Introduction and R

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About Us

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Learning Objectives

- Introduction to the Statistical Software R
- Reading and Writing Images
- Visualization of Images and Image Data
- Inhomogeneity Correction
- Brain Extraction
- Image Segmentation
- Coregistration Within and Between MRI Studies
- Intensity Normalization

Course Website/Materials

The Course overview is located at (with slides):
`http://johnmuschelli.com/ISBI_2017.html`

All materials for this course (including source for the slides) is located at:

`https://github.com/muschellij2/imaging_in_r`

RStudio Server

For this course, we will use an RStudio Server because installing all the packages can be a lengthy process. Mostly all the code we show requires a Linux/Mac OSX platform for FSL and other systems:

`http://johnmuschelli.com/rstudio_server.html`

The code to make the server is located at: `https://github.com/muschellij2/rneuro/blob/master/ms_rstudio_droplet.sh`

Installing R: Local

If you want to install

- You can install the latest R from `http://cran.r-project.org/`
- Install RStudio

Introduction to R

What is R?

- R is a language and environment for statistical computing and graphics
- R is the open source implementation of the S language, which was developed by Bell laboratories
- R is both open source and open development

(source: `http://www.r-project.org/`)

Why R?

- Powerful and flexible
- Free (open source)
- Extensive add-on software (packages)
- Designed for statistical computing
- High level language

Why not R?

- Fairly steep learning curve
  - “Programming” oriented
  - Minimal interface
- Little centralized support, relies on online community and package developers
- Annoying to update
- Slower, and more memory intensive, than the more traditional programming languages (C, Java, Perl, Python)

Working with R

- The R Console “interprets” whatever you type
  - Calculator
  - Creating variables
  - Applying functions
- “Analysis” Script + Interactive Exploration
  - Static copy of what you did (reproducability)
  - Try things out interactively, then add to your script

R essentially is a command line with a set of functions loaded

R Uses Functions, in Packages

- R revolves around functions
  - Commands that take input, performs computations, and returns results
  - When you download R, it has a “base” set of functions/packages (**base R**)
- Functions are enclosed in packages
  - These written by R users/developers (like us) - **some are bad**
  - Think of them as “R Extensions”

RStudio (the software)

RStudio is an Integrated Development Environment (IDE) for R

- It helps the user effectively use R.
- Makes things easier
- Is NOT dropdown statistical tools (such as Stata)
    - See Rcmdr or Radiant
- All snapshots in these slides are taken from `http://ayeimanol-r.net/2013/04/21/289/`

RStudio

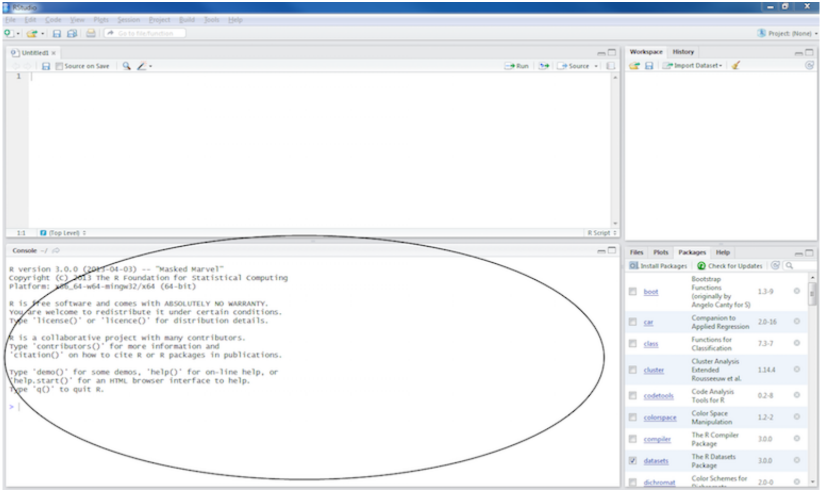
Easier working with R

- Syntax highlighting, code completion, and smart indentation
- Easily manage multiple working directories and projects

More information

- Workspace browser and data viewer
- Plot history, zooming, and flexible image and PDF export
- Integrated R help and documentation
- Searchable command history

RStudio/R Console



```
R version 3.0.0 (2013-04-03) -- "Masked Marvel"
Copyright (C) 2013 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.

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.

> |
```

☐	boot	Bootstrap Functions (originally by Angelo Canty for S)	1.3-9
☐	car	Companion to Applied Regression	2.0-16
☐	class	Functions for Classification	7.3-7
☐	cluster	Cluster Analysis Extended Rousseeuw et al.	1.14.4
☐	codetools	Code Analysis Tools for R	0.2-8
☐	colorspace	Color Space Manipulation	1.2-2
☐	compiler	The R Compiler Package	3.0.0
✓	datasets	The R Datasets Package	3.0.0
☐	dichromat	Color Schemes for	2.0-0

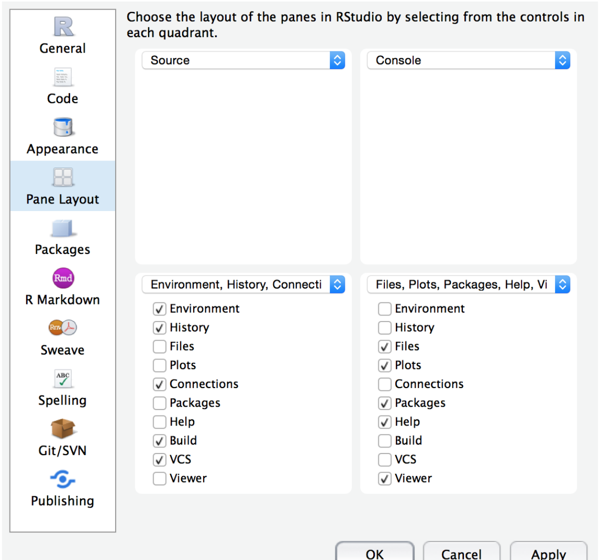
RStudio/R Console

- Where code is executed (where things happen)
- You can type here for things interactively
- Code is **not saved** on your disk

RStudio Layout

If RStudio doesn't look like this (or our RStudio), then do:

RStudio –> Preferences –> Pane Layout



Choose the layout of the panes in RStudio by selecting from the controls in each quadrant.

Source | Console

Environment, History, Connecti

- ✓ Environment
- ✓ History
- ☐ Files
- ☐ Plots
- ✓ Connections
- ☐ Packages
- ☐ Help
- ✓ Build
- ✓ VCS
- ☐ Viewer

Files, Plots, Packages, Help, Vi

- ☐ Environment
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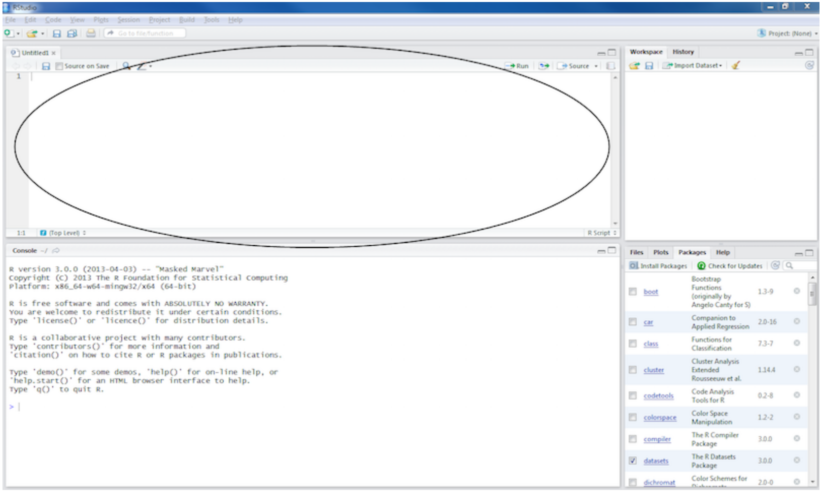
- ✓ Plots
- ☐ Connections
- ✓ Packages
- ✓ Help
- ☐ Build
- ☐ VCS
- ✓ Viewer

Source/Editor



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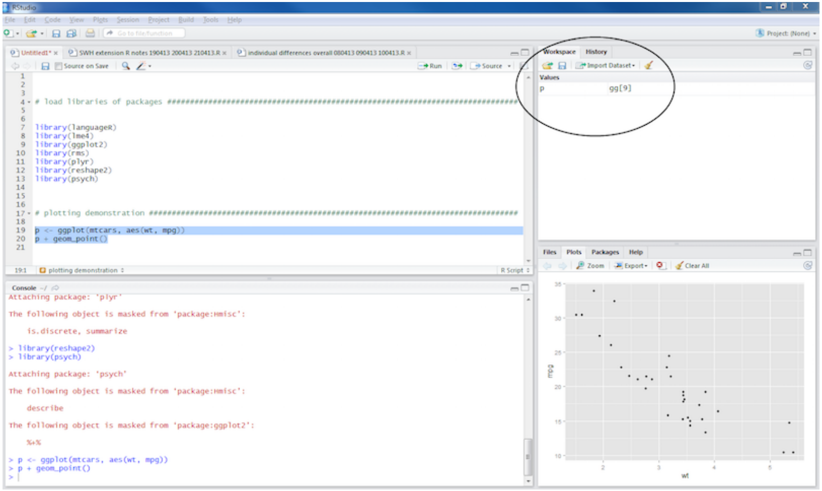
Source

- Where files open to
- Have R code and comments in them
- Can highlight and press (CMD+Enter (Mac) or Ctrl+Enter (Windows)) to run the code

In a .R file (we call a script), code is saved on your disk

Workspace/Environment



```
# load libraries of packages ##################################################################


library(languageR)
library(lme4)
library(ggplot2)
library(rms)
library(plyr)
library(reshape2)
library(psych)



# plotting demonstration #######################################################################

p <- ggplot(mtcars, aes(wt, mpg))
p + geom_point()
```

```
p                  gg[9]
```

```
Attaching package: 'plyr'

The following object is masked from 'package:Hmisc':

    is.discrete, summarize

> library(reshape2)
> library(psych)

Attaching package: 'psych'

The following object is masked from 'package:Hmisc':

    describe

The following object is masked from 'package:ggplot2':

    %+%

> p <- ggplot(mtcars, aes(wt, mpg))
> p + geom_point()
> 
```

Workspace/Environment

- Tells you what **objects** are in R
- What exists in memory/what is loaded?/what did I read in?

History

- Shows previous commands. Good to look at for debugging, but **don't rely** on it as a script. Make a script!
- Also type the "up" key in the Console to scroll through previous commands

Other Panes

- **Files** - shows the files on your computer of the directory you are working in
- **Viewer** - can view data or R objects
- **Help** - shows help of R commands
- **Plots** - pretty pictures
- **Packages** - list of R packages that are loaded in memory

Main Packages we will use

- `oro.nifti` - reading/writing NIfTI images
- `neurobase` - extends `oro.nifti` and provides helpful imaging functions
- `fslr` - wraps FSL commands to use in R
    - registration, image manipulation
- `ANTsR` - wrapper for Advanced normalization tools (ANTs) code
    - registration, inhomogeneity correction, lots of tools
- `extrantsr` - allows `ANTsR` to work with objects from `oro.nifti`

Data Packages we will use

- `ms.lesion` - contains training/testing data of patients with multiple sclerosis (MS)
  - from the MS lesion challenge 2016 (`http://iacl.ece.jhu.edu/index.php/MSChallenge`)
- `kirby21.t1` - scan-rescan data for 3 subjects from Landman et al. (2011)
  - `https://www.nitrc.org/projects/multimodal`

Landman, Bennett A, Alan J Huang, Aliya Gifford, Deepti S Vikram, Issel Anne L Lim, Jonathan AD Farrell, John A Bogovic, et al. 2011. "Multi-Parametric Neuroimaging Reproducibility: A 3-T Resource Study." *Neuroimage* 54 (4). Elsevier: 2854–66. `https://www.nitrc.org/projects/multimodal/`.