



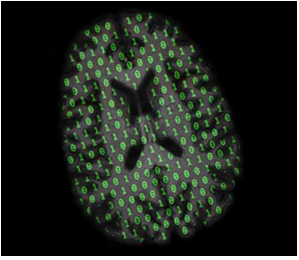
R TUTORIAL FOR NEUROIMAGING: NEUROHACKING IN R

JOHN MUSCHELLI, ELIZABETH SWEENEY, CIPRIAN CRAINICEANU

BIOSTATISTICS DEPARTMENT,
JOHNS HOPKINS BLOOMBERG SCHOOL OF PUBLIC HEALTH
BALTIMORE, MD

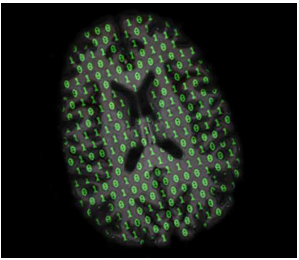


THEME 1 / LECTURE 1: NEUROHACKING

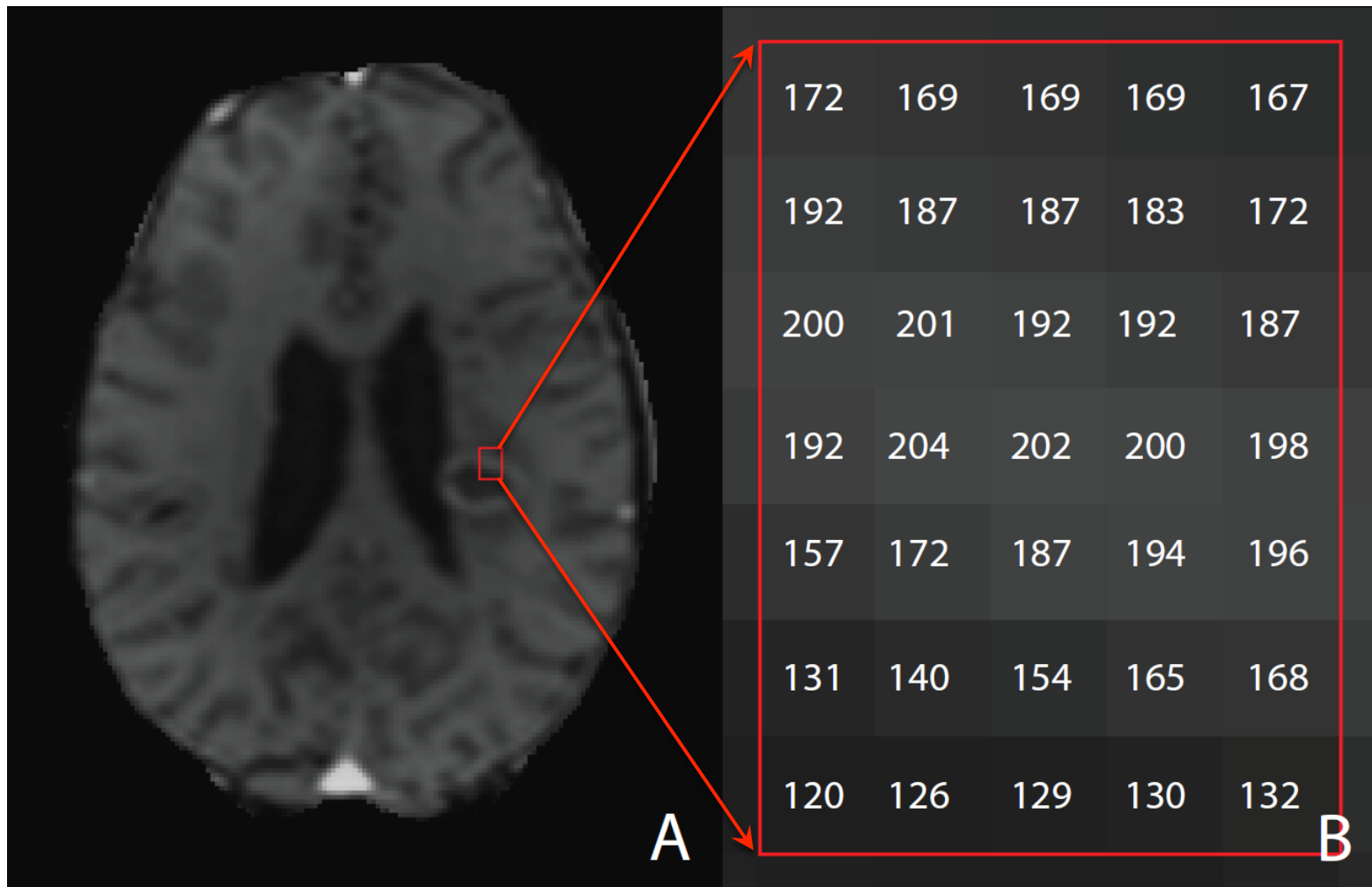


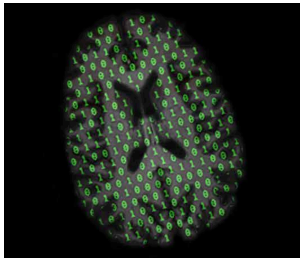
Overview

- Neurohacking definition
- Course goals
- Course structure
- Suggested prerequisites



What is Neurohacking?

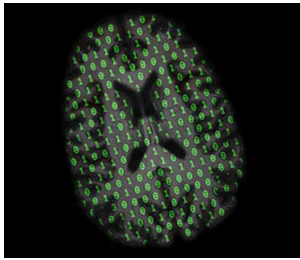




What is Neurohacking?

Neurohacking is the continuous process of using, improving and designing the simplest open source scripted software that depends on the minimum number of software platforms and is dedicated to improving the correctness, reproducibility, and speed of neuroimage data analysis

Goal of neurohacking: democratization of neuroimaging data analysis



Course goals

- Interactively explore data with R
- Image preprocessing with R, `fsl`, and ANTs
- Reading, writing, plotting, and manipulating neuroimaging data in R

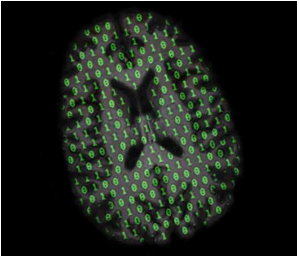
M. Jenkinson, C.F. Beckmann, T.E. Behrens, M.W. Woolrich, S.M. Smith. *FSL*. *NeuroImage*, 62:782-90, 2012.

<http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/>

R Core Team (2014). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org/>

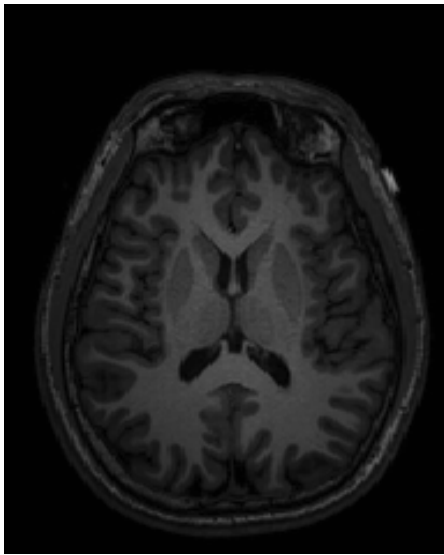
J.G. Sled, A.P. Zijdenbos, and A.C. Evans. A nonparametric method for automatic correction of intensity nonuniformity in MRI data". In: *Medical Imaging, IEEE Transactions on* 17.1 (1998), pp. 87-97

N.J. Tustison et al. N4ITK: improved N3 bias correction". In: *Medical Imaging, IEEE Transactions on* 29.6 (2010), pp. 1310-1320. <http://www.nitrc.org/projects/antsr/>
<http://stnava.github.io/ANTs/>

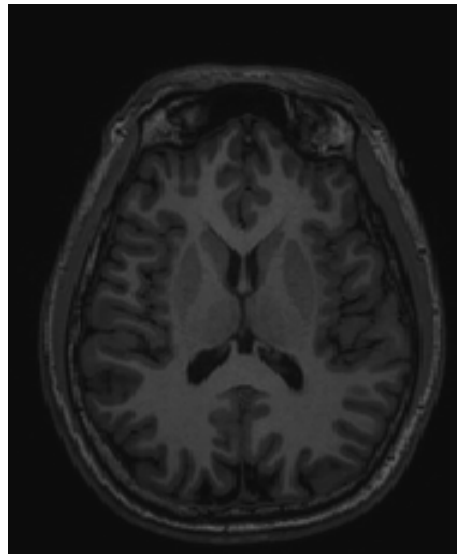


Course goals: subtract two images

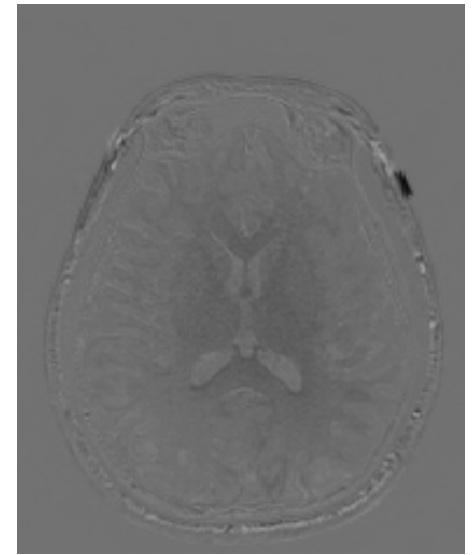
Subtract the follow-up T1-w from a baseline T1-w volume

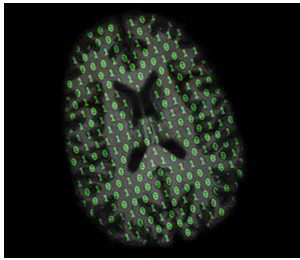


-



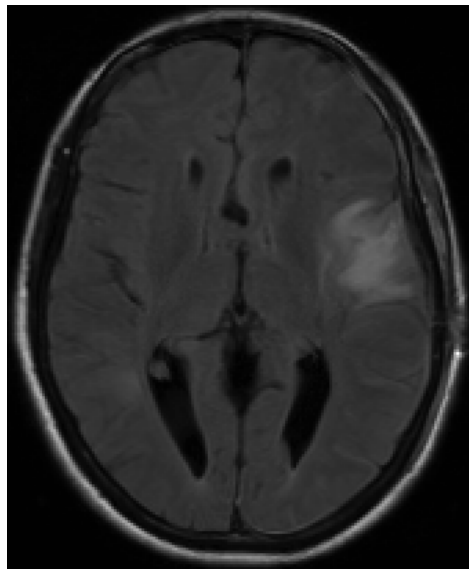
=



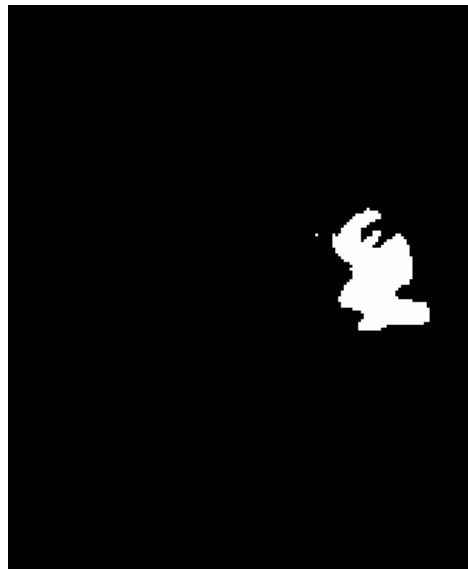


Course goals: template-based analysis

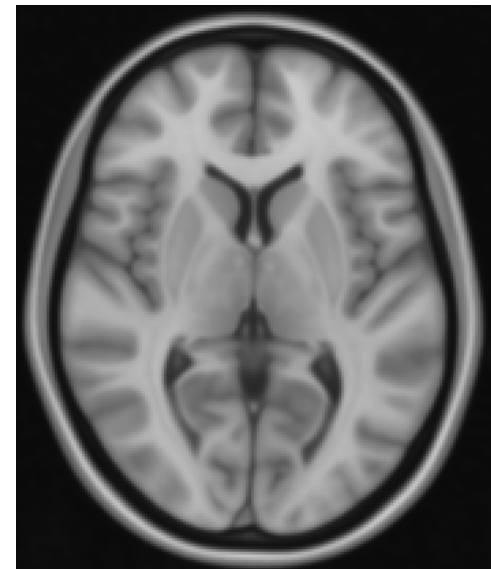
Warped FLAIR image

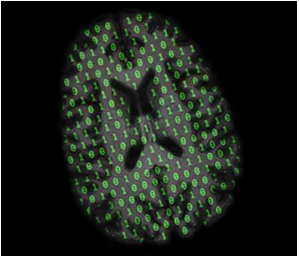


Warped ROI image



MNI T1 Template





Course structure

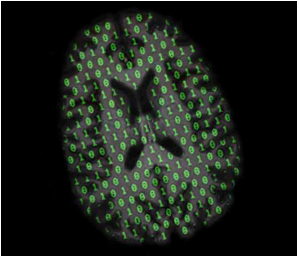
Theme 1 / Overview, set up

Theme 2 / Data structure and operations (file types, visualization and data manipulation, multi-sequence sMRI)

Theme 3 / Preprocessing (inhomogeneity correction, intensity normalization, registration, tools in R)

Theme 4 / Registration, ROI quantification, segmentation

Theme 5 / Dynamic visualization in R (papayar, itknapr)



Suggested prerequisites

The course is self-contained

Very helpful

Linux/Unix

A basic knowledge of programming

A basic knowledge of array data structures (e.g. 2d and 3d arrays)

Interest in “hacking” with neuroimaging data

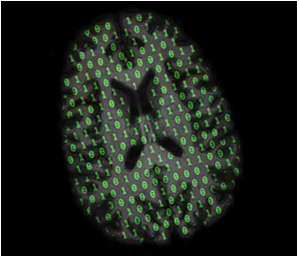
Useful

Coursera Data Science Specialization

<https://www.coursera.org/specialization/jhudatascience/1>

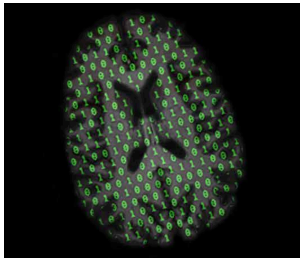


THEME 1 / LECTURE 2: COURSE OVERVIEW



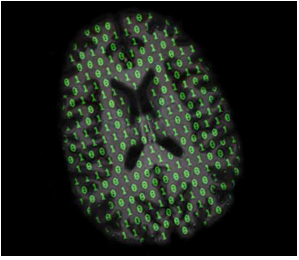
Overview

- ☐ Why R?
- ☐ Why structural MRI?
- ☐ Set up



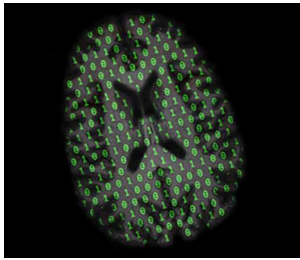
Why R?

- ☐ Hackable
- ☐ Free, open source
- ☐ One platform for processing/analysis
- ☐ Developed for data analysis
- ☐ Large number of user-developed packages
- ☐ Easy interaction with state-of-the art neuroimaging software (FSL, ANTS)

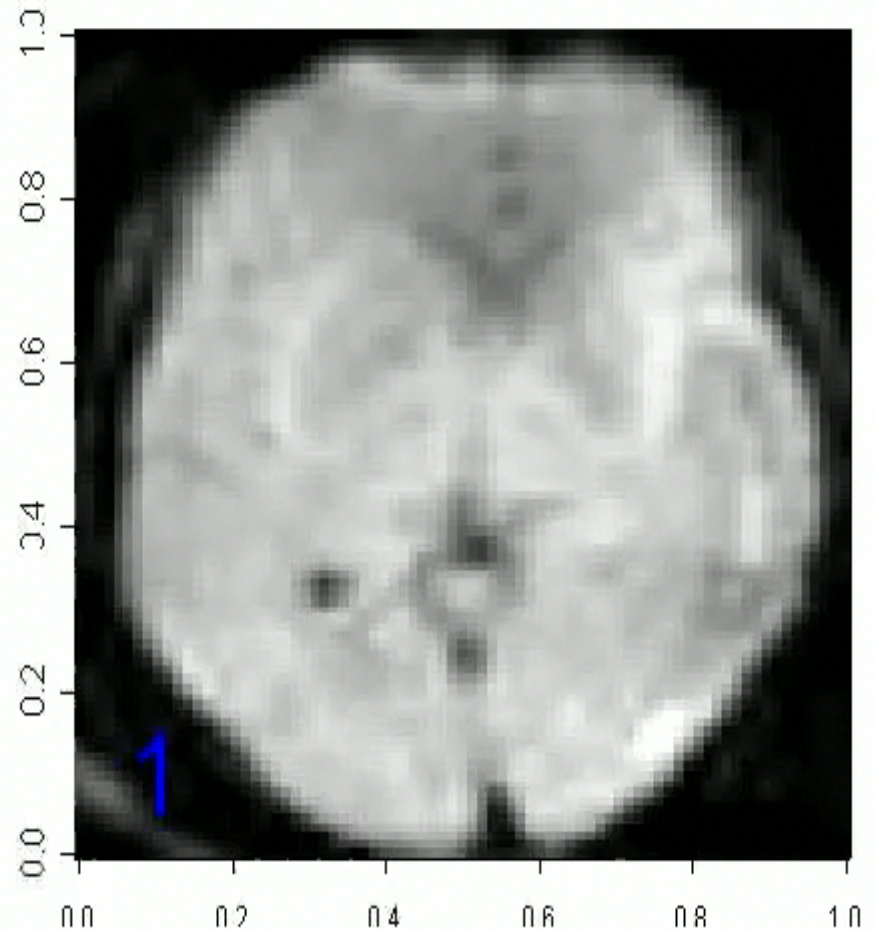
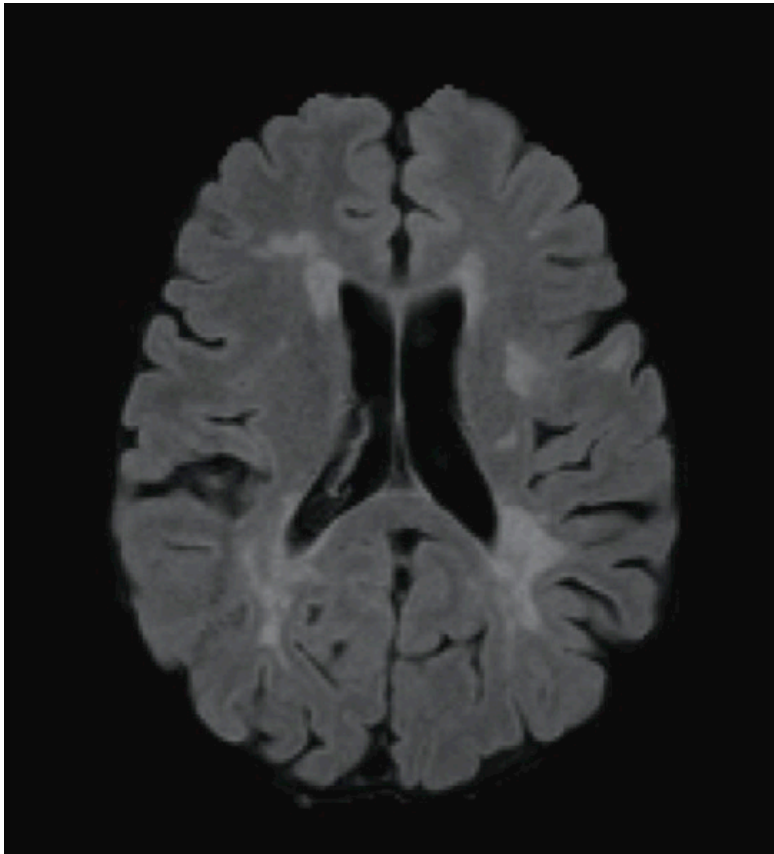


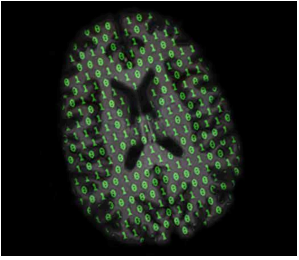
Why structural MRI?

- High spatial resolution
- Reveals the anatomic structure of soft tissues
- Used extensively in clinical and research practice
- Versatile: different contrasts can target different tissue types
 - ▣ FLAIR, T1, T2, PD, ...
 - ▣ DTI, ...
 - ▣ DCE, ...
- Sensitive to pathology (e.g. brain cancer, Multiple Sclerosis lesions)



Structural MRI vs. fMRI

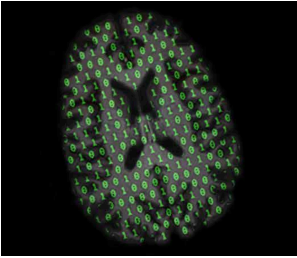




Set up

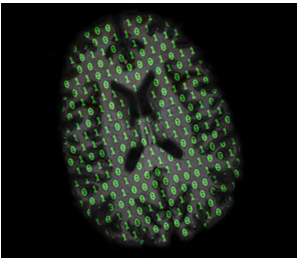
- ❑ Install R (<http://cran.r-project.org>)
- ❑ Install R Studio (<http://www.rstudio.com>)
- ❑ Download data:
https://github.com/muschellij2/Neurohacking_data/archive/v0.0.zip
 - ❑ Copy into a directory on your computer
 - ❑ For example ~/Neurohacking_data
- ❑ Open R Studio and install the devtools package in R

```
install.packages("devtools")  
library(devtools)
```

Data Used

```
Neurohacking_data
  BRAINIX
    DICOM
      T1
        IM-0001-0001.dcm
        ...
        IM-0001-0022.dcm
      ROI
      FLAIR
      T2
    NIFTI
      T1.nii.gz
      ROI.nii.gz
      FLAIR.nii.gz
      T2.nii.gz
  Kirby21
    113
      visit_1
        113-01-FLAIR.nii.gz
        113-01-MPRAGE.nii.gz
        113-01-T2w.nii.gz
      visit_2
        113-02-FLAIR.nii.gz
        113-02-MPRAGE.nii.gz
        113-02-T2w.nii.gz
  Template
    MNI152_T1_1mm_brain.nii.gz
    JHU_MNI_SS_T1_brain.nii.gz
    ...
```



Data Used

Neurohacking_data

BRAINIX

DICOM

T1

IM-0001-0001.dcm

...

IM-0001-0022.dcm

ROI

FLAIR

T2

NIFTI

T1.nii.gz

ROI.nii.gz

FLAIR.nii.gz

T2.nii.gz

Kirby21

113

visit_1

113-01-FLAIR.nii.gz

113-01-MPRAGE.nii.gz

113-01-T2w.nii.gz

visit_2

113-02-FLAIR.nii.gz

113-02-MPRAGE.nii.gz

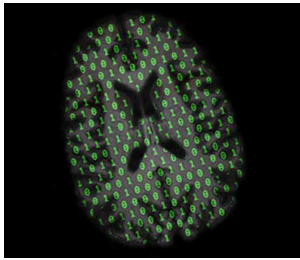
113-02-T2w.nii.gz

Template

MNI152_T1_1mm_brain.nii.gz

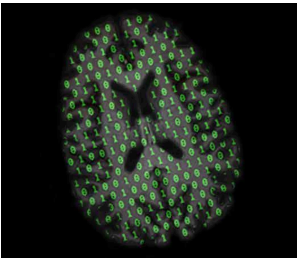
JHU_MNI_SS_T1_brain.nii.gz

...



Data Used

```
Neurohacking_data
  BRAINIX
    DICOM
      T1
        IM-0001-0001.dcm
        ...
        IM-0001-0022.dcm
      ROI
      FLAIR
      T2
    NIFTI
      T1.nii.gz
      ROI.nii.gz
      FLAIR.nii.gz
      T2.nii.gz
  Kirby21
    113
      visit_1
        113-01-FLAIR.nii.gz
        113-01-MPRAGE.nii.gz
        113-01-T2w.nii.gz
      visit_2
        113-02-FLAIR.nii.gz
        113-02-MPRAGE.nii.gz
        113-02-T2w.nii.gz
  Template
    MNI152_T1_1mm_brain.nii.gz
    JHU_MNI_SS_T1_brain.nii.gz
    ...
```



Data Used

Neurohacking_data

BRAINIX

DICOM

T1

IM-0001-0001.dcm

...

IM-0001-0022.dcm

ROI

FLAIR

T2

NIFTI

T1.nii.gz

ROI.nii.gz

FLAIR.nii.gz

T2.nii.gz

Kirby21

113

visit_1

113-01-FLAIR.nii.gz

113-01-MPRAGE.nii.gz

113-01-T2w.nii.gz

visit_2

113-02-FLAIR.nii.gz

113-02-MPRAGE.nii.gz

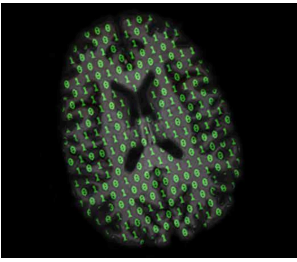
113-02-T2w.nii.gz

Template

MNI152_T1_1mm_brain.nii.gz

JHU_MNI_SS_T1_brain.nii.gz

...



Data sources

- **OsiriX:** A number of open source DICOM imaging datasets of various parts of the body
www.osirix-viewer.com/datasets/
- **NITRC:** Kirby 21, Multi-Modal MRI reproducibility Resource
<https://www.nitrc.org/projects/multimodal>
- **MNI-ICBM:** Various atlases, we are using MNI-ICBM 152-linear
<http://www.bic.mni.mcgill.ca/ServicesAtlases/HomePage>
- **Eve:** Single-subject white matter atlas
<http://cmrm.med.jhmi.edu/>