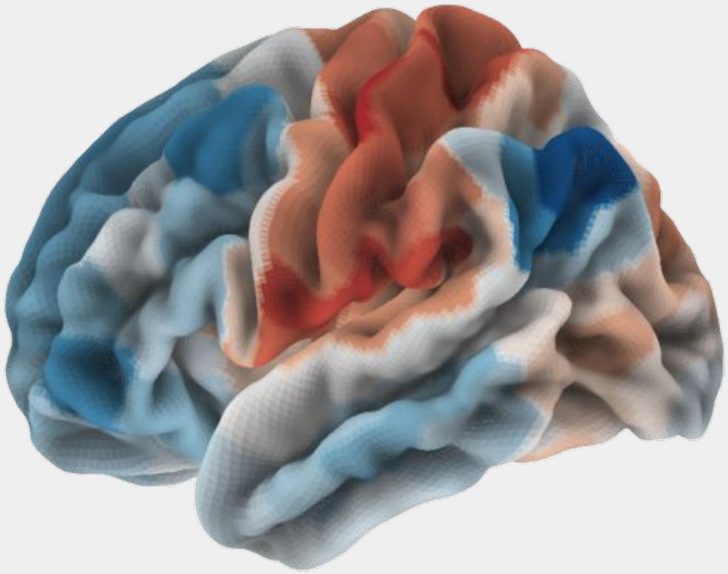
Fundamentals of fMRI data analysis



Karolina Finc

Centre for Modern Interdisciplinary Technologies

Nicolaus Copernicus University in Toruń

COURSE #2: fMRI data manipulation and plotting in python

Study plan

BEFORE

Open science &
neuroimaging

fMRI data manipulation
in python

fMRI data
preprocessing

General
Linear Model

Functional
connectivity

Machine Learning
on fMRI data

AFTER

Study plan

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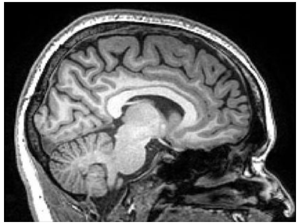
AFTER

Structural vs. functional neuroimaging

Structural

MRI (T1)



Structural vs. functional neuroimaging

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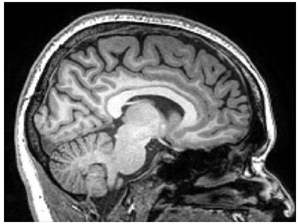
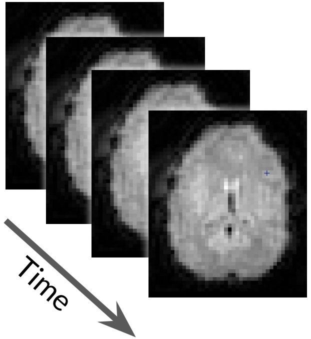


Functional

fMRI (T2*)



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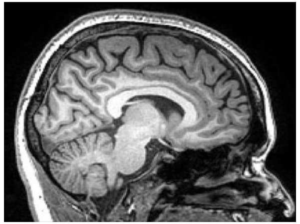
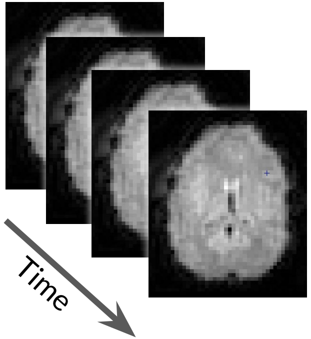
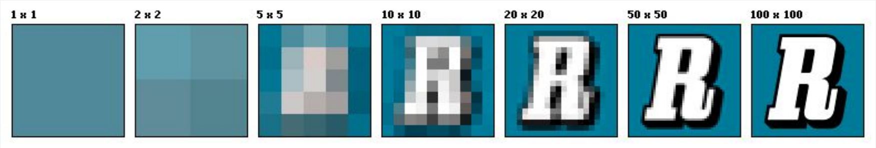


Functional

fMRI (T2*)



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



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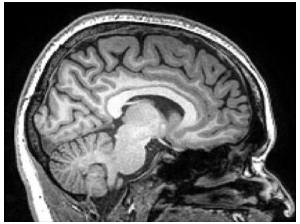

Functional

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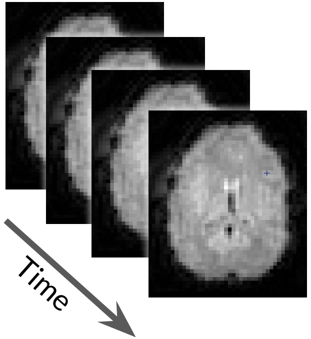

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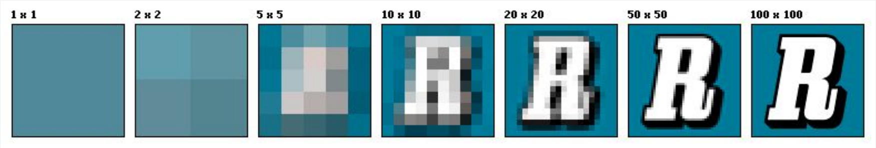

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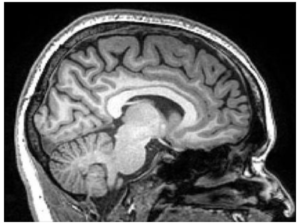
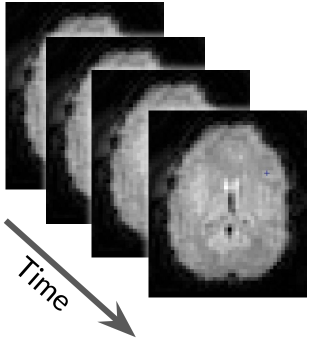


Functional

fMRI (T2*)



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Structural vs. functional neuroimaging

Structural

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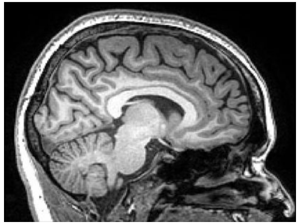
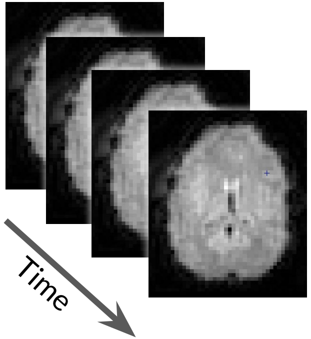


Functional

fMRI (T2*)



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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).

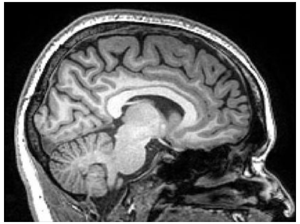
Frequency - number of measurements per second (Hz)

EEG? fMRI?
Which one has better temporal resolution?

Structural vs. functional neuroimaging

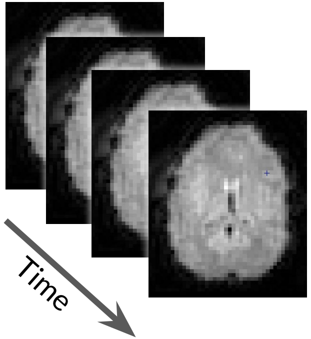
Structural

MRI (T1)



Functional

fMRI (T2*)



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Structural vs. functional neuroimaging

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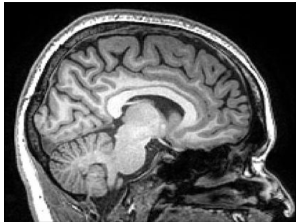

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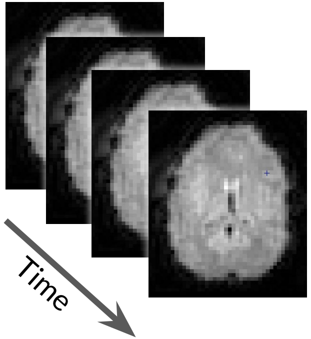
fMRI (T2*)



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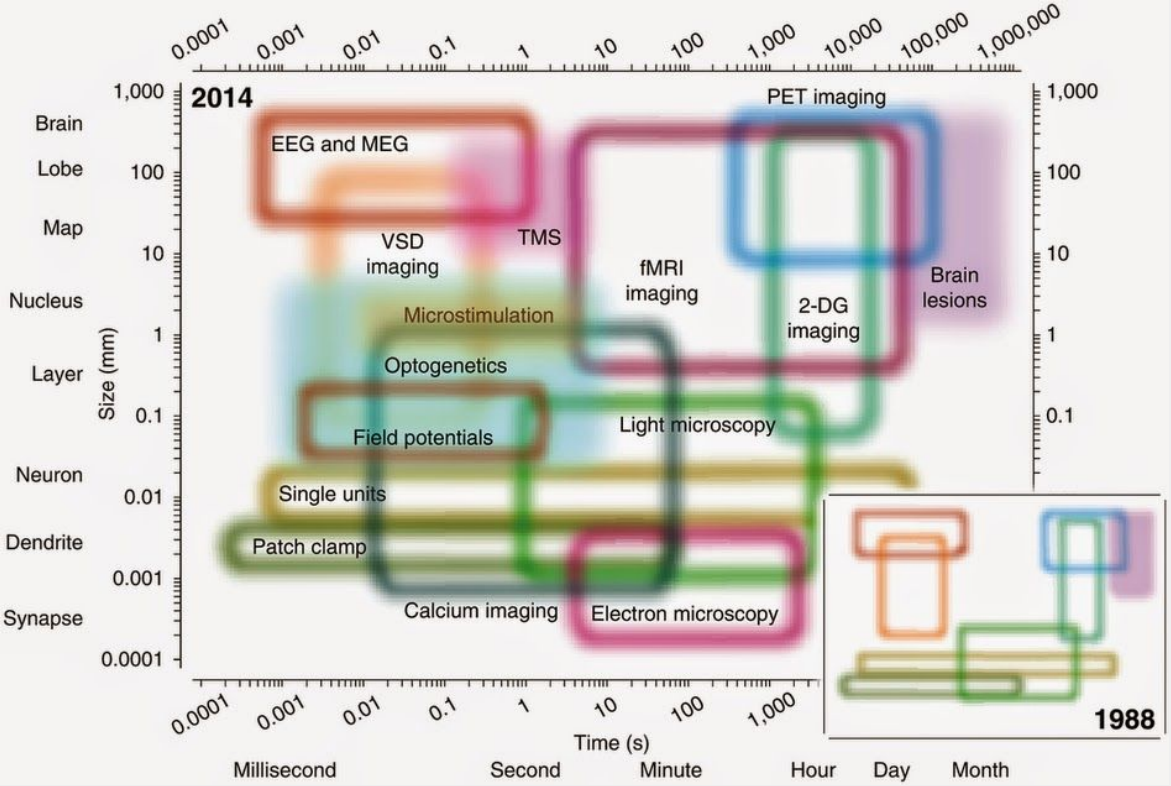
Temporal resolution - determines our ability to separate events in time (**TR**; r.g. TR = 2000 ms).

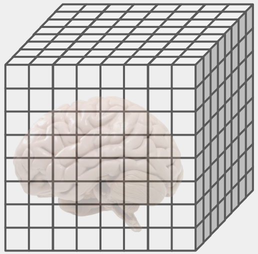
Frequency - number of measurements per second (Hz)

EEG: ~ 1000 Hz
fMRI: ~ 0.5 Hz

Neuroimaging techniques resolution



MRI data structure



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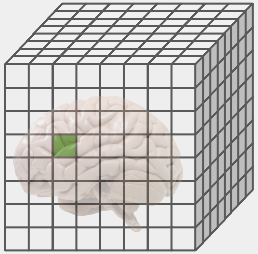

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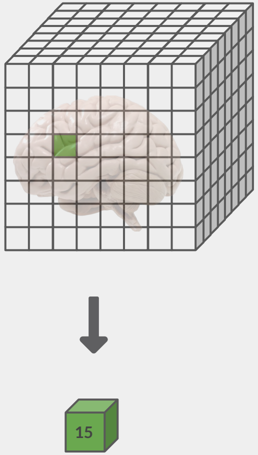
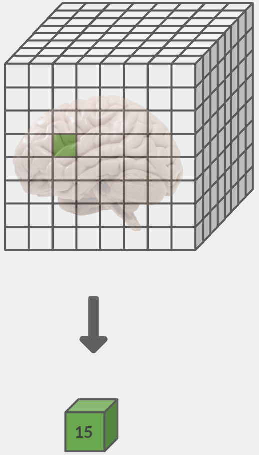


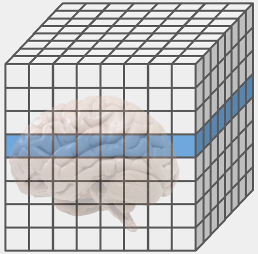
Voxel

Voxel size
(e.g. 1 × 1 × 1 mm)

MRI data structure



Voxel



Voxel size
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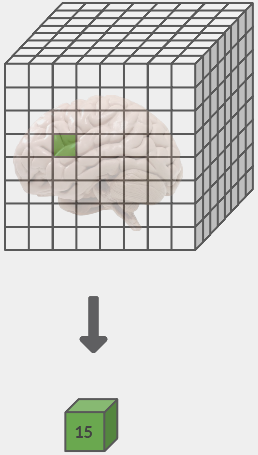
MRI data structure



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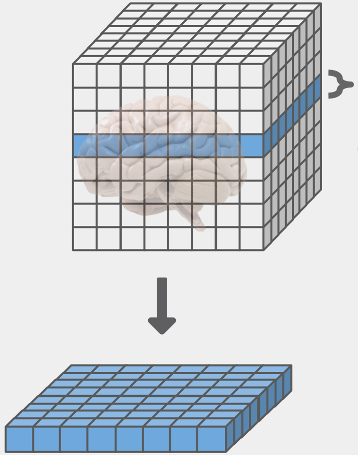
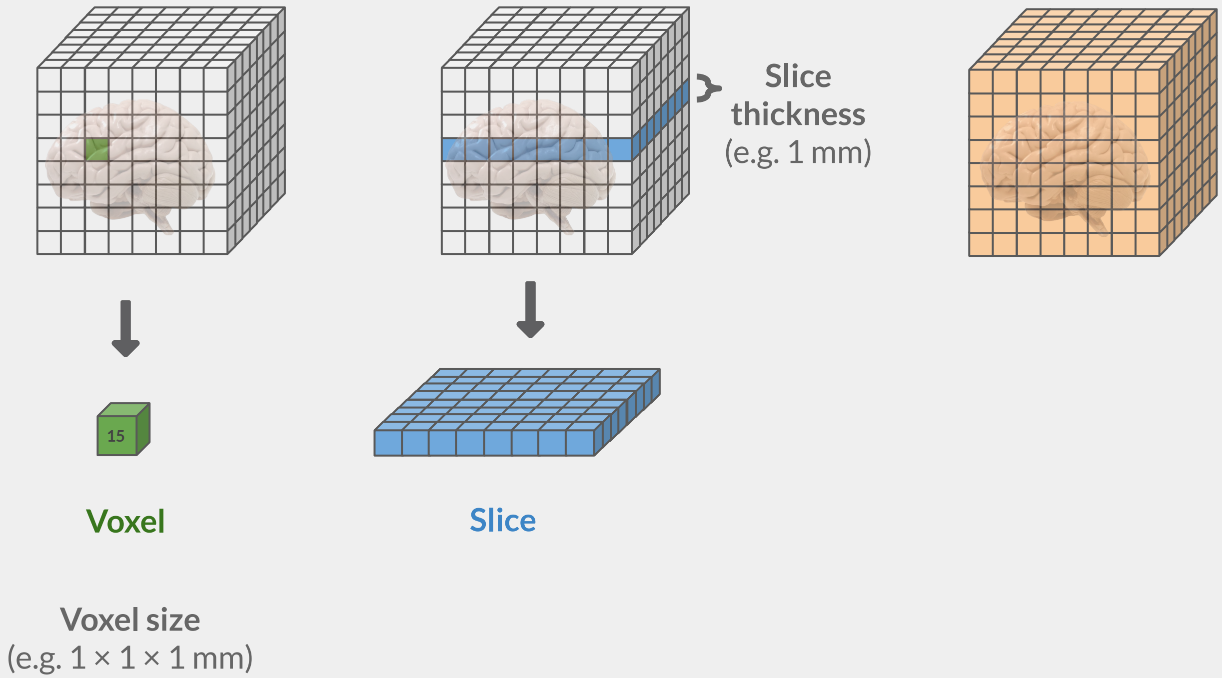


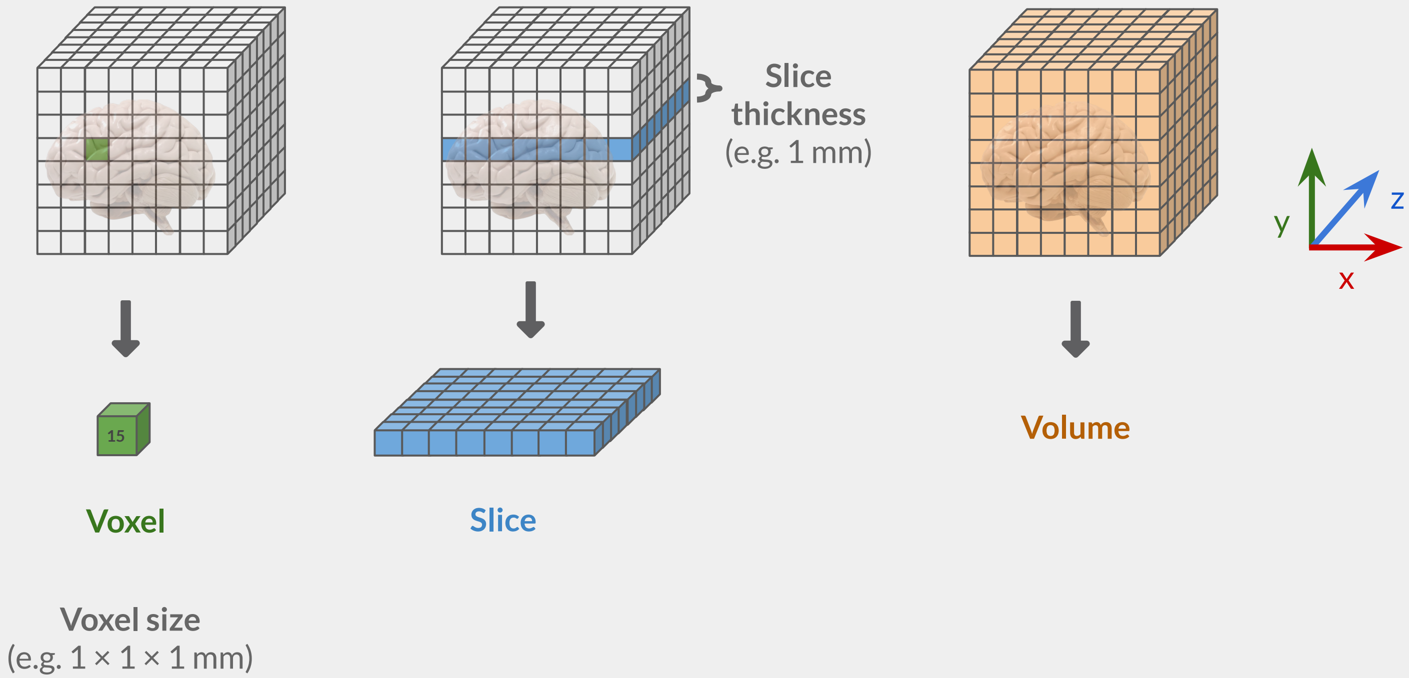
Slice thickness
(e.g. 1 mm)

Slice

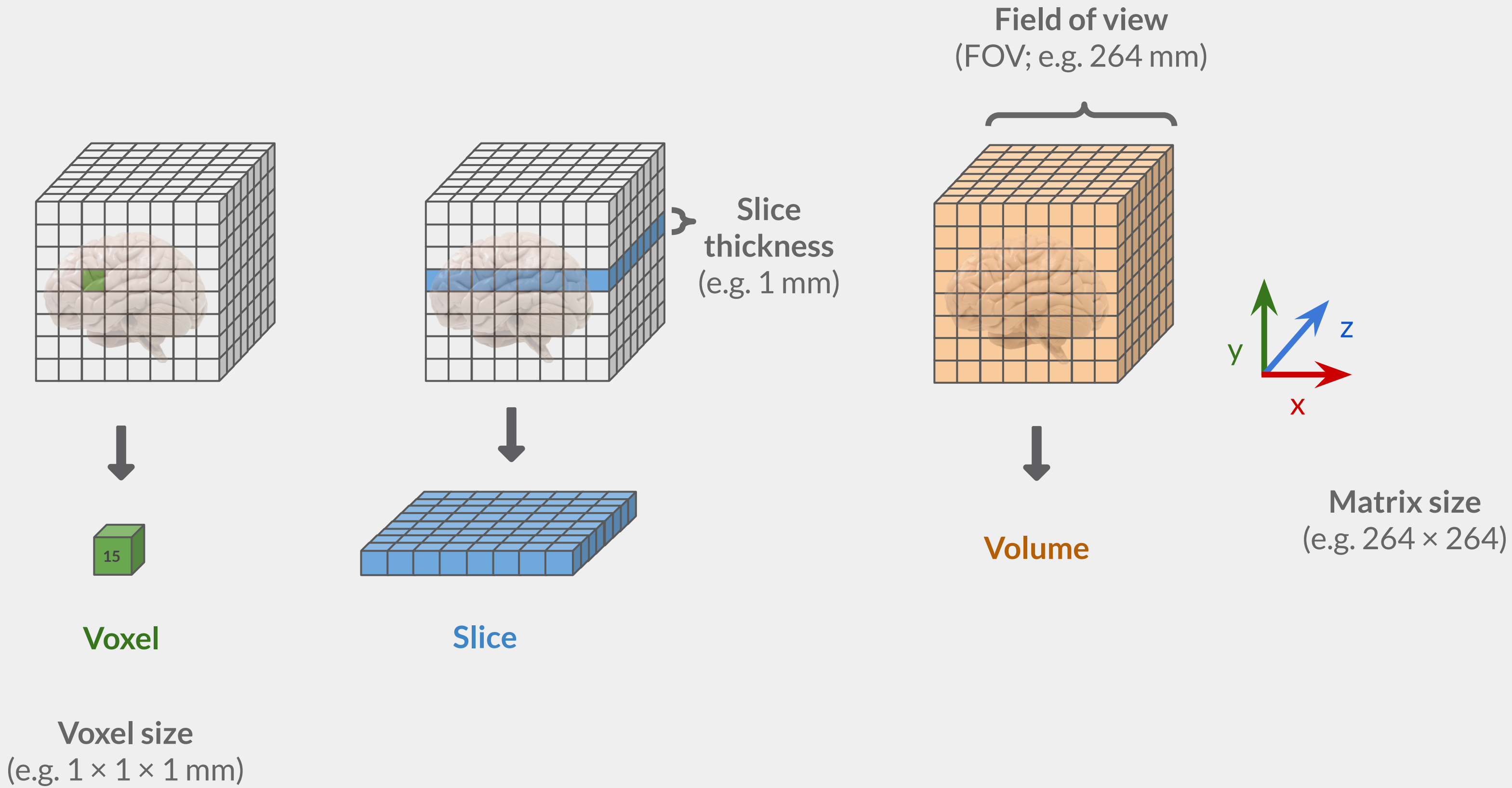
MRI data structure



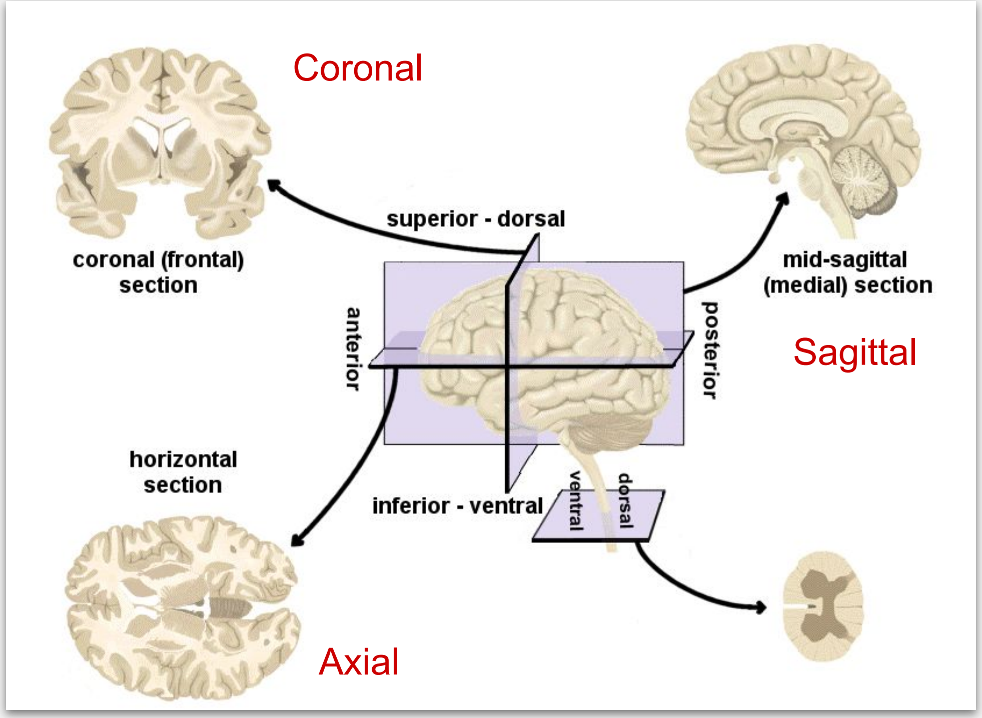
MRI data structure



MRI data structure



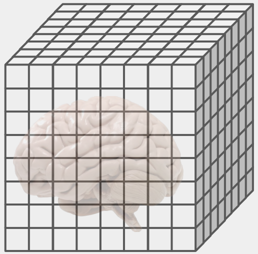
Brain sections



http://homepage.smc.edu/russell_richard/Psych2/Graphics/human_brain_directions.htm

fMRI data structure

Structural data



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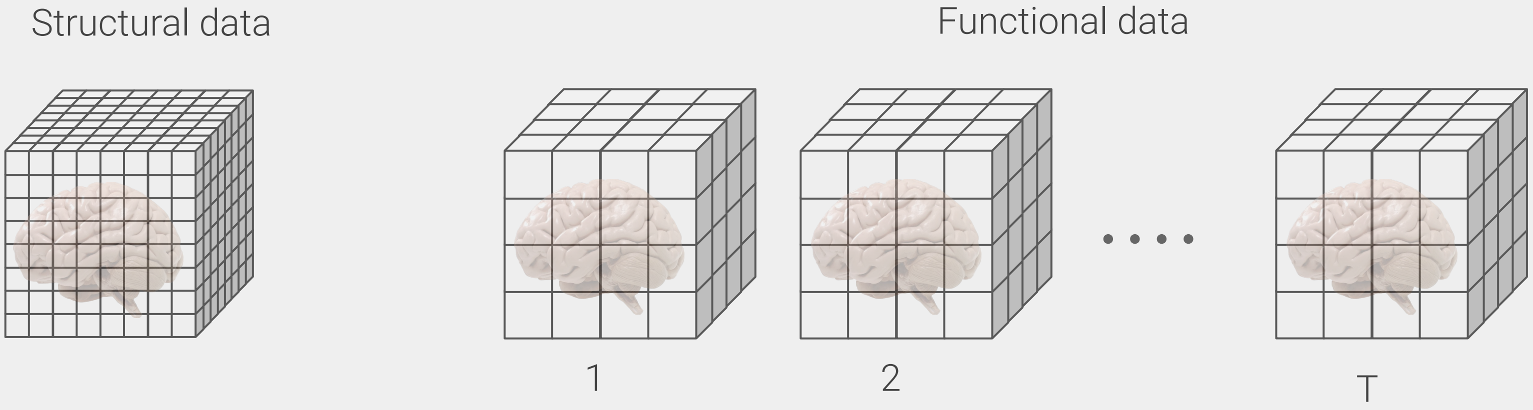

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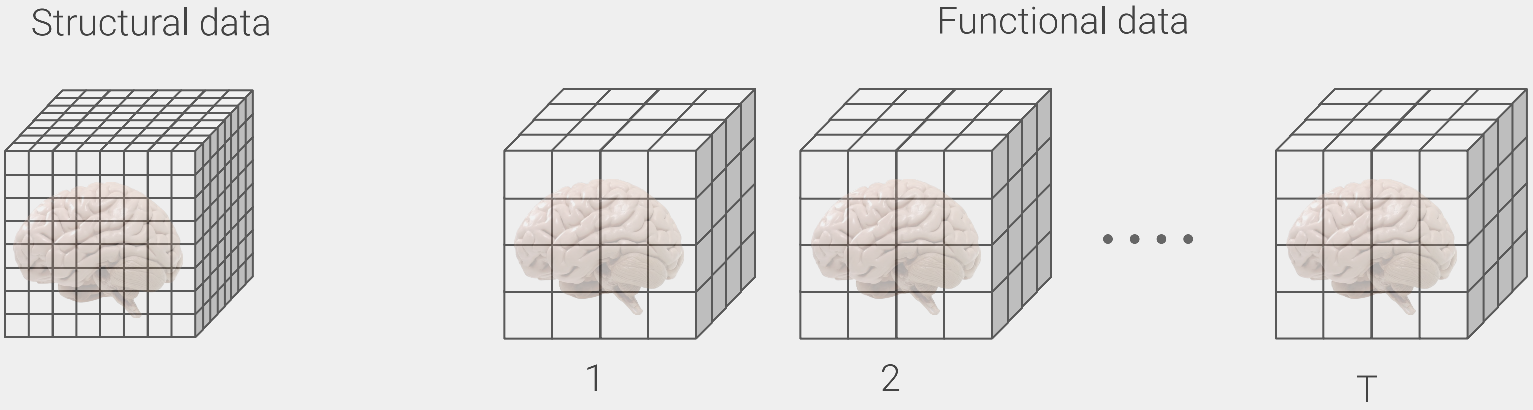

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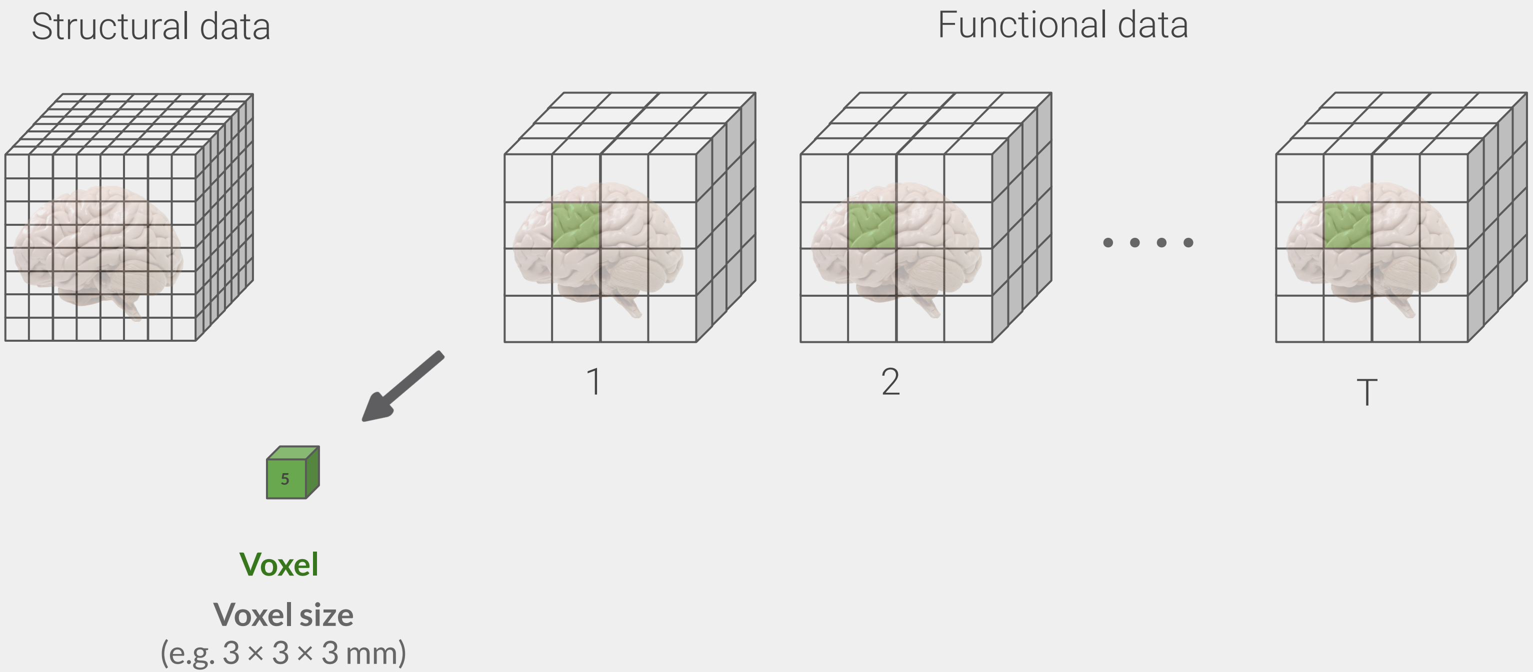

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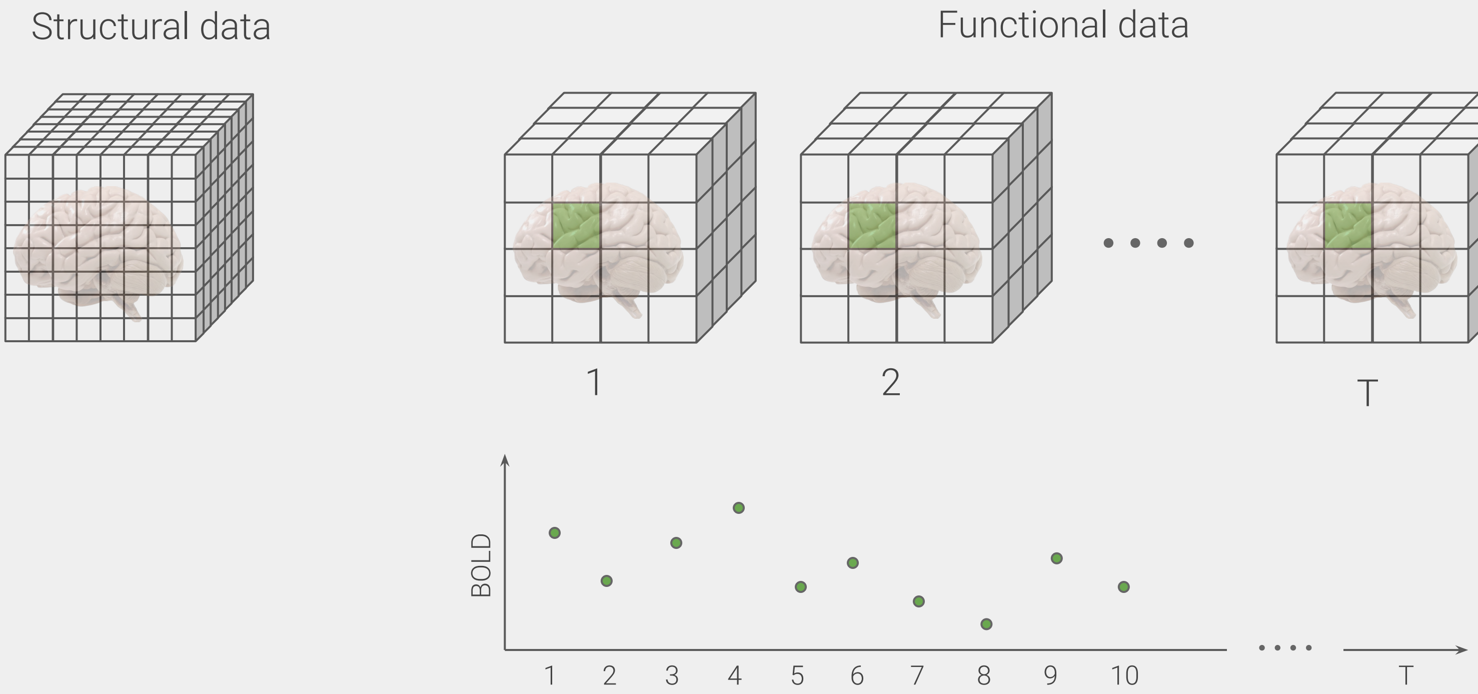

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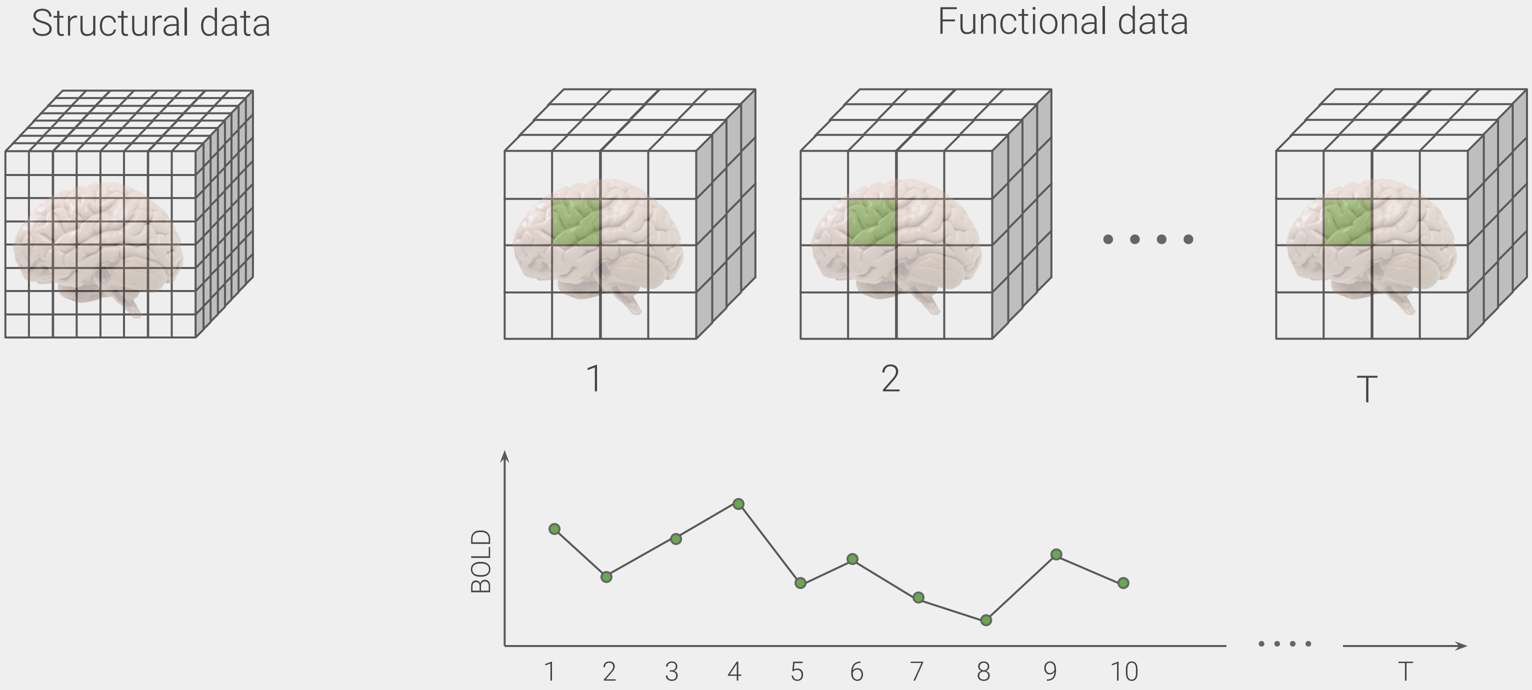

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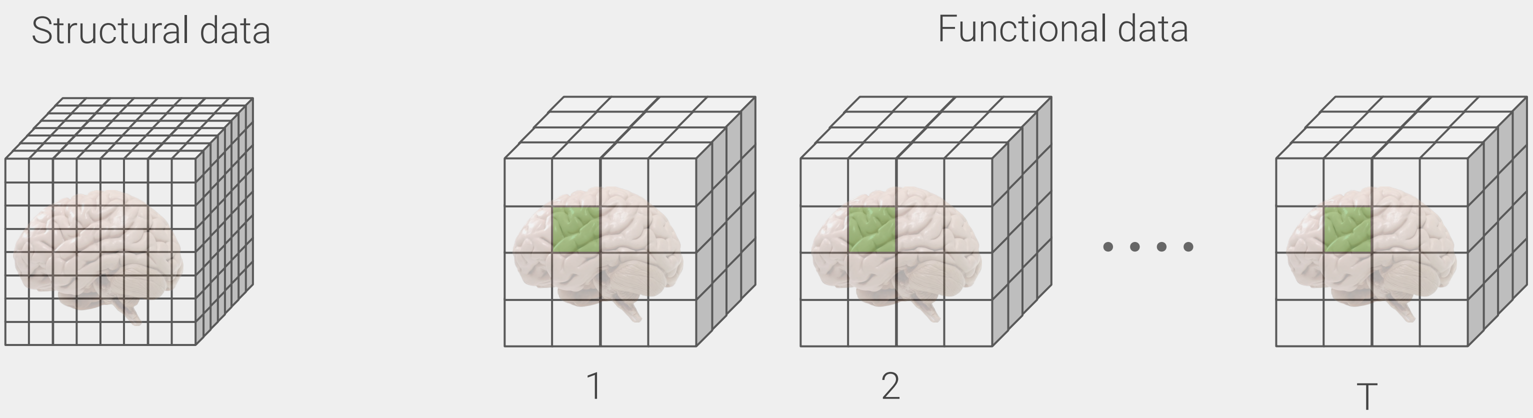
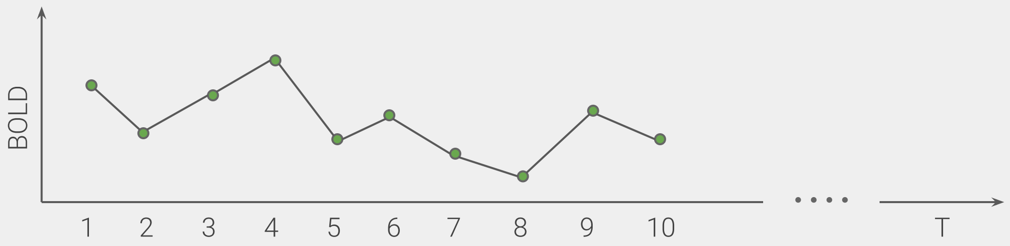


Time series - is a series of data points listed in time order.



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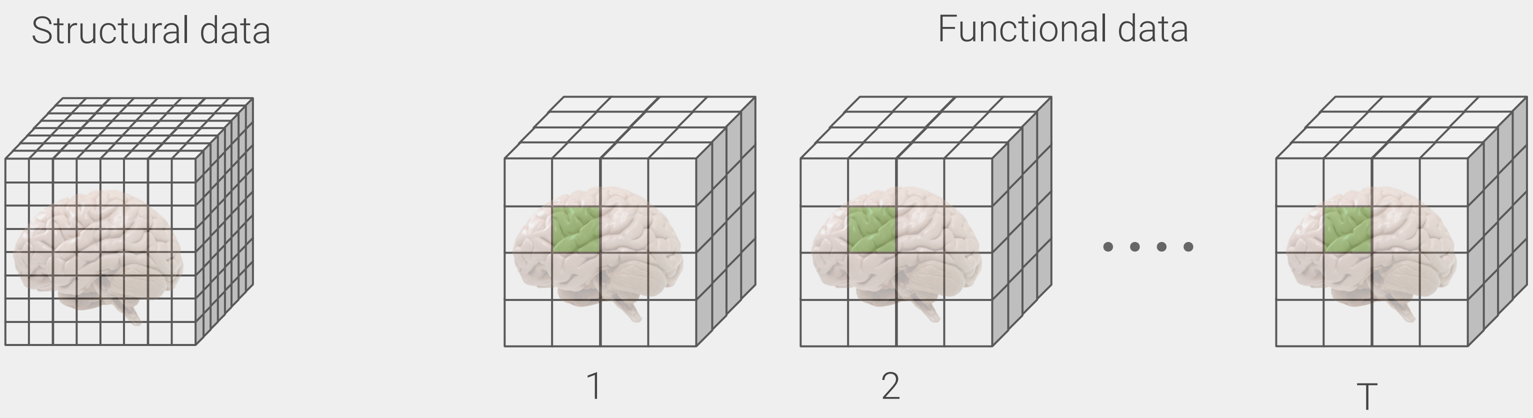
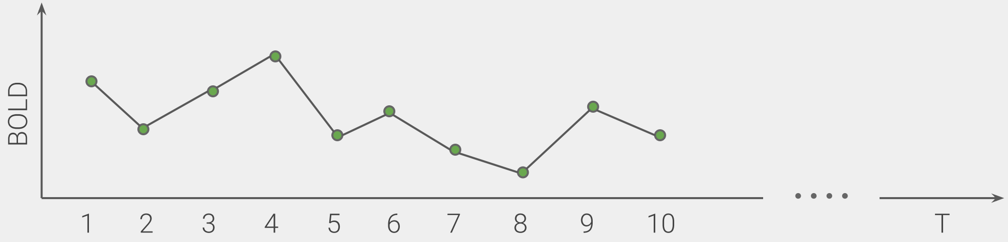


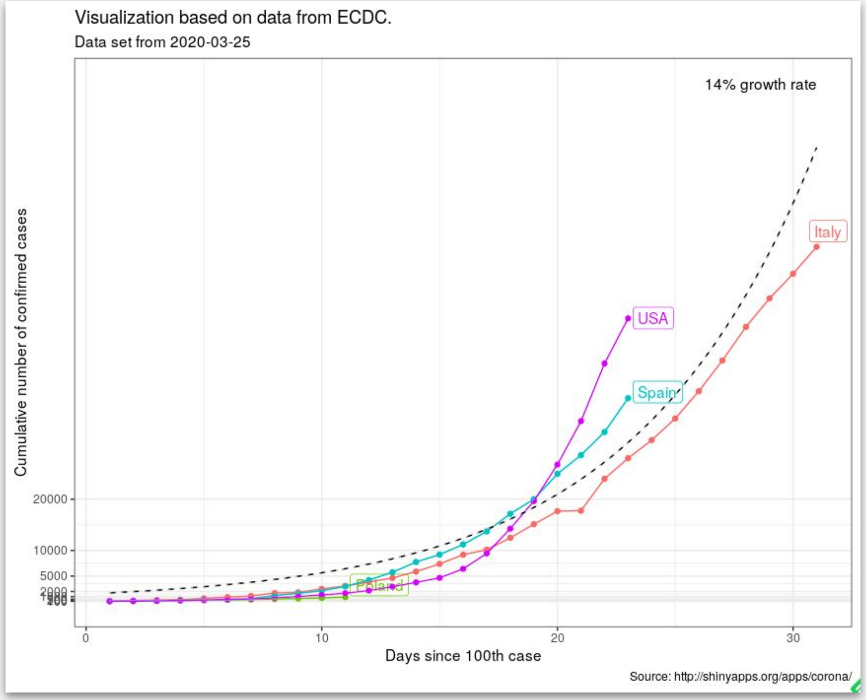
Time series - is a series of data points listed in time order.

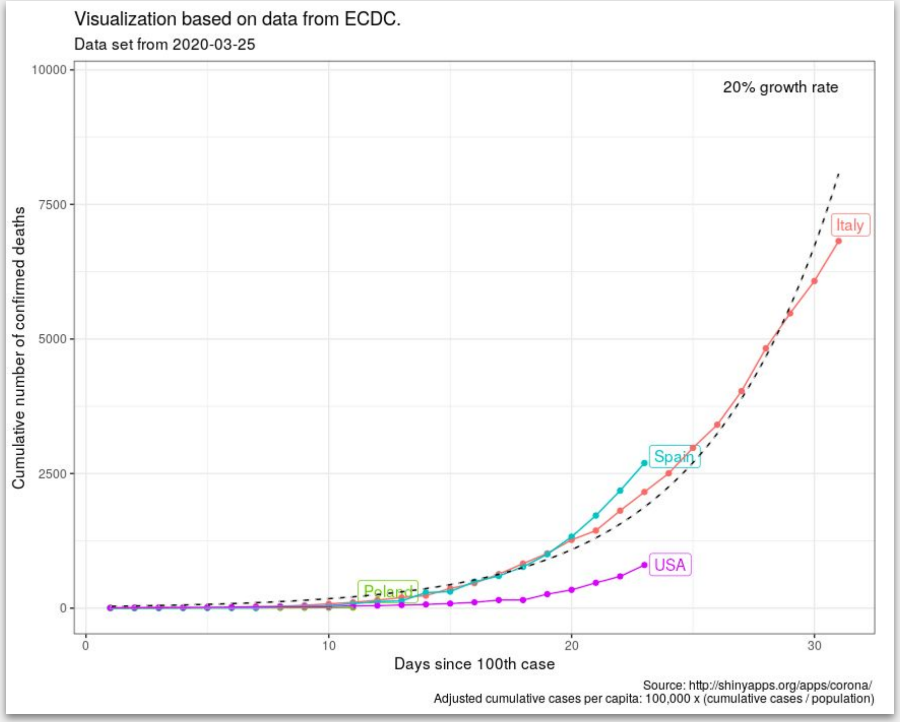
Every voxel has its own time-series.



What data can also be represented as time-series?

Time-series example - COVID-19





http://shinyapps.org/apps/corona/

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

Nilearn:

Statistics for NeuroImaging in Python

SVM Ward clustering
Searchlight ICA
Nifti IO Datasets

ENHANCED BY Google

Nilearn Home | User Guide | Examples | Reference | Glossary | Bibliography | Nilearn: Statistical Analysis for NeuroImaging in Python | Nipy ecosystem

This is the *stable* documentation for the latest release of Nilearn, the current development version is available here.

Nilearn enables **approachable and versatile analyses of brain volumes**. It provides statistical and machine-learning tools, with **instructive documentation & open community**.

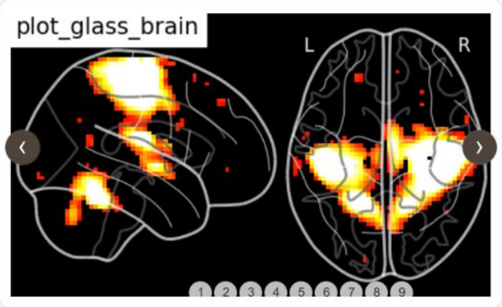
It supports general linear model (GLM) based analysis and leverages the scikit-learn Python toolbox for multivariate statistics with applications such as predictive modelling, classification, decoding, or connectivity analysis.

Nilearn now includes the functionality of Nistats. Here's a guide to replacing Nistats imports to work in Nilearn.

First Steps
Get started with nilearn

Examples
Visit our example gallery

User Guide
Browse the full documentation



News

January 2022: Nilearn 0.9.0 released
September 2021: Nilearn 0.8.1 released
June 2021: Nilearn 0.8.0 released

Ongoing: What's new.

Software

Installation

Development

Nilearn on GitHub
All material Free Software: **BSD license** (3 clause).
Authors
Contributing

Giving credit

Please consider citing the papers.

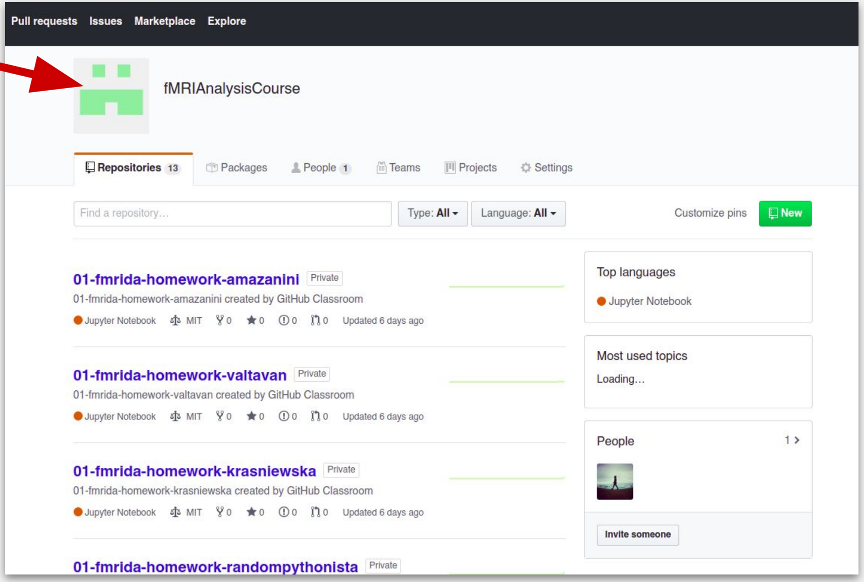
https://nilearn.github.io/stable/index.html

Python exercises

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

Homework

Logo contest!



1. **GitHub Classroom**

   Data manipulation in Python

2. **Data Camp Classroom**

   Introduction to Data Visualization with Matplotlib

Next

Preprocessing