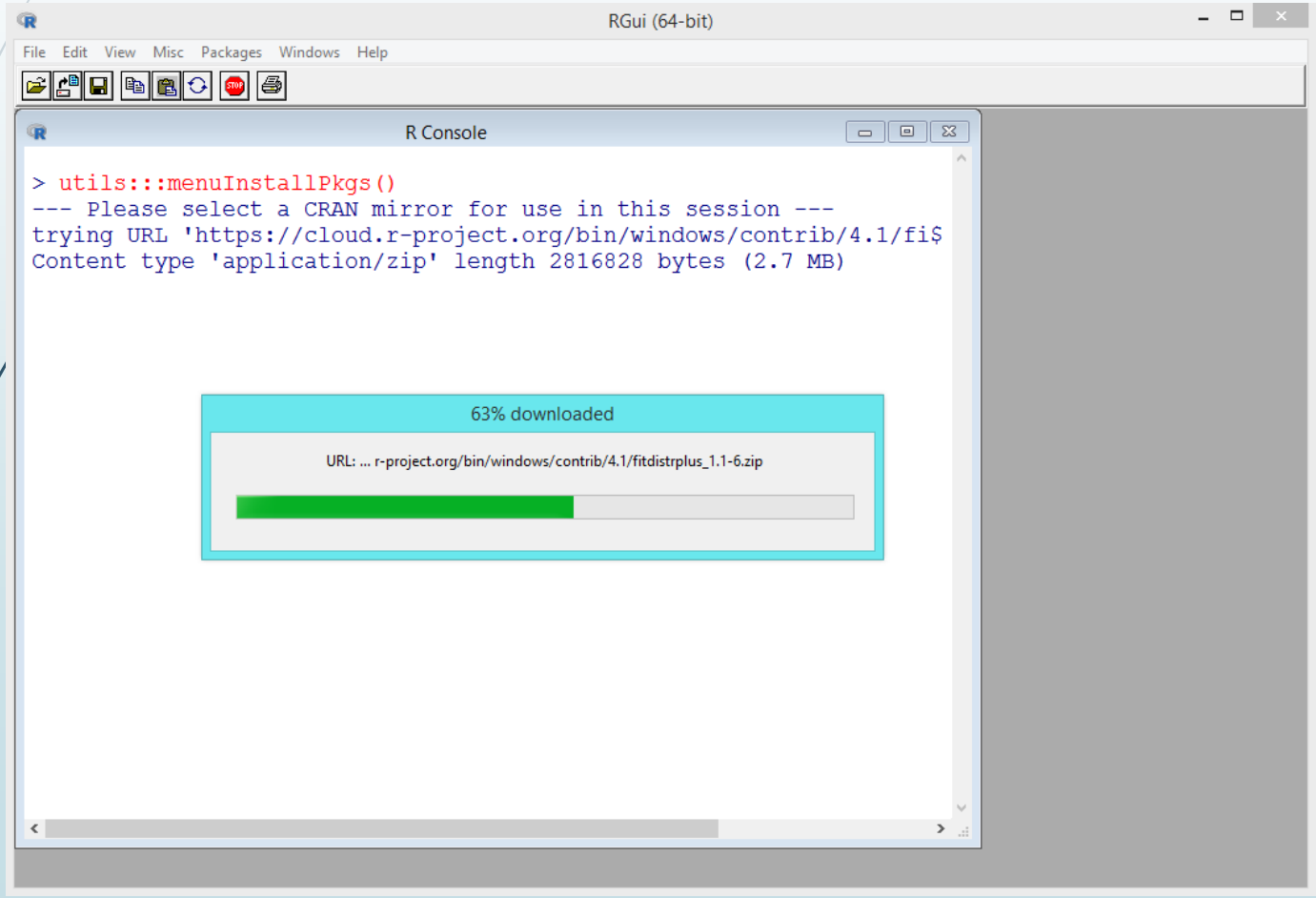
Downloading and Installing a Package

- First method (example 1)



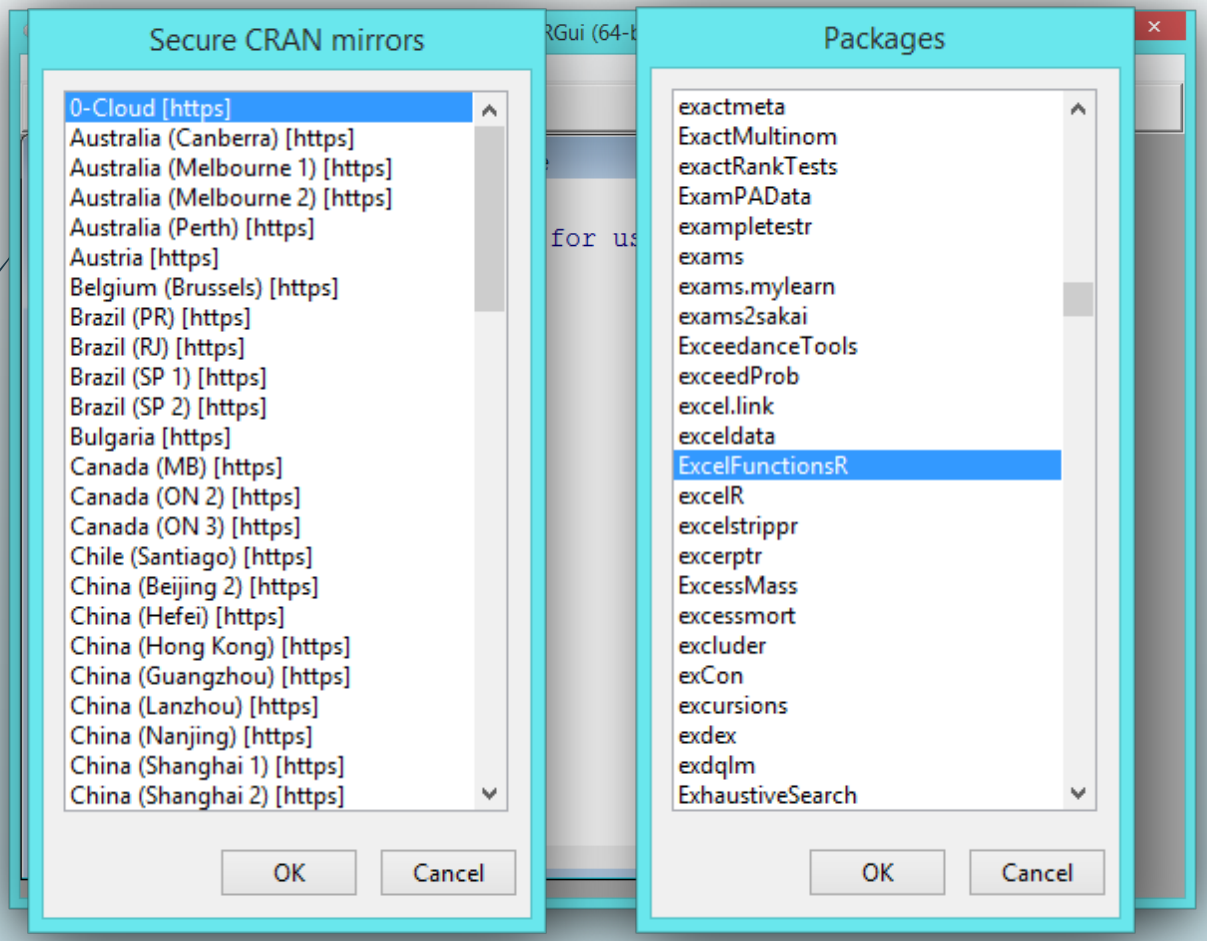
Downloading and Installing a Package

- First method (example 1)



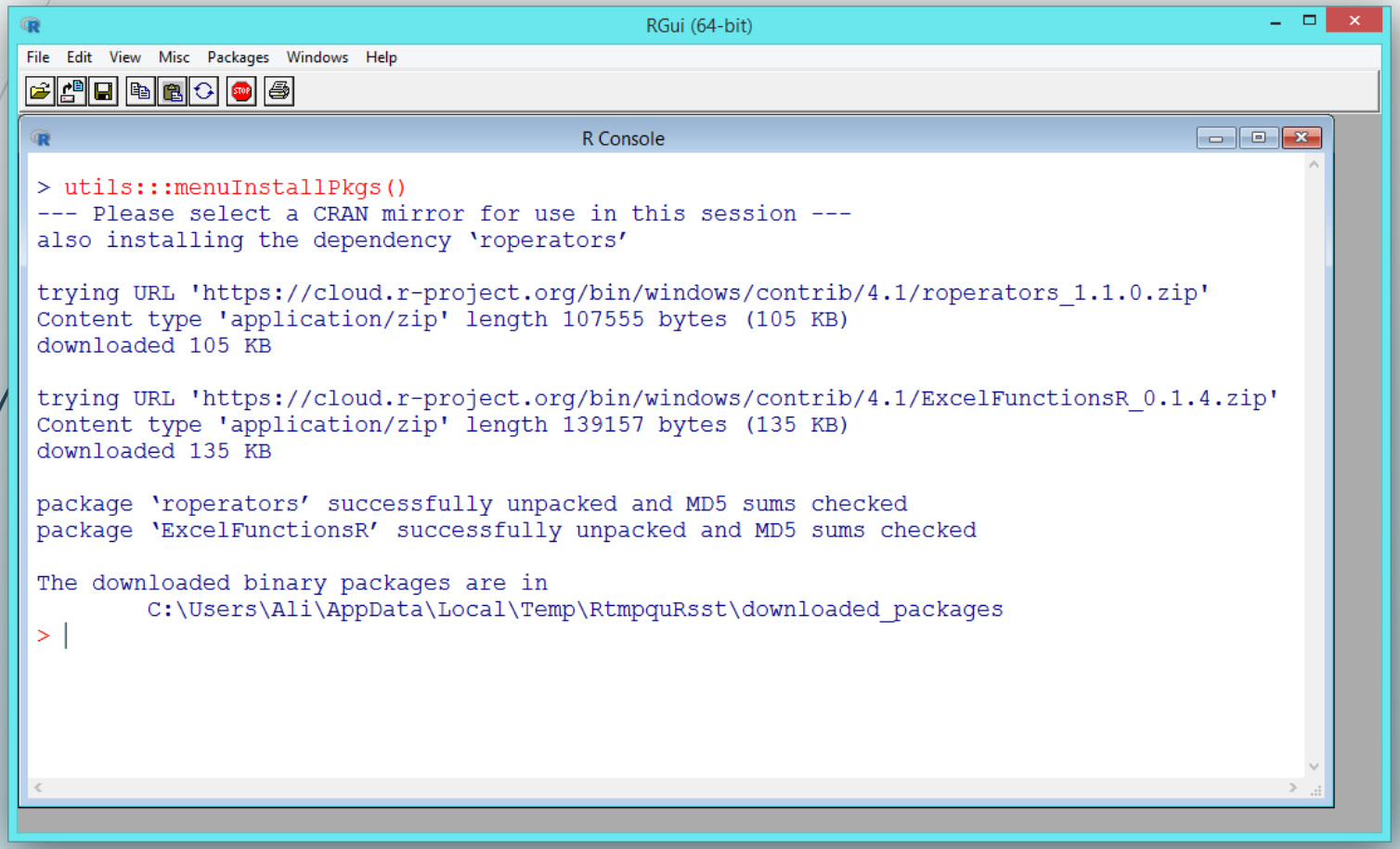
Downloading and Installing a Package

- First method (example 2)



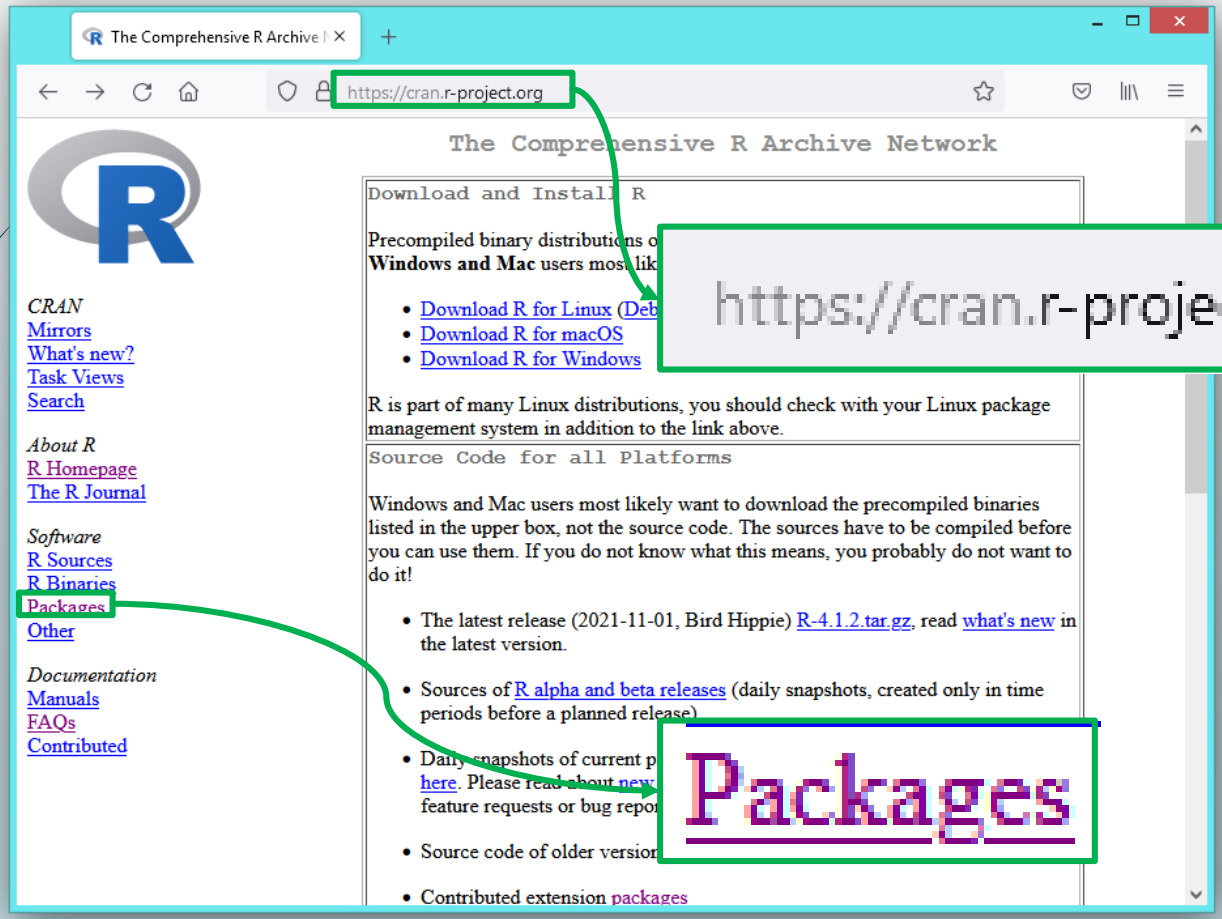
Downloading and Installing a Package

- First method (example 2)



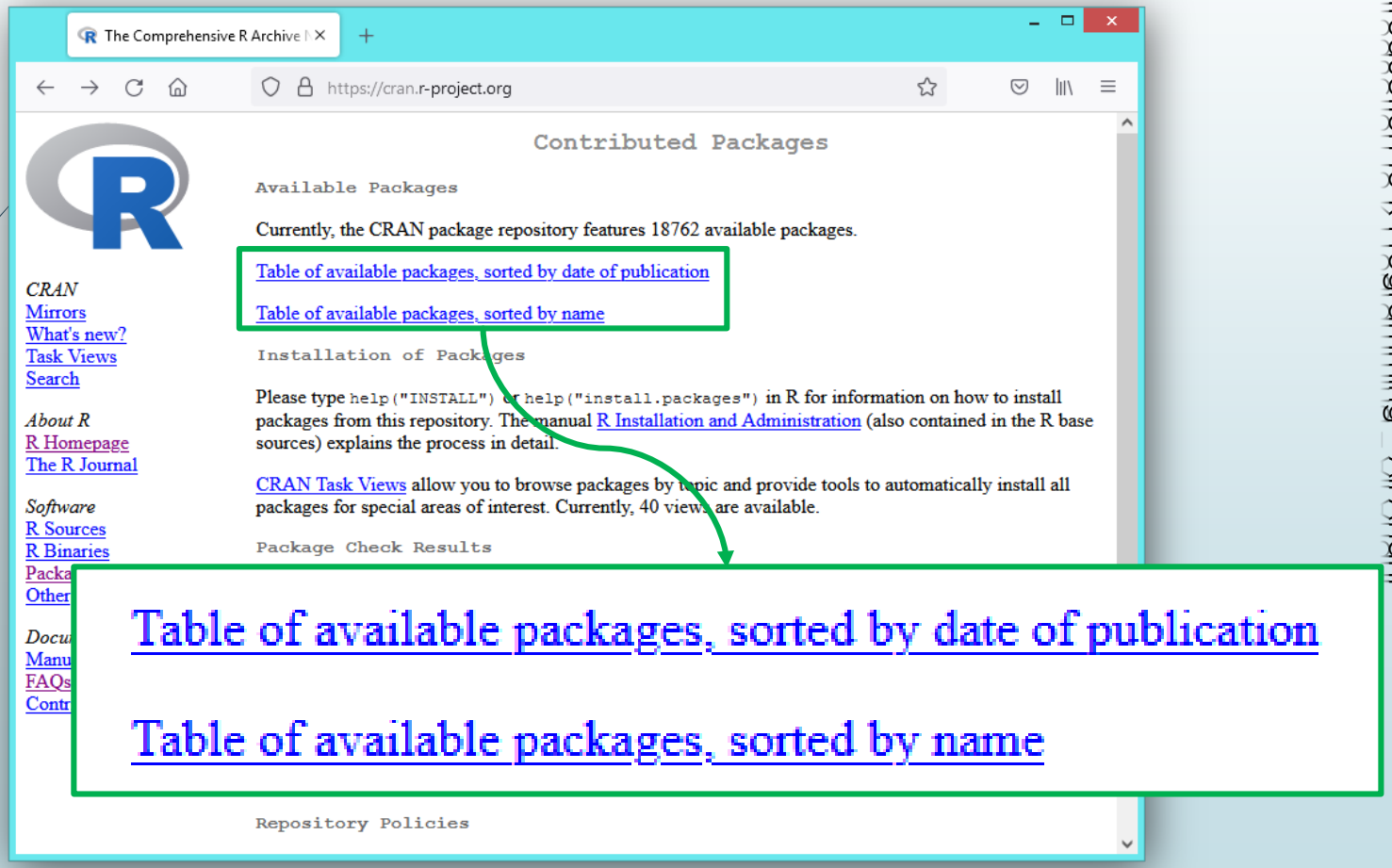
Downloading and Installing a Package

- Second method



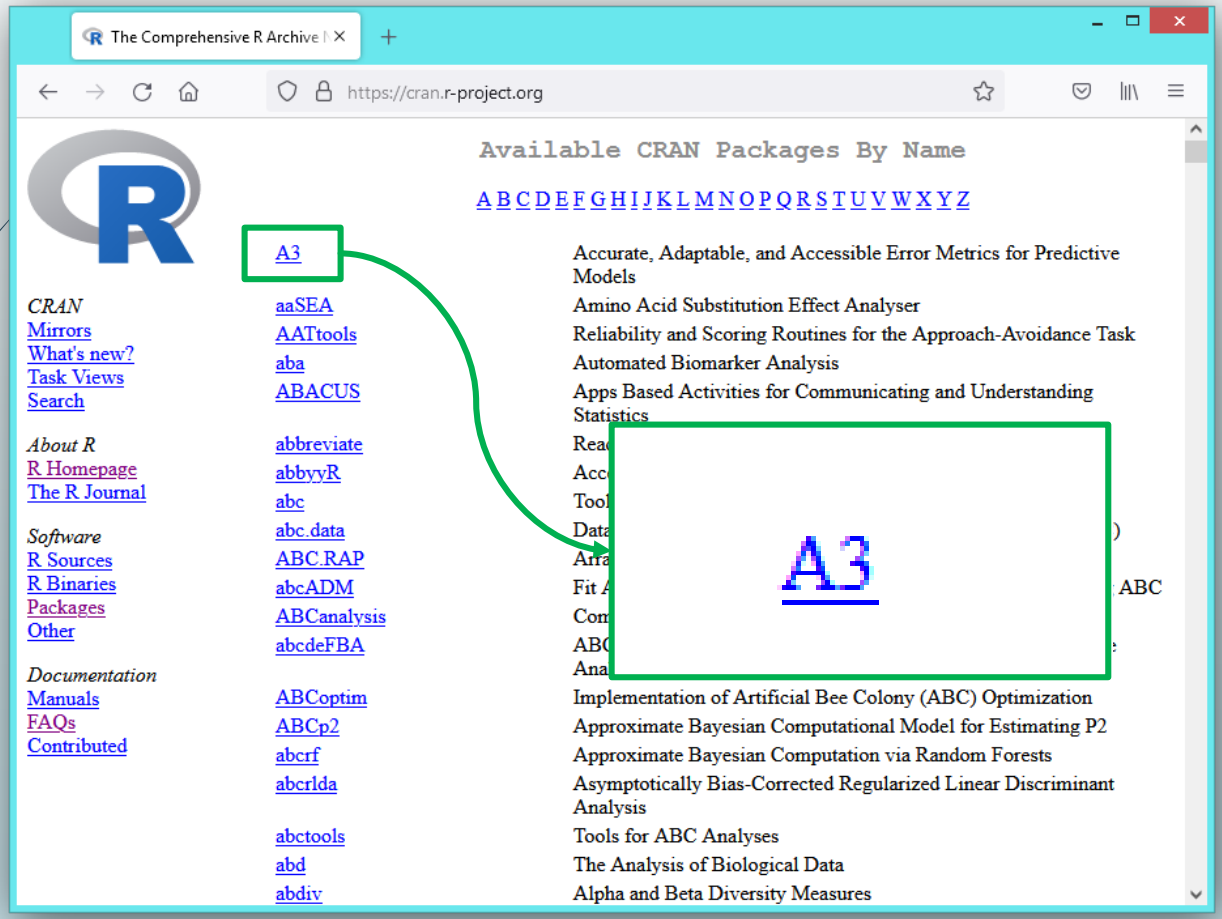
Downloading and Installing a Package

- Second method



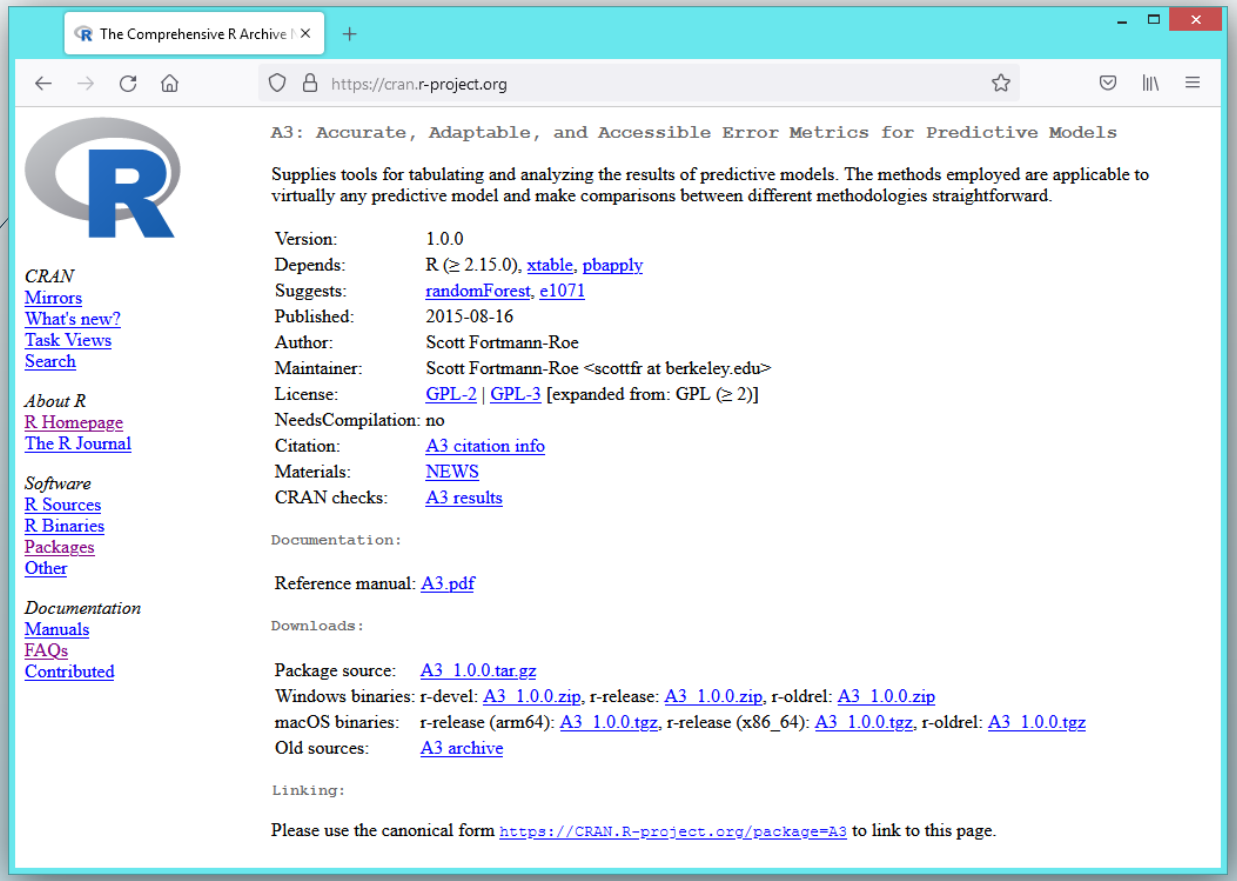
Downloading and Installing a Package

- Second method



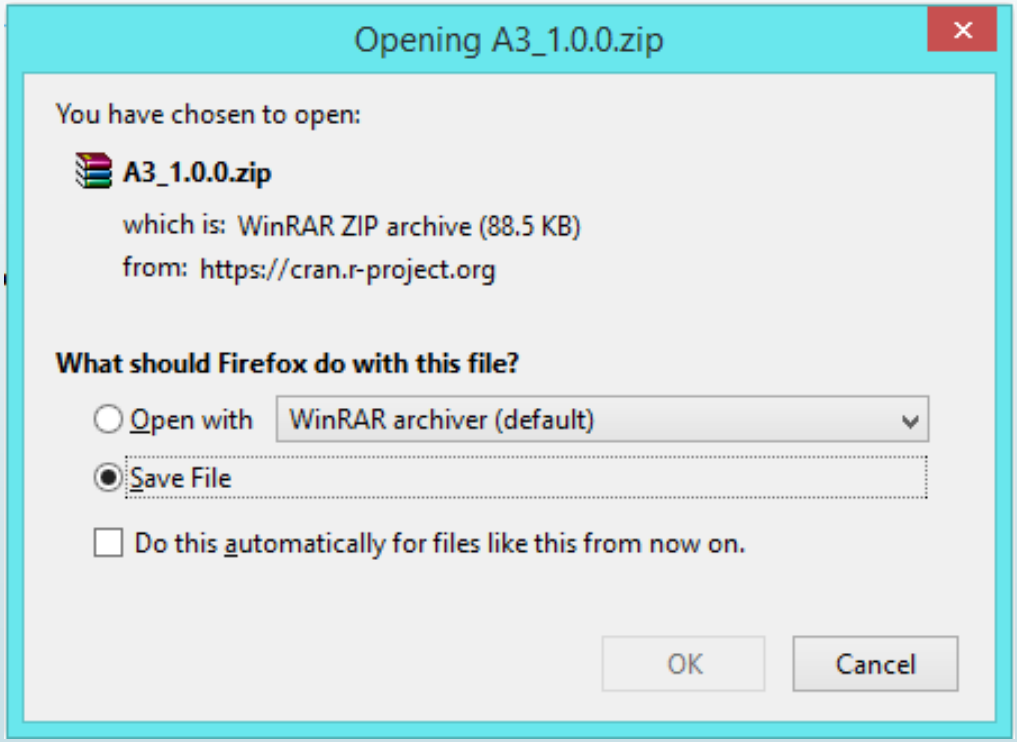
Downloading and Installing a Package

- Second method



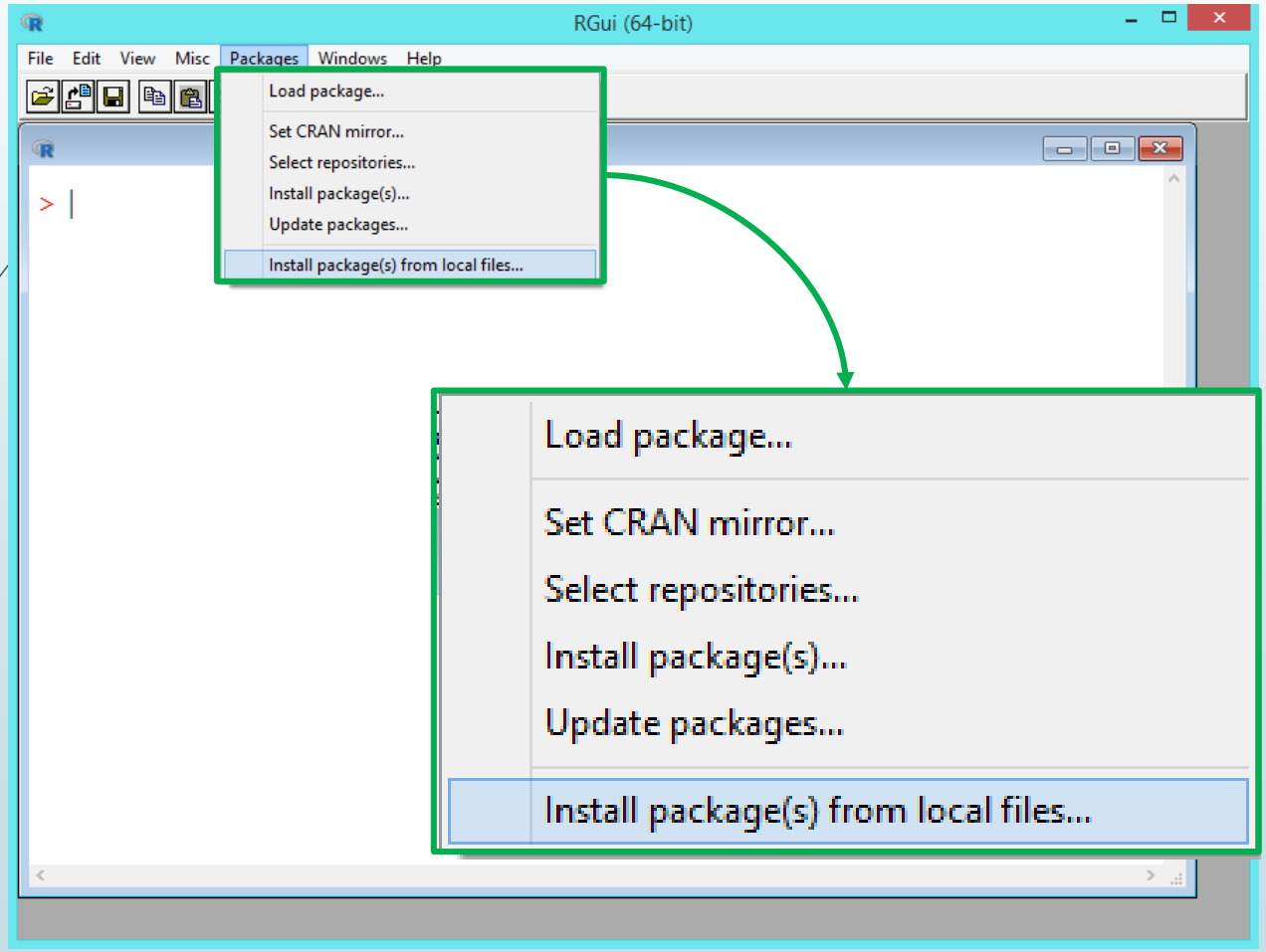
Downloading and Installing a Package

- Second method



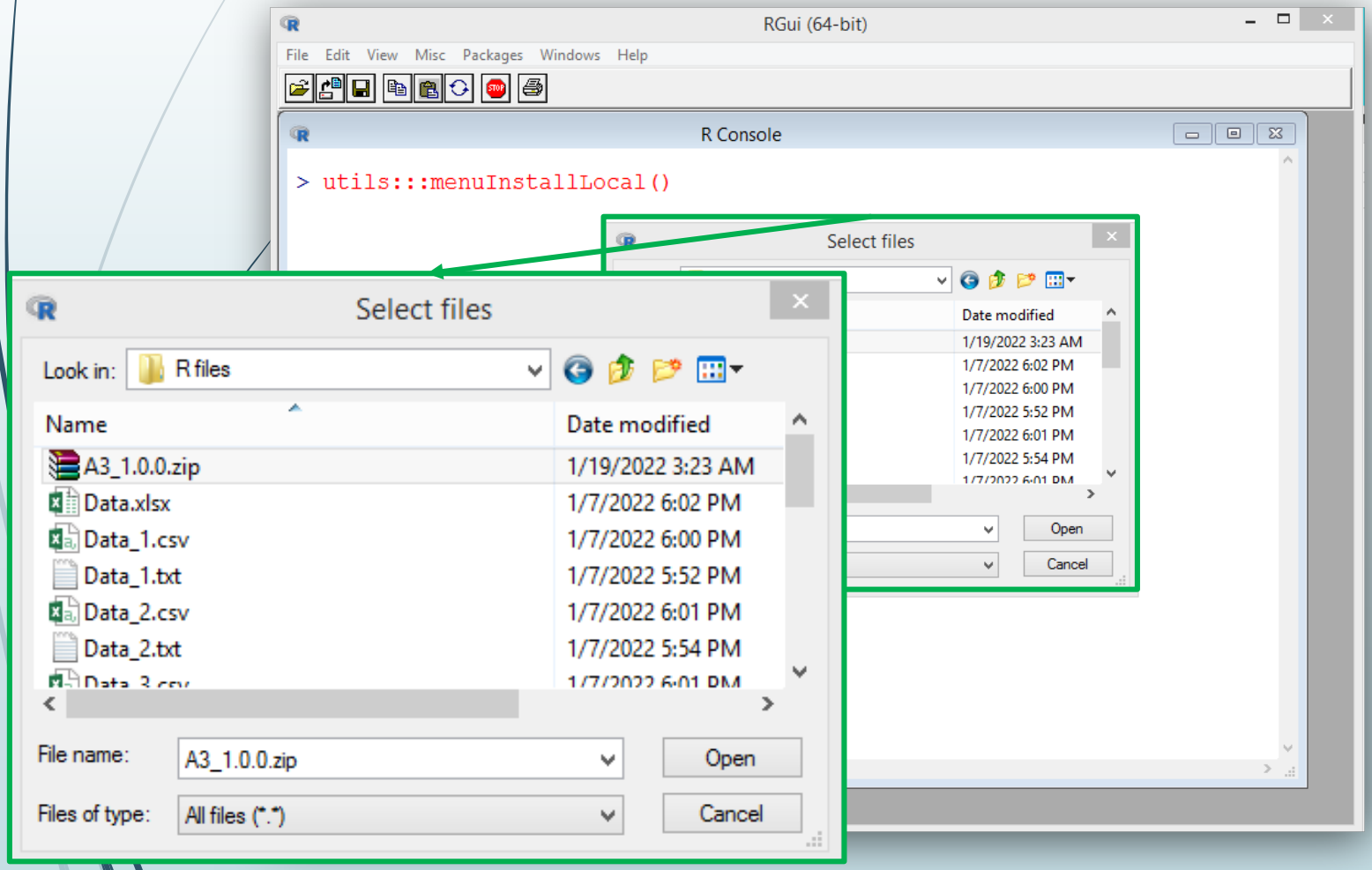
Downloading and Installing a Package

- Second method



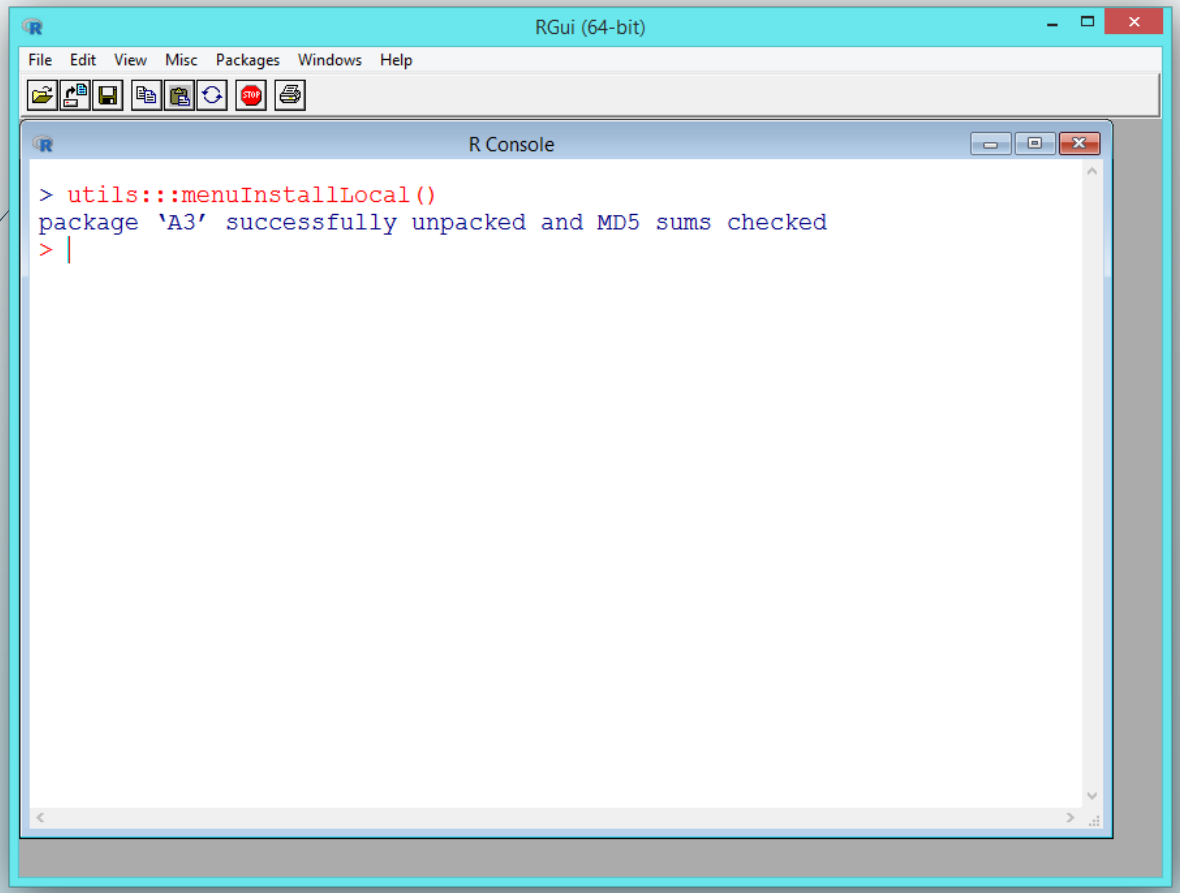
Downloading and Installing a Package

- Second method

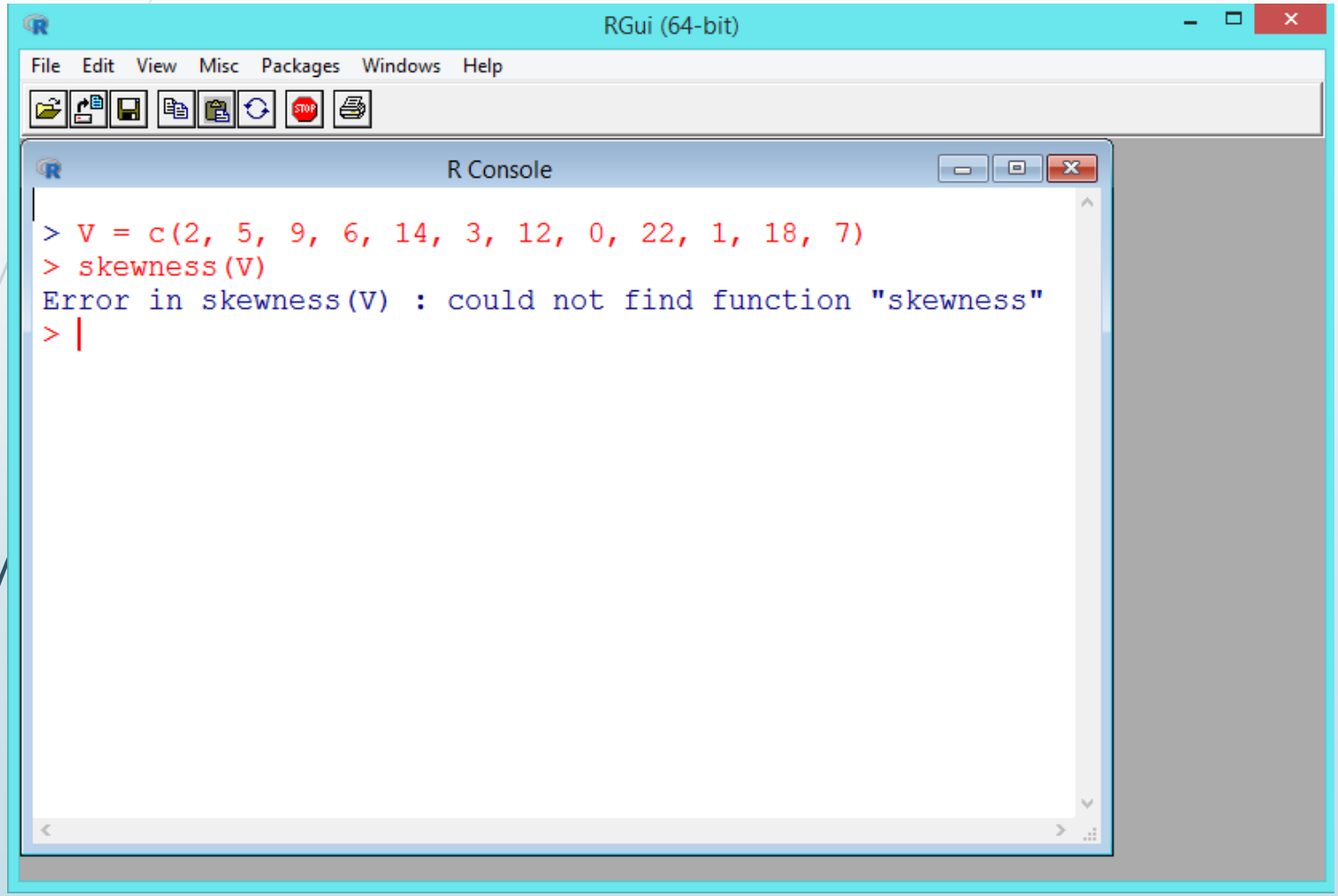


Downloading and Installing a Package

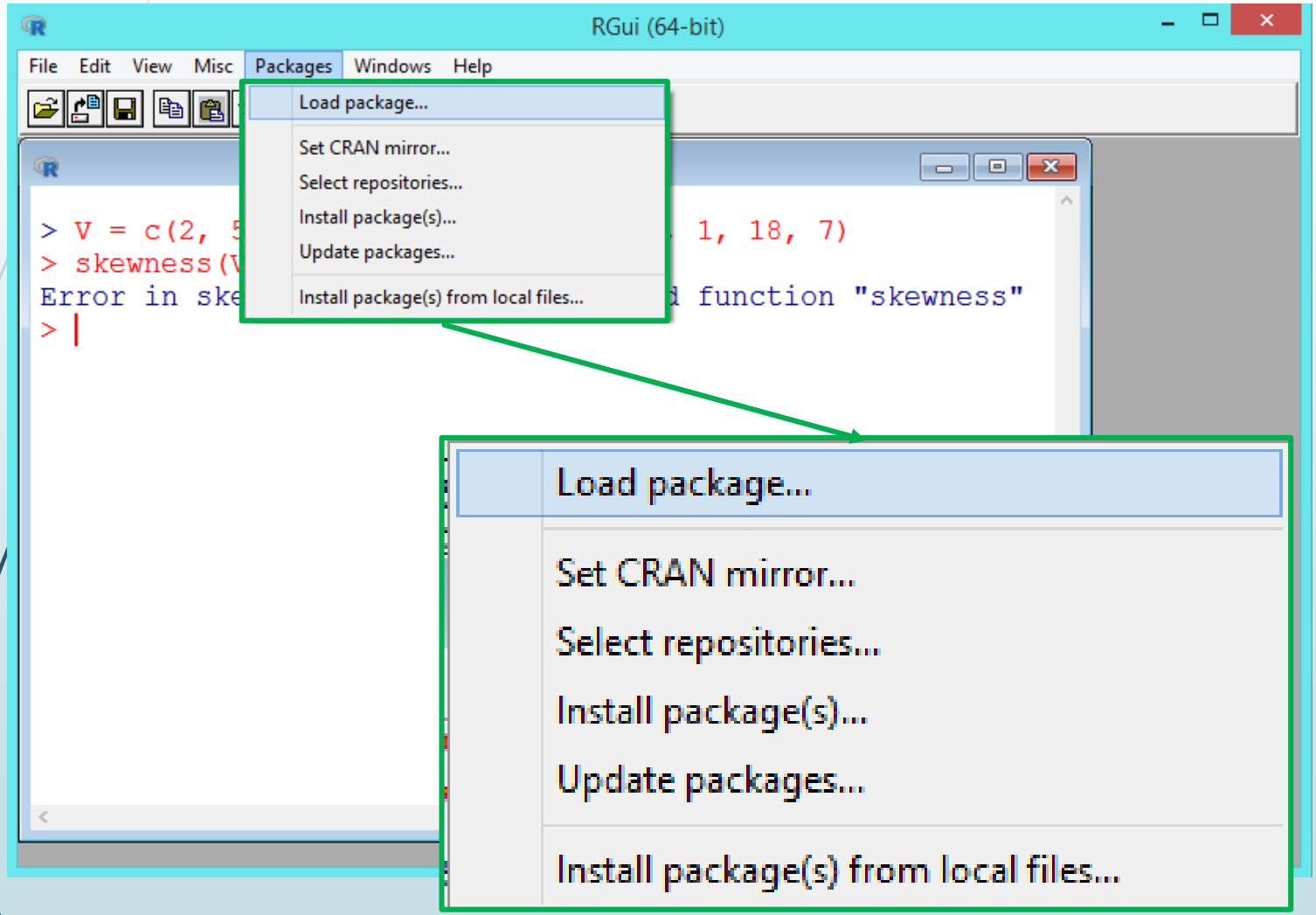
- Second method



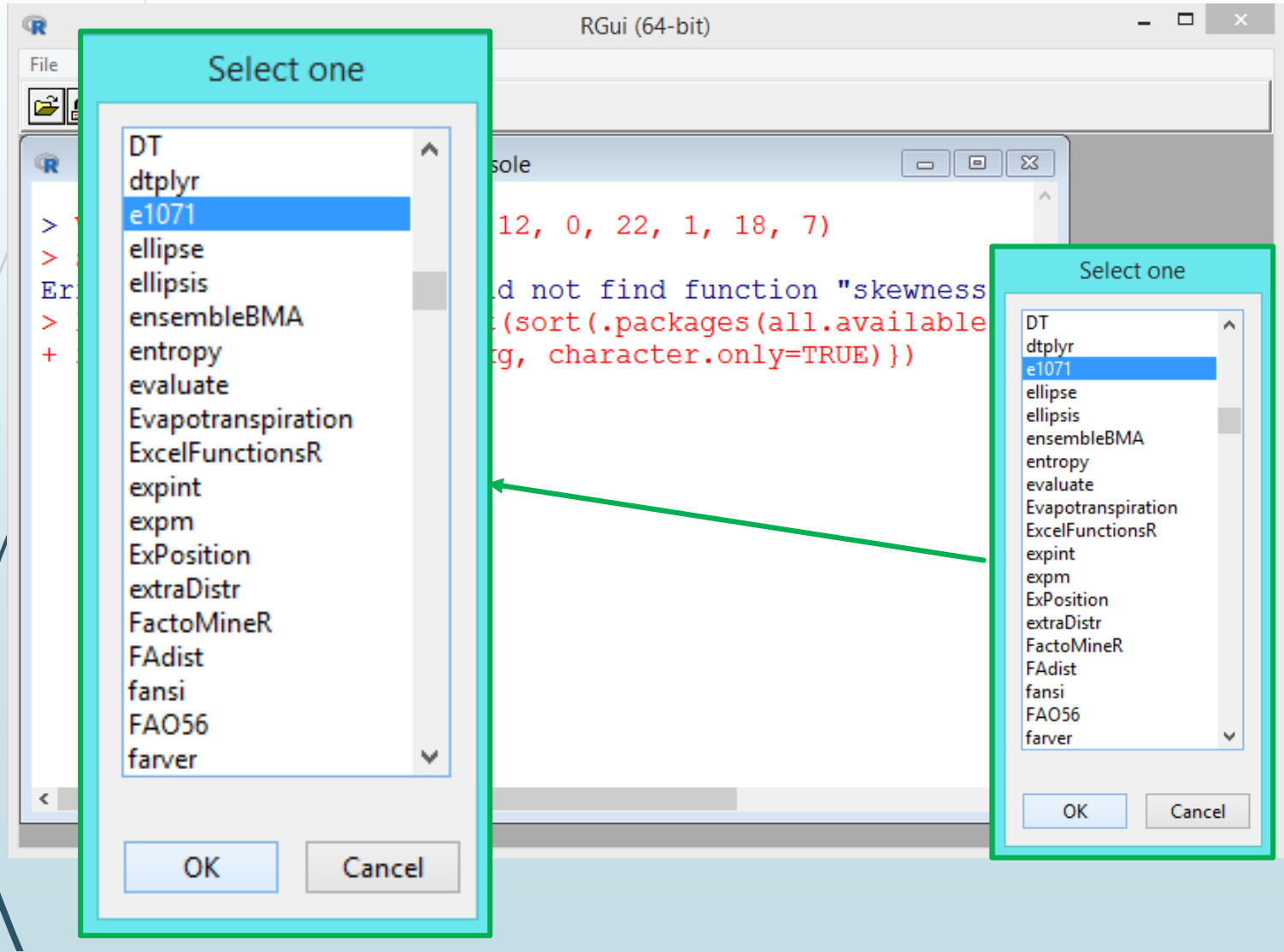
Loading a Package



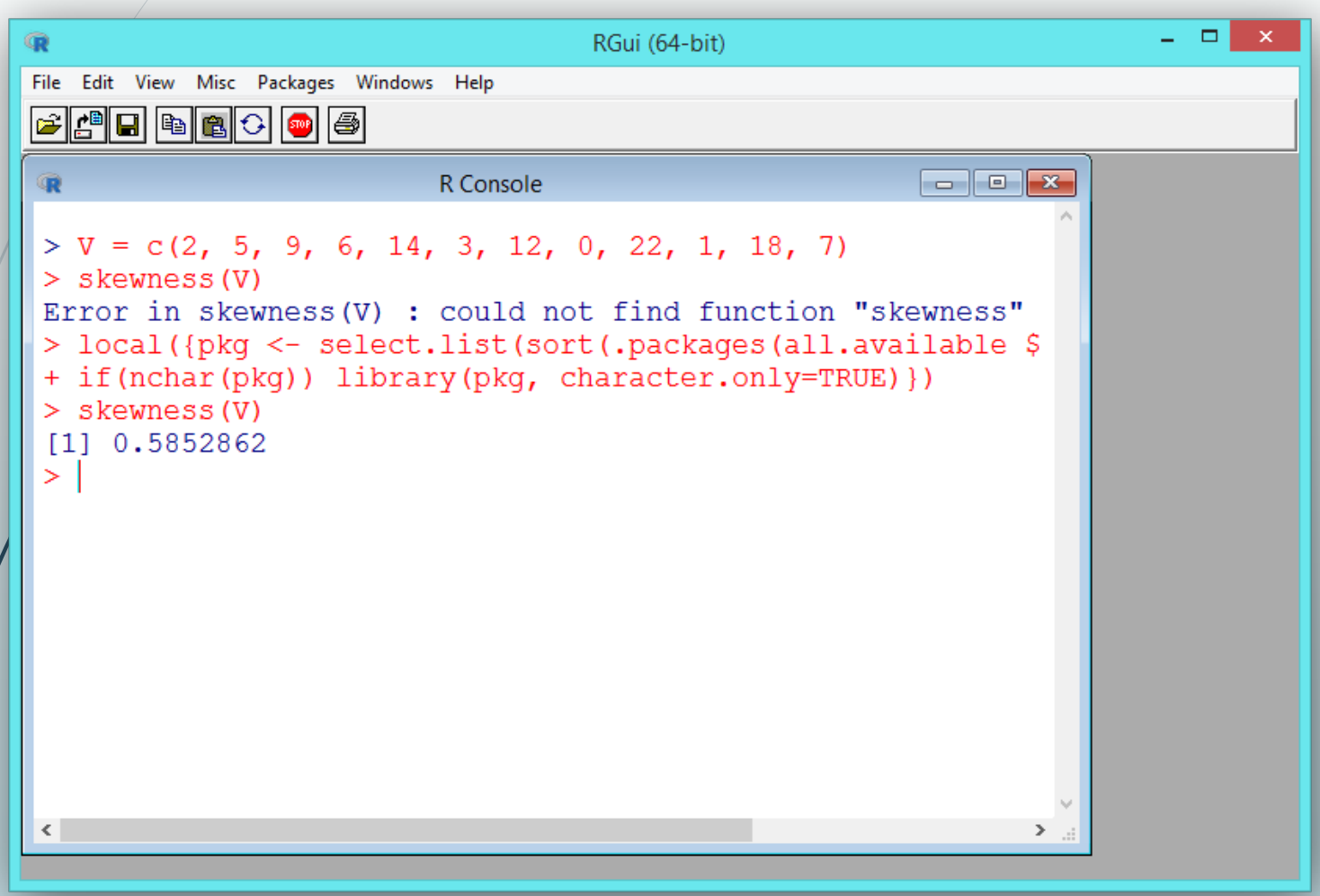
Loading a Package



Loading a Package

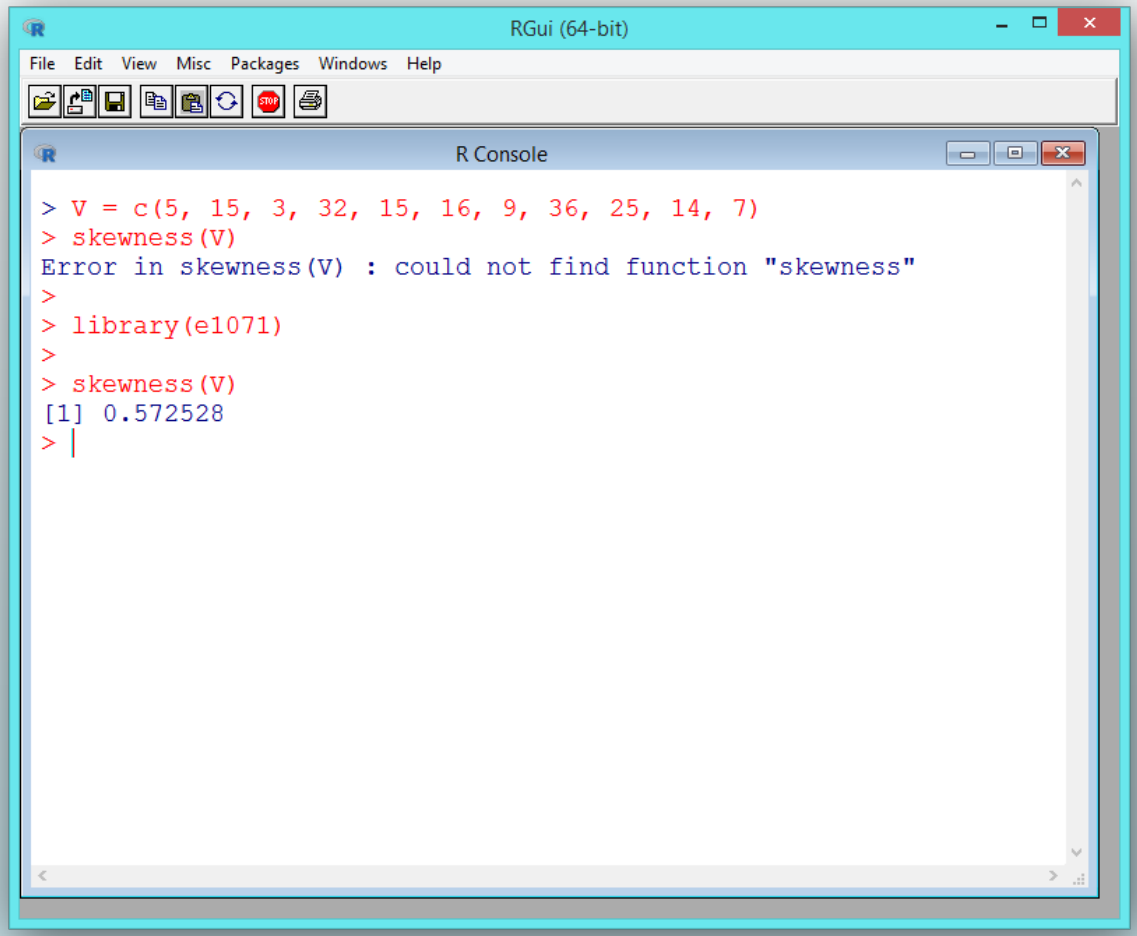


Loading a Package



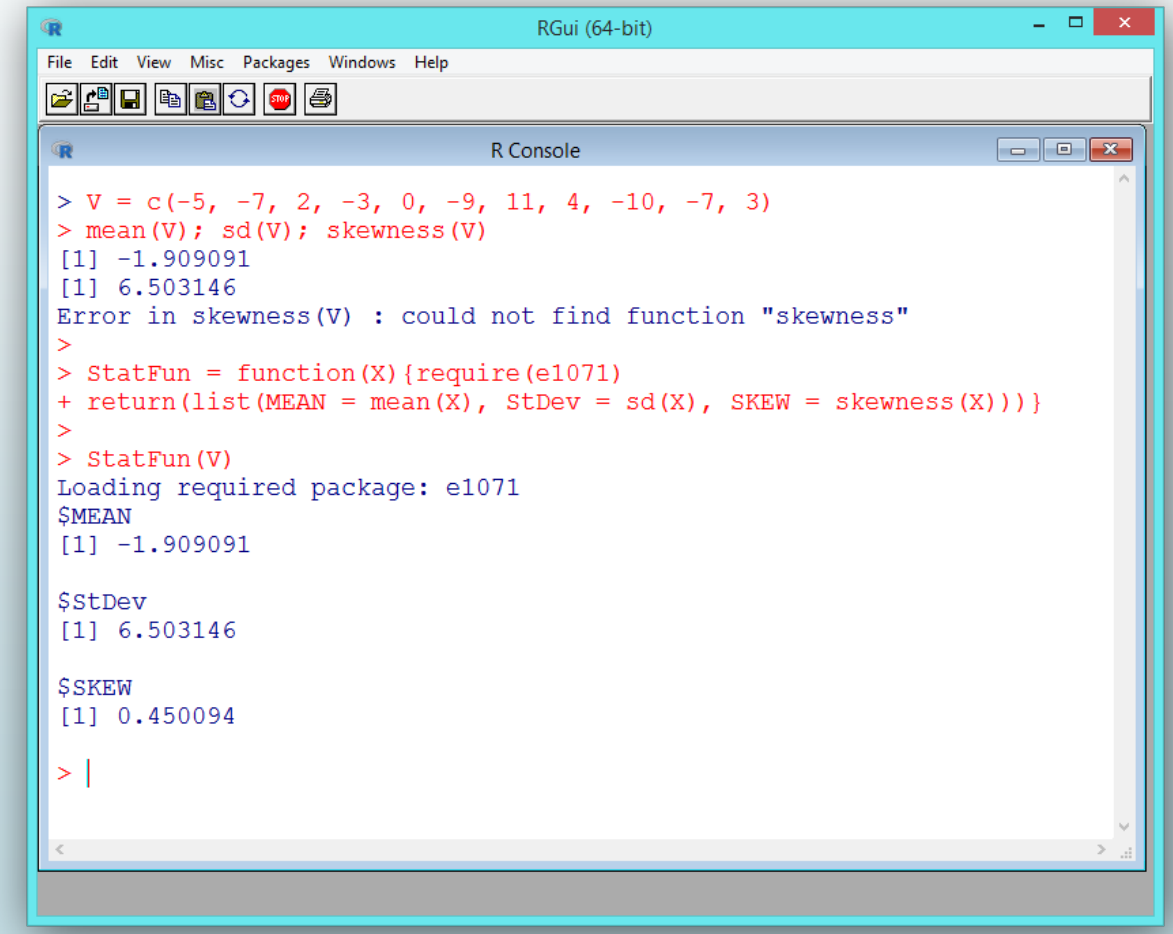
Loading a Package

- `library()`



Loading a Required Package

- `require()`

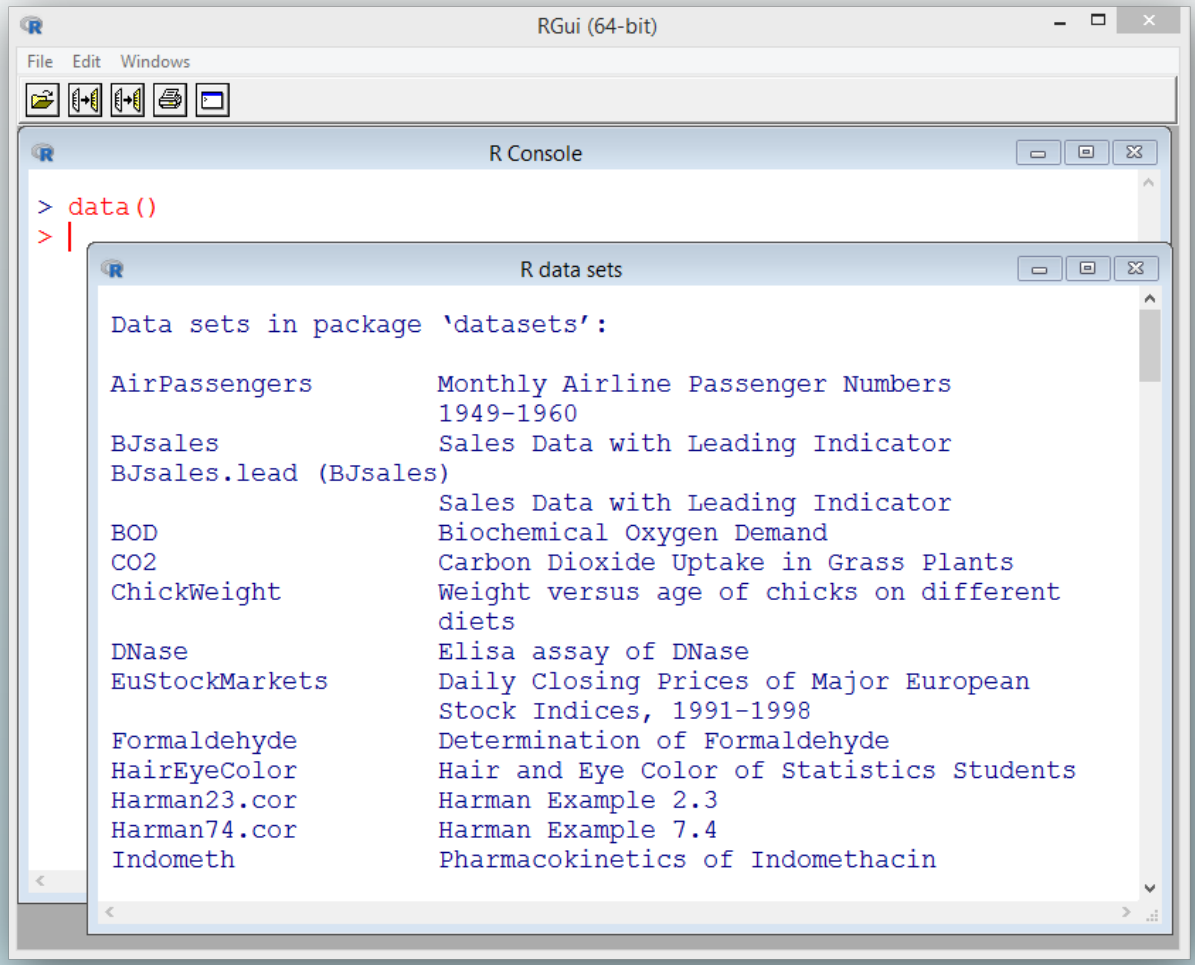


R Data Sets

Built-in Data Sets

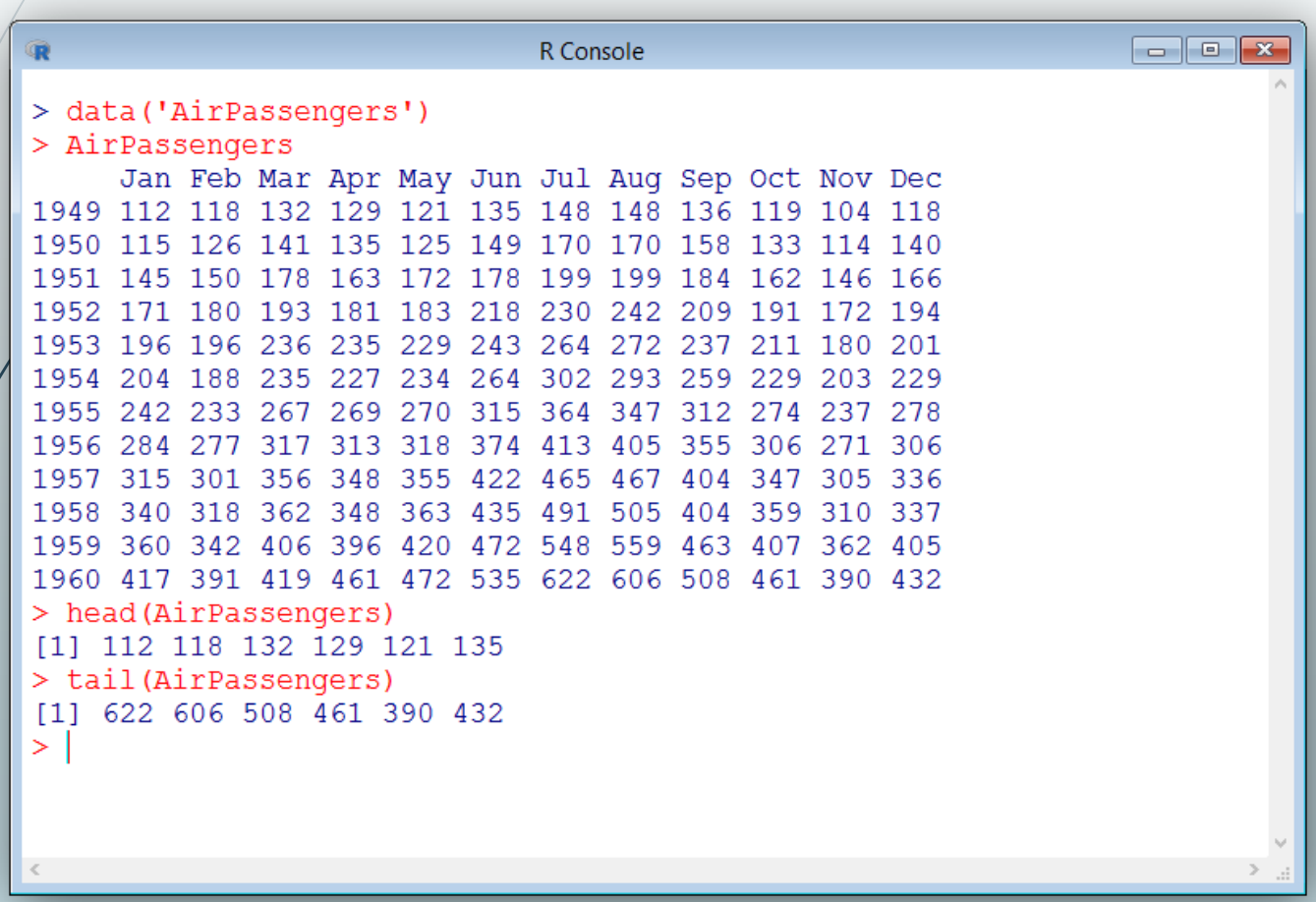
R Data Sets

- `data()`



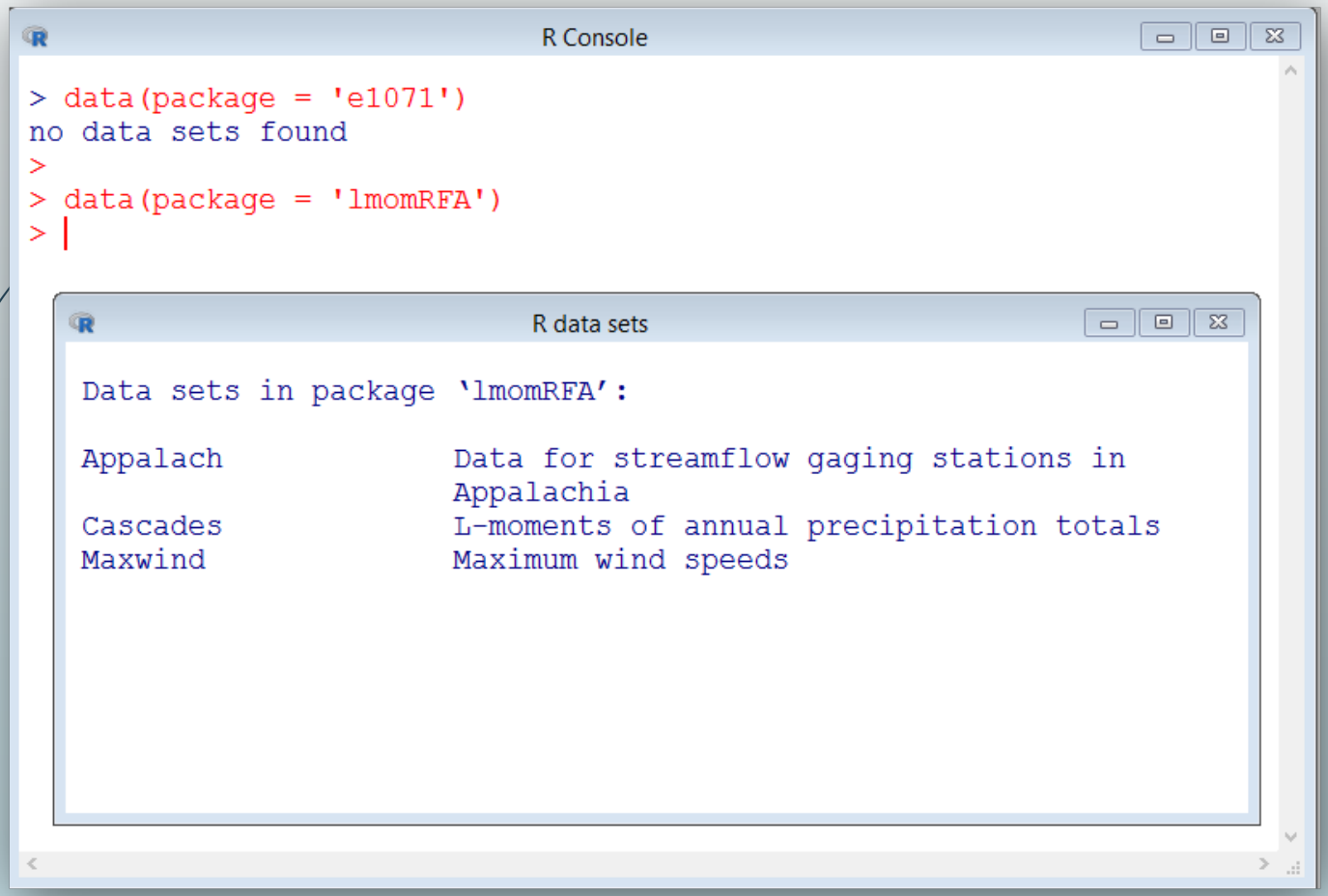
R Data Sets

- `data()`, `head()`, `tail()`



Data Sets in the R Packages

- `data()`



References

- Venables, W. N., Smith, D. M., and the R Core Team. 2021. An Introduction to R - Notes on R: A Programming Environment for Data Analysis and Graphics Version 4.1.1 (2021-08-10).

- موسوی ندوشنی، س. س. ۱۳۹۱. آشنایی با زبان محاسبات آماری R (ویراست نوشتار ۱/۸/۰).

Thank you for your attention