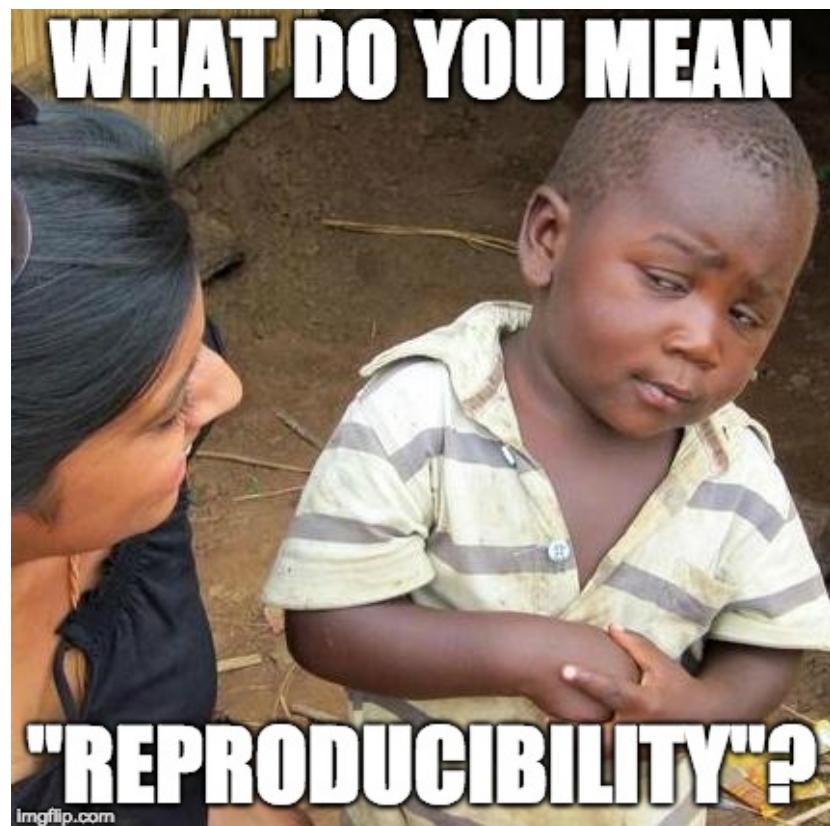


Neuroconductor and Reproducibility: Imaging in R

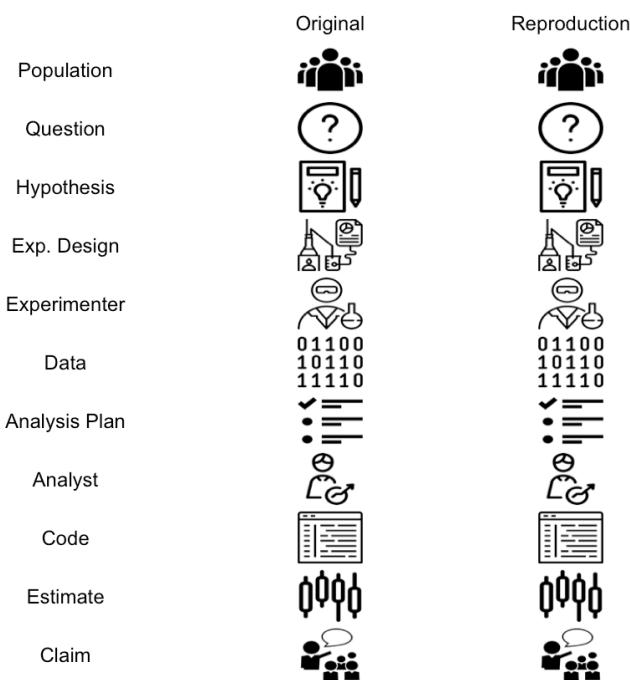
https://github.com/muschellij2/Neuroimaging_in_R

<https://imgflip.com/i/2ep2jb>



“Reproducibility” in General

(Patil, Peng, and Leek 2016)



Seldomly Reported Inclusion/Exclusion

(Patil, Peng, and Leek 2016)

Population



<https://imgflip.com/i/2bltgh>

SCANNED (N = 100), ANALYZED (N = 20)



Exp. Design



Experimenter

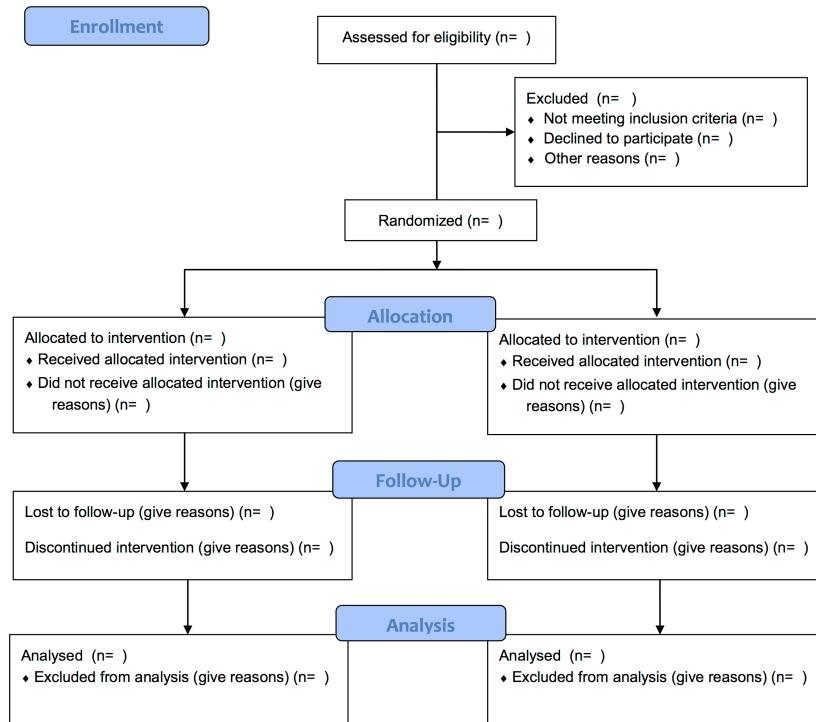


Data

01100
10110
11110

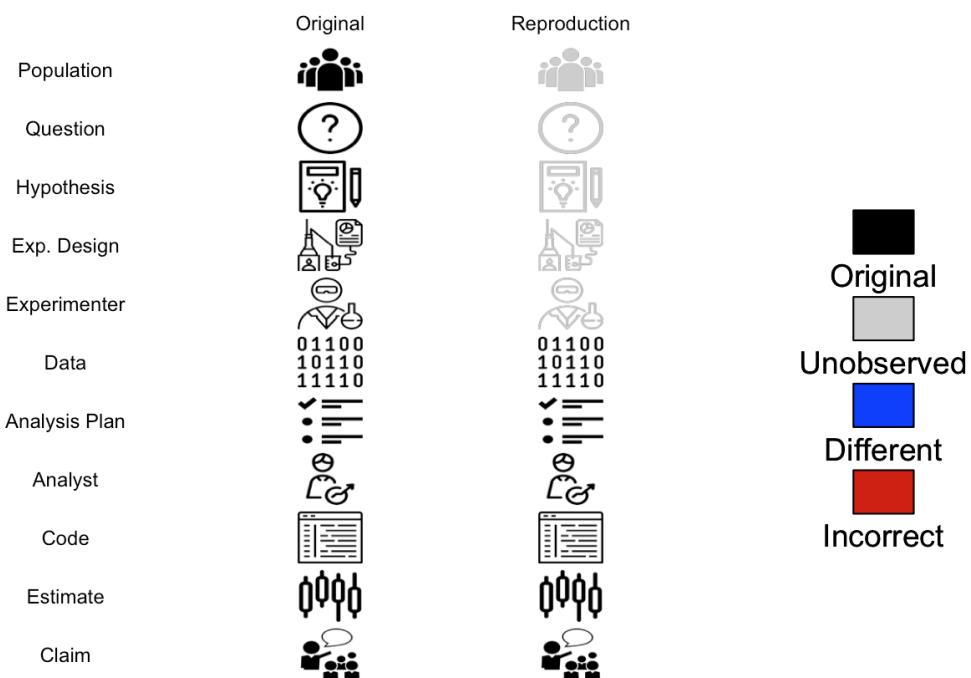
01100
10110
11110

Solutions: RCT/CONSORT diagrams



Neuroimaging Reproducibility

(Patil, Peng, and Leek 2016)



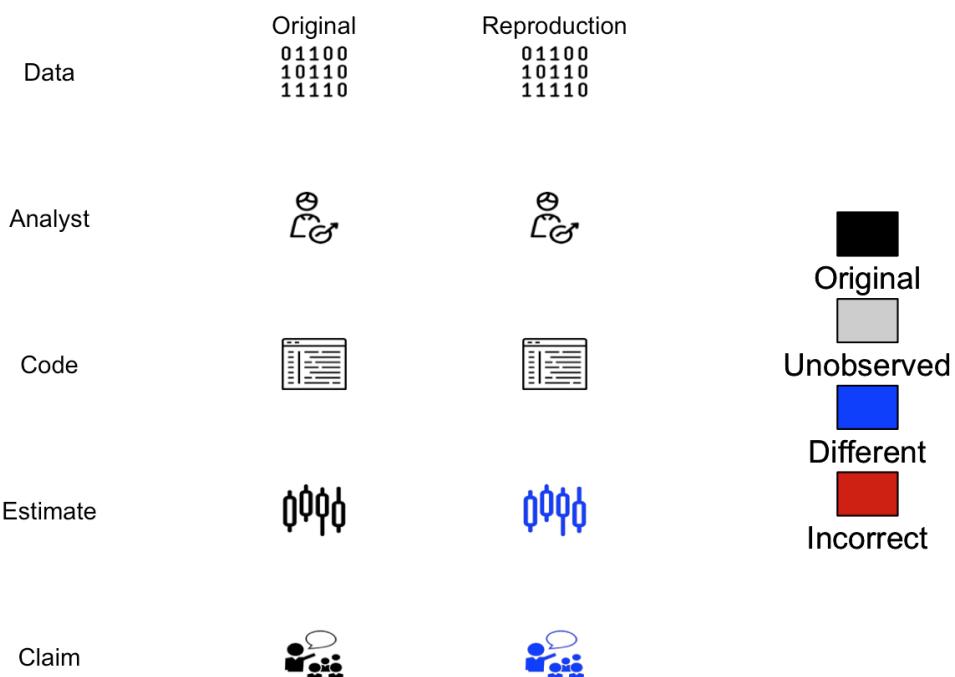
Neuroimaging Reproducibility Starts w/Data

(Patil, Peng, and Leek 2016)

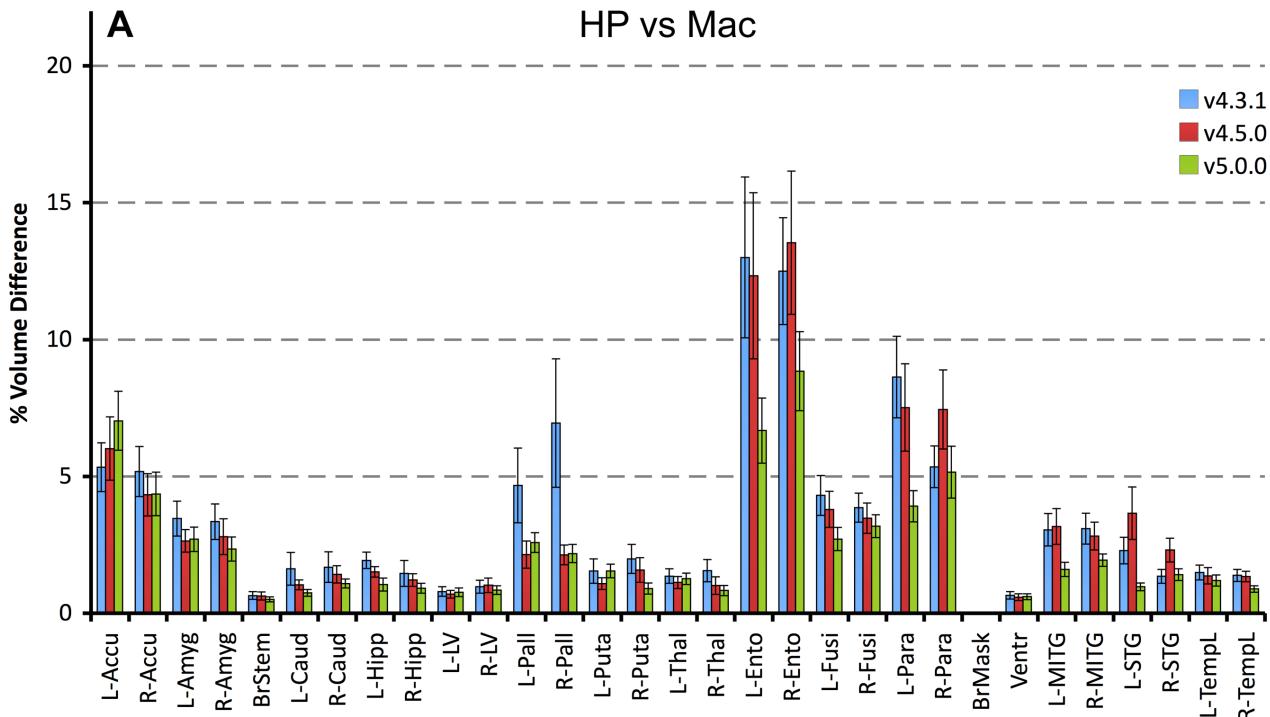
	Original	Reproduction
Data	<code>01100</code> <code>10110</code> <code>11110</code>	<code>01100</code> <code>10110</code> <code>11110</code>
Analyst		
Code		
Estimate		
Claim		

Controversy in Neuroimaging: Won't Reproduce!

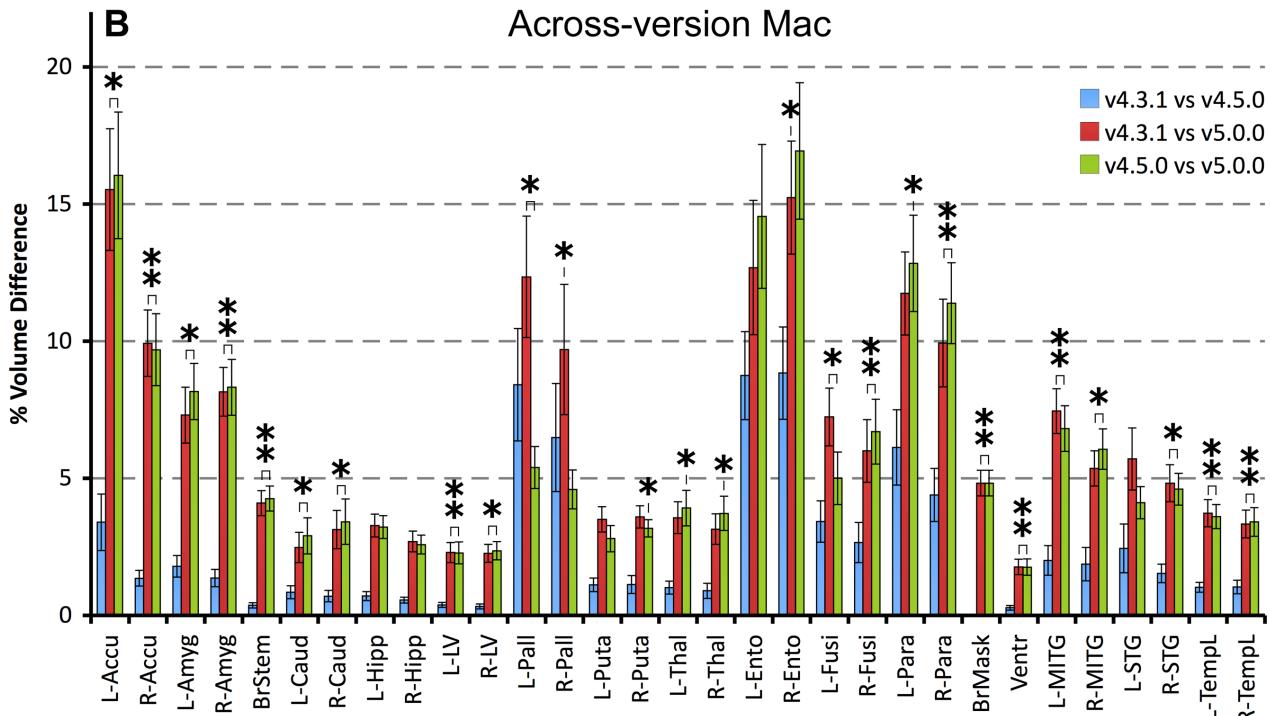
(Patil, Peng, and Leek 2016)



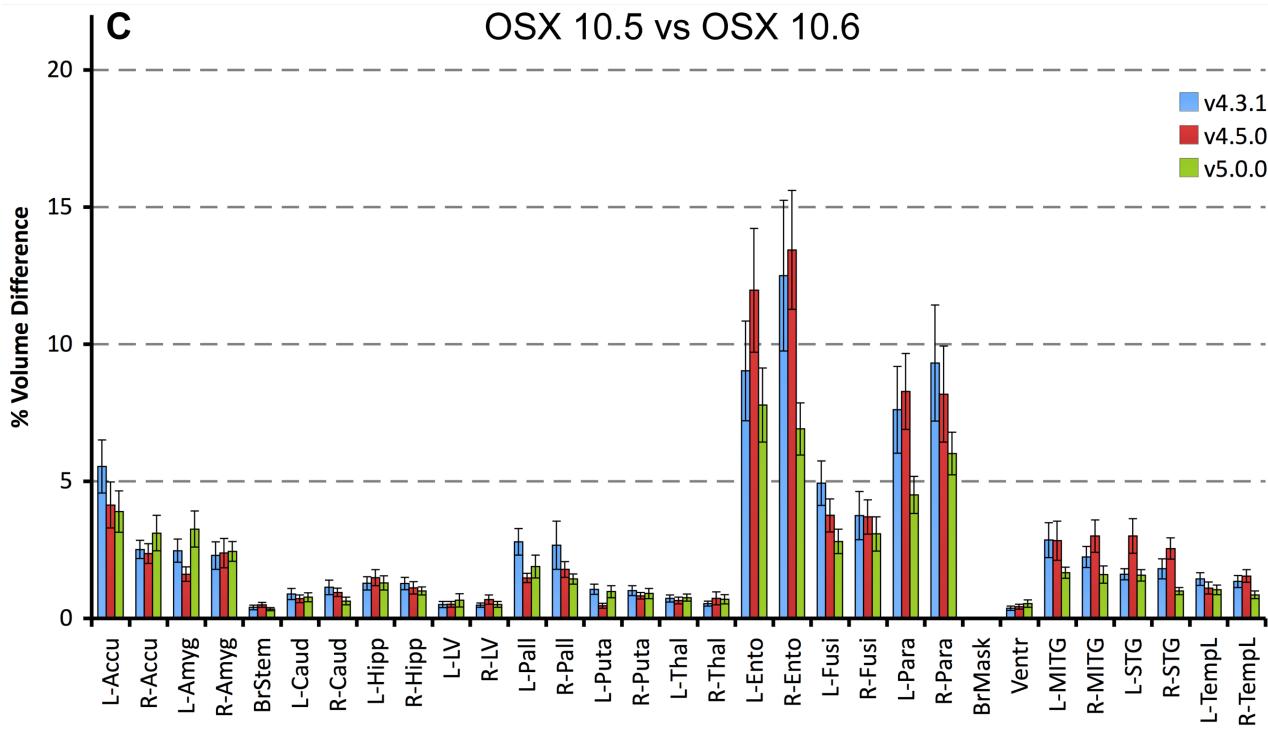
Gronenschild et al. (2012): Freesurfer Thickness



Gronenschild et al. (2012): Freesurfer Thickness



Gronenschild et al. (2012): Freesurfer Thickness

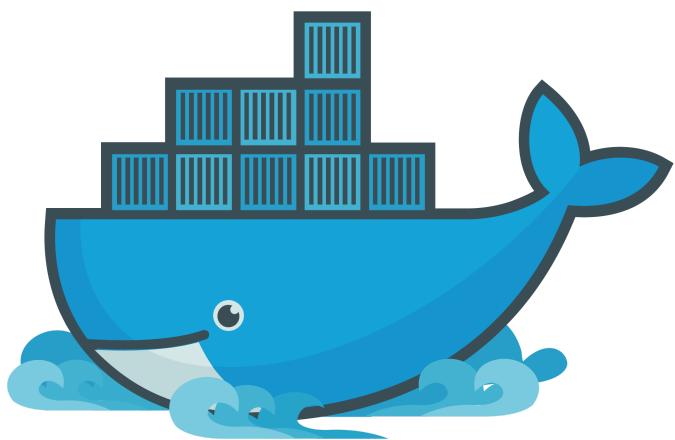


Gronenschild et al. (2012): Freesurfer Thickness

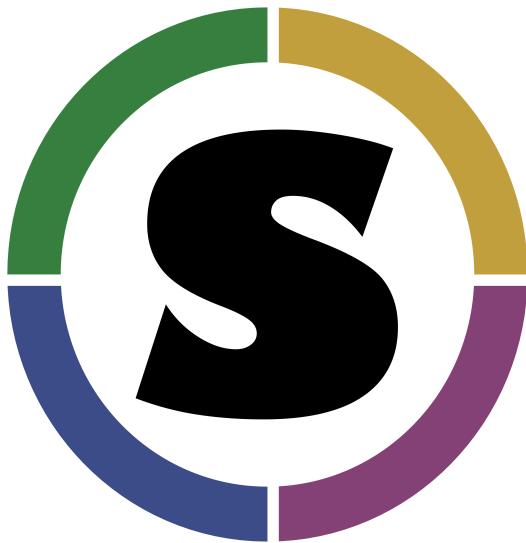
"The observed differences are similar in magnitude as effect sizes reported in accuracy evaluations and neurodegenerative studies."

“Solutions”/Debugging: Containers

Docker

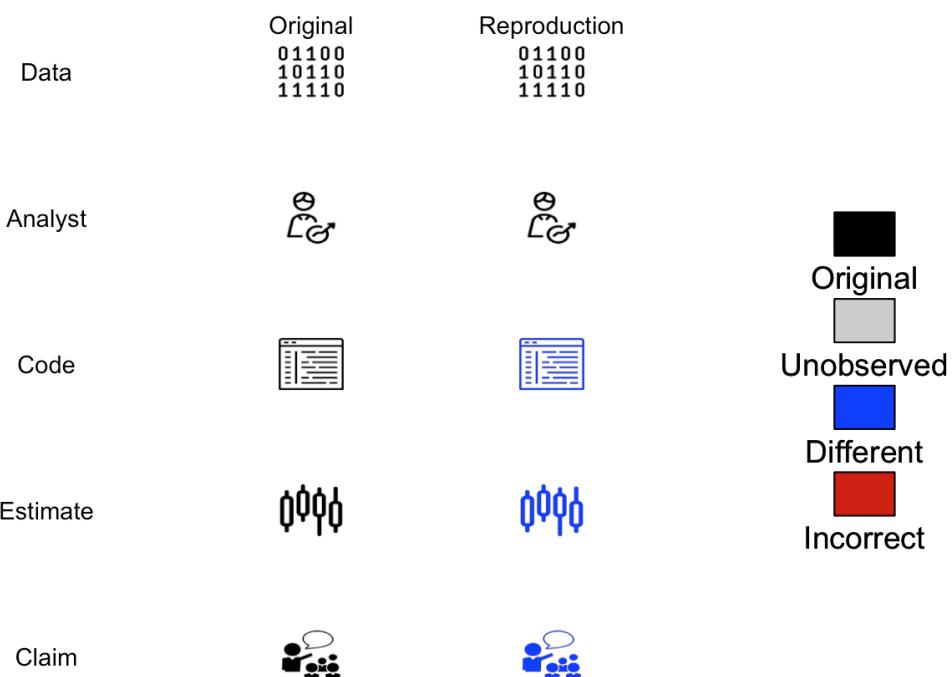


Singularity



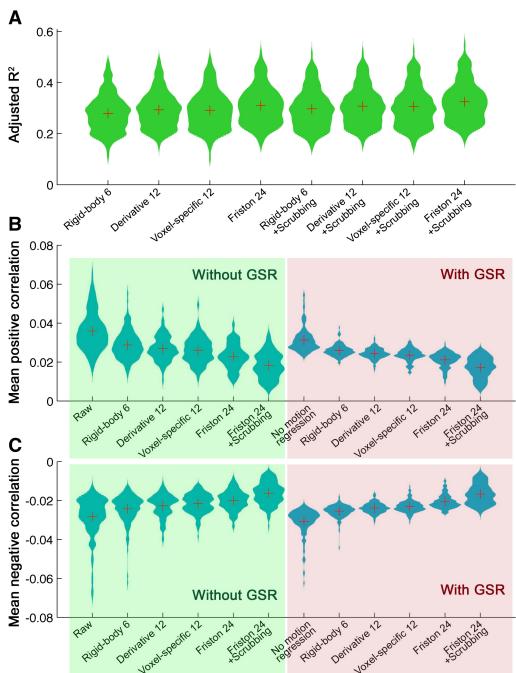
Not Same as “Choosing a Pipeline”

(Patil, Peng, and Leek 2016)



No General Solutions for Pipeline Choices

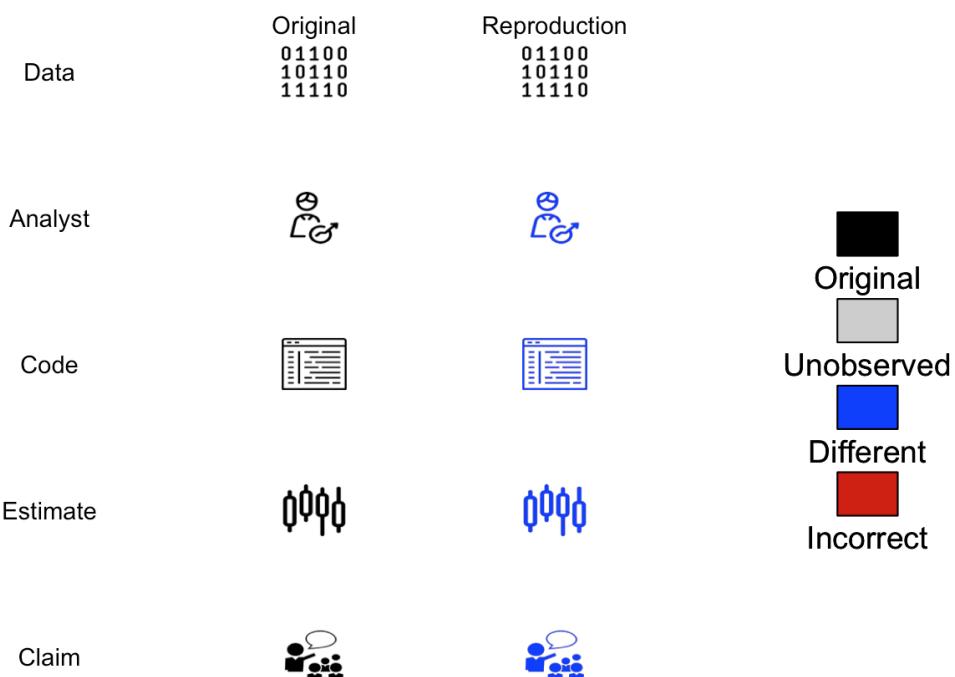
Many combinations (Yan et al. 2013):



See which predicts outcome of interest. Cross validated, of course

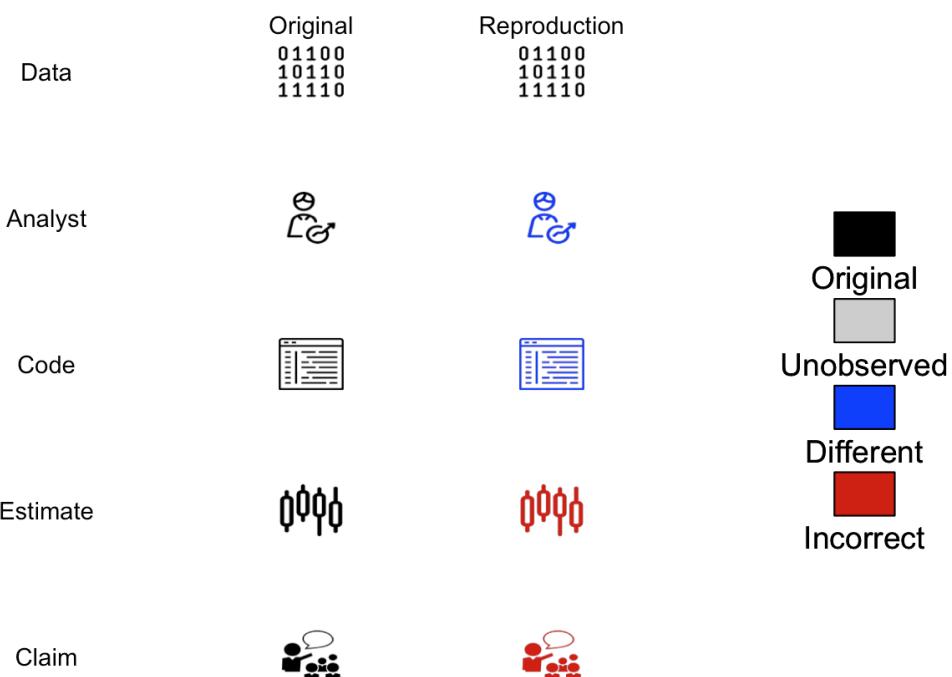
Different Pipelines give Different Results

(Patil, Peng, and Leek 2016)

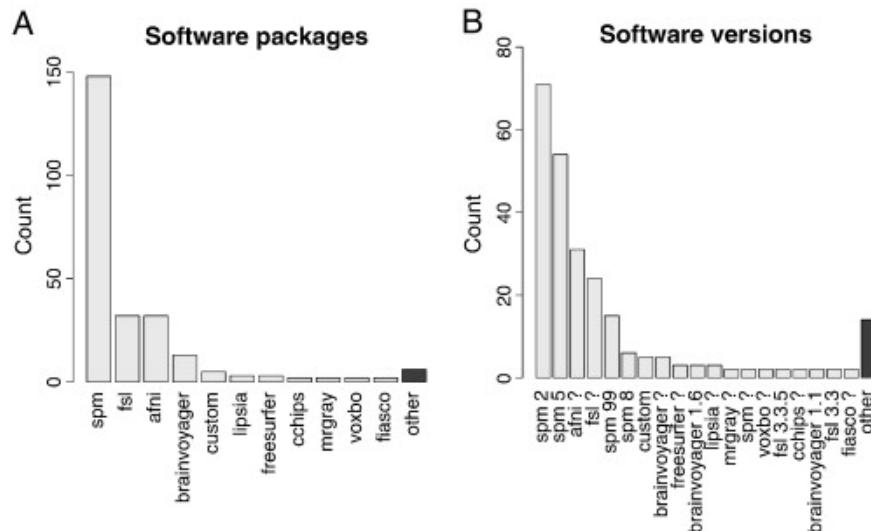


Original Authors May Claim “Incorrect”

(Patil, Peng, and Leek 2016)



It's typical to have lots of software choices

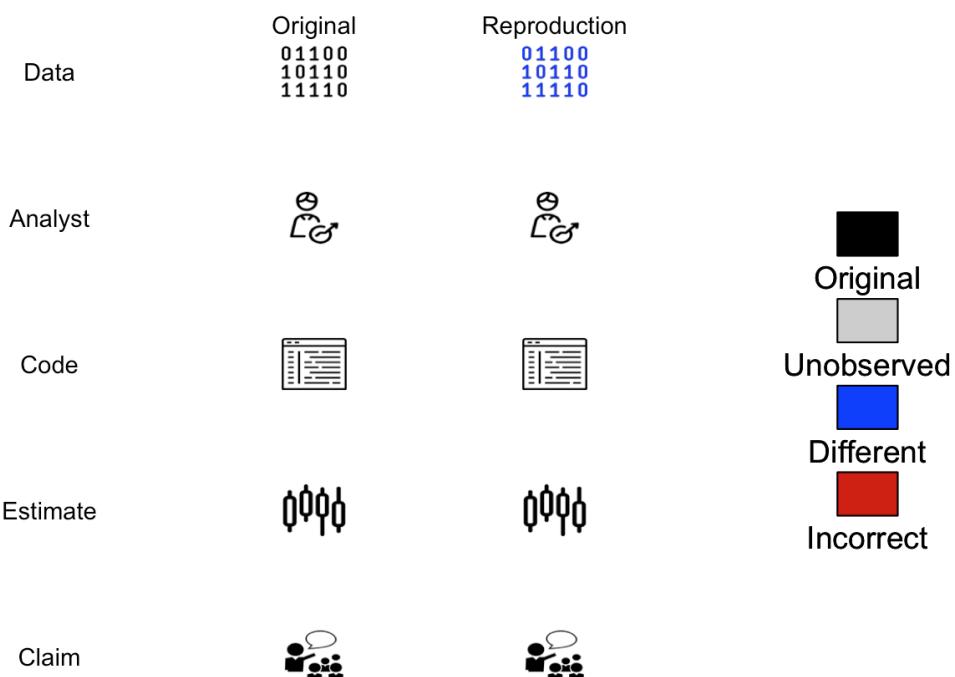


Carp (2012) "The secret lives of experiments: methods reporting in the fMRI literature." Neuroimage 63.1 (2012): 289-300.

(Carp 2012)

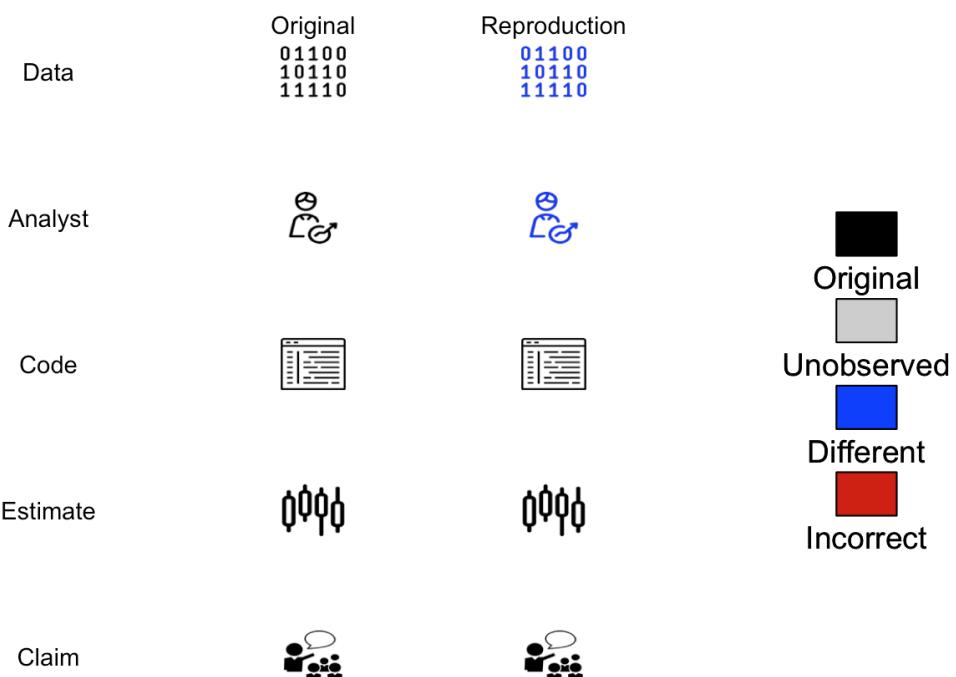
One Solution: Replication

(Patil, Peng, and Leek 2016)



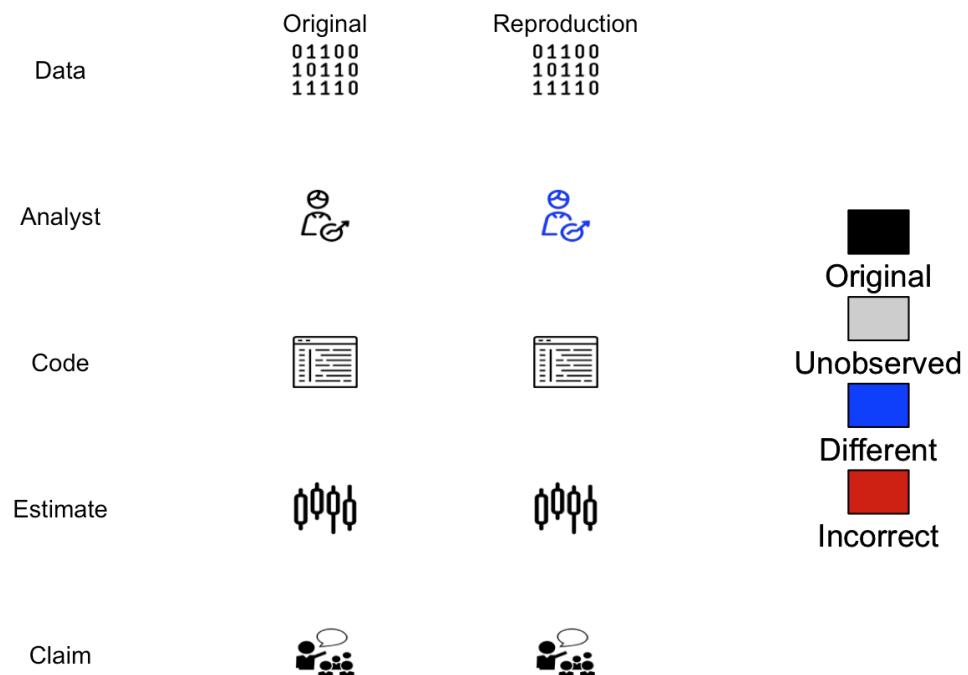
Want External Replication

(Patil, Peng, and Leek 2016)



Minimum Reproducibility Goal

(Patil, Peng, and Leek 2016)





An R Platform for
Medical Imaging Analysis

What is Neuroconductor?

1. A community of developers and users of R packages for imaging
2. A website <https://neuroconductor.org/>.
 - with tutorials and help
3. A team helping developers and users (John, Adi Gherman, Ciprian Crainiceanu, Brian Caffo)
4. A centralized repository of maintained packages

Goal: Centralize the packages (currently 73)

List Packages

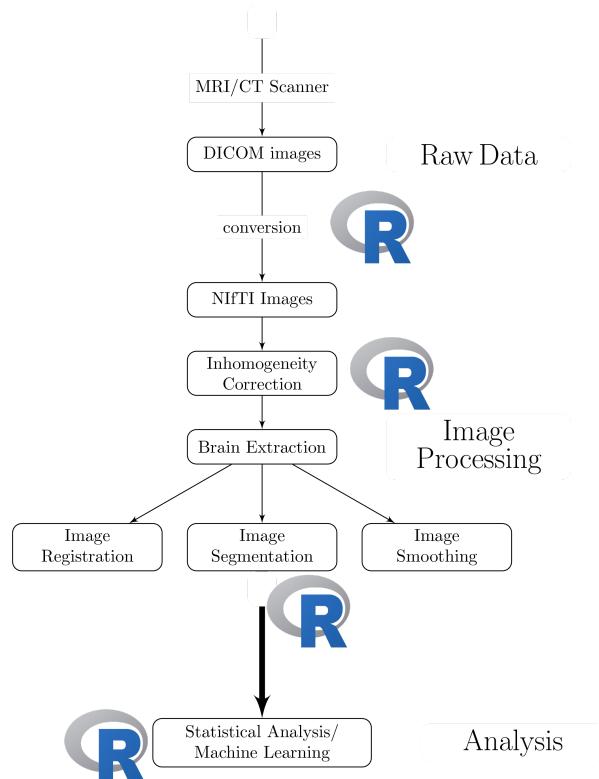
List Packages					
View Dependency Graph			View Pending Packages		
Show 50 entries			Search:		
Package Name	Version	Package Title	Maintainer(s)		
Last updated	GitHub URL				
ANTsR	0.4.0	ANTs in R: quantification tools for biomedical images	Brian B. Avants	2017-03-18	stnava/ANTsR
ANTsRCore	0.0.0	ANTsRCore: core software infrastructure for ANTsR	Brian B. Avants	2017-03-18	stnava/ANTsRCore.git
brainR	1.4.2.1	Helper Functions to Misc3d and rgl Packages for Brain Imaging	John Muschelli	2017-05-26	muschelli/j2/brainR
cifti	0.4.2	Toolbox for Connectivity Informatics Technology Initiative ('CIFTI') Files	John Muschelli	2017-05-26	muschelli/j2/cifti
dcemriS4	0.57.1.2	A Package for Image Analysis of DCE-MRI (S4 Implementation)	Brandon, Whitcher	2017-05-26	bjw34032/dcemriS4
dcm2nir	0.5	Conversion of 'DICOM' to 'NifTI' Imaging Files Through R	John Muschelli	2017-02-24	muschelli/j2/dcm2nir
divest	0.3.0.1	Get Images Out of DICOM Format Quickly	Jon Clayden	2017-05-25	jonclayden/divest
EveTemplate	0.99.14.2	JHU-MNI-ss (Eve) template	Jean-Philippe Fortin	2017-05-26	JFortin1/EveTemplate
extrantsr	2.17.2.3	Extra Functions to Build on the ANTsR Package	John Muschelli	2017-05-26	muschelli/j2/extrantsr.git
freesurfer	1.6.6	Wrapper Functions for 'Freesurfer'	John Muschelli	2017-05-26	muschelli/j2/freesurfer
fslr	2.12.6	Wrapper Functions for FSL ('FMRIB' Software Library) from Functional MRI of the Brain ('FMRIB')	John Muschelli	2017-05-26	muschelli/j2/fslr
gifti	0.7	Reads in Neuroimaging 'GIFTI' Files with Geometry Information	John Muschelli	2016-11-09	muschelli/j2/gifti
ITKR	0.0.1	ITK in R	Brian B. Avants	2017-02-24	stnava/ITKR
itksnapr	2.1.6	Package of ITK-SNAP	John Muschelli	2017-05-26	muschelli/j2/itksnapr
kirby21.asl	1.5.1	Example ASL Data from the Multi-Modal MRI Reproducibility Resource	John Muschelli	2017-05-03	muschelli/j2/kirby21.asl

Need Workflows

- all R code
 - interface/pipeline tool
 - “native” R code

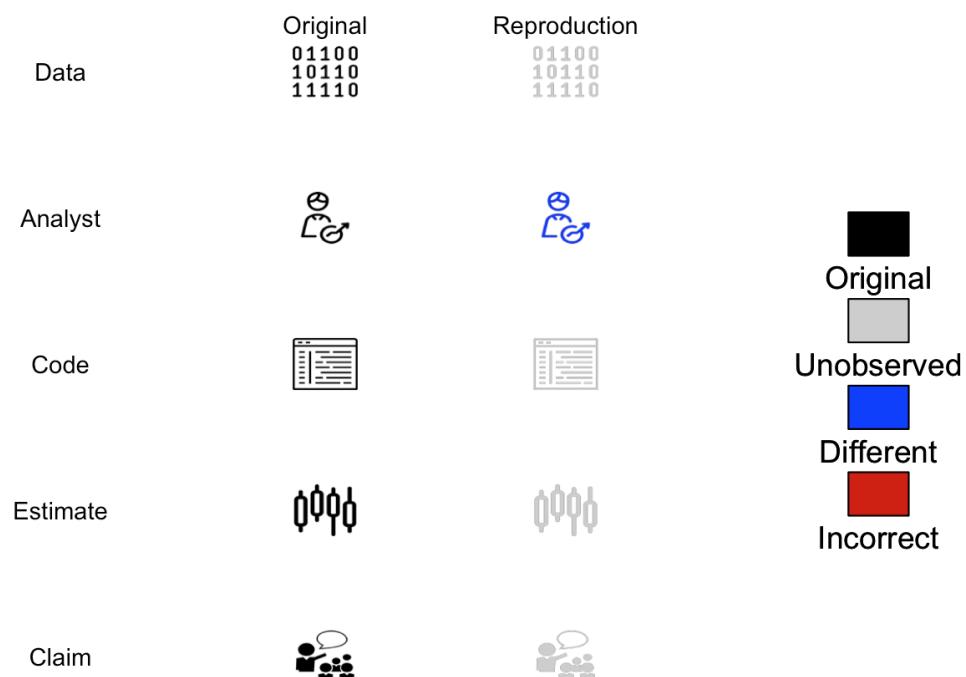
Complete pipeline

- preprocessing and analysis



Many Cases in Neuroimaging: Why?

(Patil, Peng, and Leek 2016)



Data: Submitting Not Required



R packages to access these repositories

- so if there, need ability to access
 1. neurovault - access neurovault
 2. neurohcp - Human Connectome Project
 3. Rxnat - XNAT interface (NITRC)

Conclusions

- Reproducible code a minimum
- Need data submitted (journals need to help)
 - but need easy tools to access the data
- Analysis tools exist but need more
- Develop more standardization like BioConductor
 - standard data structures
 - publishable pipelines

Thanks

Example Packages

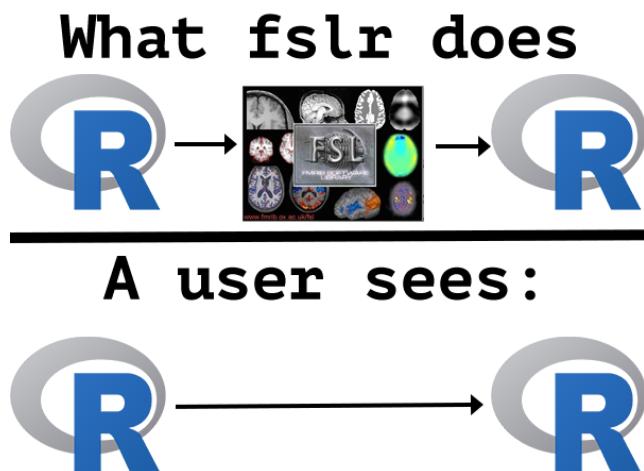
ANTsR

Based on ANTs: Advanced Normalization Tools

- State-of-the-art image processing pipelines
- Group has won challenges for imaging analysis
- Still actively maintained and developed
- Depends on the Insight ToolKit (ITK) medical image processing library

Using R as a Pipeline Tool: fslr

- fslr package - call FSL from R
- Requires FSL to be installed (only *nix systems)



spm12r: Wrapper Functions for SPM

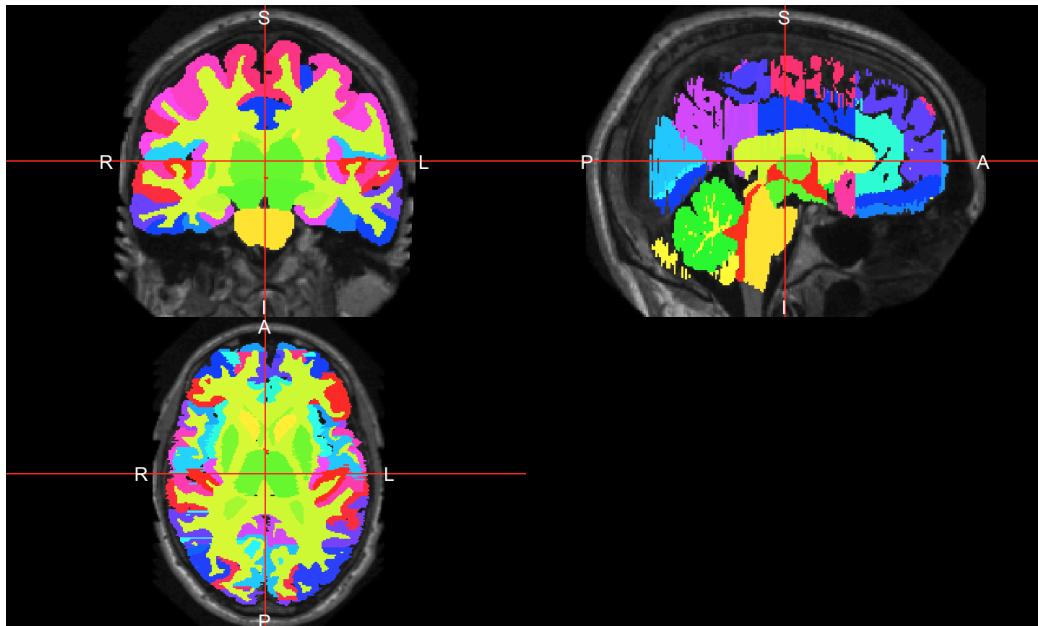
- Wraps some MATLAB code to call SPM scripts
- Using R syntax (but MATLAB runs the code)
- Built from SPM batch commands
- Shown in worked example:
http://johnmuscelli.com/talks/fMRI_task_processing/index.html#1

neurohcp: Human Connectome Project

- Allows you to download data from [Human Connectome Project](#)
- The 1200 Subjects release: behavioral and 3T MR imaging data from 1206 healthy young adult participants. Standardized protocol.
- Tutorial:
<http://johnmuschelli.com/neuroc/neurohcp>

mfal.templates: Segmented T1-weighted Images

- Data from the MICCAI 2012 Challenge on Multi-atlas Labelling Data
- From OASIS project and the labeled data as provided by Neuromorphometrics, Inc. (<http://Neuromorphometrics.com/>)



Current limitations

- R is cross platform, but some packages that depend on *nix system
- Still in beta testing, but more likely to incorporate requests
- Rcpp requires compiled code, (see below)
- Licenses with data can be tricky

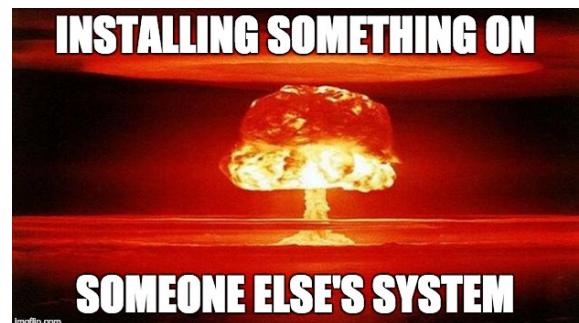
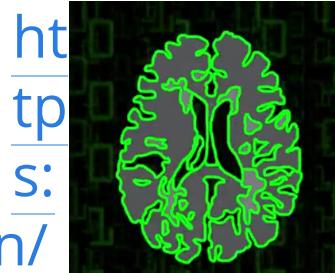


Image from: <https://imgflip.com/i/22gplr>

Training we are providing

Coursera Course:
Introduction to
Neurohacking In R

<https://www.coursera.org/learn/neurohacking/>



http://johnmuschelli.com/imaging_in_r/ ENAR 2018

Bibliography

- Carp, Joshua. 2012. "The Secret Lives of Experiments: Methods Reporting in the fMRI Literature." 63 (1). Elsevier:289–300.
- Gronenschild, Ed HBM, Petra Habets, Heidi IL Jacobs, Ron Mengelers, Nico Rozendaal, Jim Van Os, and Machteld Marcelis. 2012. "The Effects of Freesurfer Version, Workstation Type, and Macintosh Operating System Version on Anatomical Volume and Cortical Thickness Measurements." 7 (6). Public Library of Science:e38234.
- Patil, Prasad, Roger D. Peng, and Jeffrey Leek. 2016. "A Statistical Definition for Reproducibility and Replicability." . Cold Spring Harbor Laboratory. <https://doi.org/10.1101/066803>.
- Yan, Chao-Gan, Brian Cheung, Clare Kelly, Stan Colcombe, R Cameron Craddock, Adriana Di Martino, Qingyang Li, Xi-Nian Zuo, F Xavier Castellanos, and Michael P Milham. 2013. "A Comprehensive Assessment of Regional Variation in the Impact of Head Micromovements on Functional Connectomics." 76. Elsevier:183–201.