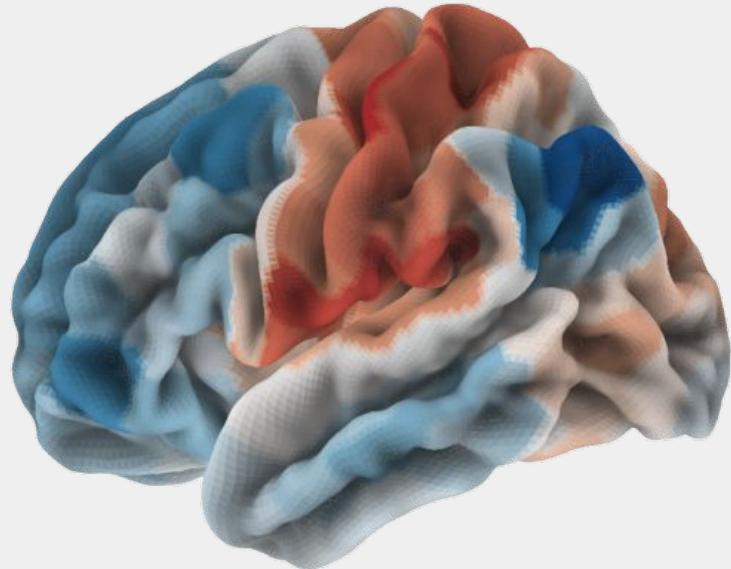


# Advanced fMRI data analysis

Karolina Finc

Centre for Modern Interdisciplinary Technologies

Nicolaus Copernicus University in Toruń



COURSE #2: **fMRI data manipulation and plotting in python** | 19<sup>th</sup> October 2020

# Study plan

Open science & neuroimaging



**BEFORE**

fMRI data manipulation  
in python



fMRI data  
preprocessing



3

General  
Linear Model



5

Functional  
connectivity



**AFTER**



6

Machine Learning  
on fMRI data

# Study plan

Open science & neuroimaging



**BEFORE**

fMRI data manipulation  
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5



4

General  
Linear Model



**AFTER**



6

Machine Learning  
on fMRI data

# Structural vs. functional neuroimaging

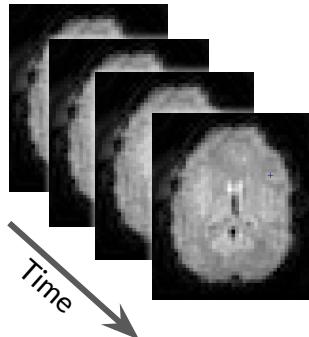
Structural

MRI (T1)



Functional

fMRI (T2\*)



# Structural vs. functional neuroimaging

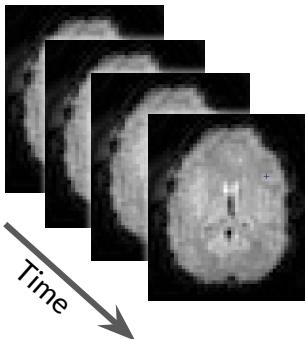
## Structural

MRI (T1)

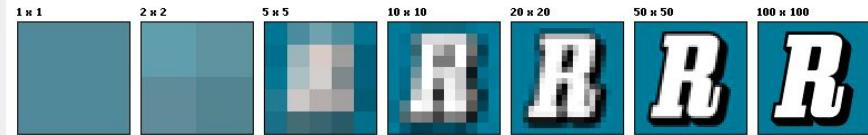


## Functional

fMRI (T2\*)



**Spatial resolution** - determines our ability to distinguish changes in an image across spatial location.



# Structural vs. functional neuroimaging

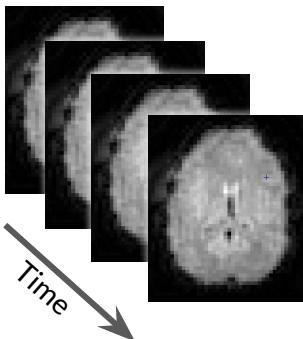
## Structural

MRI (T1)



## Functional

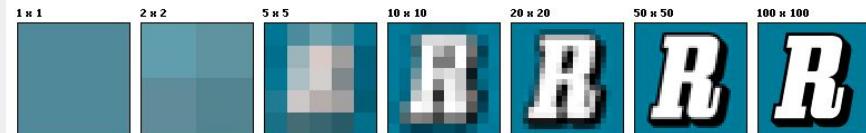
fMRI (T2\*)



↑ spatial resolution



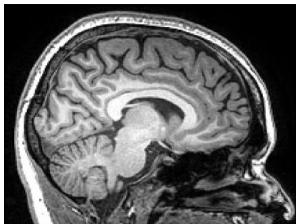
**Spatial resolution** - determines our ability to distinguish changes in an image across spatial location.



# Structural vs. functional neuroimaging

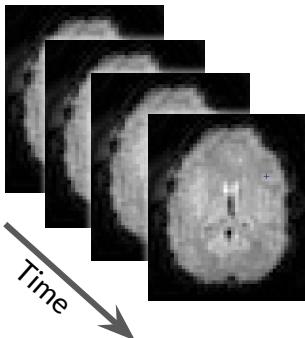
## Structural

MRI (T1)



## Functional

fMRI (T2\*)



↑ spatial resolution



**Spatial resolution** - determines our ability to distinguish changes in an image across spatial location.

**Temporal resolution** - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).

# Structural vs. functional neuroimaging

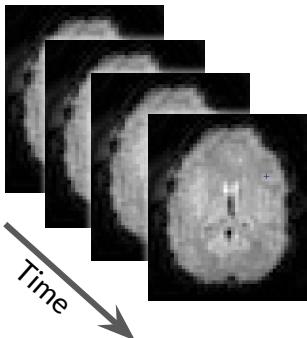
## Structural

MRI (T1)



## Functional

fMRI (T2\*)



↑ spatial resolution



**Spatial resolution** - determines our ability to distinguish changes in an image across spatial location.

**Temporal resolution** - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).

**Frequency** - number of measurements per second (Hz)

# EEG? fMRI? Which one has better temporal resolution?



# Structural vs. functional neuroimaging

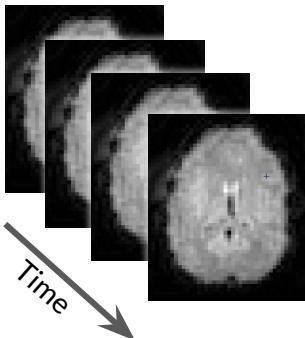
## Structural

MRI (T1)



## Functional

fMRI (T2\*)



↑ spatial resolution



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# Structural vs. functional neuroimaging

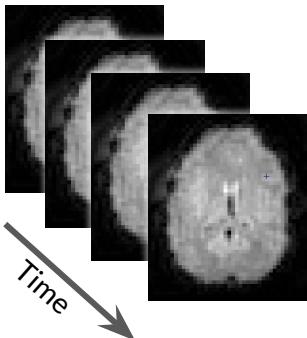
## Structural

MRI (T1)



## Functional

fMRI (T2\*)



↑ spatial resolution



**Spatial resolution** - determines our ability to distinguish changes in an image across spatial location.

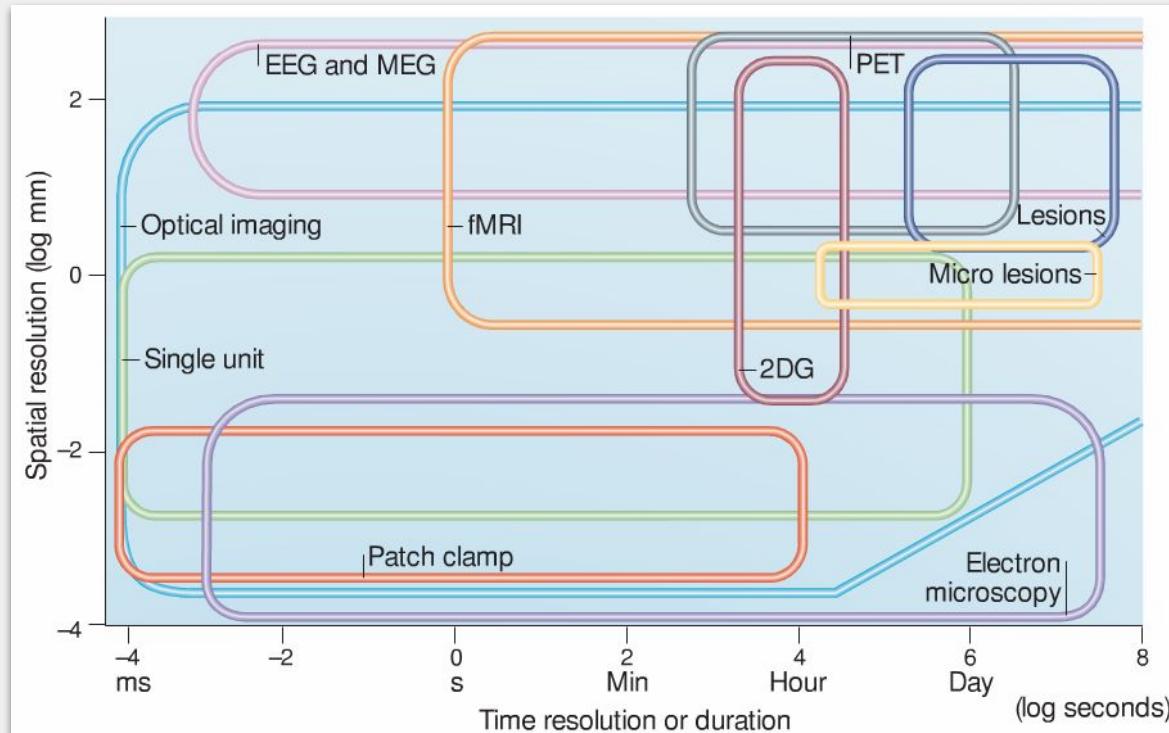
**Temporal resolution** - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).

**Frequency** - number of measurements per second (Hz)

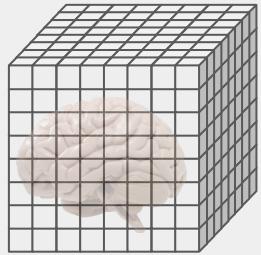
**EEG**: ~ 1000 Hz

**fMRI**: ~ 0.5 Hz

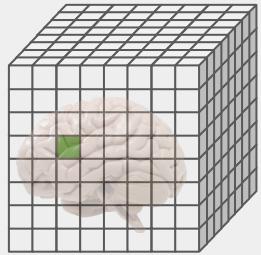
# Neuroimaging techniques resolution



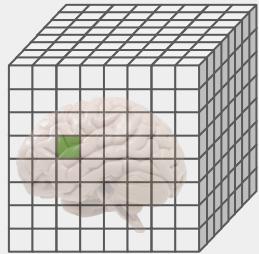
# MRI data structure



# MRI data structure



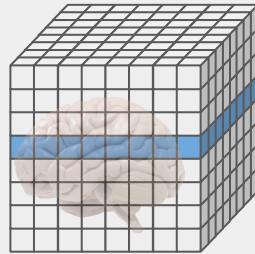
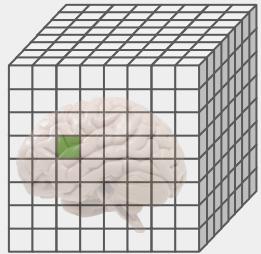
# MRI data structure



Voxel

Voxel size  
(e.g.  $1 \times 1 \times 1$  mm)

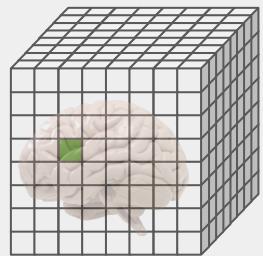
# MRI data structure



Voxel

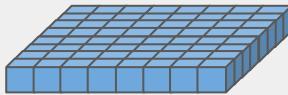
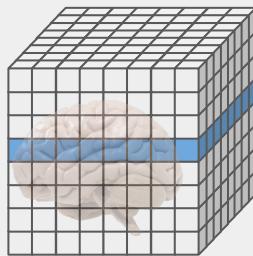
Voxel size  
(e.g.  $1 \times 1 \times 1$  mm)

# MRI data structure



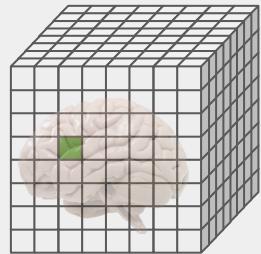
Voxel

Voxel size  
(e.g.  $1 \times 1 \times 1$  mm)

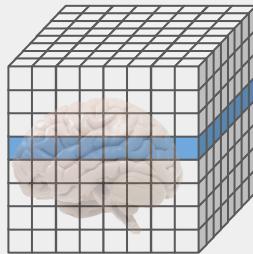


Slice

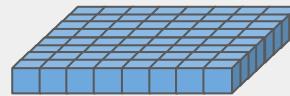
# MRI data structure



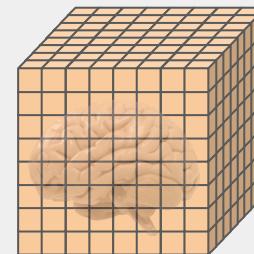
Voxel



Slice  
thickness  
(e.g. 1 mm)

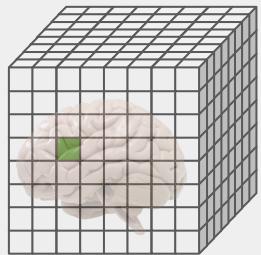


Slice



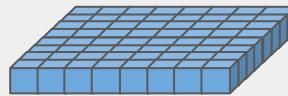
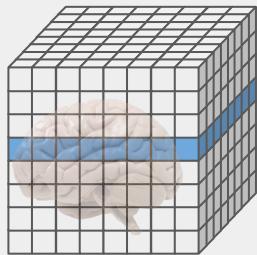
Voxel size  
(e.g.  $1 \times 1 \times 1$  mm)

# MRI data structure

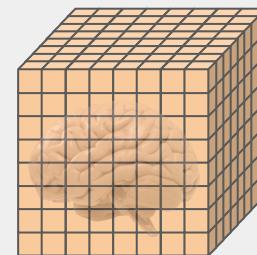


15

Voxel



Slice

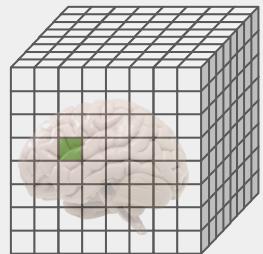


Volume

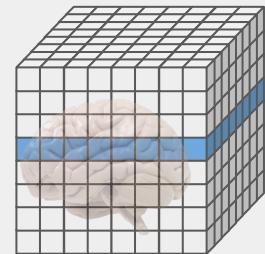


Voxel size  
(e.g.  $1 \times 1 \times 1$  mm)

# MRI data structure



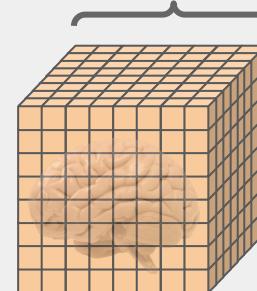
Voxel



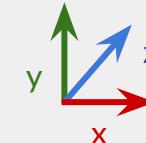
Slice

Voxel size  
(e.g.  $1 \times 1 \times 1$  mm)

Field of view  
(FOV; e.g. 264 mm)

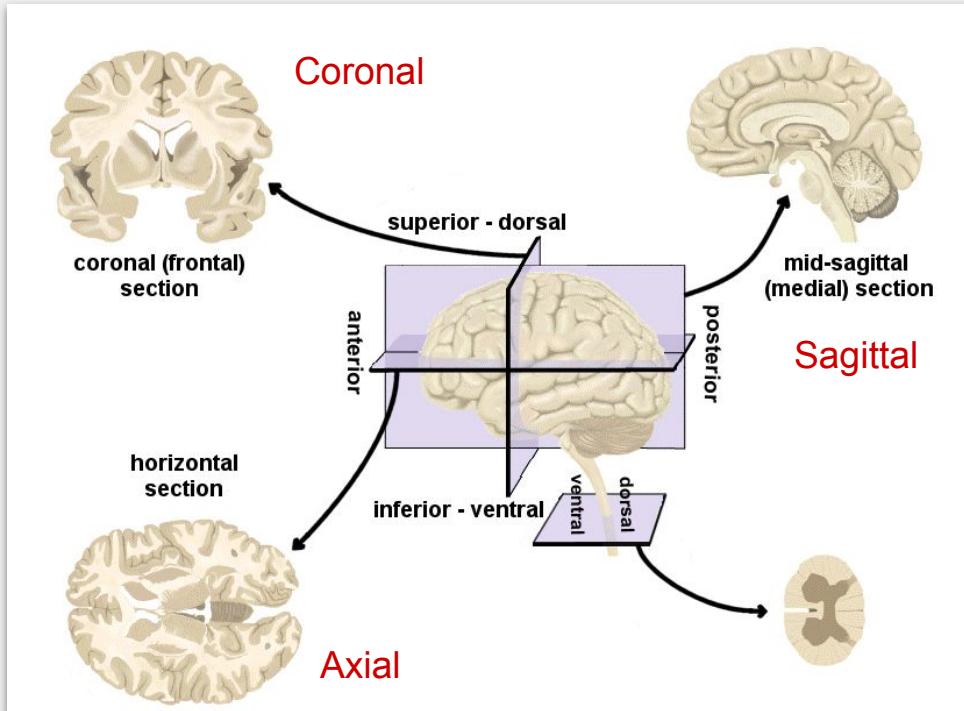


Volume



Matrix size  
(e.g.  $264 \times 264$ )

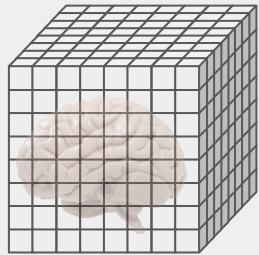
# Brain sections



[http://homepage.smc.edu/russell\\_richard/Psych2/Graphics/human\\_brain\\_directions.htm](http://homepage.smc.edu/russell_richard/Psych2/Graphics/human_brain_directions.htm)

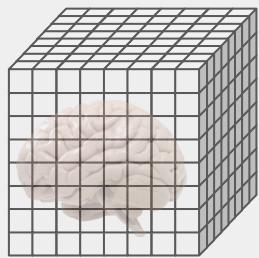
# fMRI data structure

Structural data

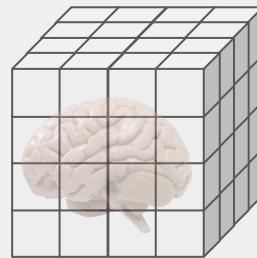


# fMRI data structure

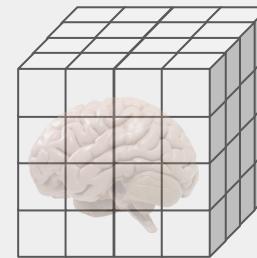
Structural data



Functional data

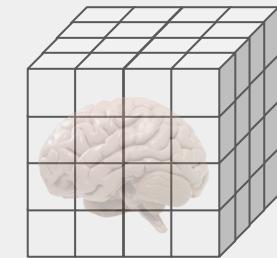


1



2

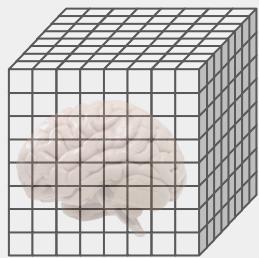
• • •



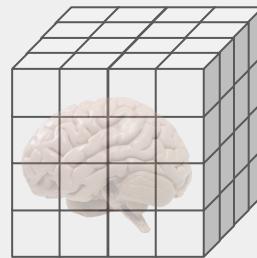
T

# fMRI data structure

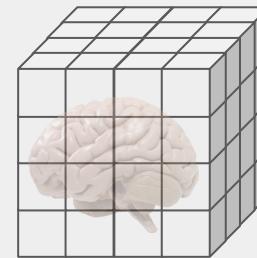
Structural data



Functional data

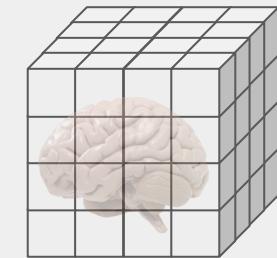


1



2

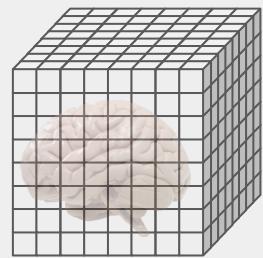
• • •



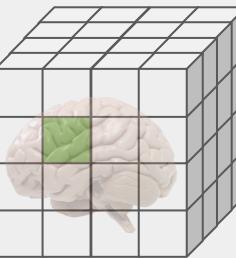
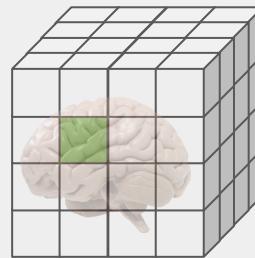
T

# fMRI data structure

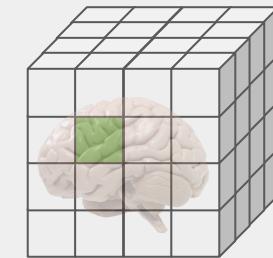
Structural data



Functional data



• • •

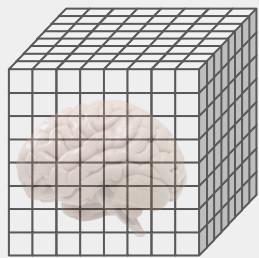


Voxel

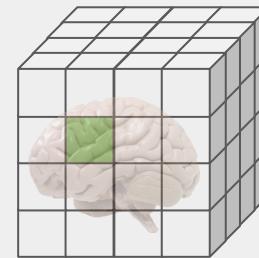
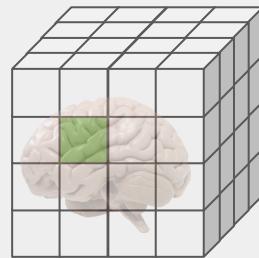
Voxel size  
(e.g.  $3 \times 3 \times 3$  mm)

# fMRI data structure

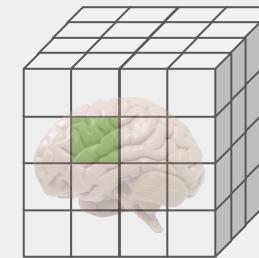
Structural data



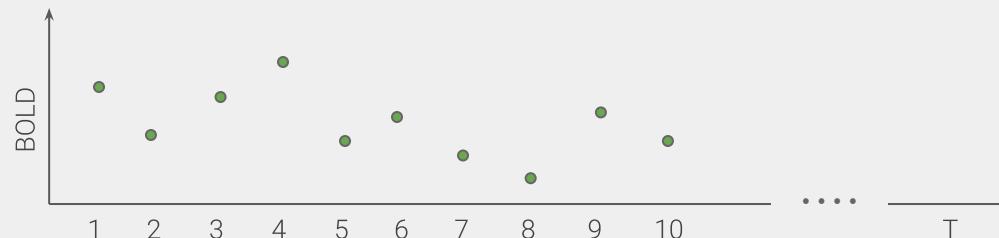
Functional data



• • •

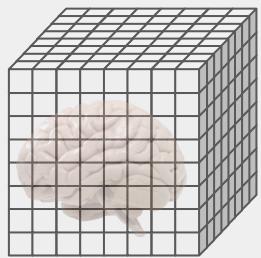


T

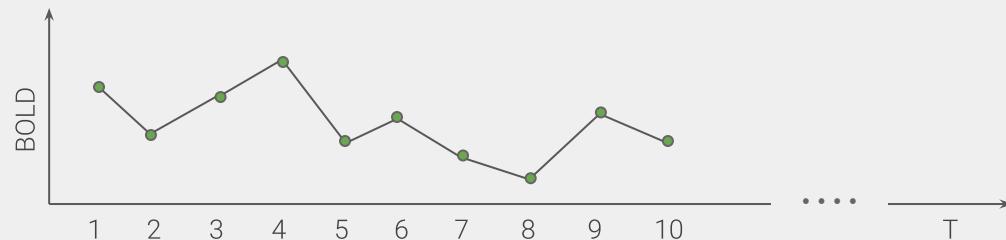
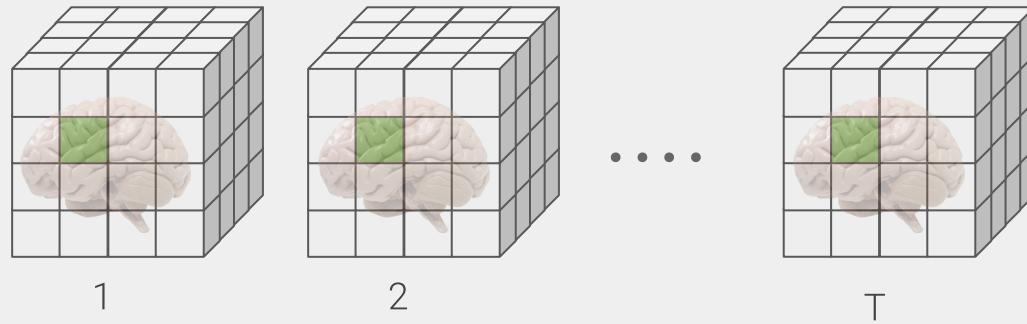


# fMRI data structure

Structural data

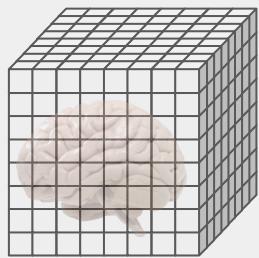


Functional data

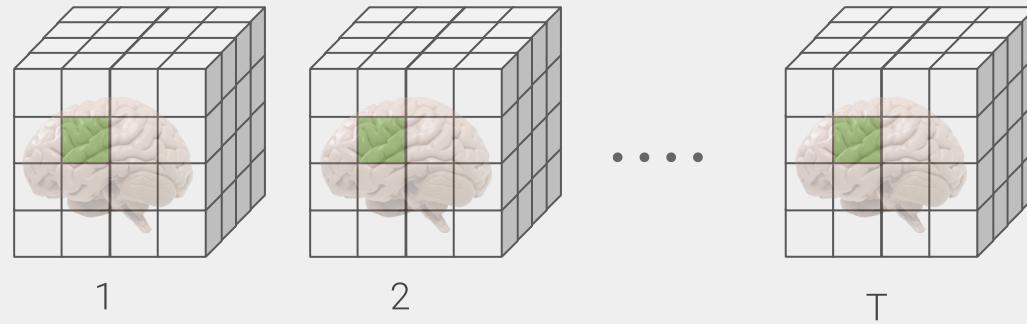


# fMRI data structure

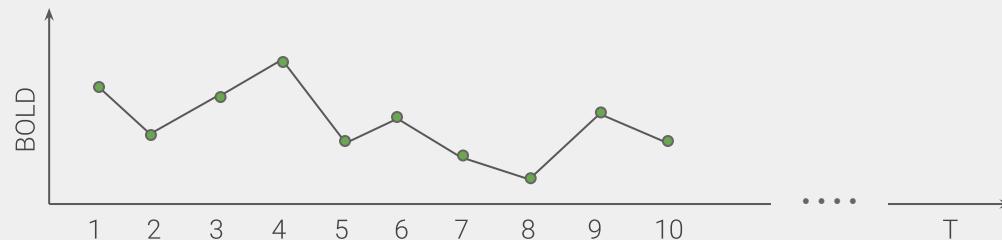
Structural data



Functional data

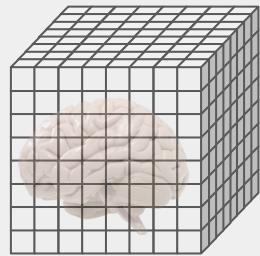


**Time series** - is a series of data points listed in time order.

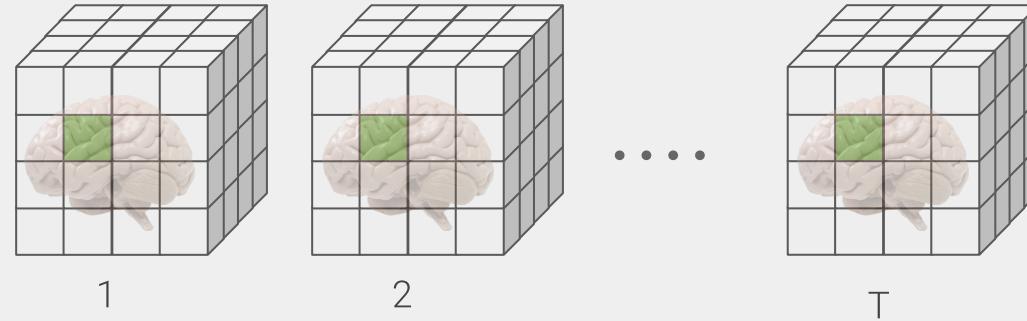


# fMRI data structure

Structural data

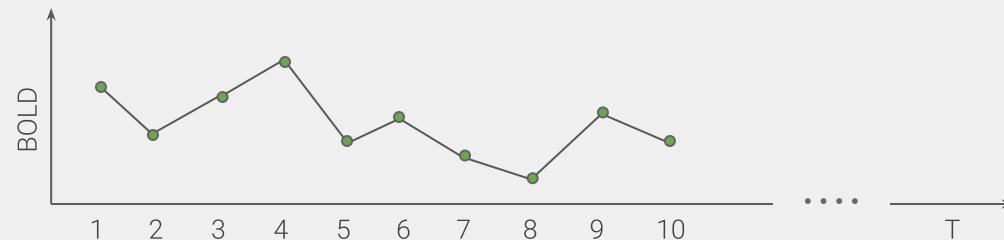


Functional data



**Time series** - is a series of data points listed in time order.

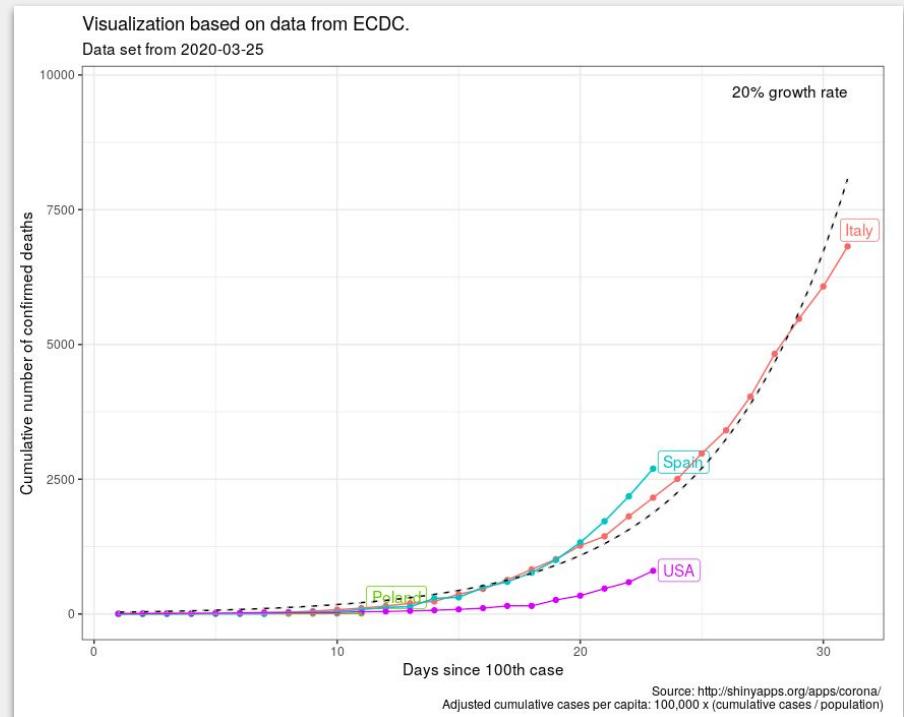
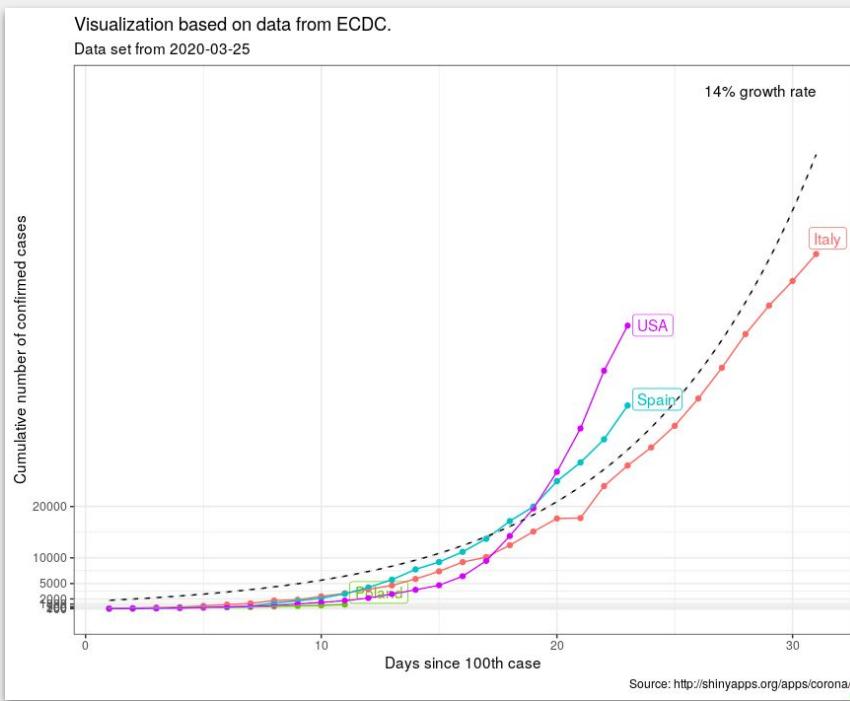
Every voxel has its own time-series.



# What data can also be represented as time-series?



# Time-series example - COVID-19



# DICOM & NIfTI formats

**DICOM** (*Digital Imaging and Communications in Medicine*) format:

- Raw data format for storing and transmitting medical images
- Extension: **.dcm**
- One slice, one file



**NIfTI** (*Neuroimaging Informatics Technology Initiative*) format:

- Extensions: **.nii, nii.gz**
- Standardized representation of brain images
- Developed to facilitate cross-platform, cross-software interpretability
- 3-dimensional (3D) or 4-dimensional (4D) array: stacking individual slices on top of each other



# Python exercises



<https://github.com/fMRIAnalysisCourse/fmri-analysis-course>



# Homework

Logo contest!

## 1. GitHub Classroom

Data manipulation in Python

Deadline: 01-11-2020

## 2. Data Camp Classroom

Introduction to Data Visualization  
with Matplotlib

Deadline: 01-11-2020

A screenshot of a GitHub Classroom repository page. The repository is named 'fMRIAnalysisCourse'. A red arrow points to the repository icon, which is a green and white blocky logo. The page shows 13 repositories. On the right, there are sections for 'Top languages' (Jupyter Notebook), 'Most used topics' (Loading...), and 'People' (1). There are four listed repositories under the main heading:

- 01-fmrida-homework-amazanini** [Private]  
01-fmrida-homework-amazanini created by GitHub Classroom  
• Jupyter Notebook MIT 0 stars 0 forks 0 updated 6 days ago
- 01-fmrida-homework-valtavan** [Private]  
01-fmrida-homework-valtavan created by GitHub Classroom  
• Jupyter Notebook MIT 0 stars 0 forks 0 updated 6 days ago
- 01-fmrida-homework-krasniewska** [Private]  
01-fmrida-homework-krasniewska created by GitHub Classroom  
• Jupyter Notebook MIT 0 stars 0 forks 0 updated 6 days ago
- 01-fmrida-homework-randompythonista** [Private]

Below the repositories, there is a button labeled 'Invite someone'.

Next



# Preprocessing