Lecture notes for Statistical Computing 1 (SC1) Stat 590 University of New Mexico

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Contents

Chapter 1

LaTeX and R

Welcome!
About me

I'm an Assistant Professor of Statistics here at UNM.

Sometimes, I'm also the Director of the Statistics Consulting Clinic: `www.stat.unm.edu/~clinic`

Syllabus

Tools

Computer: Windows/Mac/Linux

Software: LaTeX, R, text editor (Rstudio)

Brain: scepticism, curiosity, organization

planning, execution, clarity

Syllabus

http://statacumen.com/teaching/sc1

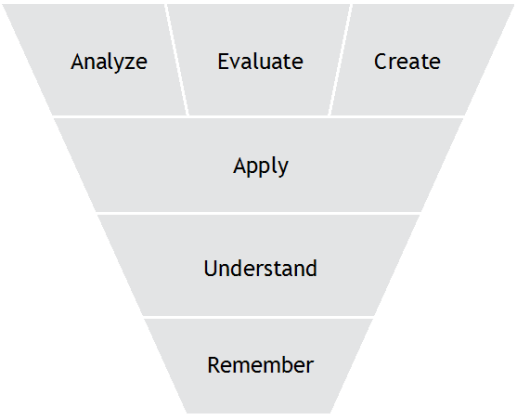
- Step 0
- Tentative timetable
- Grading
- Homework

Statistics can be challenging

because

we operate at the higher levels of Bloom's Taxonomy `en.wikipedia.org/wiki/Bloom's_Taxonomy`

1. * Create/synthesize
2. * Evaluate
3. * Analyze
4. Apply
5. Understand
6. Remember



This week: Reproducible research

The goal of reproducible research is to tie specific instructions to data analysis and experimental data so that scholarship can be recreated, better understood, and verified.

Formula: success = LaTeX + R + knitr (Sweave)

`http://cran.r-project.org/web/views/ReproducibleResearch.html`

Rstudio

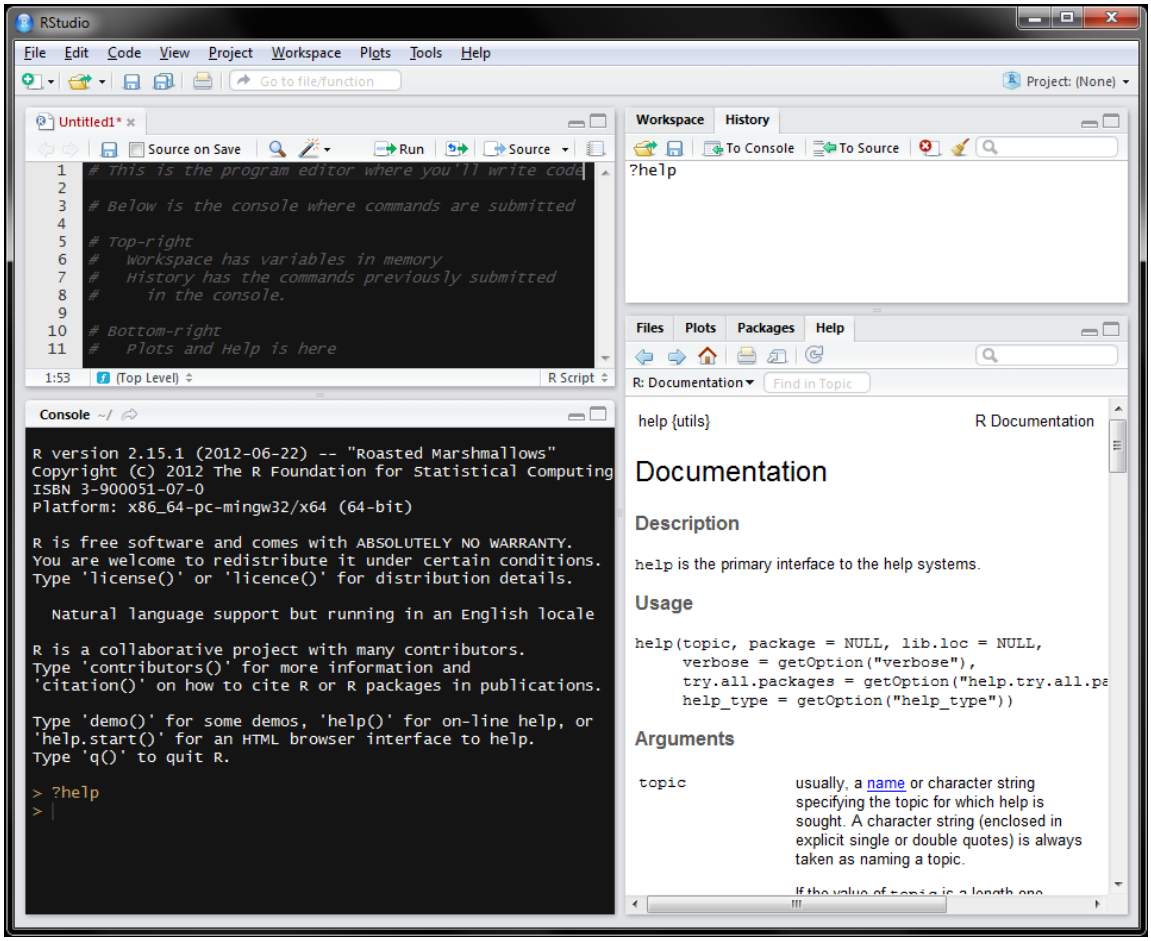
Rstudio

Setup

Install LaTeX, R, and Rstudio on your computer, as outlined at the top of the course webpage.

Rstudio

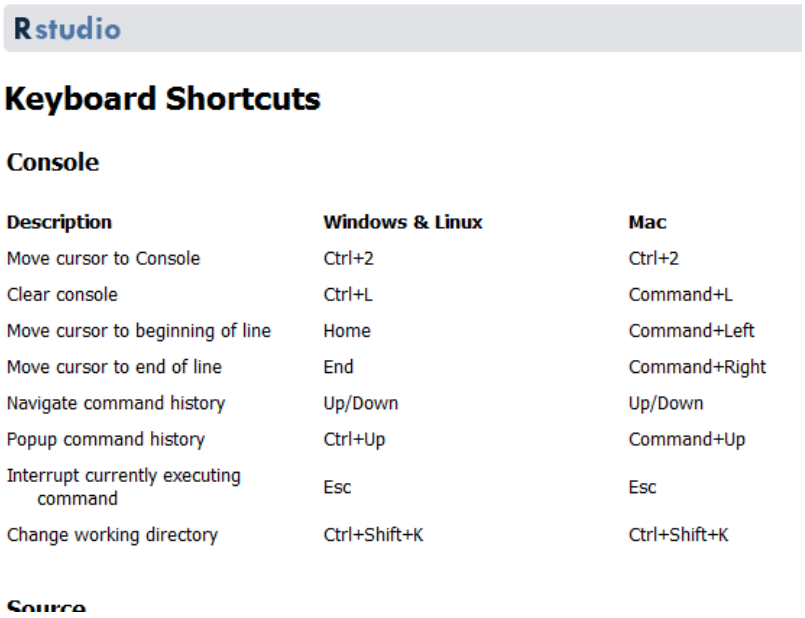
Quick tour (I changed my background to black for stealth coding at night)



Rstudio

Quick tour

Learning the keyboard shortcuts will make your life more wonderful.



Rstudio

Keyboard Shortcuts

Console

Description	Windows & Linux	Mac
Move cursor to Console	Ctrl+2	Ctrl+2
Clear console	Ctrl+L	Command+L
Move cursor to beginning of line	Home	Command+Left
Move cursor to end of line	End	Command+Right
Navigate command history	Up/Down	Up/Down
Popup command history	Ctrl+Up	Command+Up
Interrupt currently executing command	Esc	Esc
Change working directory	Ctrl+Shift+K	Ctrl+Shift+K

Source

(Under Help menu)

Introduction to R
R building blocks

R as calculator

```
# Arithmetic
2 * 10
```

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

```
1 + 2
```

```
## [1] 3
```

```
# Order of operations is preserved
1 + 5 * 10
```

```
## [1] 51
```

```
(1 + 5) * 10
```

```
## [1] 60
```

```
# Exponents use the ^ symbol
2 ^ 5
```

```
## [1] 32
4 ^ (1/2)
## [1] 2
```

Vectors

```
# Create a vector with the c (short for combine) function
c(1, 4, 6, 7)
## [1] 1 4 6 7
c(1:5, 10)
## [1]  1  2  3  4  5 10
# or use a function
# (seq is short for sequence)
seq(1, 10, by = 2)
## [1] 1 3 5 7 9
seq(0, 50, length = 11)
##  [1]  0  5 10 15 20 25 30 35 40 45 50
seq(1, 50, length = 11)
##  [1]  1.0  5.9 10.8 15.7 20.6 25.5 30.4 35.3 40.2 45.1 50.0
1:10 # short hand for seq(1, 10, by = 1), or just
##  [1]  1  2  3  4  5  6  7  8  9 10
seq(1, 10)
##  [1]  1  2  3  4  5  6  7  8  9 10
5:1
## [1] 5 4 3 2 1
```

Assign variables

```
# Assign a vector to a variable with <-
a <- 1:5
a
## [1] 1 2 3 4 5
b <- seq(15, 3, length = 5)
b
## [1] 15 12  9  6  3
c <- a*b
c
## [1] 15 24 27 24 15
```

Basic functions

```
# Lots of familiar functions work
a
## [1] 1 2 3 4 5
sum(a)
## [1] 15
prod(a)
## [1] 120
mean(a)
## [1] 3
sd(a)
## [1] 1.581139
var(a)
## [1] 2.5
min(a)
## [1] 1
median(a)
## [1] 3
max(a)
## [1] 5
range(a)
## [1] 1 5
```

Extracting subsets

```
# Specify the indices you want in the square brackets []
a <- seq(0, 100, by = 10)
# blank = include all
a
##  [1]   0  10  20  30  40  50  60  70  80  90 100
a[]
##  [1]   0  10  20  30  40  50  60  70  80  90 100
# integer +=include, 0=include none, -=exclude
a[5]
## [1] 40
a[c(2, 4, 6, 8)]
## [1] 10 30 50 70
a[0]
## numeric(0)
a[-c(2, 4, 6, 8)]
## [1]   0  20  40  60  80  90 100
```

```
a[c(1, 1, 1, 6, 6, 9)]   # subsets can be bigger
## [1]  0  0  0 50 50 80
a[c(1,2)] <- c(333, 555) # update a subset
a
##  [1] 333 555  20  30  40  50  60  70  80  90 100
```

True/False

```
a
##  [1] 333 555  20  30  40  50  60  70  80  90 100
(a > 50)
##  [1]  TRUE  TRUE FALSE FALSE FALSE FALSE  TRUE  TRUE  TRUE  TRUE  TRUE
a[(a > 50)]
## [1] 333 555  60  70  80  90 100
!(a > 50)        # ! negates (flips) TRUE/FALSE values
##  [1] FALSE FALSE  TRUE  TRUE  TRUE  TRUE FALSE FALSE FALSE FALSE FALSE
a[!(a > 50)]
## [1] 20 30 40 50
```

Comparison functions

```
# < > <= >= != == %in%
a
##  [1] 333 555  20  30  40  50  60  70  80  90 100
# equal to
a[(a == 50)]
## [1] 50
# equal to
a[(a == 55)]
## numeric(0)
# not equal to
a[(a != 50)]
##  [1] 333 555  20  30  40  60  70  80  90 100
# greater than
a[(a > 50)]
## [1] 333 555  60  70  80  90 100
# less than
a[(a < 50)]
## [1] 20 30 40
# less than or equal to
a[(a <= 50)]
## [1] 20 30 40 50
```

```
# which values on left are in the vector on right
(c(10, 14, 40, 60, 99) %in% a)
## [1] FALSE FALSE  TRUE  TRUE FALSE
```

Boolean operators

```
# & and, | or, ! not
a
##  [1] 333 555  20  30  40  50  60  70  80  90 100
a[(a >= 50) & (a <= 90)]
## [1] 50 60 70 80 90
a[(a < 50) | (a > 100)]
## [1] 333 555  20  30  40
a[(a < 50) | !(a > 100)]
## [1]  20  30  40  50  60  70  80  90 100
a[(a >= 50) & !(a <= 90)]
## [1] 333 555 100
```

Missing values

```
# NA (not available) means the value is missing.
#   Any calculation involving NA will return an NA by default
NA + 8
## [1] NA
3 * NA
## [1] NA
mean(c(1, 2, NA))
## [1] NA
# Many functions have an na.rm argument  (NA remove)
mean(c(NA, 1, 2), na.rm = TRUE)
## [1] 1.5
sum(c(NA, 1, 2))
## [1] NA
sum(c(NA, 1, 2), na.rm = TRUE)
## [1] 3
```

Missing values

```
# Or you can remove them yourself
a <- c(NA, 1:5, NA)
a
## [1] NA  1  2  3  4  5 NA
a[!is.na(a)]
## [1] 1 2 3 4 5
a
## [1] NA  1  2  3  4  5 NA
# To save the results of removing the NAs, reassign
#   write over variable a and the
#   previous version is gone forever!
a <- a[!is.na(a)]

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

Ch 0, R building blocks

Q1

What value will R return for z?

```
x <- 3:7
y <- x[c(1, 2)] + x[-c(1:3)]
z <- prod(y)
z
```

A 99

B 20

C 91

D 54

E NA

R building blocks 1

Answer

```
x <- 3:7
x
## [1] 3 4 5 6 7
x[c(1, 2)]
## [1] 3 4
x[-c(1:3)]
## [1] 6 7
y <- x[c(1, 2)] + x[-c(1:3)]
y
## [1]  9 11
z <- prod(y)
z
## [1] 99
```

Ch 0, R building blocks

Q2

What value will R return for z?

```
x <- seq(-3, 3, by = 2)
a <- x[(x > 0)]
b <- x[(x < 0)]
z <- a[1] - b[2]
z
```

A -2

B 0

C 1

D 2

E 6

R building blocks 2

Answer

```
x <- seq(-3, 3, by = 2)
x
## [1] -3 -1  1  3
a <- x[(x > 0)]
a
## [1] 1 3
b <- x[(x < 0)]
b
## [1] -3 -1
z <- a[1] - b[2]
z
## [1] 2
```

[bottom=yellow!10,top=green!15] [step=8mm,color=gray!20]

Clicker, Q3

What value will R return for z?

```
a <- 2:-3
b <- a[(a > 0) & (a <= 0)]
d <- a[!(a > 1) & (a <= -1)]
z <- sum(c(b,d))
z
```

E -6

A -3

D 0

B 3

C 6

R building blocks 3

Answer

```
a <- 2:-3
a
## [1]  2  1  0 -1 -2 -3
a[(a > 0)]
## [1] 2 1
a[(a <= 0)]
## [1]  0 -1 -2 -3
b <- a[(a > 0) & (a <= 0)]
b
## integer(0)
a[!(a > 1)]
## [1]  1  0 -1 -2 -3
a[(a <= -1)]
## [1] -1 -2 -3
d <- a[!(a > 1) & (a <= -1)]
d
## [1] -1 -2 -3
z <- sum(c(b,d))
z
## [1] -6
```

How'd you do?

Outstanding Understanding the operations and how to put them together, without skipping steps.

Good Understanding most of the small steps, missed a couple details.

Hang in there Understanding some of the concepts but all the symbols make my eyes spin.

Reading and writing a new language takes work.
You'll get better as you practice.
Having a buddy to work with will help.

Summary

R commands

```
# <-

# + - * / ^

# c()

# seq() # by=, length=

# sum(), prod(), mean(), sd(), var(),

# min(), median(), max(), range()

# a[]

# (a > 1), ==, !=, >, <, >=, <=, %in%

# &, |, !

# NA, mean(a, na.rm = TRUE), !is.na()
```

Your turn
How's it going so far?

Muddy Any "muddy" points — anything that doesn't make sense yet?

Thumbs up Anything you really enjoyed or feel excited about?

LaTeX

LaTeX is a high-quality typesetting system; it includes features designed for the production of technical and scientific documentation. LaTeX is the *de facto* standard for the communication and publication of scientific documents. LaTeX is available as free software.

`http://www.latex-project.org/`

All files are plain text files. Images of many formats can be included.

LaTeX

Our first document

From the course website:

1. Download `http://statacumen.com/teach/SC1/SC1_LaTeX_basic.tex`
2. Open in Rstudio
3. Click "Compile PDF"
4. You've made your (possibly) first LaTeX document
5. Make some edits and recompile

LaTeX + R + knitr

Embed code and results

Rstudio set-up for knitr:

1. Menu, Tools, Options
2. Sweave
3. Weave Rnw files using: **knitr**
4. Preview PDF: (System Viewer might be good)
5. Save options

From the course website:

1. Download `http://statacumen.com/teach/SC1/SC1_student_template.Rnw`

2. Open in Rstudio
3. Click "Compile PDF"
4. Look carefully at the Rnw (R new web) source and pdf output
5. Make some edits and recompile

- See the LaTeX resources on the course website.
- Practice.
- When you have errors, become good at reading the log file (with respect to the generated .tex file line numbers).
- Can't find the errors? Comment big chunks of code until no errors, then uncomment small chunks until you see the error. Fix it.

For next time

- Step 0 for Thursday
- Set up LaTeX + R + Rstudio
- Homework: read the introductions to LaTeX and R
- Read the rubric `http://statacumen.com/teach/rubrics.pdf`
- If you have a disability requiring accommodation, please see me and register with the UNM Accessibility Resource Center.