R mini-course: week 1

NORC, Academic Research Centers

http://lefft.xyz/r_minicourse

timothy leffel, spring 2017

welcome!

agenda for course:

- **week 1** – R workflow, navigation, programming basics
- **week 2** – working with datasets and external files, data cleaning + manipulation
- **week 3** – summarizing data with `dplyr::`, visualizing data with `ggplot2::`
- **week 4** – document authoring with R Markdown, working with the web

course materials will eventually all be on the course website:

http://lefft.xyz/r_minicourse

each week we'll have slides, notes, and a script. little exercises will be interleaved throughout the notes. the best way to write up solutions is to start a new R script called (e.g.) `week1_exercises.r` and type directly into that.

there will also be a list of links to useful resources up on the site

types of files we'll be using

R scripts

- a plain-text file with extension `.R` or `.r`
- all plain-text files (e.g. `.txt`) can be opened and edited directly in any text editor
- contains R code that we'll run interactively in R Studio
- also contains comments, which are just annotations that explain what the code is doing

types of files we'll be using

datasets

- all kinds of extensions, e.g. `.csv`, `.tsv`, `.xls`, `.xlsx`, `.dat`, `.sav`, `.dta`. nowadays, R can read them all. we'll go through examples of several in week 2.
- working with `.csv` files is generally preferable, since they are simple and come in plain-text format.
- proprietary formats like `.xlsx` have certain nice features, but they're binary files, which can make their behavior unpredictable (and depend on the Excel version used to create them).
- a less common format is `.Rdata`/`.rda`, which contains an R workspace with datasets and objects pre-loaded. (not plain-text so I try to avoid them)

types of files we'll be using

R Markdown files

- extension `.Rmd` or `.rmd`
- plain-text format (opens in any text editor)
- a special kind of R script from which nice, clean documents can be easily generated (in .pdf, .html, or .docx formats)
- easiest way to compile is with `cmd+shift+k` from R Studio

firing up R via R Studio

when you're using R, it's "looking" in a specific directory (folder). many tears have been shed over trying to get R to look in the desired directory (mine and those of countless other victims).

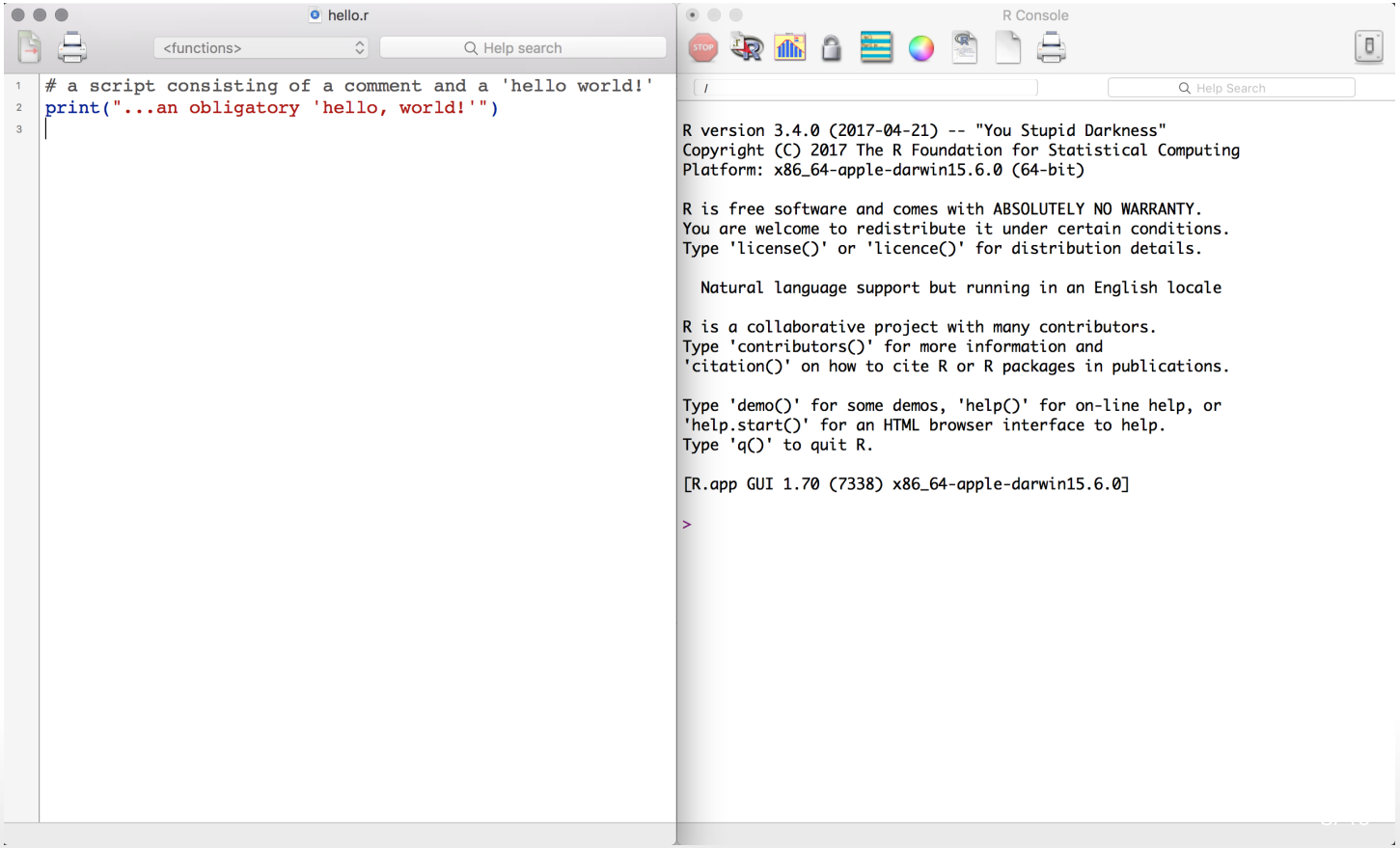
the best way to start an R session is to grab/make a plain text file with extension `.r` (e.g. `my_script.r`), put it in its own folder (e.g. `R_folder`), and then open it with R Studio (which you should set as the default).

if you start R by opening a specific script in R Studio, R will be looking into the folder containing your script and you won't have to mess with working directories.

you can also to go "tools" –> "global options" –> "default working directory" within R Studio to tell R where it should look if you just open R Studio directly

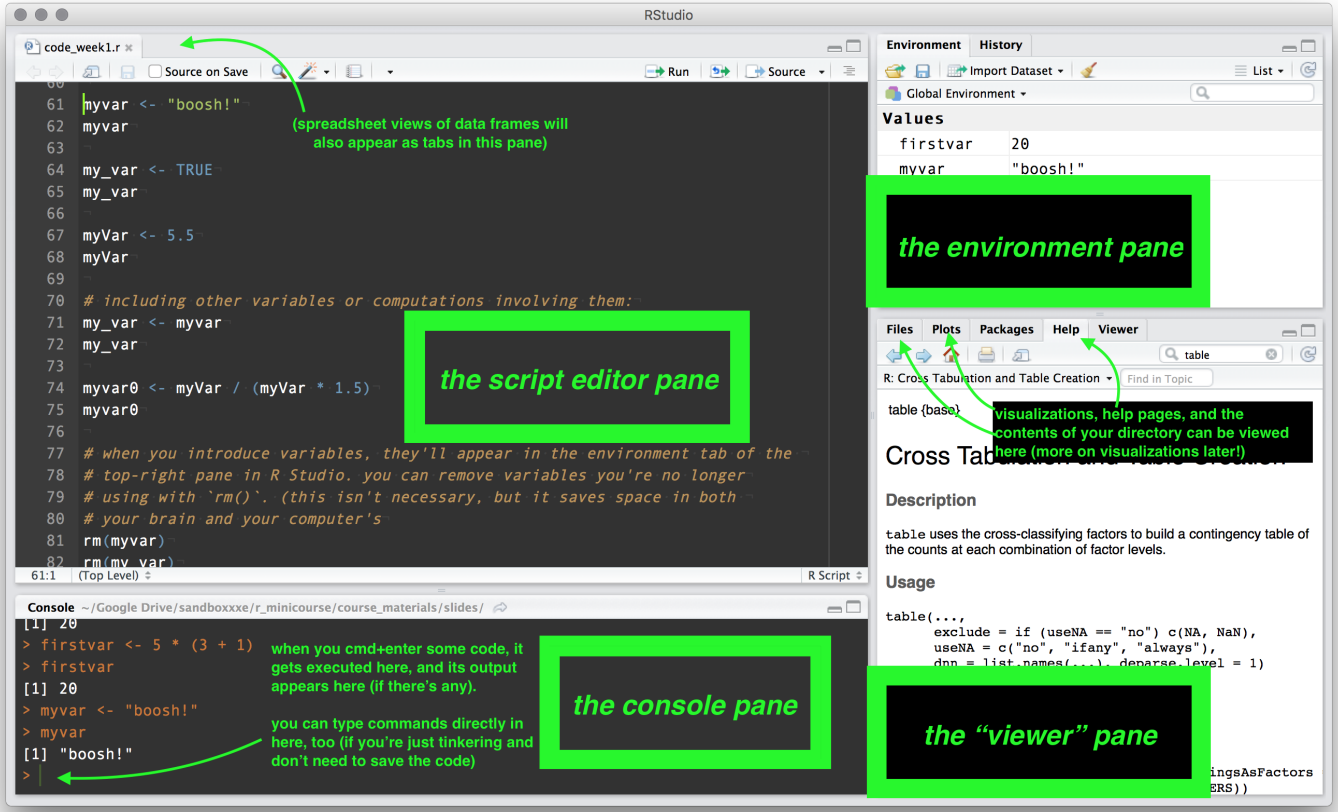
how to talk to R – via command-line interface (yikes :/)

how to talk to R – via default R GUI (better…)



how to talk to R – via R Studio IDE (waaaaaow!)

navigating R Studio


RStudio
code_week1.r
Source on Save
Run
Source
61 myvar <- "boosh!"
62 myvar
64 my_var <- TRUE
65 my_var
67 myVar <- 5.5
68 myVar
70 # including other variables or computations involving them:
71 my_var <- myvar
72 my_var
74 myvar0 <- myVar / (myVar * 1.5)
75 myvar0
77 # when you introduce variables, they'll appear in the environment tab of the
78 # top-right pane in R Studio. you can remove variables you're no longer
79 # using with `rm()`. (this isn't necessary, but it saves space in both
80 # your brain and your computer's
81 rm(myvar)
82 rm(my_var)
61:1 (Top Level)
R Script
(spreadsheet views of data frames will also appear as tabs in this pane)
the script editor pane
Console ~/Google Drive/sandboxxxe/r_minicourse/course_materials/slides/
[1] 20
> firstvar <- 5 * (3 + 1)
> firstvar
[1] 20
> myvar <- "boosh!"
> myvar
[1] "boosh!"
when you cmd+enter some code, it gets executed here, and its output appears here (if there's any).
you can type commands directly in here, too (if you're just tinkering and don't need to save the code)
the console pane
Environment
History
Import Dataset
List
Global Environment
Values
firstvar 20
myvar "boosh!"
the environment pane
Files
Plots
Packages
Help
Viewer
table
R: Cross Tabulation and Table Creation
Find in Topic
table {base}
visualizations, help pages, and the contents of your directory can be viewed here (more on visualizations later!)
Description
table uses the cross-classifying factors to build a contingency table of the counts at each combination of factor levels.
Usage
table(...,
exclude = if (useNA == "no") c(NA, NaN),
useNA = c("no", "ifany", "always"),
the "viewer" pane

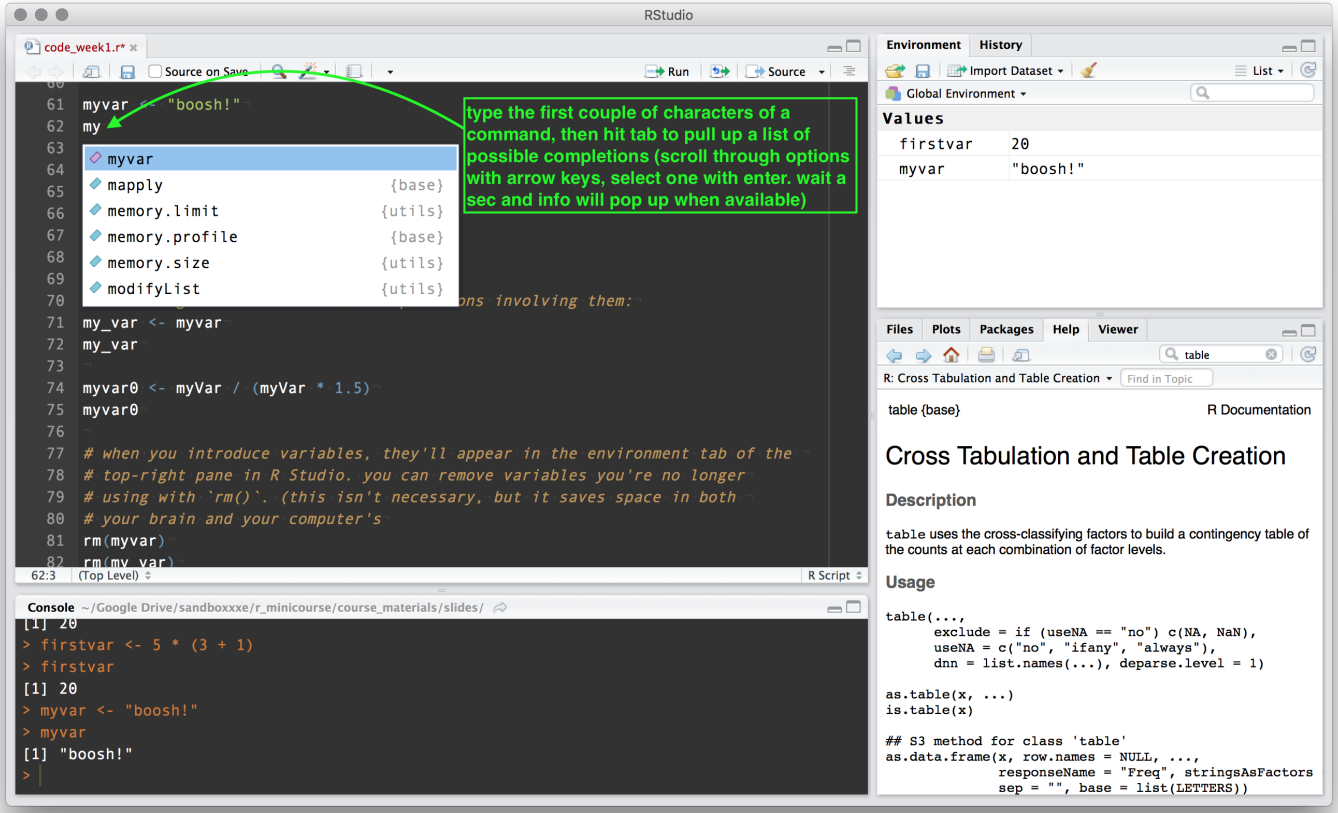

RStudio
code_week1.r*
Source on Save
Run
Source
myvar <- "boosh!"
my
myvar
mapply {base}
memory.limit {utils}
memory.profile {base}
memory.size {utils}
modifyList {utils}
type the first couple of characters of a command, then hit tab to pull up a list of possible completions (scroll through options with arrow keys, select one with enter. wait a sec and info will pop up when available)
my_var <- myvar
my_var
myvar0 <- myVar / (myVar * 1.5)
myvar0
# when you introduce variables, they'll appear in the environment tab of the
# top-right pane in R Studio. you can remove variables you're no longer
# using with `rm()`. (this isn't necessary, but it saves space in both
# your brain and your computer's
rm(myvar)
62:3
(Top Level)
R Script
Console ~/Google Drive/sandboxxxe/r_minicourse/course_materials/slides/
[1] 20
> firstvar <- 5 * (3 + 1)
> firstvar
[1] 20
> myvar <- "boosh!"
> myvar
[1] "boosh!"
Environment
History
Import Dataset
List
Global Environment
Values
firstvar 20
myvar "boosh!"
Files
Plots
Packages
Help
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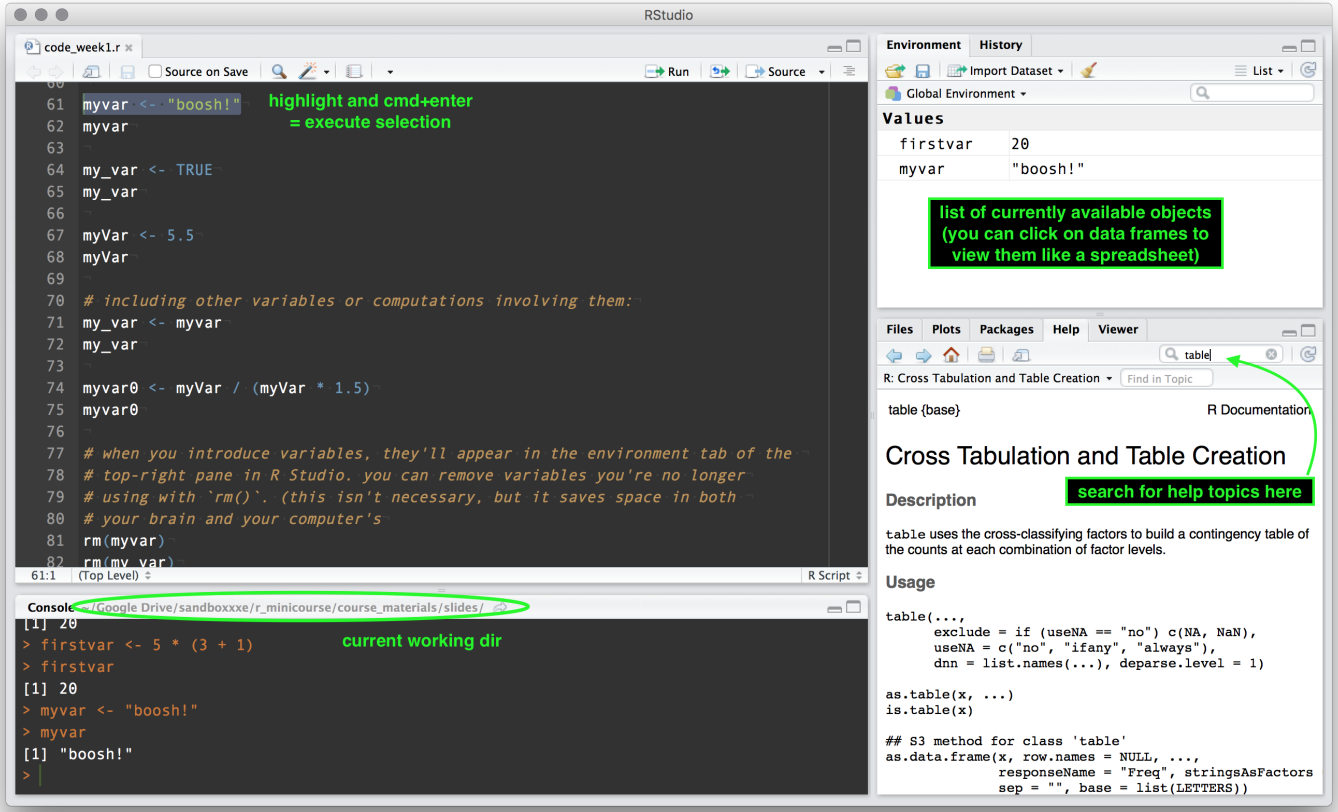
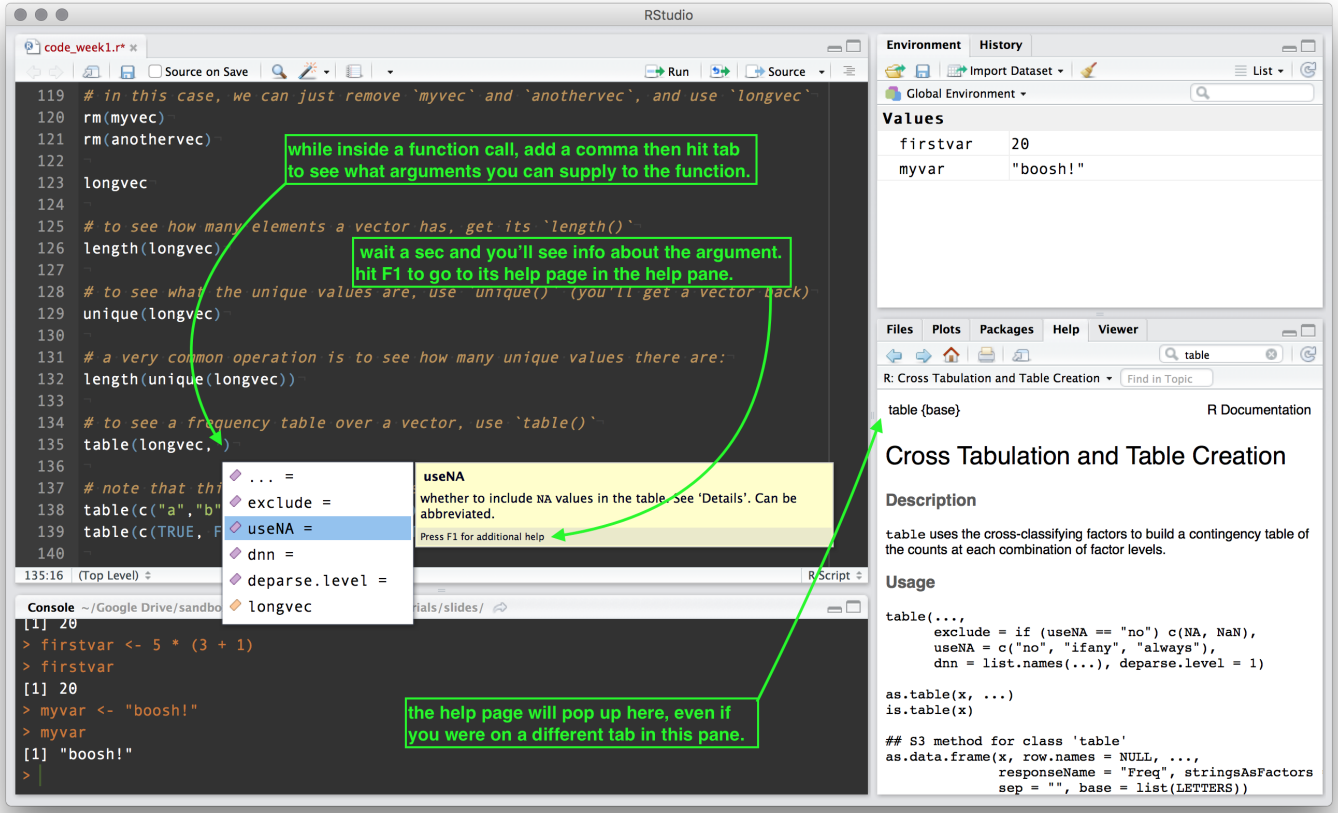
table
R: Cross Tabulation and Table Creation
Find in Topic
table {base}
R Documentation
Cross Tabulation and Table Creation
Description
table uses the cross-classifying factors to build a contingency table of the counts at each combination of factor levels.
Usage
table(...,
exclude = if (useNA == "no") c(NA, NaN),
useNA = c("no", "ifany", "always"),
dnn = list.names(...), deparse.level = 1)
as.table(x, ...)
is.table(x)
S3 method for class 'table'
as.data.frame(x, row.names = NULL, ...,
responseName = "Freq", stringsAsFactors
sep = "", base = list(LETTERS))


RStudio
code_week1.r
Source on Save
Run
Source
myvar <- "boosh!"
highlight and cmd+enter
= execute selection
myvar
my_var <- TRUE
my_var
myVar <- 5.5
myVar
# including other variables or computations involving them:
my_var <- myvar
my_var
myvar0 <- myVar / (myVar * 1.5)
myvar0
# when you introduce variables, they'll appear in the environment tab of the
# top-right pane in R Studio. you can remove variables you're no longer
# using with `rm()`. (this isn't necessary, but it saves space in both
# your brain and your computer's
rm(myvar)
rm(my_var)
61:1
(Top Level)
R Script
Console
~/Google Drive/sandboxxxe/r_minicourse/course_materials/slides/
current working dir
[1] 20
> firstvar <- 5 * (3 + 1)
> firstvar
[1] 20
> myvar <- "boosh!"
> myvar
[1] "boosh!"
Environment
History
Import Dataset
List
Global Environment
Values
firstvar 20
myvar "boosh!"
list of currently available objects
(you can click on data frames to
view them like a spreadsheet)
Files
Plots
Packages
Help
Viewer
table
R: Cross Tabulation and Table Creation
Find in Topic
table {base}
R Documentation
Cross Tabulation and Table Creation
search for help topics here
Description
table uses the cross-classifying factors to build a contingency table of the counts at each combination of factor levels.
Usage
table(...,
exclude = if (useNA == "no") c(NA, NaN),
useNA = c("no", "ifany", "always"),
dnn = list.names(...), deparse.level = 1)
as.table(x, ...)
is.table(x)
S3 method for class 'table'
as.data.frame(x, row.names = NULL, ...,
responseName = "Freq", stringsAsFactors
sep = "", base = list(LETTERS))


RStudio
code_week1.r*
Source on Save
Run
Source
# in this case, we can just remove `myvec` and `anothervec`, and use `longvec`
rm(myvec)
rm(anothervec)
longvec
# to see how many elements a vector has, get its `length()`
length(longvec)
# to see what the unique values are, use `unique()` (you'll get a vector back)
unique(longvec)
# a very common operation is to see how many unique values there are:
length(unique(longvec))
# to see a frequency table over a vector, use `table()`
table(longvec,)
# note that thi
table(c("a","b"
table(c(TRUE, F
while inside a function call, add a comma then hit tab to see what arguments you can supply to the function.
wait a sec and you'll see info about the argument. hit F1 to go to its help page in the help pane.
... =
exclude =
useNA =
dnn =
deparse.level =
longvec
useNA
whether to include NA values in the table. See 'Details'. Can be abbreviated.
Press F1 for additional help
135:16
(Top Level)
R Script
Console ~/Google Drive/sandbo
rials/slides/
[1] 20
> firstvar <- 5 * (3 + 1)
> firstvar
[1] 20
> myvar <- "boosh!"
> myvar
[1] "boosh!"
>
the help page will pop up here, even if you were on a different tab in this pane.
Environment
History
Import Dataset
List
Global Environment
Values
firstvar 20
myvar "boosh!"
Files
Plots
Packages
Help
Viewer
table
R: Cross Tabulation and Table Creation
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exclude = if (useNA == "no") c(NA, NaN),
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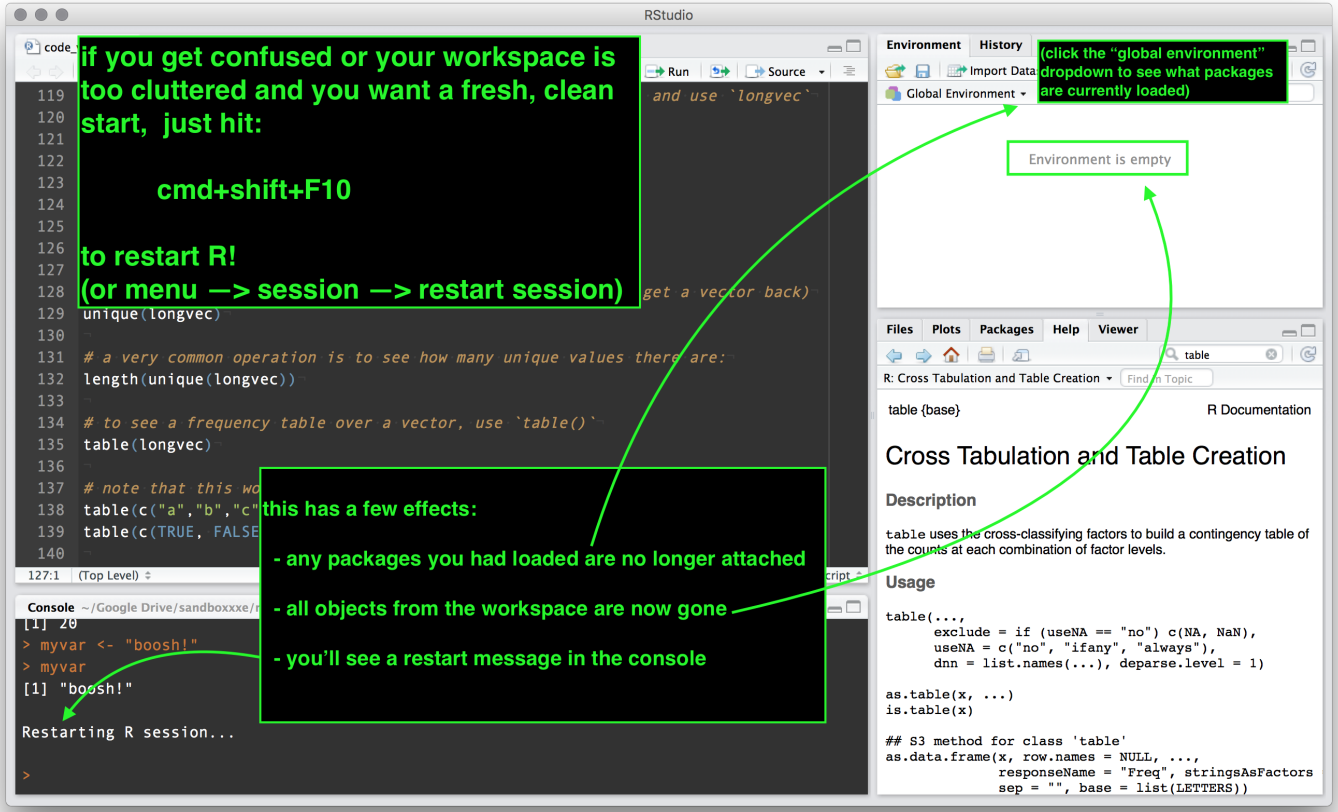
dnn = list.names(...), deparse.level = 1)
as.table(x, ...)
is.table(x)
S3 method for class 'table'
as.data.frame(x, row.names = NULL, ...,
responseName = "Freq", stringsAsFactors
sep = "", base = list(LETTERS))


RStudio
if you get confused or your workspace is too cluttered and you want a fresh, clean start, just hit:
cmd+shift+F10
to restart R!
(or menu —> session —> restart session)
this has a few effects:
- any packages you had loaded are no longer attached
- all objects from the workspace are now gone
- you'll see a restart message in the console
(click the "global environment" dropdown to see what packages are currently loaded)
Environment is empty
Restarting R session...
Cross Tabulation and Table Creation
Description
Usage

2. Variables and Assignments

time to start writing code!

```
# welcome to the R mini-course. in keeping with tradition...
print("...an obligatory 'hello, world!'")
```

```
## [1] "...an obligatory 'hello, world!'"
```

```r
# this line is a comment, so R will always ignore it.
# this is a comment too, since it also starts with "#".

# but the next one is a line of real R code, which does some arithmetic:
5 * 3
```

```
## [1] 15
```

```r
# we can do all kinds of familiar math operations:
5 * 3 + 1
```

```
## [1] 16
```

```r
# 'member "PEMDAS"?? applies here too -- compare the last line to this one:
5 * (3 + 1)
```

```
## [1] 20
```

```r
# usually when we do some math, we want to save the result for future use.
# we can do this by **assigning** a computation to a **variable**
firstvar <- 5 * (3 + 1)
```

```r
# now 'firstvar' is an **object**. we can see its value by printing it.
# sending `firstvar` to the interpreter is equivalent to `print(firstvar)`
firstvar
```

```
## [1] 20
```

```r
# we can put basically anything into a variable, and we can call a variable
# pretty much whatever we want (but do avoid special characters besides "_")
myvar <- "boosh!"
myvar

myVar <- 5.5
myVar
```

```
## [1] "boosh!"
## [1] 5.5
```

```r
# including other variables or computations involving them:
my_var <- myvar
my_var

myvar0 <- myVar / (myVar * 1.5)
myvar0
```

```
## [1] "boosh!"
## [1] 0.6666667
```

```
# when you introduce variables, they'll appear in the environment tab of the
# top-right pane in R Studio. you can remove variables you're no longer
# using with `rm()`. (this isn't necessary, but it saves space in both
# your brain and your computer's)
rm(myvar)
rm(my_var)
rm(myVar)
rm(myvar0)
```

3. Vectors

```
# R was designed with statistical applications in mind, so naturally there's
# lots of ways to represent collections or sequences of values (e.g. numbers).

# in R, a **vector** is the simplest list-like data structure.
# (but be careful with this terminology -- a **list** is something else)
# you can create a vector with the `c()` function (for "concatenate")
myvec <- c(1, 2, 3, 4, 5)
myvec
```

```
## [1] 1 2 3 4 5
```

```
anothervec <- c(4.5, 4.12, 1.0, 7.99)
anothervec
```

```
## [1] 4.50 4.12 1.00 7.99
```

```r
# vectors can hold elements of any type, but they must all be of the same type.
# to keep things straight in your head, maybe include the data type in the name
myvec_char <- c("a", "b", "c", "d", "e")
myvec_char
```

```
## [1] "a" "b" "c" "d" "e"
```

```r
# if we try the following, R will coerce the numbers into characters:
myvec2 <- c("a", "b", "c", 1, 2, 3)
myvec2
```

```
## [1] "a" "b" "c" "1" "2" "3"
```

```r
rm(myvec2)
```

suppose the only reason we created `myvec` and `anothervec` was to put them together with some other stuff, and save that to `longvec`. in this case, we can just remove `myvec` and `anothervec`, and use `longvec` henceforth (assuming we don't care about `myvec` or `anothervec`)

```
# you can put vectors or values together with `c()`
longvec <- c(0, myvec, 9, 80, anothervec, 0, 420)
rm(myvec)
rm(anothervec)

longvec
```

```
##  [1]   0.00   1.00   2.00   3.00   4.00   5.00   9.00  80.00   4.50   4.12
## [11]   1.00   7.99   0.00 420.00
```

now we can see what the `[1]` in the console output was – it tells you the index of the first element on each line! here, `7.99` is the 11th, so the second line starts with `[11]`.

note also that the whole numbers (**integers**) now have decimals because they've been **coerced** into decimal-based numbers called **doubles** in R. see the notes for more info.

```
    # to see how many elements a vector has, get its `length()`
    length(longvec)
```

```
## [1] 14
```

```
    # to see what the unique values are, use `unique()` (you'll get a vector back)
    unique(longvec)
```

```
##  [1]   0.00   1.00   2.00   3.00   4.00   5.00   9.00  80.00   4.50   4.12
## [11]   7.99 420.00
```

```
    # a very common operation is to see how many unique values there are:
    (blah <- length(unique(longvec)))
```

```
## [1] 12
```

note: putting parentheses around an assignment statement causes the variable targeted by the assignment (here `blah`) to be printed to the console. this is often convenient because it saves a line of space (w/o parentheses, we would've had to say `blah` or `print(blah)` on the next line to see it).

```r
# to see a frequency table over a vector, use `table()`
table(longvec)
```

```
## longvec
##    0    1    2    3    4 4.12  4.5    5 7.99    9   80  420
##    2    2    1    1    1    1    1    1    1    1    1    1
```

```r
# note that this works for all kinds of vectors
table(c("a", "b", "c", "b", "b", "b", "a"))
```

```
##
## a b c
## 2 4 1
```

```r
table(c(TRUE, FALSE, FALSE, FALSE, TRUE, FALSE))
```

```
##
## FALSE  TRUE
##     4     2
```

an important but not obvious thing:

R has a special value called **`NA`**, which represents missing data.

by default, **`table()`** won't tell you about **`NA`**'s (annoying, ik!). so get in the habit of specifying the **`useNA` argument** of **`table()`**

```
vec_with_NA <- c(1, 2, 3, 2, 2, NA, 3, NA, NA, 1, 1)
table(vec_with_NA)
```

```
## vec_with_NA
## 1 2 3
## 3 3 2
```

```
table(vec_with_NA, useNA="ifany") # "ifany" or "always" or "no"
```

```
## vec_with_NA
##    1    2    3 <NA>
##    3    3    2    3
```

notice that the structure of the last table command is:

```
table(VECTOR, useNA=CHARACTERSTRING)
```

some terminology:

- `table()` is a **function**
- `table()` has **argument positions** for a vector and for a string
- we provided `table()` with two **arguments**:
  - a vector (that we refer to with `vec_with_NA`)
  - a character string (the string `"ifany"`)
- the second argument position was **named** `useNA`
- we used the **argument binding** syntax `useNA="ifany"`

argument-binding is kind of like variable assignment, but `useNA` doesn't become directly available for use after we give it a value (it's "trapped" inside the function call).

this might feel kinda abstract, but i promise the intuition will become clearer the further along we get.

some arguments – like `useNA` here – can be thought of as "options" of the function they belong to.

```
# here's an example that might clarify the concept of argument binding:
round(3.141592653, digits=4)
round(3.141592653, digits=1)

# if we don't tell it how many digits to round to, it defaults to 0
round(3.141592653)
```

```
## [1] 3.1416
## [1] 3.1
## [1] 3
```

`round()` is a commonly used function that illustrates an important concept called **vectorization**.

many functions in R are vectorized by default, which means that they can take an individual value (like the `round()` call above), or they can take a vector of values.

in the latter case, the function applies pointwise to each element of the vector, and returns a vector with the same length as the input (and same order of elements):

```
round(longvec, digits=4)
```

```
##  [1]   0.00   1.00   2.00   3.00   4.00   5.00   9.00  80.00   4.50   4.12
## [11]   1.00   7.99   0.00 420.00
```

in fact **MOST STUFF IS VECTORIZED AND VECTORIZATION IS GREAT**

---

technically: the return value of a vectorized function `f()` applied to a vector

```
v <- c(v_1, v_2, ... , v_n)
```

is the vector `f(v)`, which is

```
c(f(v_1), f(v_2), ... , f(v_n))
```

4. Subsetting and Indexing

we will *very* often want to access individual elements or subsets of a vector (e.g. if we've sorted a vector and want to look at its first element)

there are several ways to do this. here are some examples to give you an idea (note that `1:5` is the vector `c(1,2,3,4,5)`, and `==` is *actual* "equals")

```
# a vector of several words
vec_words <- c("first","second","third","fourth","fifth")
vec_words[1]
vec_words[2:3]
vec_words[c(1,4)]
vec_words[vec_words=="first"]
```

```
## [1] "first"
## [1] "second" "third"
## [1] "first"  "fourth"
## [1] "first"
```

we inspect these in more detail in the notes.

it's annoying to have to type every element of a vector. fortunately, there are many functions designed to make this unnecessary. for example `rep()` is short for "replicate"; `seq()` is short for "sequence"; `letters` is a built-in constant for the vector `c("a","b",...,"z")`); and we just saw the range operator `:`.

```
# you can also combine 'times' and 'each' inside of rep()
# putting parentheses around an assignment statement causes it to print
(vec_num <- rep(1:5, times=2))
```

```
##  [1] 1 2 3 4 5 1 2 3 4 5
```

```
(vec_abc <- rep(letters[1:5], each=2))
```

```
##  [1] "a" "a" "b" "b" "c" "c" "d" "d" "e" "e"
```

```
(vec_odd <- seq(from=1, to=19, by=2))
```

```
##  [1]  1  3  5  7  9 11 13 15 17 19
```

see this week's notes for discussion of the "DRY" principle in programming.

very often we'll want to e.g. get the average value or the sum of a vector. we'll get way more into this in future sessions, but here's a preview:

```
# get the mean with mean(), or calculate it ourselves!
(vec_num_mean <- mean(vec_num))
(vec_num_mean <- sum(vec_num) / length(vec_num))

# get the (sample) variance with var(), or calculate it ourselves!
(vec_num_var <- var(vec_num))
(vec_num_var <- sum((vec_num - mean(vec_num))^2)/(length(vec_num) - 1))

# get the correlation between vec_num and vec_odd (pearson's r)
cor(vec_num, vec_odd, method="pearson")
```

```
## [1] 3
## [1] 3
## [1] 2.222222
## [1] 2.222222
## [1] 0.492366
```

exercise: compute pearson's r on `vec_num` and `vec_odd` using only arithmetic.

why should we care about vectors?!

here's an analogy to keep in mind: vectors are like columns of an abstract spreadsheet (**not** like rows).

- all their elements have to have the same type
- they have a length and you can perform operations on them
- they can contain missing values (`NA`)

in fact, this is a bit more than an analogy in R!

R's implementation of a "spreadsheet" – the **data frame** – is quite literally a list of vectors. the data frame is a beautiful data structure, and is used to represent (flat) datasets e.g. the contents of an excel sheet.

we'll have a first look at data frames next

5. Data Frames!

a data frame is a `list` of vectors all of which have the same length.

```
first_df <- data.frame(1:5, letters[1:5], c(TRUE, TRUE, FALSE, NA, FALSE))

# a slightly more interesting data frame, with names for columns.
(cool_df <- data.frame(
  id=paste0("id_", 1:6),             # unique identifier for each person
  group=rep(c("a","b"), each=3),     # "a" = NYU law school, "b" = Columbia
  score=runif(n=6, min=50, max=100)   # score on the NY bar exam
))
```

```
##     id group    score
## 1 id_1     a 77.16688
## 2 id_2     a 96.19345
## 3 id_3     a 54.00271
## 4 id_4     b 85.81876
## 5 id_5     b 59.09128
## 6 id_6     b 98.41579
```

we can access rows or columns using square-bracket syntax `[ , ]`. the `$` for individual columns is nice too – that gives us back a vector. lots of ways to slice + dice a df – below are some examples.

```
cool_df[1:3, ]
```

```
##     id group    score
## 1 id_1     a 77.16688
## 2 id_2     a 96.19345
## 3 id_3     a 54.00271
```

```
cool_df[, 1]
```

```
## [1] id_1 id_2 id_3 id_4 id_5 id_6
## Levels: id_1 id_2 id_3 id_4 id_5 id_6
```

```
cool_df$score
```

```
## [1] 77.16688 96.19345 54.00271 85.81876 59.09128 98.41579
```

```
    cool_df[["score"]]
```

```
## [1] 77.16688 96.19345 54.00271 85.81876 59.09128 98.41579
```

```
    cool_df[, "score"]
```

```
## [1] 77.16688 96.19345 54.00271 85.81876 59.09128 98.41579
```

```
    cool_df[, c("id","score")]
```

```
##     id    score
## 1 id_1 77.16688
## 2 id_2 96.19345
## 3 id_3 54.00271
## 4 id_4 85.81876
## 5 id_5 59.09128
## 6 id_6 98.41579
```

look at the Base R cheatsheet for an excellent overview!

let's see who passed the exam:

```
cool_df$id[cool_df$score >= 60]
```

```
## [1] id_1 id_2 id_4 id_6
## Levels: id_1 id_2 id_3 id_4 id_5 id_6
```

note: the output isn't quoted, and it says `Levels: ...`. more next week/in notes!

we can add columns to a data frame by combining assignment `<-` with the dollar-sign `$` column-grabbing syntax:

```
cool_df$passed <- ifelse(cool_df$score > 60, TRUE, FALSE)
cool_df$aced   <- ifelse(cool_df$score >= 90, TRUE, FALSE)
cool_df$failed <- !cool_df$passed
```

- **exercise:** compute the percentage of law students who aced the exam.
- **exercise:** compute the mean score for each group. (hint: google `aggregate()`)
- **exercise:** how does the `failed` column get computed?!

finally, some useful functions to use on data frames to check them out a bit. (note that you can combine `names()` with assignment to change the column names)

```
head(cool_df, n=2)
dim(cool_df)        # a vector of length 2: number of rows, number of cols
nrow(cool_df)       # number of rows
ncol(cool_df)       # number of columns
names(cool_df)      # the names of the columns
```

```
##     id group    score passed  aced failed
## 1 id_1     a 77.16688   TRUE FALSE  FALSE
## 2 id_2     a 96.19345   TRUE  TRUE  FALSE
## [1] 6 6
## [1] 6
## [1] 6
## [1] "id"     "group"  "score"  "passed" "aced"   "failed"
```

exercise: change the name of the `group` column to "`school`""

exercise: recode `school`'s values as `"nyu"` and `"columbia"`

```r
str(cool_df[, 1:4])      # the structure of the data frame    (first four cols)
```

```
## 'data.frame':    6 obs. of  4 variables:
##  $ id    : Factor w/ 6 levels "id_1","id_2",..: 1 2 3 4 5 6
##  $ group : Factor w/ 2 levels "a","b": 1 1 1 2 2 2
##  $ score : num  77.2 96.2 54 85.8 59.1 ...
##  $ passed: logi  TRUE TRUE FALSE TRUE FALSE TRUE
```

```r
summary(cool_df[, 1:4])  # get useful info about each column  (first four cols)
```

```
##     id    group     score          passed
##  id_1:1   a:3   Min.   :54.00   Mode :logical
##  id_2:1   b:3   1st Qu.:63.61   FALSE:2
##  id_3:1         Median :81.49   TRUE :4
##  id_4:1         Mean   :78.45
##  id_5:1         3rd Qu.:93.60
##  id_6:1         Max.   :98.42
```

6. Next Week

- installing and loading **packages**
- more on data frames (factors, character, etc.)
- reading in external datasets as data frames
- manipulating data frames
- cleaning up data frames
- summarizing columns of data frames
- group-wise summaries involving multiple columns
- data frames data frames data frames woop woop!!!

remember the bead curtain analogy ~~
groovy dude