Introduction to R

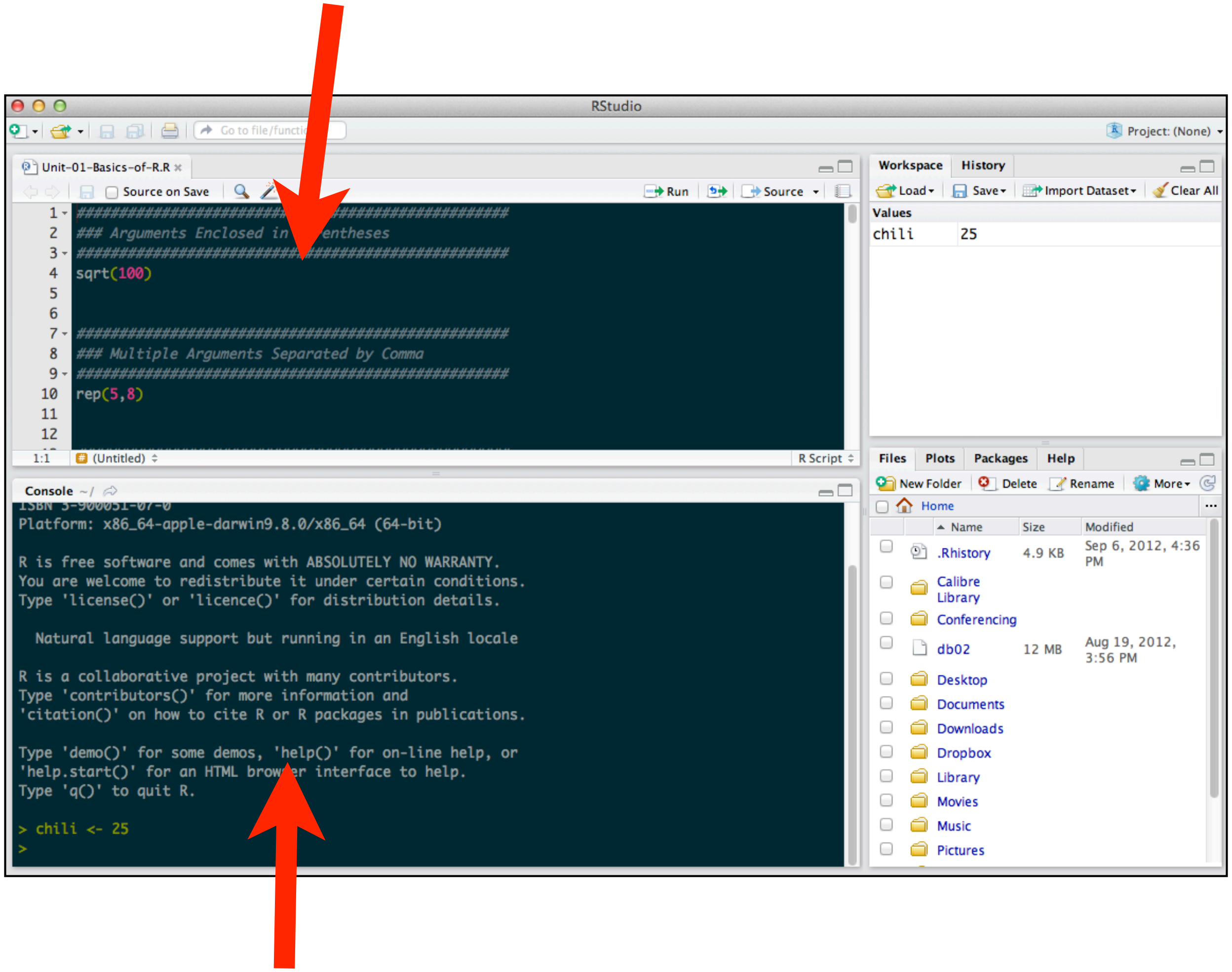
Andrew Zieffler

Some Things to Remember...

- R is case-sensitive
    - `anova` is different than `Anova` is different than `ANOVA`
- R does exactly what the user codes
    - The user and R often don’t see “eye-to-eye”
- R has a "long-term" memory...
    - ...but only in the current session

RStudio

Script pane: non-interactive typing



```
###################################################
### Arguments Enclosed in Parentheses
###################################################
sqrt(100)


###################################################
### Multiple Arguments Separated by Comma
###################################################
rep(5,8)
```

```
ISBN 3-900051-07-0
Platform: x86_64-apple-darwin9.8.0/x86_64 (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.

> chili <- 25
>
```

Values	
chili	25

	Name	Size	Modified
□	.Rhistory	4.9 KB	Sep 6, 2012, 4:36 PM
□	Calibre Library		
□	Conferencing		
□	db02	12 MB	Aug 19, 2012, 3:56 PM
□	Desktop		
□	Documents		
□	Downloads		
□	Dropbox		
□	Library		
□	Movies		
□	Music		
□	Pictures		

Console pane: Interactive typing

Console Pane (Interactive)

```
>
```

R **prompt**...R is waiting for a command

```
> 3 + 2
[1] 5
```

After inputting a command hit **<enter>**

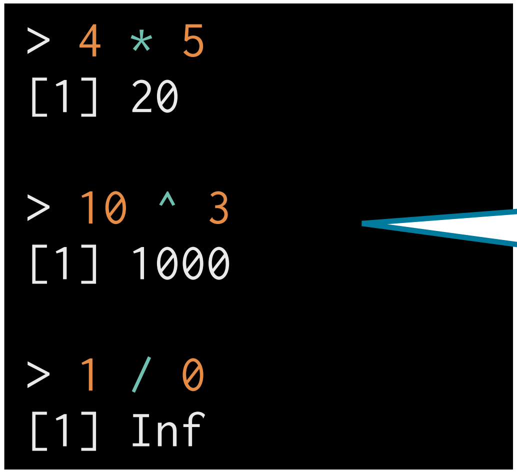
R **returned value**...the brackets indicate the *i*th returned element.
Here they indicate the first returned element.
(They can be ignored for now (we are more interested in the returned value of 5.)

```
> 3 +
+
```

Continuation prompt... The previous command was not properly ended prior to hitting **<enter>**

- Finish command
- Hit **<esc>** until you get the command prompt again. Then re-try

Two options



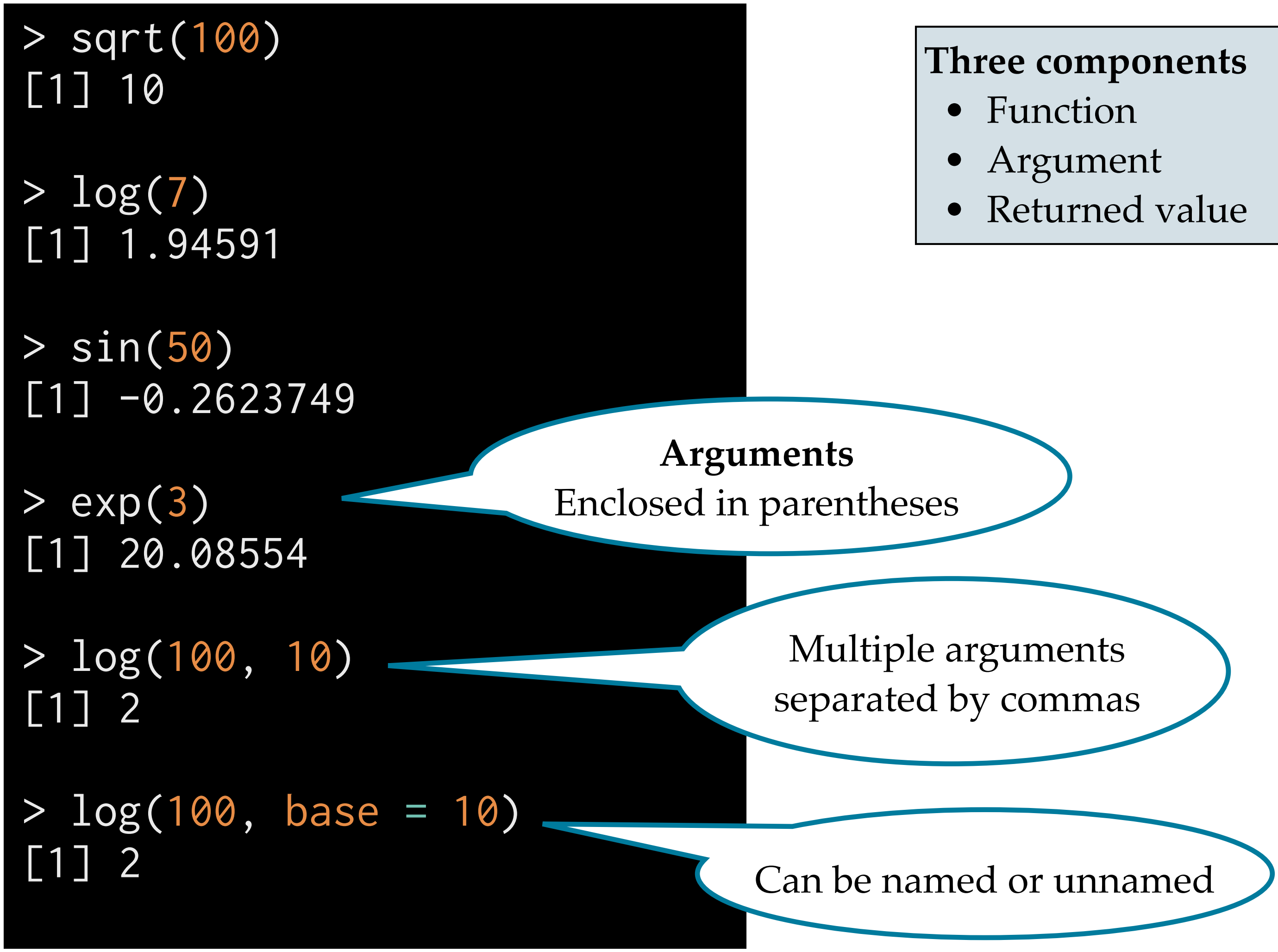
```
> 4 * 5
[1] 20

> 10 ^ 3
[1] 1000

> 1 / 0
[1] Inf
```

Space is for humans.

```
> 4 * 5
> 4*5
> 4   *5
```

are all the same to R

Computations in R using Functions



```
> sqrt(100)
[1] 10

> log(7)
[1] 1.94591

> sin(50)
[1] -0.2623749

> exp(3)
[1] 20.08554

> log(100, 10)
[1] 2

> log(100, base = 10)
[1] 2
```

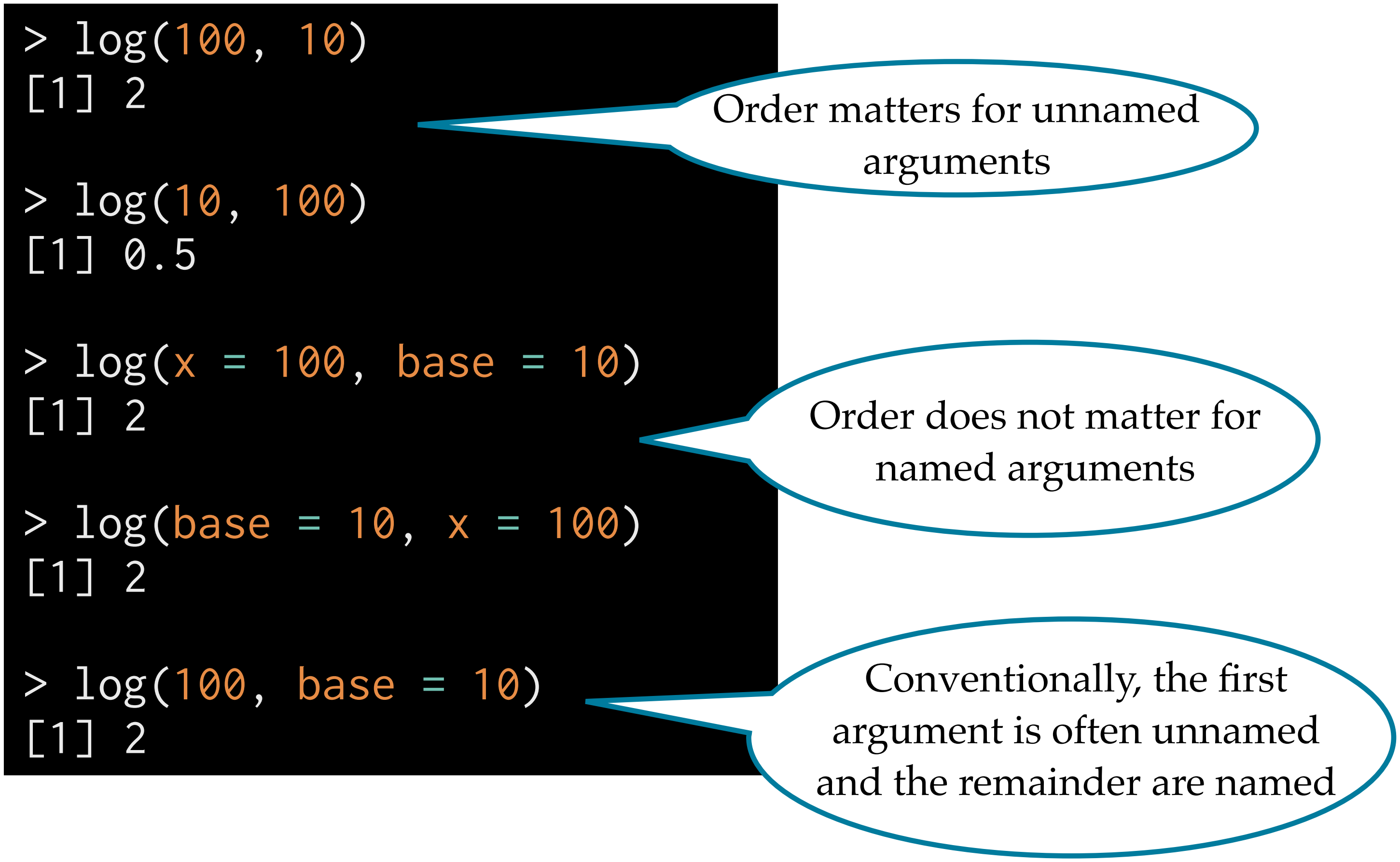
Arguments
Enclosed in parentheses

Multiple arguments
separated by commas

Can be named or unnamed

Three components

- Function
- Argument
- Returned value



```
> log(100, 10)
[1] 2

> log(10, 100)
[1] 0.5

> log(x = 100, base = 10)
[1] 2

> log(base = 10, x = 100)
[1] 2

> log(100, base = 10)
[1] 2
```

Order matters for unnamed arguments

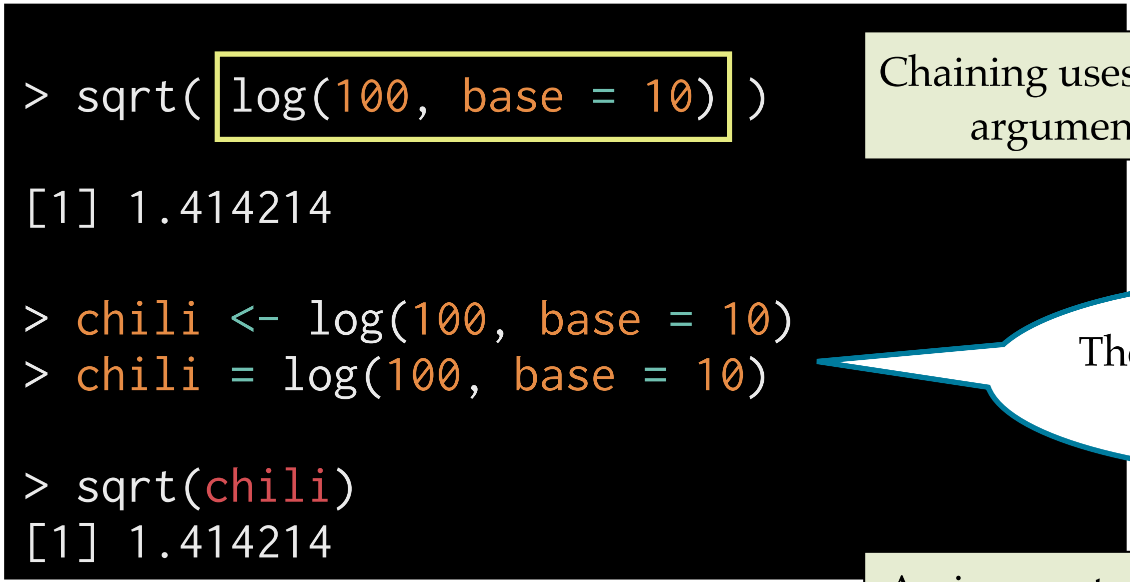
Order does not matter for named arguments

Conventionally, the first argument is often unnamed and the remainder are named

Connecting Computations in R

Two methods of connecting computations

- Chaining
- Assignment



```
> sqrt( log(100, base = 10) )

[1] 1.414214

> chili <- log(100, base = 10)
> chili = log(100, base = 10)

> sqrt(chili)
[1] 1.414214
```

Chaining uses a complete computation as the argument for another computation.

The assignment operator is either <- or =

Assignment stores the returned value from a computation as a named object.

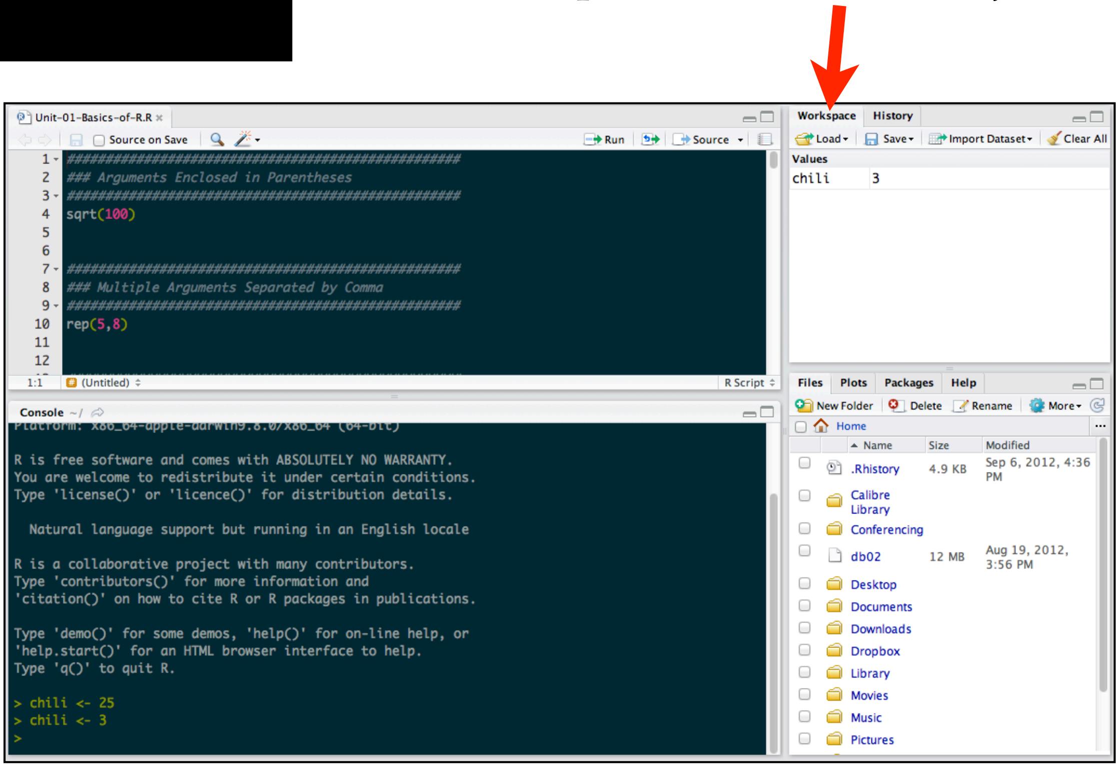
Objects

```
> chili = 3

> sqrt(chili)
[1] 1.732051

> chili
[1] 3
```

When an object name is re-used, the previous value of the object is lost.

- Pretty much any name can be used
- Descriptive is better
    - `chili` is not a good object name
- Names cannot include hyphens or spaces
- Names cannot begin with a digit
- Conventions in CS
    - `myData` (bumpy/camel-case)
    - my_data (use underscore/period)

Workspace: List of current objects



```
###################################################
### Arguments Enclosed in Parentheses
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###################################################
### Multiple Arguments Separated by Comma
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> chili <- 25
> chili <- 3
>
```

Values

chili	3

Name	Size	Modified
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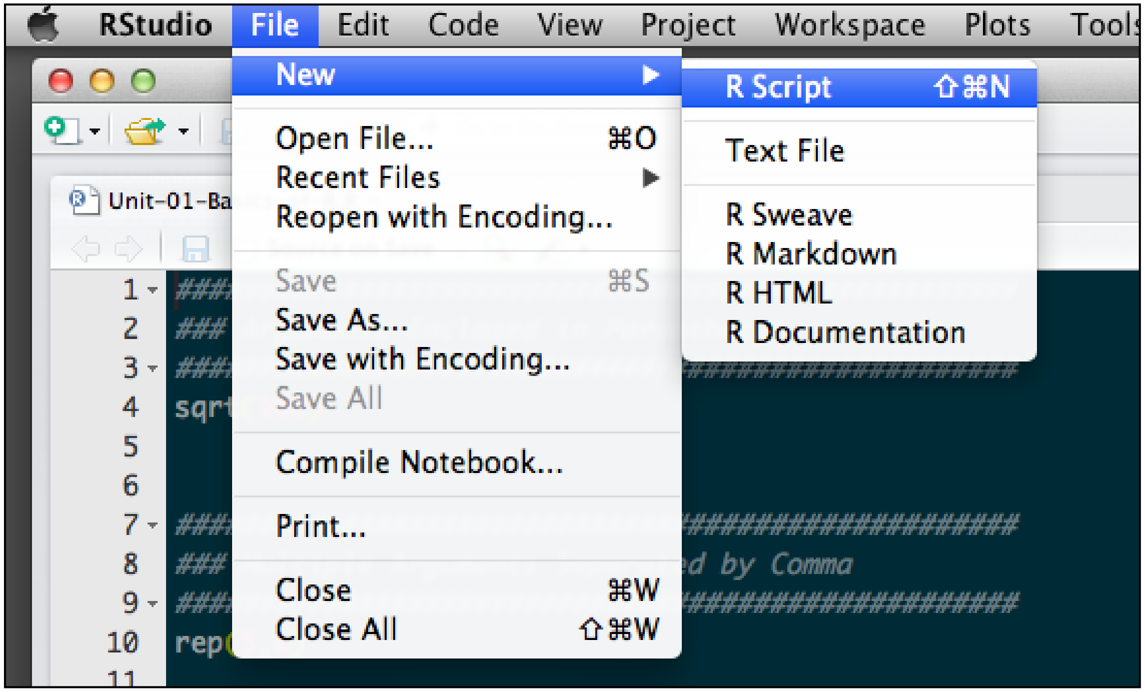
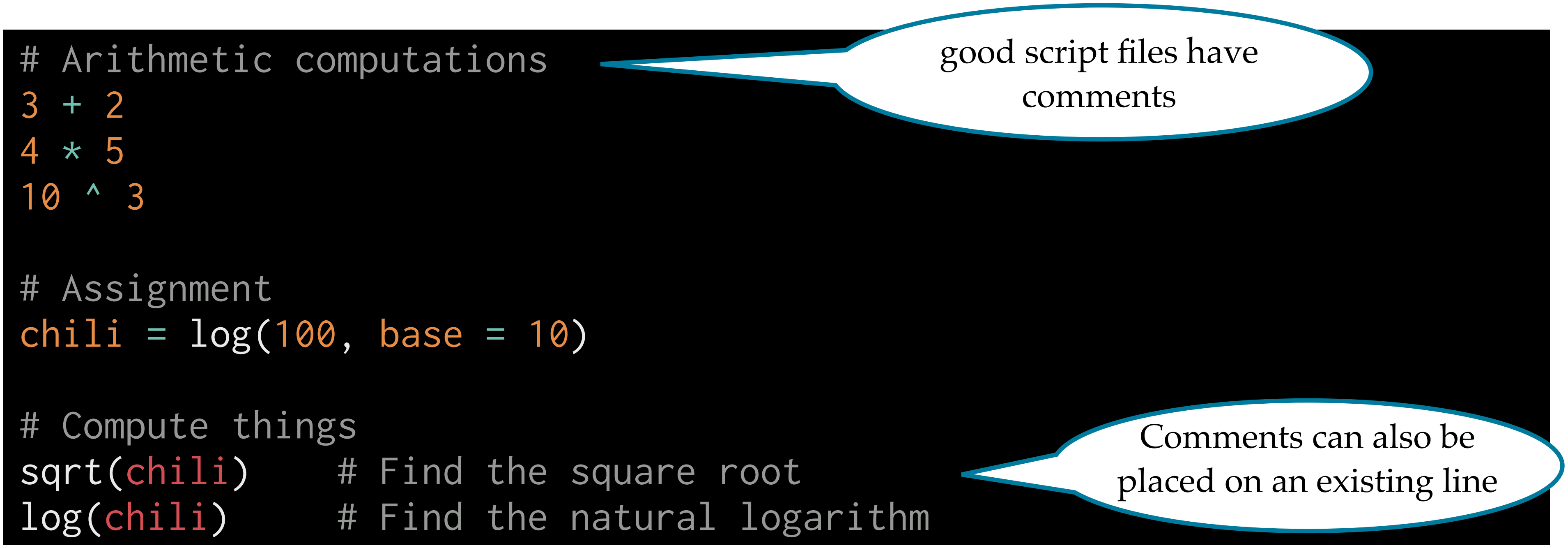
Calibre Library		
Conferencing		
db02	12 MB	Aug 19, 2012, 3:56 PM
Desktop		
Documents		
Downloads		
Dropbox		
Library		
Movies		
Music		
Pictures		

Saving Your Work: Script Files



Record syntax in a **script file**

- Includes syntax (R commands) only
  - No prompts
  - No output
- Should also include comments
  - # indicates a comment



```
# Arithmetic computations
3 + 2
4 * 5
10 ^ 3

# Assignment
chili = log(100, base = 10)

# Compute things
sqrt(chili)    # Find the square root
log(chili)     # Find the natural logarithm
```

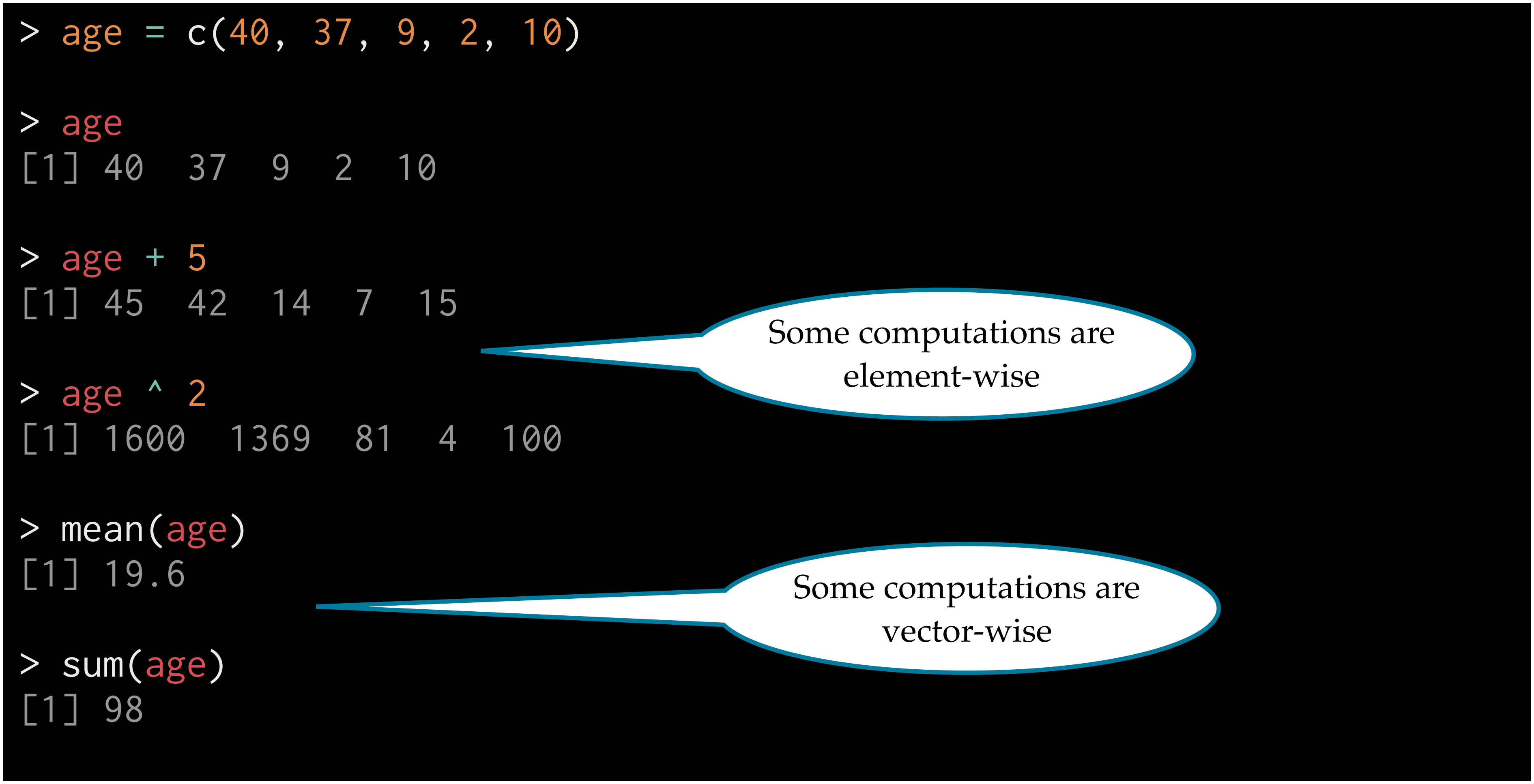
good script files have comments

Comments can also be placed on an existing line

Syntax in the script file can be executed by highlighting it and pressing the **Run** button

Data Structures: Vectors

Vectors are collections of data (univariate; a single variable). They are typically assigned to an object. To create a vector use the `c()` function.



```
> age = c(40, 37, 9, 2, 10)

> age
[1] 40  37  9  2  10

> age + 5
[1] 45  42  14  7  15

> age ^ 2
[1] 1600  1369  81  4  100

> mean(age)
[1] 19.6

> sum(age)
[1] 98
```

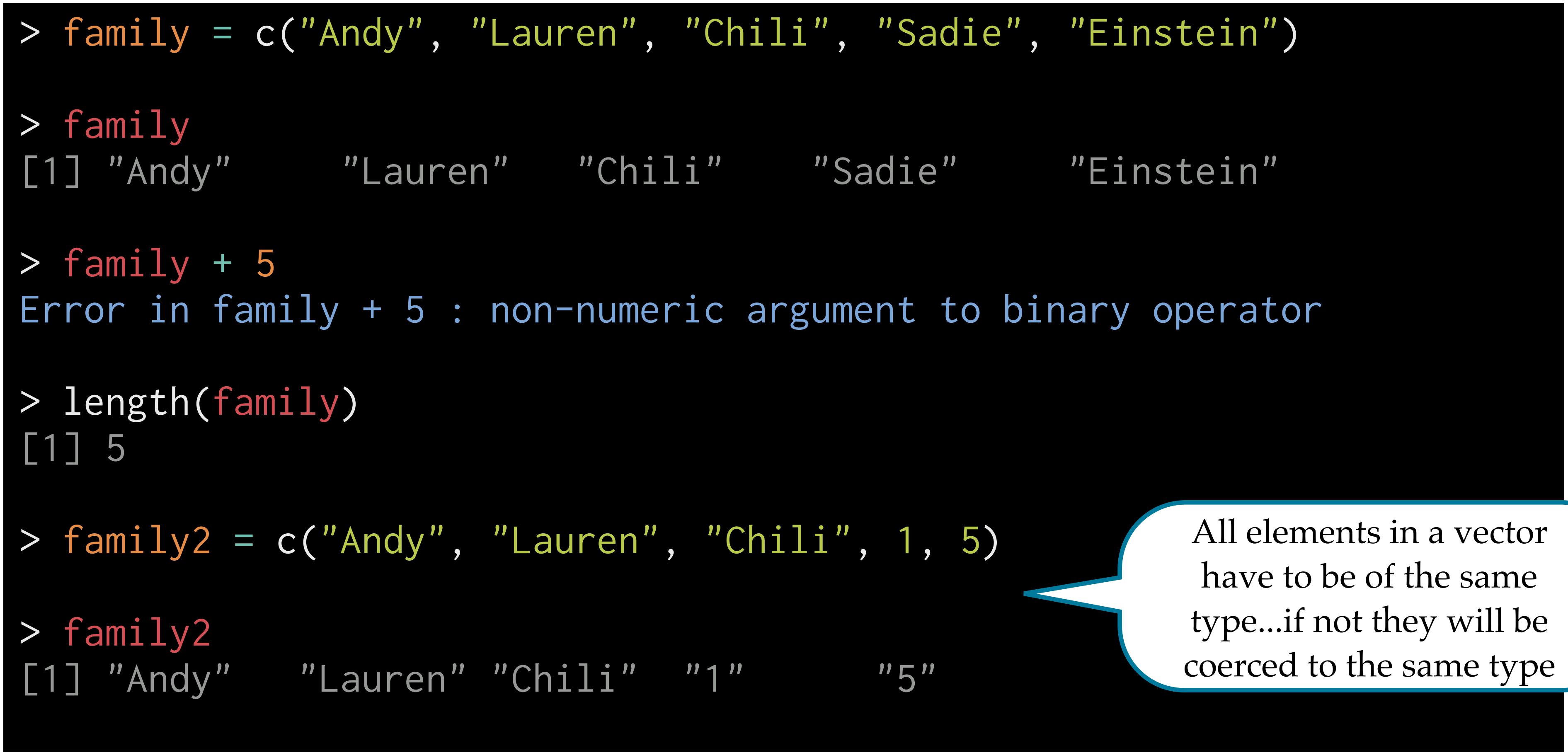
Some computations are element-wise

Some computations are vector-wise

Character Vectors

Not all vectors are numeric. R has six different types of vectors. Use `class()` to find out what type you have.

In a **character vector** (a.k.a. strings, literals) each element is a character string. Character strings are delimited by quotation marks.

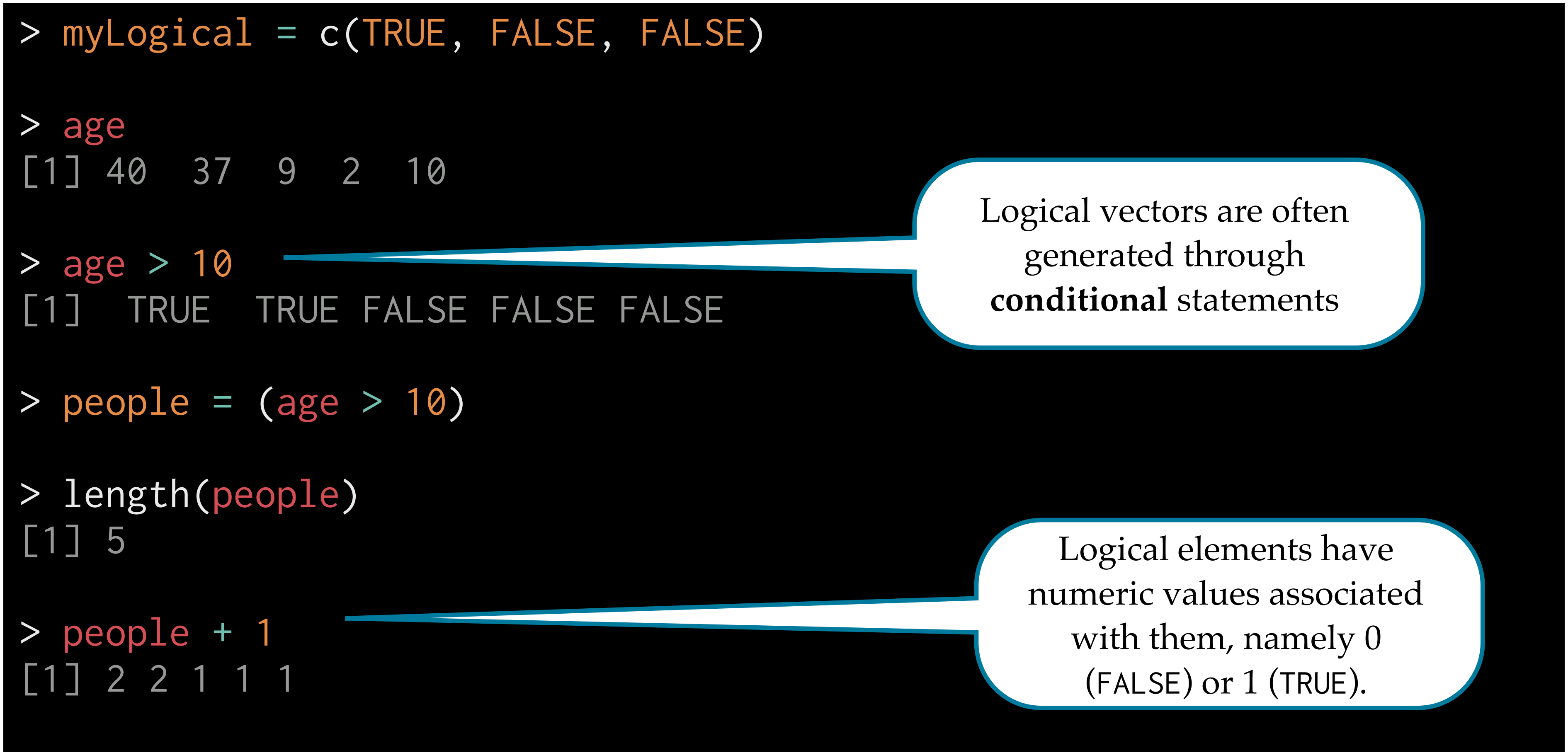


```
> family = c("Andy", "Lauren", "Chili", "Sadie", "Einstein")

> family
[1] "Andy"     "Lauren"   "Chili"    "Sadie"    "Einstein"

> family + 5
Error in family + 5 : non-numeric argument to binary operator

> length(family)
[1] 5

> family2 = c("Andy", "Lauren", "Chili", 1, 5)

> family2
[1] "Andy"   "Lauren" "Chili"  "1"      "5"
```

All elements in a vector have to be of the same type...if not they will be coerced to the same type

Logical Vectors

In a **logical vector** each element is `TRUE` or `FALSE`. Logical elements are *not* delimited by quotation marks.



```
> myLogical = c(TRUE, FALSE, FALSE)

> age
[1] 40 37  9  2 10

> age > 10
[1]  TRUE  TRUE FALSE FALSE FALSE

> people = (age > 10)

> length(people)
[1] 5

> people + 1
[1] 2 2 1 1 1
```

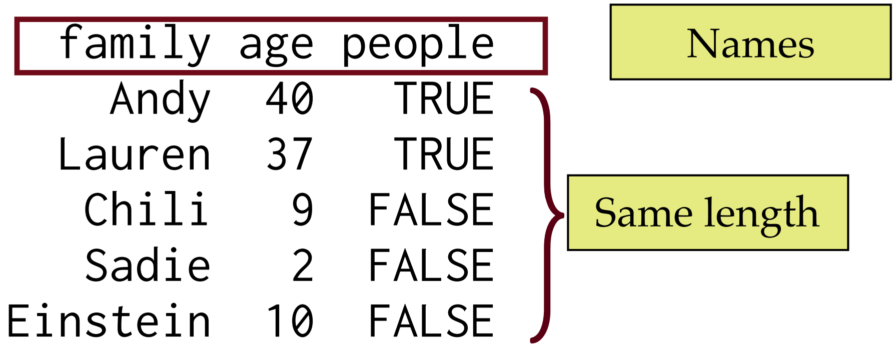
Logical vectors are often generated through **conditional** statements

Logical elements have numeric values associated with them, namely 0 (`FALSE`) or 1 (`TRUE`).

Data Structures: Data Frames

Data frames have a tabular (rectangular) structure made up of rows (cases) and columns (variables).

- Columns need to have the same length
- Columns can be of different vector types
- Columns have names



```
  family age people
    Andy  40   TRUE
  Lauren  37   TRUE
   Chili   9  FALSE
   Sadie   2  FALSE
Einstein  10  FALSE
```

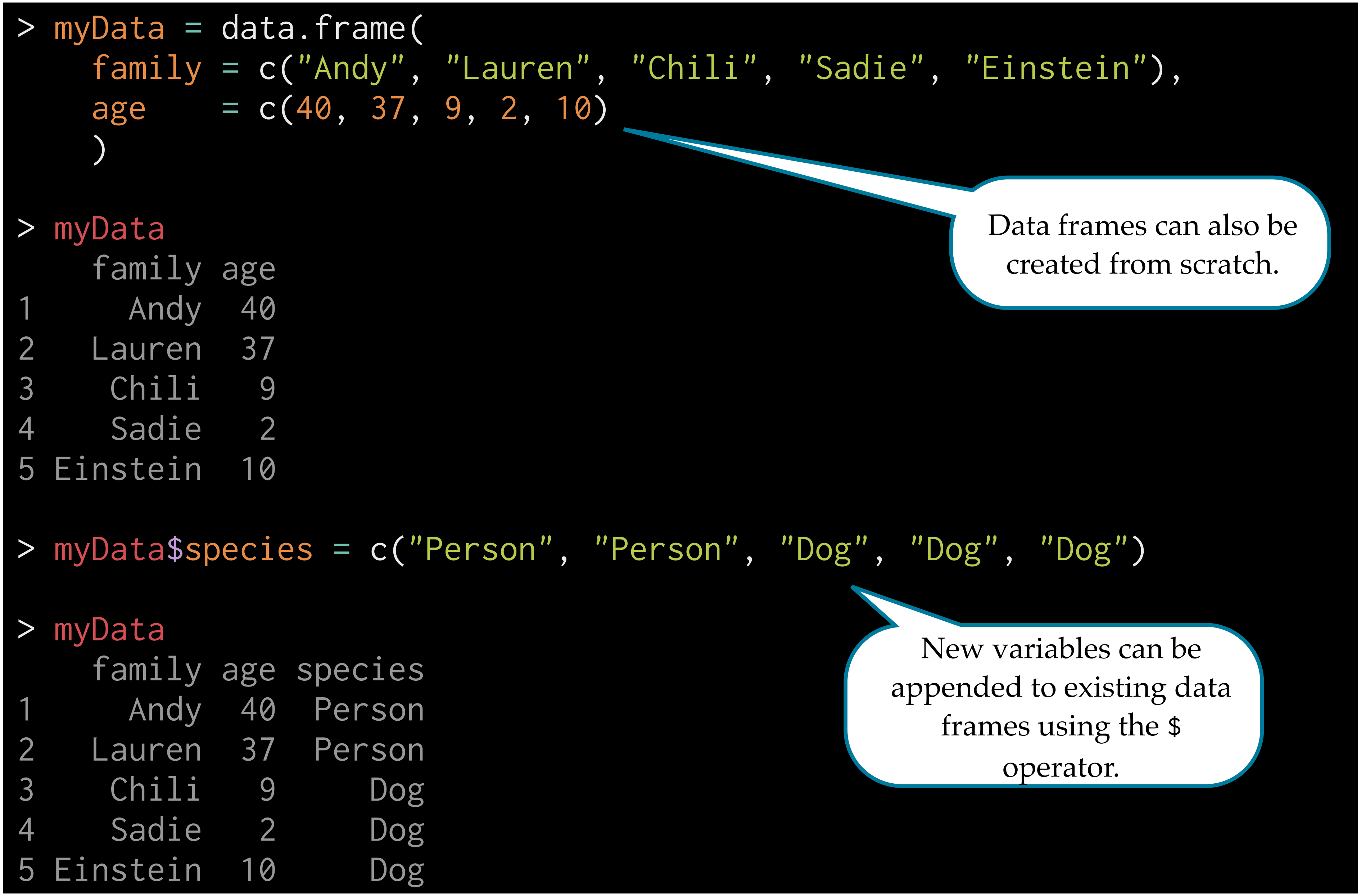
Names

Same length

Creating Data Frames

You can create data frames by binding together existing vectors.

```
> myData = data.frame(family, age, people)

> myData
    family  age  people
1     Andy    1   FALSE
2   Lauren    6    TRUE
3    Chili    7    TRUE
4     Mojo    7    TRUE
5 Einstein   10    TRUE
```

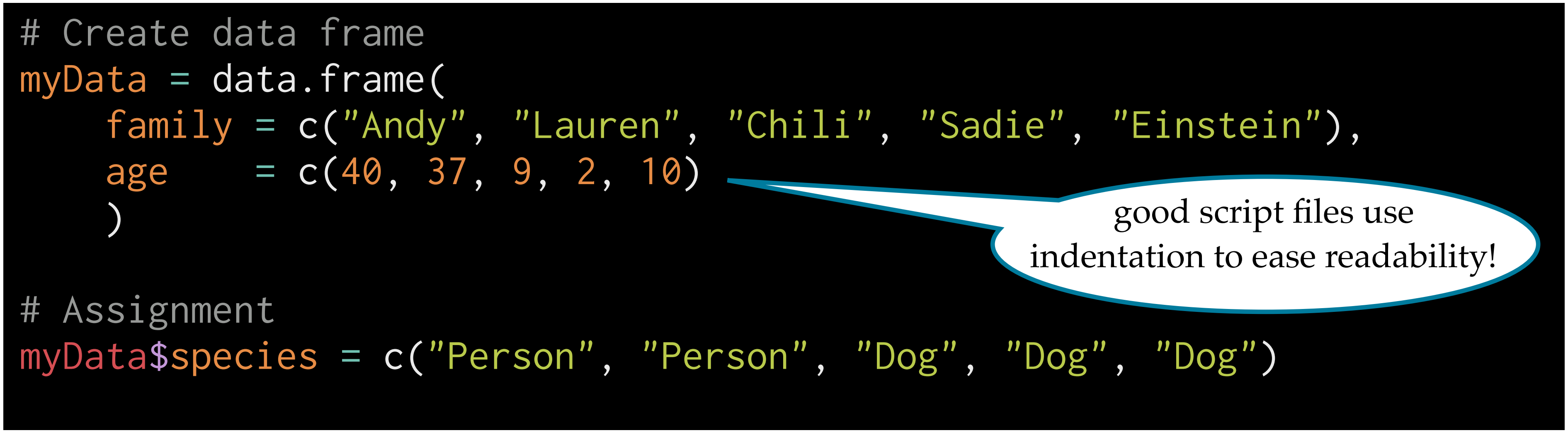


```
> myData = data.frame(
    family = c("Andy", "Lauren", "Chili", "Sadie", "Einstein"),
    age    = c(40, 37, 9, 2, 10)
    )

> myData
    family age
1     Andy  40
2   Lauren  37
3    Chili   9
4    Sadie   2
5 Einstein  10

> myData$species = c("Person", "Person", "Dog", "Dog", "Dog")

> myData
    family age species
1     Andy  40  Person
2   Lauren  37  Person
3    Chili   9     Dog
4    Sadie   2     Dog
5 Einstein  10     Dog
```

Data frames can also be created from scratch.

New variables can be appended to existing data frames using the $ operator.

Script File: Part II

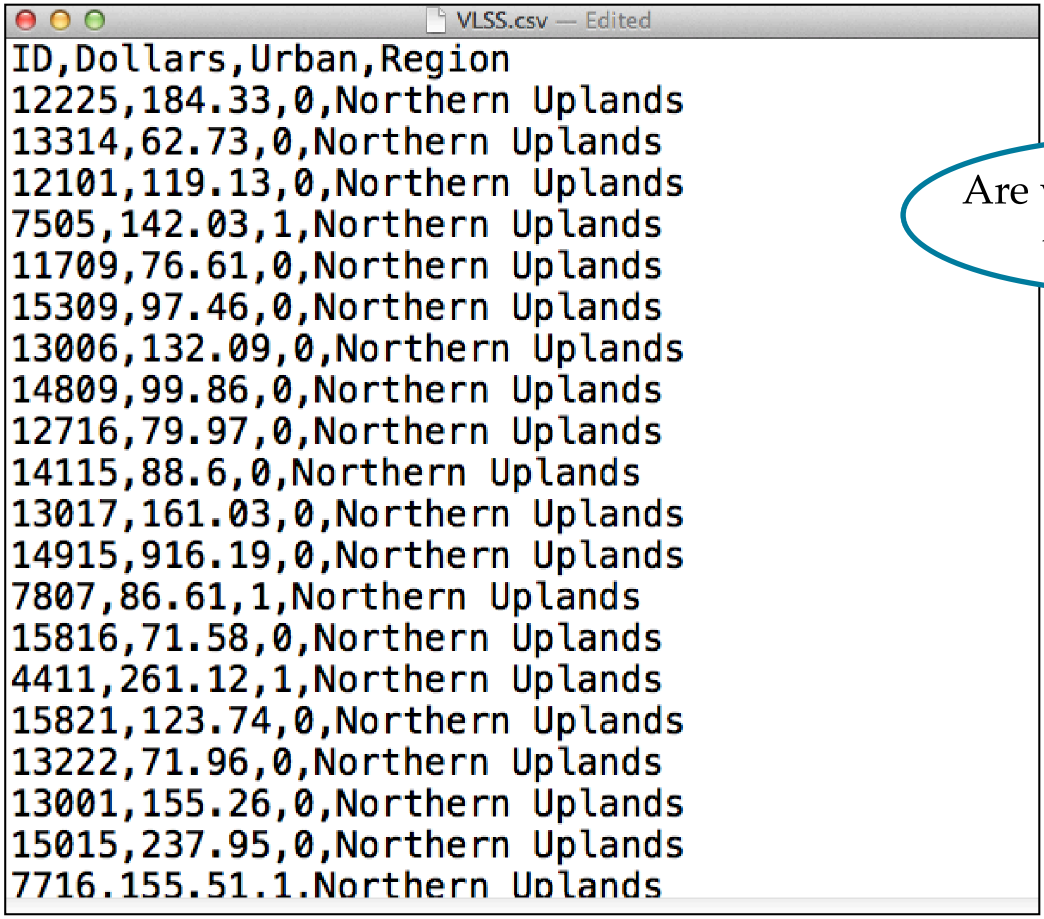


```r
# Create data frame
myData = data.frame(
    family = c("Andy", "Lauren", "Chili", "Sadie", "Einstein"),
    age    = c(40, 37, 9, 2, 10)
    )

# Assignment
myData$species = c("Person", "Person", "Dog", "Dog", "Dog")
```

good script files use indentation to ease readability!

Importing External Data into RStudio

If you didn't enter the data, generally a good idea to examine the data in a text editor or browser.



```
ID,Dollars,Urban,Region
12225,184.33,0,Northern Uplands
13314,62.73,0,Northern Uplands
12101,119.13,0,Northern Uplands
7505,142.03,1,Northern Uplands
11709,76.61,0,Northern Uplands
15309,97.46,0,Northern Uplands
13006,132.09,0,Northern Uplands
14809,99.86,0,Northern Uplands
12716,79.97,0,Northern Uplands
14115,88.6,0,Northern Uplands
13017,161.03,0,Northern Uplands
14915,916.19,0,Northern Uplands
7807,86.61,1,Northern Uplands
15816,71.58,0,Northern Uplands
4411,261.12,1,Northern Uplands
15821,123.74,0,Northern Uplands
13222,71.96,0,Northern Uplands
13001,155.26,0,Northern Uplands
15015,237.95,0,Northern Uplands
7716,155.51,1,Northern Uplands
```

Two Questions

Are variable names in the first row?

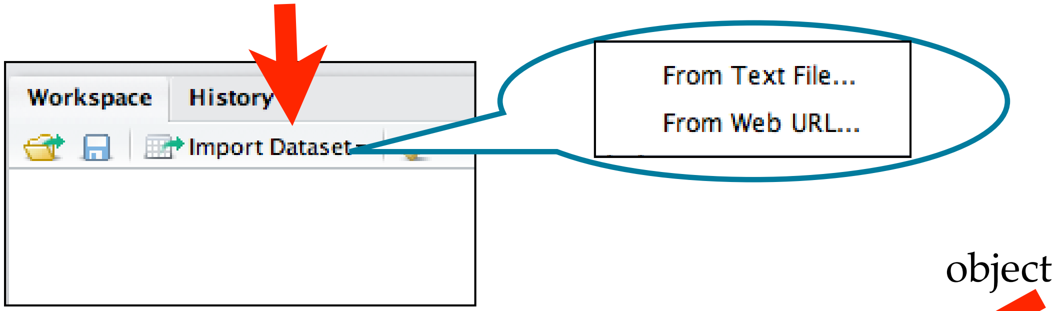
What is the delimiter?

Tip

Enter data in a spreadsheet program (e.g., Excel). Leave a blank cell for missing data.

Save as a CSV file

Workspace pane:
Import Dataset



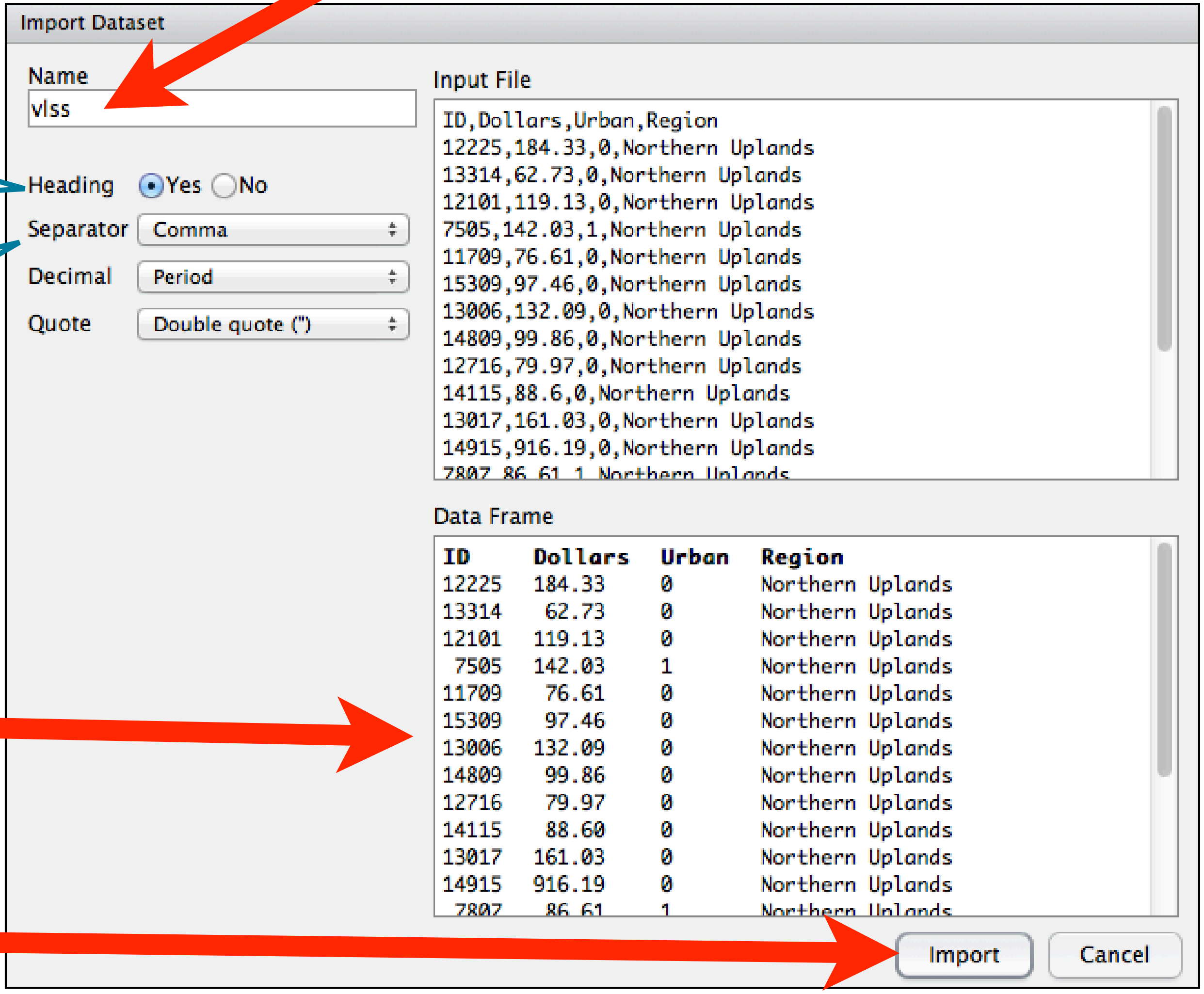
object name

Are variable names in the first row?

What is the delimiter?

How your data will look in R

When you are happy, click **Import**



Name: vlss

Heading ● Yes ○ No

Separator: Comma

Decimal: Period

Quote: Double quote (")

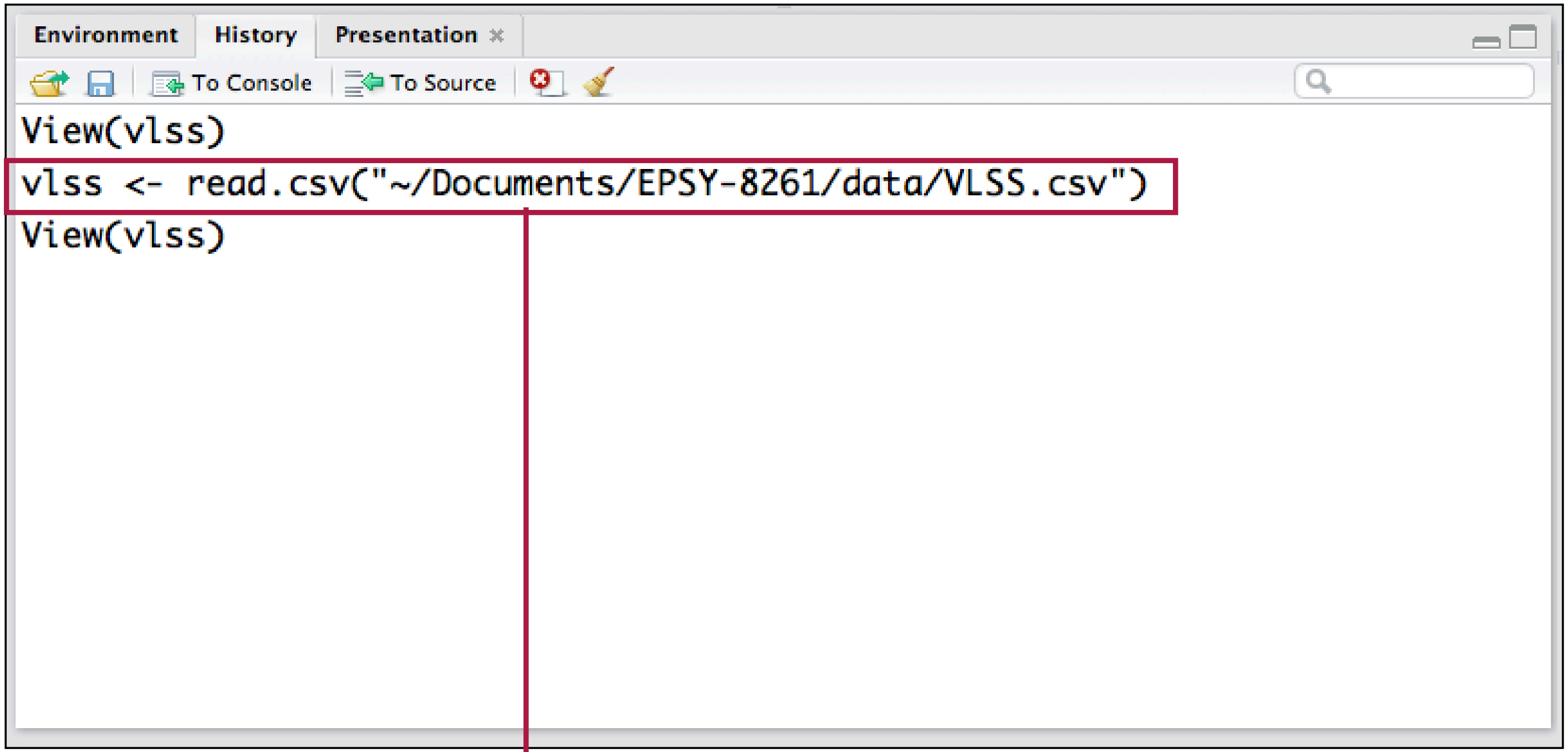
Input File

```
ID,Dollars,Urban,Region
12225,184.33,0,Northern Uplands
13314,62.73,0,Northern Uplands
12101,119.13,0,Northern Uplands
7505,142.03,1,Northern Uplands
11709,76.61,0,Northern Uplands
15309,97.46,0,Northern Uplands
13006,132.09,0,Northern Uplands
14809,99.86,0,Northern Uplands
12716,79.97,0,Northern Uplands
14115,88.6,0,Northern Uplands
13017,161.03,0,Northern Uplands
14915,916.19,0,Northern Uplands
7807,86.61,1,Northern Uplands
```

Data Frame

```
ID     Dollars   Urban   Region
12225  184.33    0       Northern Uplands
13314   62.73    0       Northern Uplands
12101  119.13    0       Northern Uplands
 7505  142.03    1       Northern Uplands
11709   76.61    0       Northern Uplands
15309   97.46    0       Northern Uplands
13006  132.09    0       Northern Uplands
14809   99.86    0       Northern Uplands
12716   79.97    0       Northern Uplands
14115   88.60    0       Northern Uplands
13017  161.03    0       Northern Uplands
14915  916.19    0       Northern Uplands
 7807   86.61    1       Northern Uplands
```

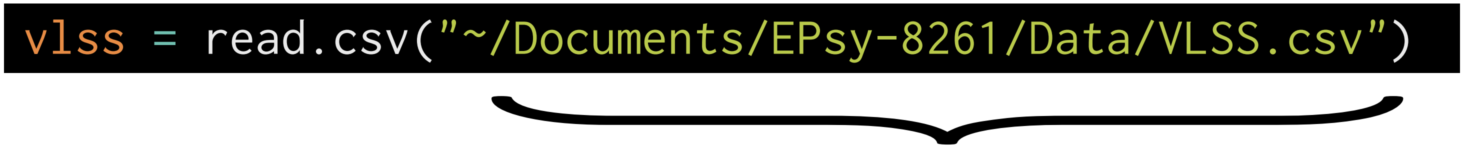
Immediately copy the syntax from the console pane into your script file and comment it...remember no prompts; no output



```
View(vlss)
vlss <- read.csv("~/Documents/EPSY-8261/data/VLSS.csv")
View(vlss)
```

```
# Read in VLSS data
vlss = read.csv("~/Documents/EPsy-8261/Data/VLSS.csv")
```

The import feature in RStudio is using the `read.csv()` function to read in an external file. The argument for this function is the file's path name given as a character string.



```
vlss = read.csv("~/Documents/EPsy-8261/Data/VLSS.csv")
```

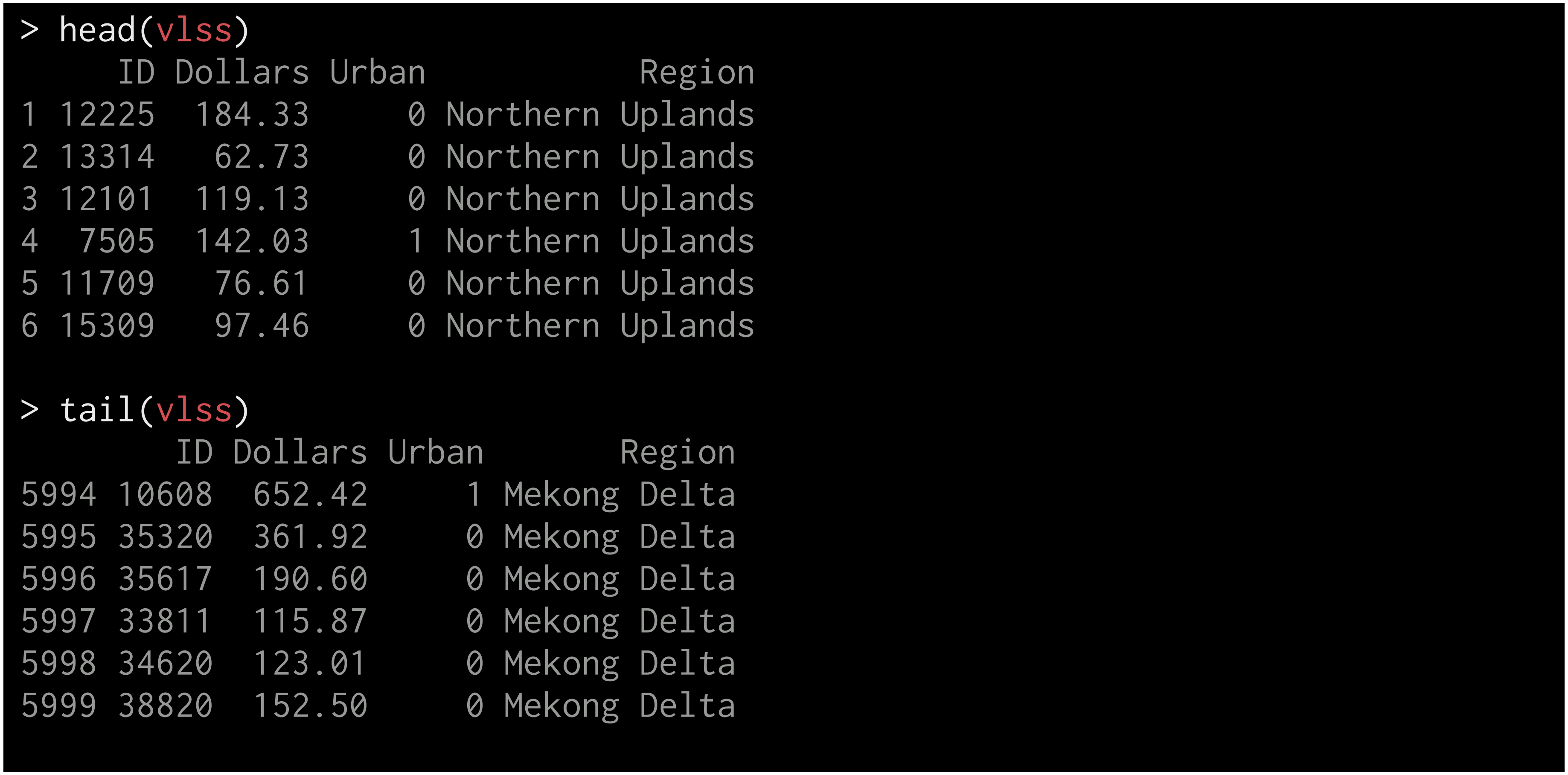
Path name

The path name is the syntactic "address" for a file on your computer.

- Go into your home directory (`~/`)
- Go into the "Documents" folder (`Documents/`)
- Go into the "EPsy-8261" folder (`EPsy-8261/`)
- Go into the "Data" folder (`Data/`)
- Open the file called "VLSS.csv" (`VLSS.csv`)

Then, assign this file into the object `vlss`, which will be a data frame.

After reading in external data examine it.



```
> head(vlss)
     ID Dollars Urban           Region
1 12225  184.33     0 Northern Uplands
2 13314   62.73     0 Northern Uplands
3 12101  119.13     0 Northern Uplands
4  7505  142.03     1 Northern Uplands
5 11709   76.61     0 Northern Uplands
6 15309   97.46     0 Northern Uplands

> tail(vlss)
        ID Dollars Urban       Region
5994 10608  652.42     1 Mekong Delta
5995 35320  361.92     0 Mekong Delta
5996 35617  190.60     0 Mekong Delta
5997 33811  115.87     0 Mekong Delta
5998 34620  123.01     0 Mekong Delta
5999 38820  152.50     0 Mekong Delta
```

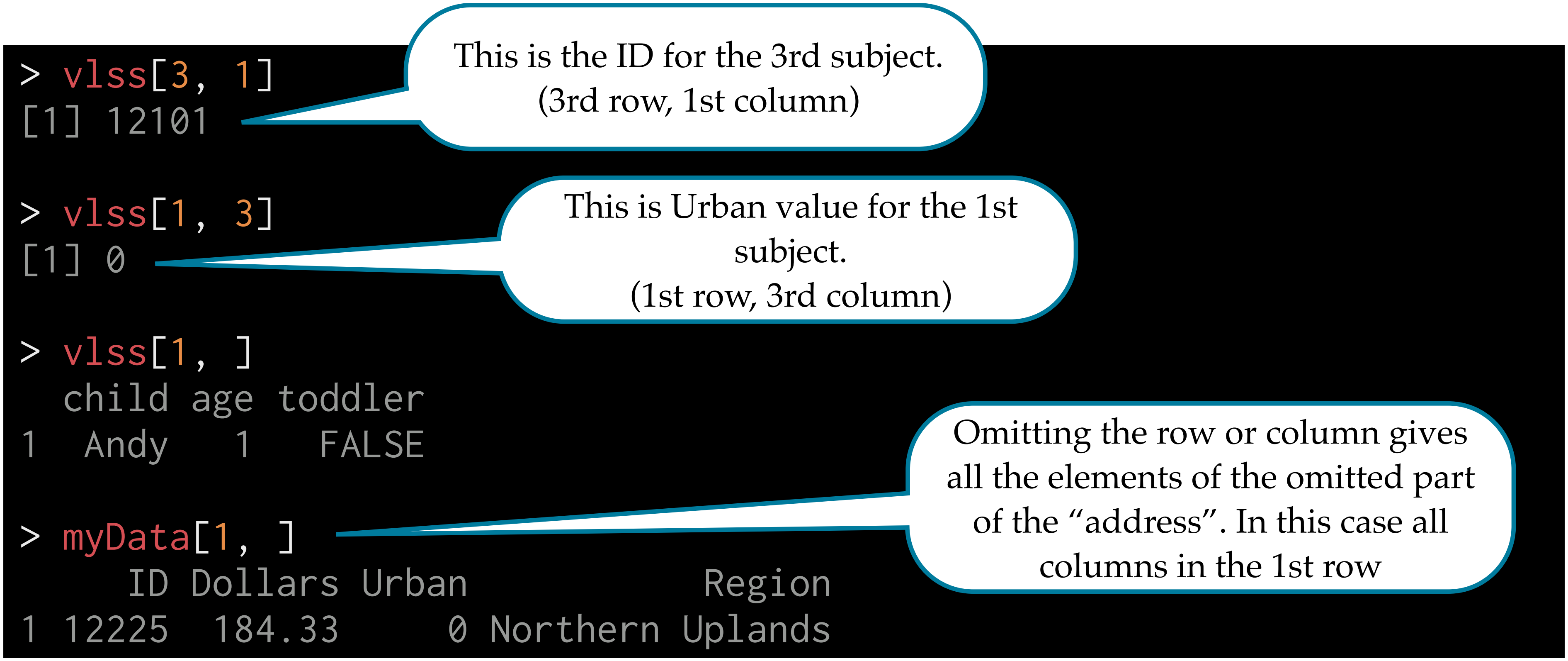
Accessing Data Frame Elements: Indexing

Think of the data frames as a rectangle (matrix) made up of rows and columns.

This data frame is a 5999 x 4 rectangle.

```
   ID Dollars Urban           Region
12225  184.33     0 Northern Uplands
13314   62.73     0 Northern Uplands
12101  119.13     0 Northern Uplands
 7505  142.03     1 Northern Uplands
11709   76.61     0 Northern Uplands
    ⋮       ⋮     ⋮         ⋮
35320  361.92     0 Mekong Delta
35617  190.60     0 Mekong Delta
33811  115.87     0 Mekong Delta
34620  123.01     0 Mekong Delta
38820  152.50     0 Mekong Delta
```

To access elements we give the “address” of the element within the rectangle, [*row*, *column*]. This is called **indexing**.



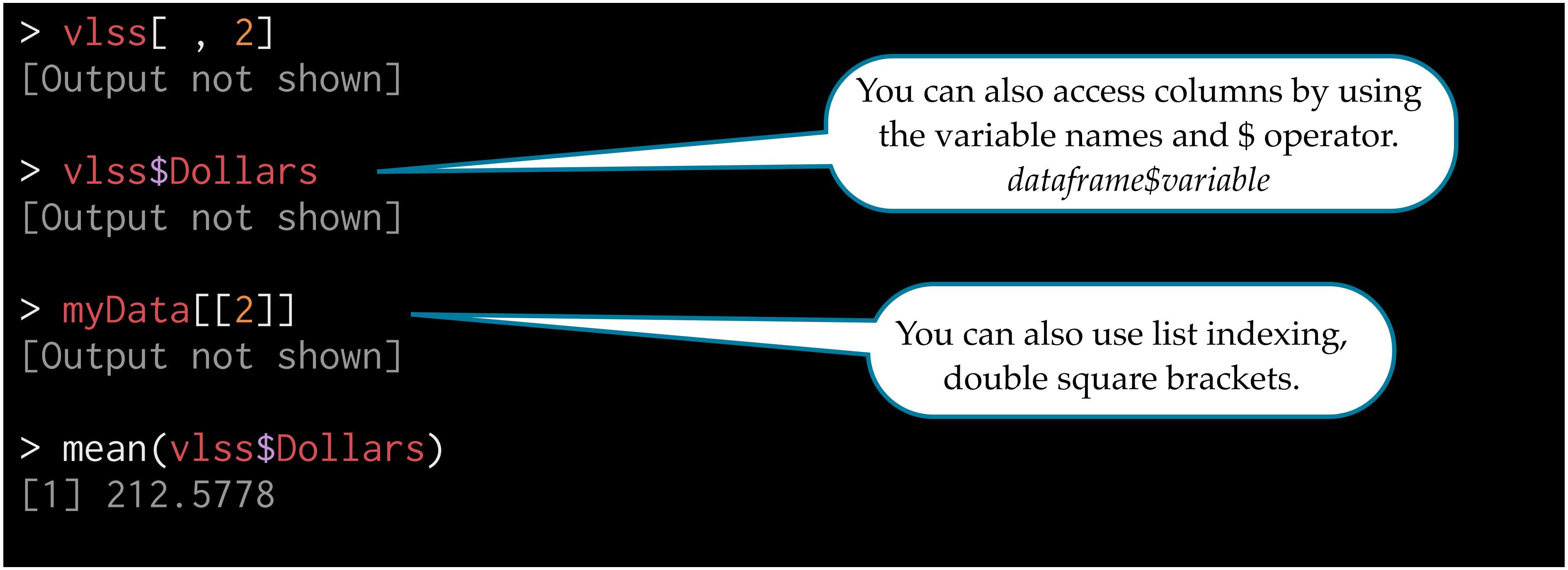
```
> vlss[3, 1]
[1] 12101

> vlss[1, 3]
[1] 0

> vlss[1, ]
  child age toddler
1  Andy   1   FALSE

> myData[1, ]
     ID Dollars Urban           Region
1 12225  184.33     0 Northern Uplands
```

This is the ID for the 3rd subject. (3rd row, 1st column)

This is Urban value for the 1st subject. (1st row, 3rd column)

Omitting the row or column gives all the elements of the omitted part of the “address”. In this case all columns in the 1st row

Accessing Variables (columns)



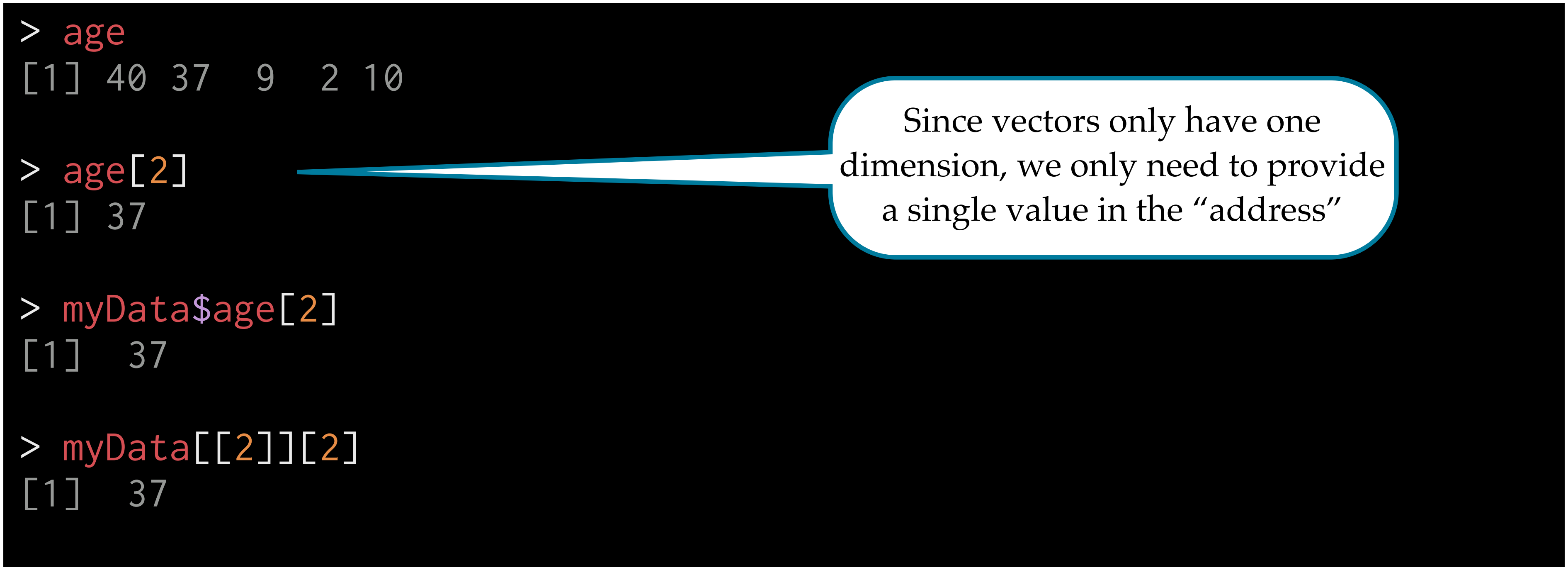
```
> vlss[ , 2]
[Output not shown]

> vlss$Dollars
[Output not shown]

> myData[[2]]
[Output not shown]

> mean(vlss$Dollars)
[1] 212.5778
```

You can also access columns by using the variable names and $ operator.
dataframe$variable

You can also use list indexing, double square brackets.

Indexing a Vector

Indexing also works on vectors.

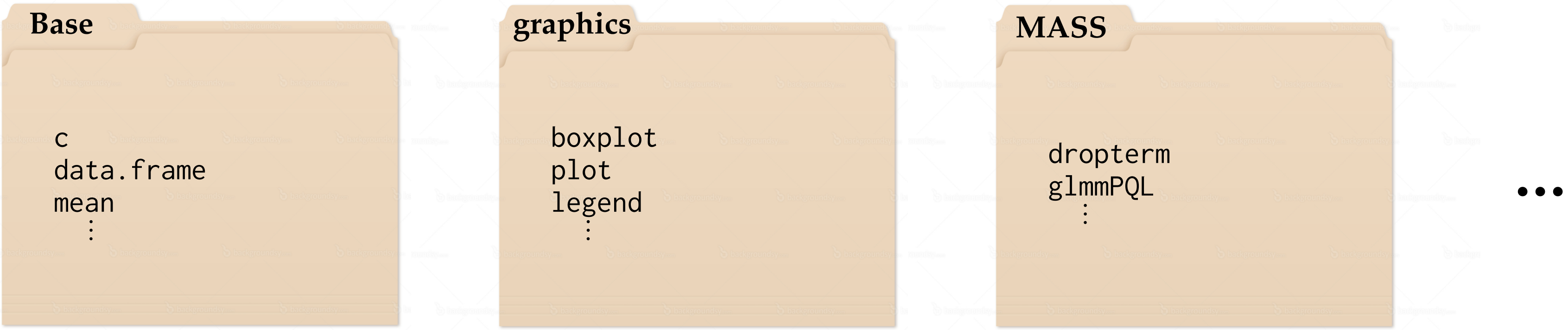


```
> age
[1] 40 37  9  2 10

> age[2]
[1] 37

> myData$age[2]
[1]  37

> myData[[2]][2]
[1]  37
```

Since vectors only have one dimension, we only need to provide a single value in the “address”

Adding Functionality: Packages (Libraries)

R functions are stored in packages (or libraries). There over 5,000 different packages available on CRAN (and more on gitHub, webpages, etc.)



Base

```
c
data.frame
mean
  ⋮
```

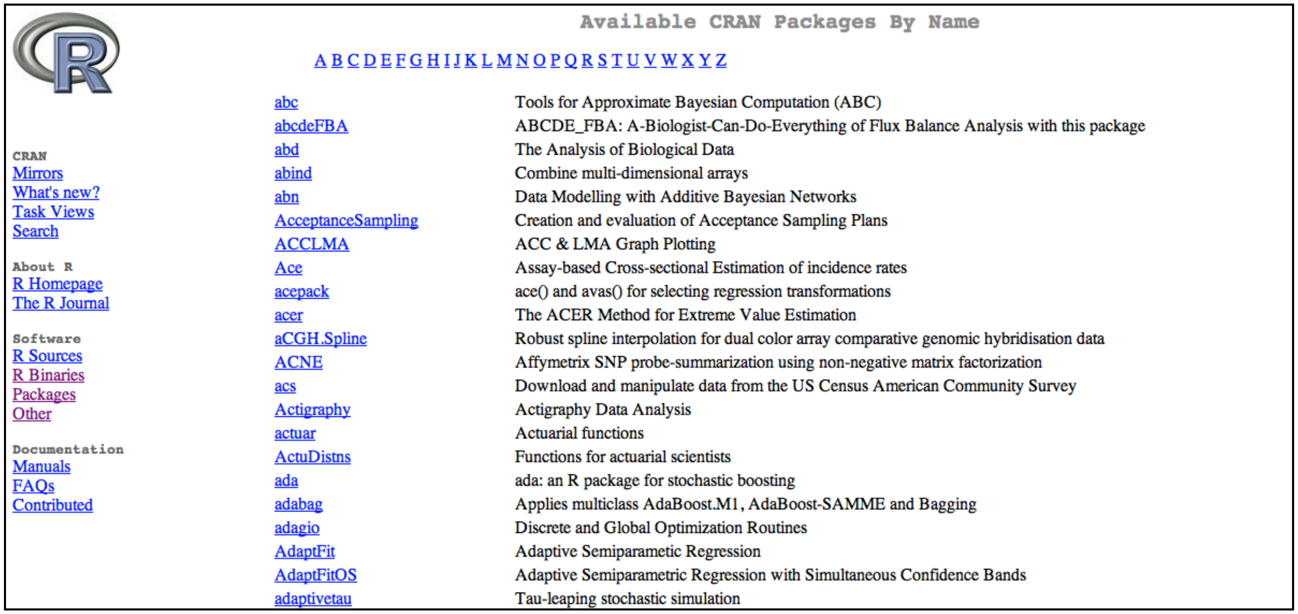
graphics

```
boxplot
plot
legend
  ⋮
```

MASS

```
dropterm
glmmPQL
  ⋮
```

•••



Available CRAN Packages By Name

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

CRAN
Mirrors
What's new?
Task Views
Search

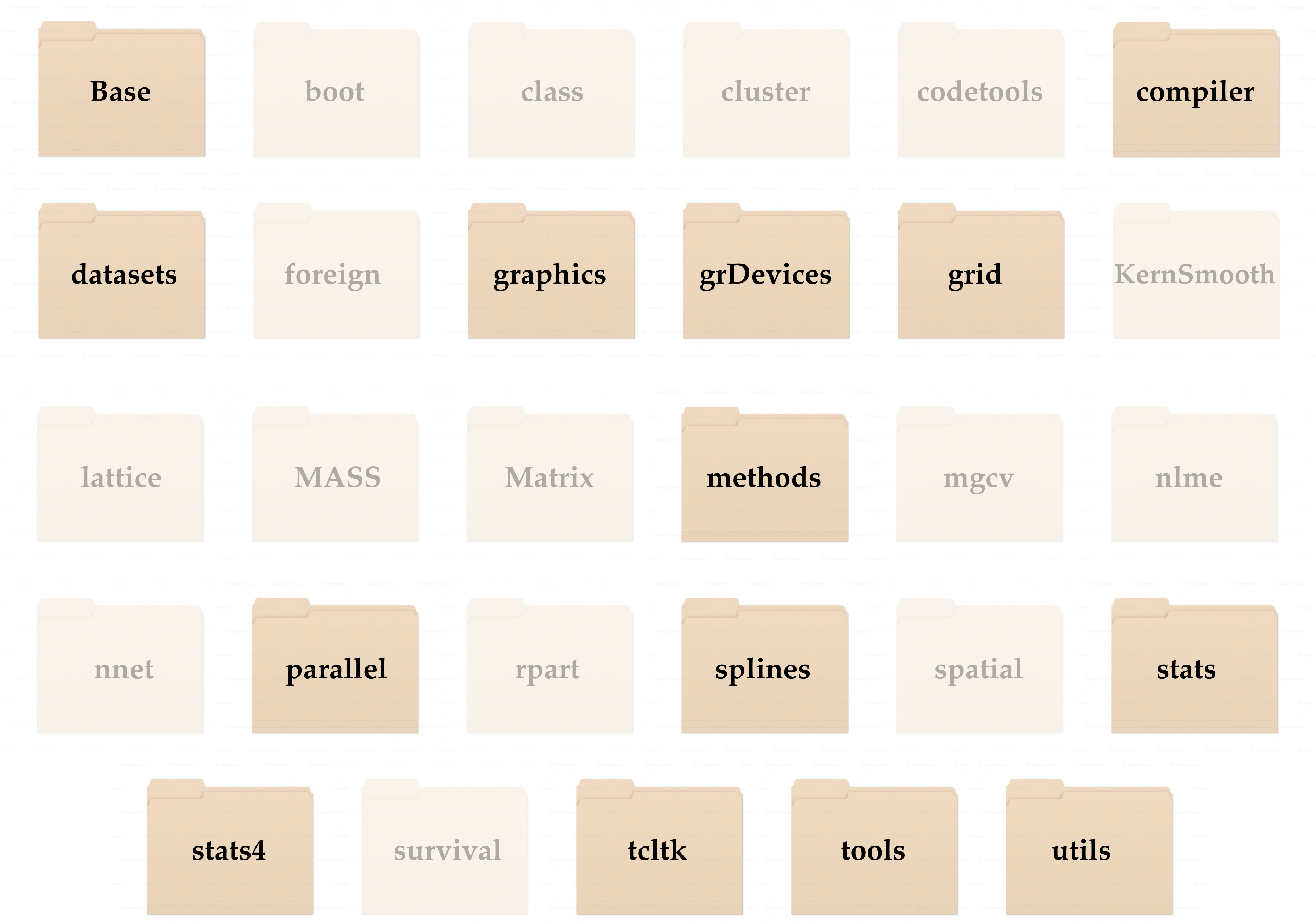
About R
R Homepage
The R Journal

Software
R Sources
R Binaries
Packages
Other

Documentation
Manuals
FAQs
Contributed

abc	Tools for Approximate Bayesian Computation (ABC)
abcdeFBA	ABCDE_FBA: A-Biologist-Can-Do-Everything of Flux Balance Analysis with this package
abd	The Analysis of Biological Data
abind	Combine multi-dimensional arrays
abn	Data Modelling with Additive Bayesian Networks
AcceptanceSampling	Creation and evaluation of Acceptance Sampling Plans
ACCLMA	ACC & LMA Graph Plotting
Ace	Assay-based Cross-sectional Estimation of incidence rates
acepack	ace() and avas() for selecting regression transformations
acer	The ACER Method for Extreme Value Estimation
aCGH.Spline	Robust spline interpolation for dual color array comparative genomic hybridisation data
ACNE	Affymetrix SNP probe-summarization using non-negative matrix factorization
acs	Download and manipulate data from the US Census American Community Survey
Actigraphy	Actigraphy Data Analysis
actuar	Actuarial functions
ActuDistns	Functions for actuarial scientists
ada	ada: an R package for stochastic boosting
adabag	Applies multiclass AdaBoost.M1, AdaBoost-SAMME and Bagging
adagio	Discrete and Global Optimization Routines
AdaptFit	Adaptive Semiparametric Regression
AdaptFitOS	Adaptive Semiparametric Regression with Simultaneous Confidence Bands
adaptivetau	Tau-leaping stochastic simulation

Packages You (probably) Already Have



Base boot class cluster codetools **compiler**

datasets foreign **graphics** **grDevices** **grid** KernSmooth

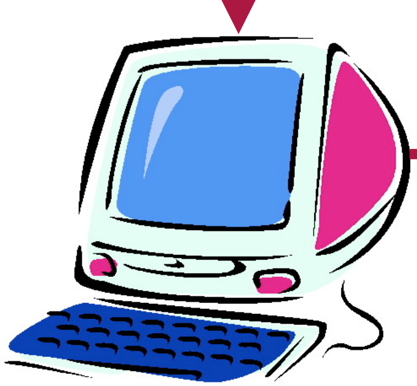
lattice MASS Matrix **methods** mgcv nlme

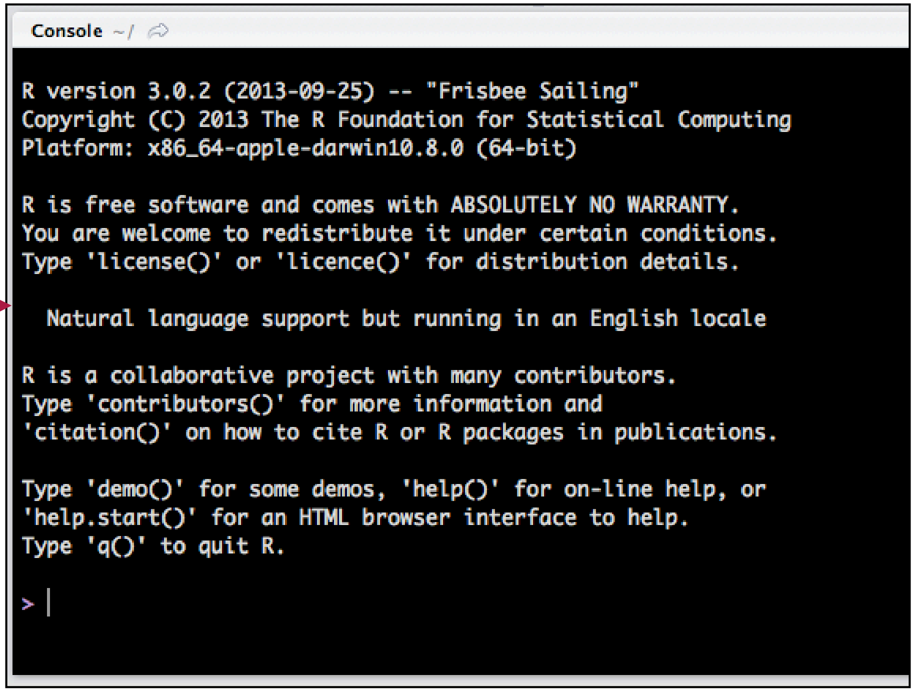
nnet **parallel** rpart **splines** spatial **stats**

stats4 survival **tcltk** **tools** **utils**

There are two distinct things you need to do to use the functions available in a package...**install** the package *and* **load** the package.

Installing the package takes it from the internet and puts it on your computer.





```
R version 3.0.2 (2013-09-25) -- "Frisbee Sailing"
Copyright (C) 2013 The R Foundation for Statistical Computing
Platform: x86_64-apple-darwin10.8.0 (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.

> |
```

Loading the package makes it useable during your R session

Loading Packages that are Installed

The `library()` function is used to load packages that have previously been installed.

```
> library(MASS)

> library(survival)
Loading required package: splines
```

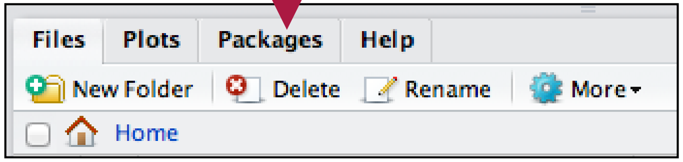
Some packages requires other packages (dependencies) to work. For example, the **survival** package is dependent on the **splines** package.

Once the package is loaded, all of the functions, data sets, etc. in that package are available to you.

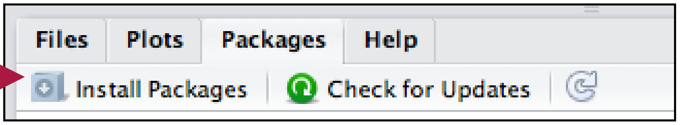
Packages will need to be loaded every time you launch a new R session.

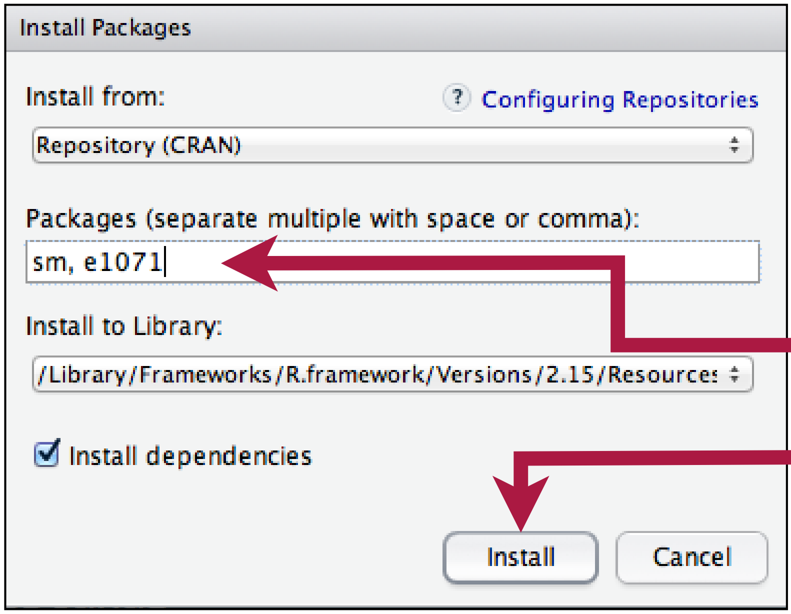
Installing New Packages

1. Click the **Package** tab in the **Files/Plots/Packages/Help pane**. This will bring up a list of all of the packages *installed* on your computer



2. To install a new package, click **Install Packages**





Install from: Repository (CRAN)

Packages (separate multiple with space or comma): sm, e1071

Install to Library: /Library/Frameworks/R.framework/Versions/2.15/Resource:

☑ Install dependencies

3. Enter the name of the package you would like to install in the text box. (Note that you can install more than one package at a time.) Click **Install**.

Packages will only need to be installed once.