- Introduction
- Relevant Questions
- Open resources
  - MRI
  - EEG
  - Data science
- Fun New Topics !!!
- OpenLabs: Possible Contribution
- References

About me

- **Doren**
  - computer engineering @BilkentTR
  - psychology & neuroscience @PaviaIT
- **Relevant-interests**
  - **FAIR** social/medical algorithms
  - the implications of **neuropsychiatry** in everyday life
  - open tools for understanding the human
- **Others**
  - web-dev
  - data-science
  - geo-tools

WARNING

The content is based on sparse readings of the literature.

It is by no means an overall introduction to neuroscience.

INFO

The topics might be **overwhelming**, so feel free to jump in at anytime!

Relevant Questions

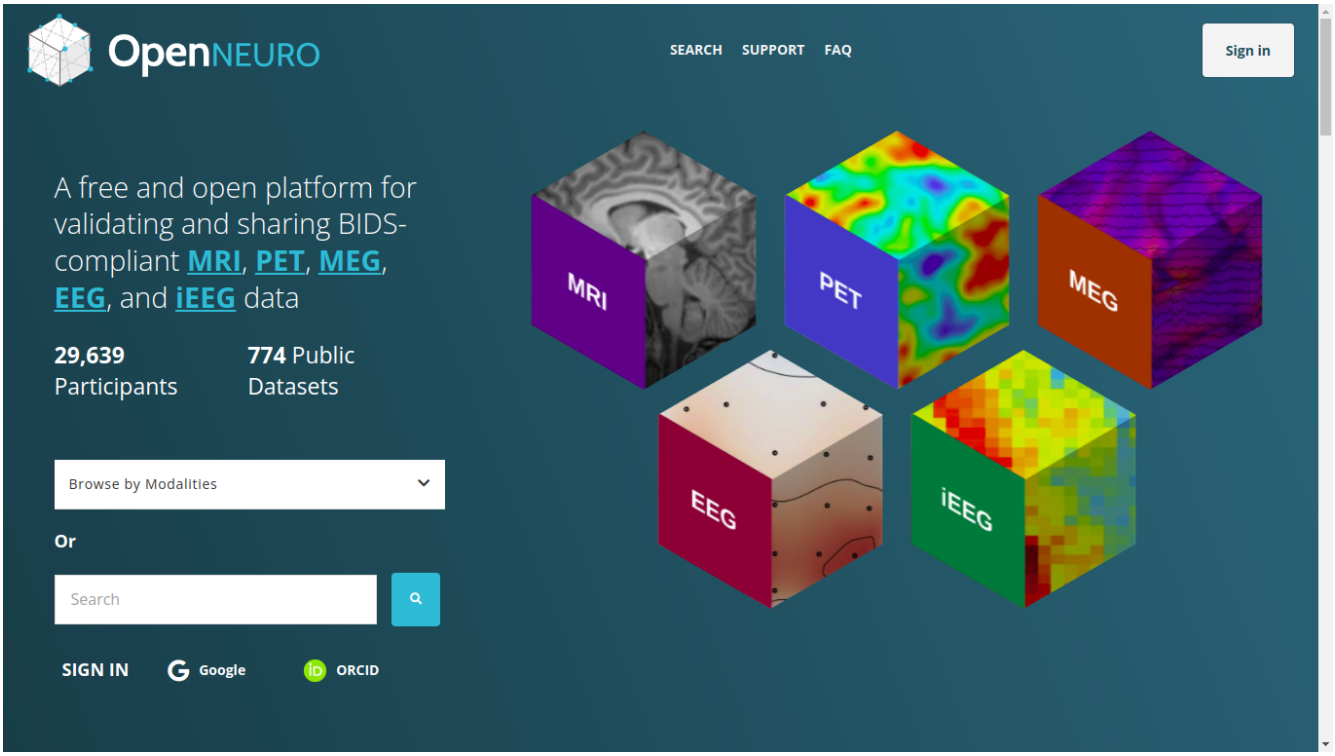
- How is it to be?
  - philosophy
  - cognitive, social, developmental
  - theoretical, computational
- When/where is something broken?
  - medical, imaging, electrophysiology
  - demographics, tests, MRI, EEG, genetics
- How to fix it?
  - therapy, pharmacology, neurotech
- Where can tech help?
  - kind of everywhere...

Fig. Computational simulation of the cerebellum.

Mapping the fields

- The dimensions of neuroscience
  - temporal
  - spatial
  - biological depth
- How to handle complexity?
  - pick a field, run with it
  - can knowledge can translate

  Fig. How different dimensions integrate.


OpenNEURO
SEARCH
SUPPORT
FAQ
Sign in
A free and open platform for validating and sharing BIDS-compliant MRI, PET, MEG, EEG, and iEEG data
29,639 Participants
774 Public Datasets
Browse by Modalities
Or
Search
SIGN IN
Google
ORCID
MRI
PET
MEG
EEG
iEEG

Neuroimaging

Can be useful for cognitive studies, stroke, oncology, or geriatrics.

You can use open datasets for studying diseases like AD, Autism, or Schizophrenia. The base idea of neuroimaging is that:

- brain consumes oxygen ~ brain activity
- oxygen usage ~ magnetic resonance

Most analytical tools are built in MATLAB/C++ (`afni`, `fsl`). Lately added some python wrappers (`nilearn`, `nipype`).

Fig. Different types of MRI.

Fig. fMRI used for finding relevant nodes.

How to: Neuroimaging

```
# here analysis code

# 1. read MRI

from nilearn import datasets, plotting

motor_images = datasets.fetch_neurovault_motor_task()  # downloads data


# check what was downloaded

!ls -l ~/nilearn_data/neurovault/*/


# significance related image

tmap_filename = motor_images.images[0]


# 2. visualize MRI

plotting.plot_stat_map(tmap_filename, threshold=3)

print()
```

```
total 196

-rw-rw-r-- 1 delta delta   4184 gen 18 11:16 collection_metadata.json

-rw-rw-r-- 1 delta delta   1802 gen 18 12:52 image_10426_metadata.json

-rw-rw-r-- 1 delta delta 186649 gen 18 11:16 image_10426.nii.gz
```

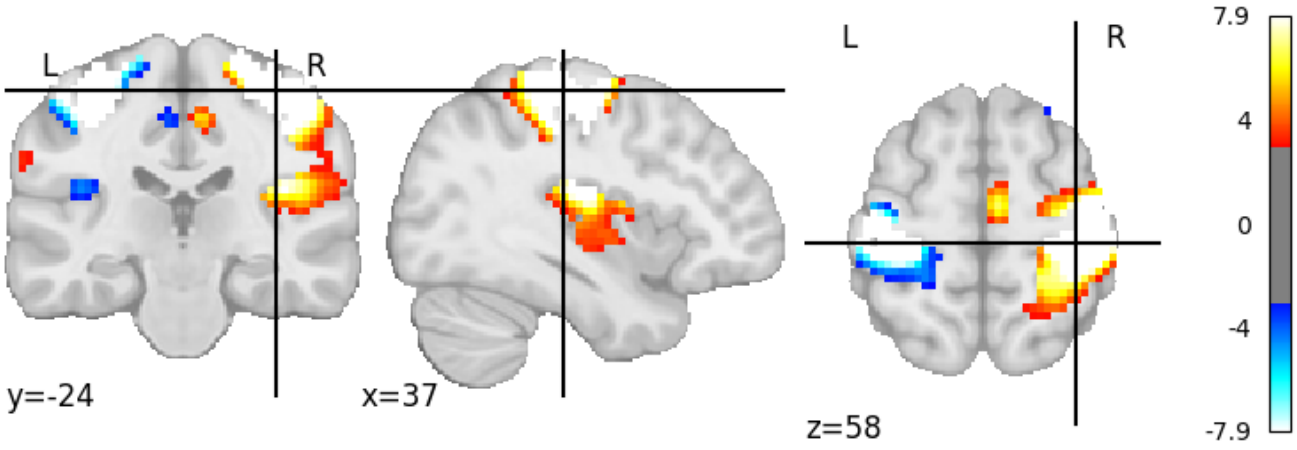


Figure 1: png

Getting started Ni-Edu

DartBrains

Andy's Brain Book: AFNI - a bit old, but good explanations.

Some Tools¶

AFNI - step by step analysis - very good tool.

FSL - software analysis toolbox - more combinations.

nilearn - python pipeline of analysis, as shown above.

Electrophysiology

Can be useful for cognition, brain computer interfaces (**BCI**), epilepsy, or sleep studies.

There are open datasets for applying tools for recognizing brain waves that might be relevant to the clinical or cognitive studies. This can be helpful for prosthetics and cognitive trainings.

The main analytical tools are `eeglab` (MATLAB) and `mne` (python).

Fig. Open-BCI waves.

How to: Electrophysiology

```
import numpy as np
import mne


# load sample data
sample_data_folder = mne.datasets.sample.data_path()  # WARNING: ~1.65GB
sample_data_raw_file = (sample_data_folder / 'MEG' / 'sample' /
                        'sample_audvis_filt-0-40_raw.fif')
raw = mne.io.read_raw_fif(sample_data_raw_file)


raw.plot(duration=5, n_channels=30)
# put in skull
```

Getting started¶

UnivBern - EEG data processing

MNE documentation

Some Tools¶

MNE - python tool for electrophysiology processing.

EEGLab - MATLAB tool for processing eeg.

EEG waves for Neuropsychiatry

Data Science/ ML

Can be useful for multimodal data analysis, creating diagnostic/prognostic models for subjects.

The open datasets for complex cases like neurodegeneration or psychiatric diseases allow for building models that can target also single cases, and can provide baseline analysis.

The analytical tools can be statistical models based on `R`, `python`, or `MATLAB`.

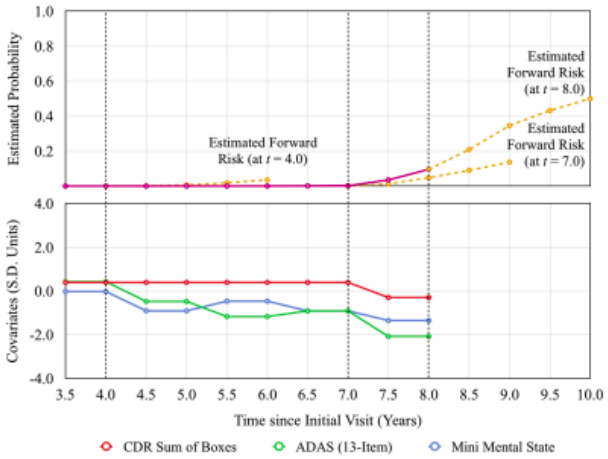
Fig. Impairment level - disorder. FTLD, DLB, AD, VaD, MCI, Healthy

How to: Datascience for tabular medical data.

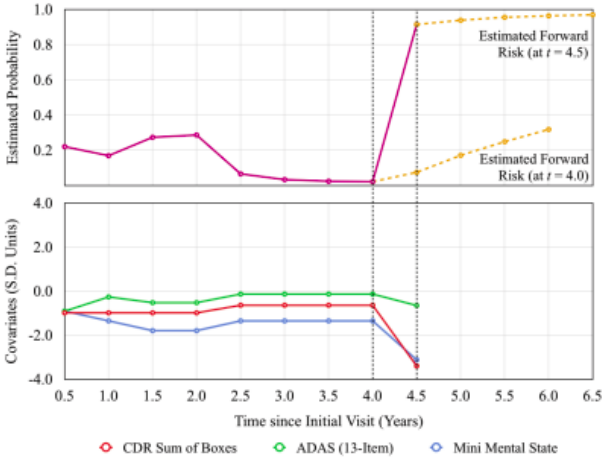
```
import pandas as pd
from sklearn.model_selection import train_test_split
from sklearn.scoring import f1_score # TODO: check which one is best
from lightgbm import LGBMClassifier


# get data
df = pd.read_csv('data/ADNI.csv')
X_train, X_test, y_train, y_test = train_test_split(
    df.drop('DX', axis=1), df['DX'], test_size=1/3, random_state=0
)
# create classifier
classifier = LGBMClassifier()
classifier.fit(X_train, y_train)
print(f1_score(X_test, y_test))
```

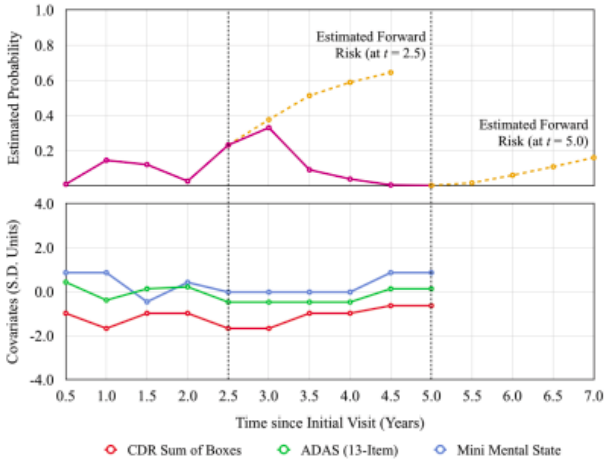
Prognosis through deep learning models



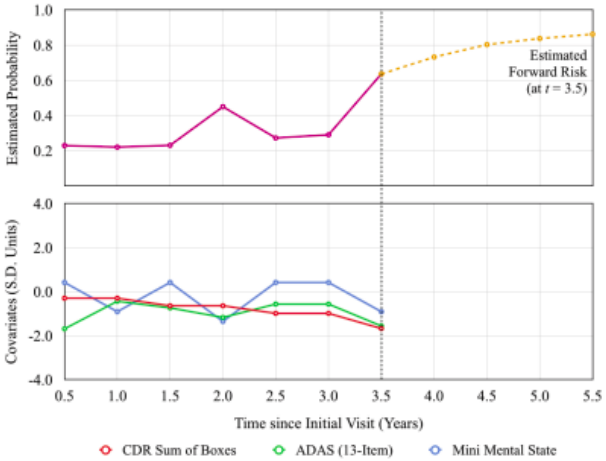
(a) Patient exhibits gradual deterioration



(b) Patient experiences sudden downturn



(c) Patient exhibits improvement over time



(d) Patient with noisy/volatile measurements

Fun New Topics !!!

- Neurotech: body control through brain waves!
- Neurogenetics: comparing brains with evolution-related projects.
- Neuropsychology: body dysmorphia disorders.
- Neuropharmacology: developing drugs through open-science.

OpenLabs: Possible Contribution

- BCI: test tools related to BCI in the lab (muse/OpenBCI headset).
- Testify: translate neuropsychological tests to ALB, help with standardization.
  - relevant for neurodegenerative diseases - link to NACC study (extensive testing)
  - relevant for psychiatric diseases - link to cambridge testing tool (open source)
- 3D-Brain: collaborate with *fab-lab*
  - OpenLabs-Tr creates a base structure
  - fab-lab fills the gaps through spongy material
  - **Voila!** You have THE SPONGY BRAIN!!!
- Hackathon: a hackathon for neuroscience in AL, including topics mentioned today.
  - neurohack-academy (great source!)
  - brainhack (possible partner)
  - neural-hack
- Open-source tools: translate tools to AL, improve existing MRI/EEG/Data-science tools.

References

- Research
  - Robin: https://www.nature.com/articles/s42003-022-04213-y
  - Prognosis: https://ieeexplore.ieee.org/ielaam/6221020/8984617/8765241-aam.pdf
- Open-*
  - OpenNeuro
  - MNE-Python
  - EEGLab
  - Open-Targets