

Introduction and R

About Us

John Muschelli

Assistant Scientist, Department of Biostatistics

PhD in Biostatistics

- worked on fMRI, sMRI, and CT for ≈ 7 years

Email: jmusche1@jhu.edu

Kristin Linn

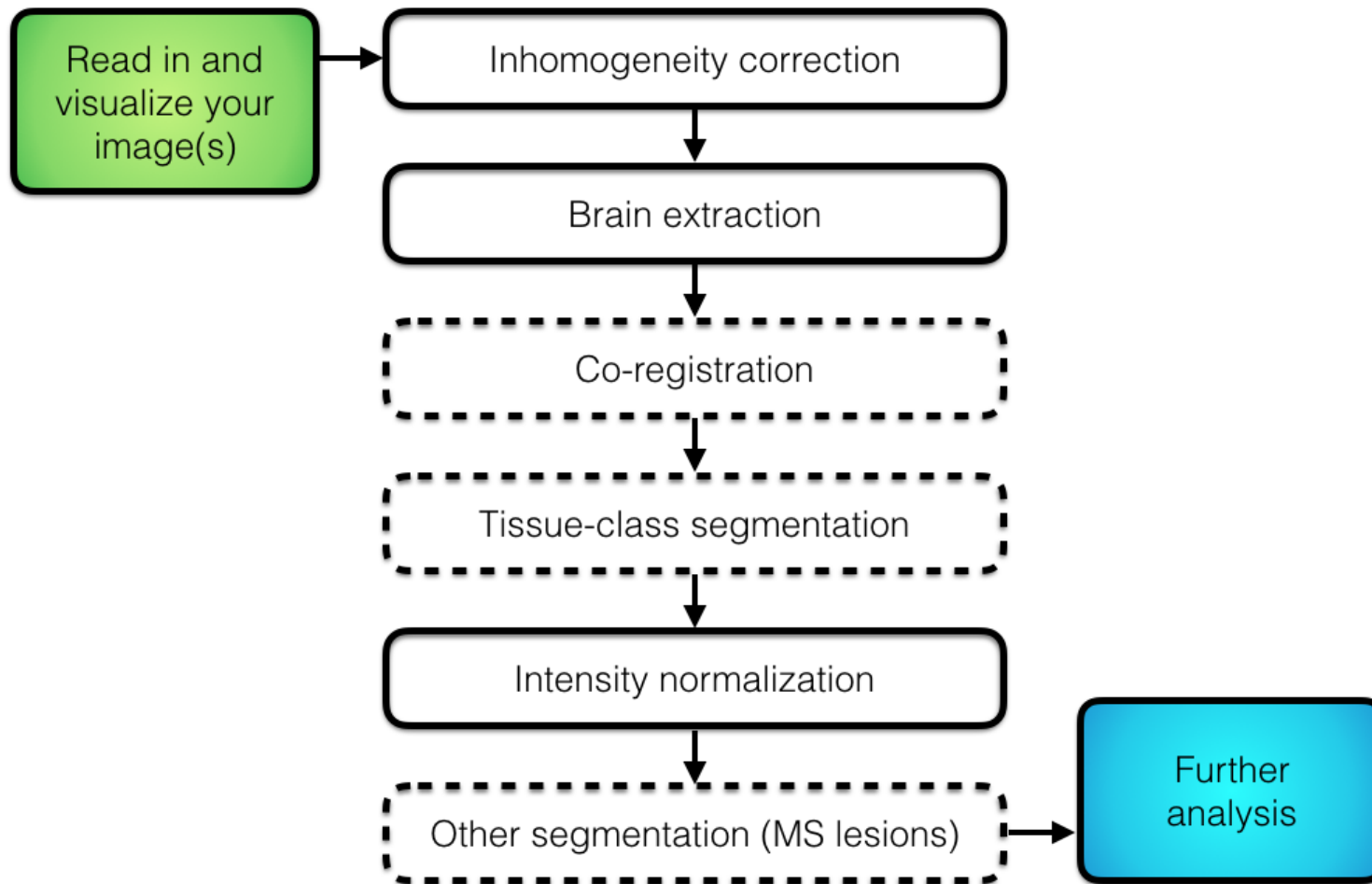
Assistant Professor, Department of Biostatistics and Epidemiology Perelman School of Medicine, University of Pennsylvania

PhD in Statistics

- worked on sMRI for 3 years

Email: klinn@mail.med.upenn.edu

Overall Pipeline

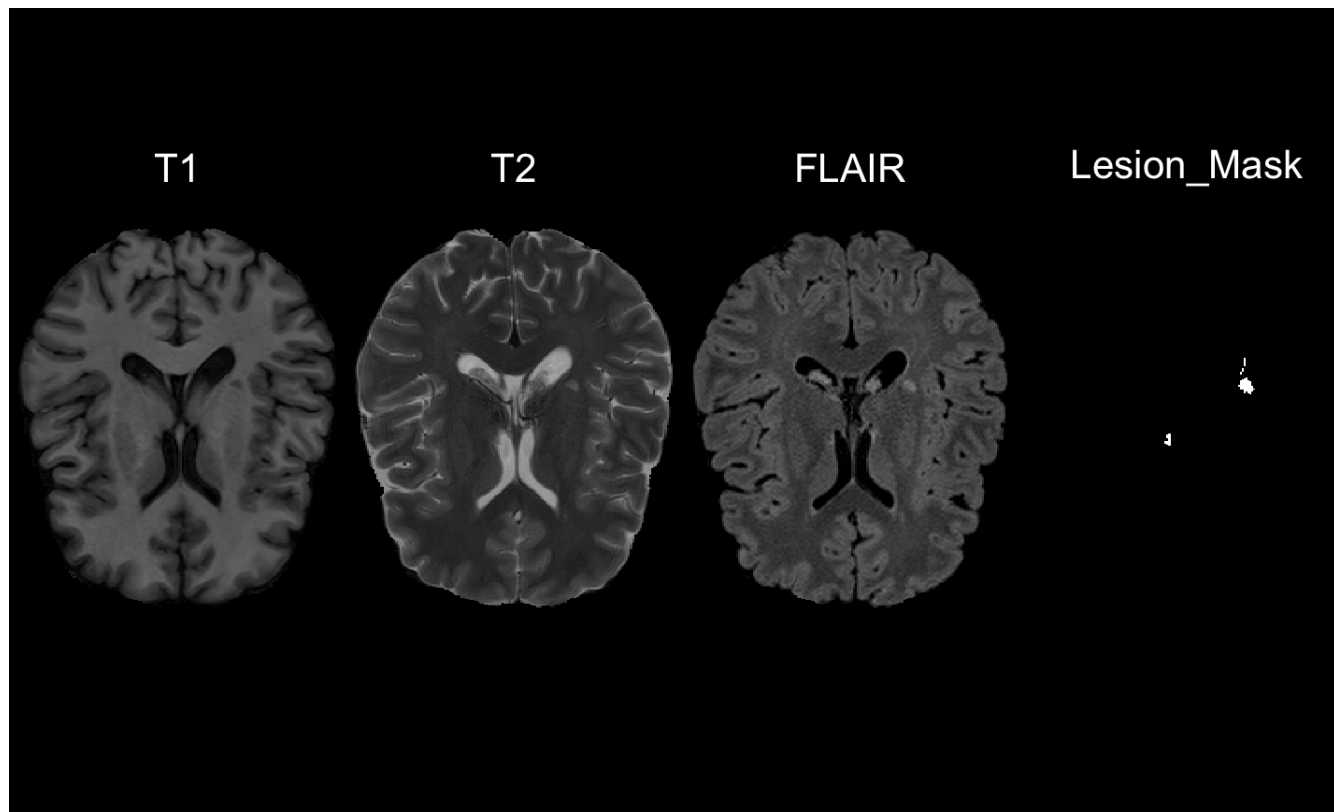


Imaging Data Used: Multiple Sclerosis

- Multiple sclerosis (MS) is a chronic disease of the central nervous system (brain, spinal chord, optic nerves)
- MS lesions in the brain are areas of active inflammation, demylenation, or permanent tissue damage.
 - lesions are primarily in the white matter
- The full data is available at <https://smart-stats-tools.org>.

Imaging Data Used: Multiple Sclerosis

- MRI is well-suited for assessing lesion burden (volume and patterns) because lesions appear as hyperintensities on FLAIR and T2-w images and as hypointensities on T1-w images.
- Using 5 training and 3 test subjects data from the an open MS data set (<http://lit.fe.uni-lj.si/tools.php?lang=eng>) (Lesjak et al. 2017)



Formats of Images

There are multiple imaging formats. We will use NIfTI:

- Neuroimaging Informatics Technology Initiative (<https://nifti.nimh.nih.gov/nifti-1>)
 - essentially a header and data (binary format)
 - will have extension .nii (uncompressed) or .nii.gz (compressed)
 - we will use 3-D images (4-D and 5-D are possible)
- ANALYZE 7.5 was a precursor to NIfTI
 - had a `hdr` file (header) and `img` file (data)

Course Website/Materials

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

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

https://github.com/muscchellij2/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://johnmuscchelli.com/rstudio_server.html

Virtual Machine

If you want to run things locally, we have a Virtual Machine you can download and install:

<https://neuroconductor.org/neuroc-vm>

Introduction to R

What is R?

- R is a language and environment for statistical computing and graphics
- R was implemented over 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
- Little centralized support, relies on online community and package developers
- Slower, and more memory intensive, than the more traditional programming languages (C, Java, Perl, Python)

What comes with R

- 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
 - A package is collection of functions, documentation, data, and tutorials (called vignettes).
 - Written by R users/developers (like us) - **some are bad**
 - You install a package using the `install.packages` command/function:

```
install.packages("oro.nifti")
```

`install.packages` is a function, `"oro.nifti"` is a character string.

Neuroconductor

- Most packages are in a repository [Comprehensive R Archive Network \(CRAN\)](#)
- Neuroconductor (<https://neuroconductor.org/>) has packages related to medical imaging

```
source("https://neuroconductor.org/neurocLite.R")  
neuro_install("oro.nifti")
```

Loading Packages

When you install a package, it's downloaded to the hard disk. That mean that you can use the functions from that package just yet.

- You “load”/import a package into memory using the `library` command

For example, to load the `oro.nifti` package:

```
library(oro.nifti)
```

Now, functions from the `oro.nifti` package can be used.

RStudio (the software)

RStudio is an Integrated Development Environment (IDE) for R (made by RStudio the company)

- It helps the user effectively and more easily use R.
 - Syntax highlighting, code completion, and smart indentation
 - Easily manage multiple working directories and projects
- Is NOT dropdown statistical tools (such as Stata)
 - See [Rcmdr](#) or [Radiant](#)

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

RStudio/R Console

- Where code is executed (where things happen)
- You can type here for things interactively
- Code is **not saved** on your disk
 - Can act as a calculator
 - Creating variables/objects
 - Applying functions

RStudio/R Console

The screenshot displays the RStudio application window. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The toolbar below the menu contains icons for creating new files, saving, running, and other functions. The main editor area on the left shows three untitled R script files. The console at the bottom left displays the R startup message, which is circled in black. The environment pane on the right shows the global environment is empty. The file explorer on the bottom right shows a list of files and folders in the current directory.

Console Output:

```
Platform: x86_64-pc-linux-gnu (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.

>
```

Environment: Global Environment (empty)

Files:

Name	Size	Modified
.Rhistory	959 B	Apr 13, 2017, 5:31 PM
113-01-T1_SS.nii.gz	3.6 MB	Apr 13, 2017, 6:26 PM
505-01-T1_N4.nii.gz	12.8 MB	Apr 13, 2017, 6:26 PM
bc_bet_ss.nii.gz	4.9 MB	Apr 13, 2017, 6:26 PM
brain_extraction_malf.R	5.8 KB	Apr 13, 2017, 6:26 PM
coregistration.R	3 KB	Apr 13, 2017, 6:26 PM
general_r.R	4.5 KB	Apr 13, 2017, 6:26 PM
inhomogeneity_correction_ms.R	2.8 KB	Apr 13, 2017, 6:26 PM
installing_everything_locally.R	2.1 KB	Apr 13, 2017, 6:26 PM
intensity_normalization.R	6.5 KB	Apr 13, 2017, 6:26 PM
intro.R	138 B	Apr 13, 2017, 6:26 PM
kirby_bc.nii.gz	11.9 MB	Apr 13, 2017, 6:26 PM
kirby_bc_bet.nii.gz	4 MB	Apr 13, 2017, 6:26 PM
kirby_naive_ss.nii.gz	2.1 MB	Apr 13, 2017, 6:26 PM
ms_lesion_segmentation.R	5 KB	Apr 13, 2017, 6:26 PM
naive_ss.nii.gz	2.1 MB	Apr 13, 2017, 6:26 PM
R		

Source

- Where files open to
- Have R code and comments in them
 - Static copy of what you did (reproducibility)
 - Try things out interactively, then add to your script
- Can highlight and press (CMD+Enter (Mac) or Ctrl+Enter (Windows)) to run the code
- Code is saved to disk

Source/Editor

The screenshot displays the RStudio Source/Editor interface. The main editor area is empty and circled in black. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The top toolbar shows icons for file operations and a search bar. The right sidebar contains the Environment pane (empty) and the Files pane (showing a list of files and folders). The bottom pane shows the Console with R startup messages.

Environment

Global Environment

Environment is empty

Files

Name	Size	Modified
.Rhistory	959 B	Apr 13, 2017, 5:31 PM
113-01-T1_SS.nii.gz	3.6 MB	Apr 13, 2017, 6:26 PM
505-01-T1_N4.nii.gz	12.8 MB	Apr 13, 2017, 6:26 PM
bc_bet_ss.nii.gz	4.9 MB	Apr 13, 2017, 6:26 PM
brain_extraction_malf.R	5.8 KB	Apr 13, 2017, 6:26 PM
coregistration.R	3 KB	Apr 13, 2017, 6:26 PM
general_r.R	4.5 KB	Apr 13, 2017, 6:26 PM
inhomogeneity_correction_ms.R	2.8 KB	Apr 13, 2017, 6:26 PM
installing_everything_locally.R	2.1 KB	Apr 13, 2017, 6:26 PM
intensity_normalization.R	6.5 KB	Apr 13, 2017, 6:26 PM
intro.R	138 B	Apr 13, 2017, 6:26 PM
kirby_bc.nii.gz	11.9 MB	Apr 13, 2017, 6:26 PM
kirby_bc_bet.nii.gz	4 MB	Apr 13, 2017, 6:26 PM
kirby_naive_ss.nii.gz	2.1 MB	Apr 13, 2017, 6:26 PM
ms_lesion_segmentation.R	5 KB	Apr 13, 2017, 6:26 PM
naive_ss.nii.gz	2.1 MB	Apr 13, 2017, 6:26 PM
R		

Console

Platform: x86_64-pc-linux-gnu (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.

> |

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

Workspace/Environment

The screenshot displays the RStudio IDE interface. The top menu bar includes File, Edit, Code, View, Plots, Session, Build, Debug, Profile, Tools, and Help. The toolbar contains icons for file operations and a 'Go to file/function' search bar. The main editor area shows three untitled R script files. The Environment pane on the right, titled 'Global Environment', is circled in black and indicates that the environment is empty. Below it, the Files pane shows a directory listing of files and folders. The Console at the bottom displays the R startup message and a prompt for user input.

Environment Pane: Global Environment (Environment is empty)

Files Pane:

Name	Size	Modified
.Rhistory	959 B	Apr 13, 2017, 5:31 PM
113-01-T1_SS.nii.gz	3.6 MB	Apr 13, 2017, 6:26 PM
505-01-T1_N4.nii.gz	12.8 MB	Apr 13, 2017, 6:26 PM
bc_bet_ss.nii.gz	4.9 MB	Apr 13, 2017, 6:26 PM
brain_extraction_malf.R	5.8 KB	Apr 13, 2017, 6:26 PM
coregistration.R	3 KB	Apr 13, 2017, 6:26 PM
general_r.R	4.5 KB	Apr 13, 2017, 6:26 PM
inhomogeneity_correction_ms.R	2.8 KB	Apr 13, 2017, 6:26 PM
installing_everything_locally.R	2.1 KB	Apr 13, 2017, 6:26 PM
intensity_normalization.R	6.5 KB	Apr 13, 2017, 6:26 PM
intro.R	138 B	Apr 13, 2017, 6:26 PM
kirby_bc.nii.gz	11.9 MB	Apr 13, 2017, 6:26 PM
kirby_bc_bet.nii.gz	4 MB	Apr 13, 2017, 6:26 PM
kirby_naive_ss.nii.gz	2.1 MB	Apr 13, 2017, 6:26 PM
ms_lesion_segmentation.R	5 KB	Apr 13, 2017, 6:26 PM
naive_ss.nii.gz	2.1 MB	Apr 13, 2017, 6:26 PM
R		

Console:

```
Platform: x86_64-pc-linux-gnu (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.

> |
```

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

Website

http://johnmuschelli.com/imaging_in_r

References

Lesjak, Žiga, Alfiia Galimzianova, Aleš Koren, Matej Lukin, Franjo Pernuš, Boštjan Likar, and Žiga Špiclin. 2017. "A Novel Public MR Image Dataset of Multiple Sclerosis Patients with Lesion Segmentations Based on Multi-Rater Consensus." , 1–13.