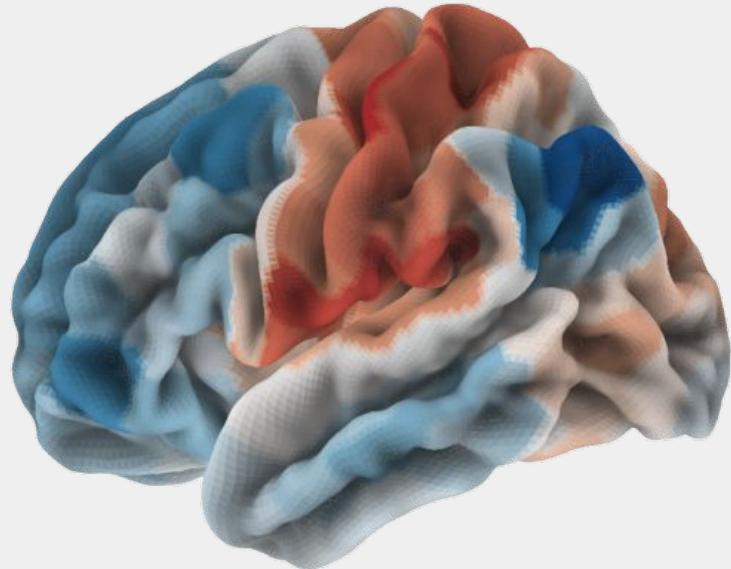


Advanced fMRI data analysis

Karolina Finc

Centre for Modern Interdisciplinary Technologies

Nicolaus Copernicus University in Toruń



COURSE #1: **Introduction** | 6th March 2020

Instructor



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Karolina Finc

Research Assistant @CMIT (ICNT) NCU

MA in Cognitive Science (2014)

PhD in Natural Sciences in Physical Sciences (2019)

Experience:

Max Planck Institute for Human Development,
University of Pennsylvania, Stanford University.

Computational Neuroimaging Team

<http://compneuro.umk.pl/>

fMRI

Functional Magnetic Resonance Imaging



fMRI

Functional Magnetic Resonance Imaging

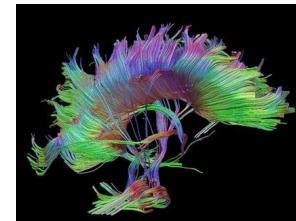


Structural

MRI (T1)



DTI



fMRI

Functional Magnetic Resonance Imaging



Structural

MRI (T1)

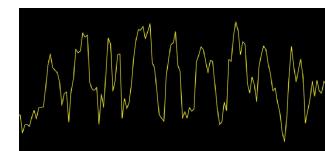
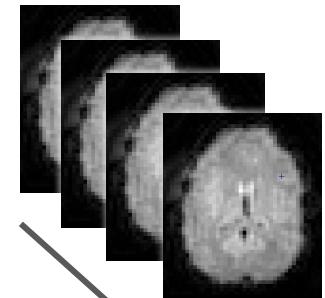


DTI



Functional

fMRI (T2*)

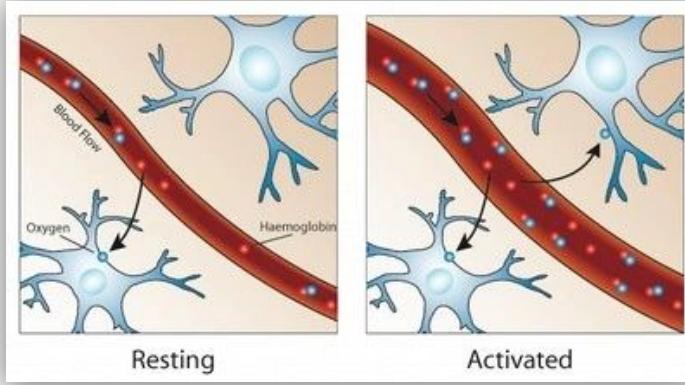


How to measure brain activity with fMRI?



BOLD signal

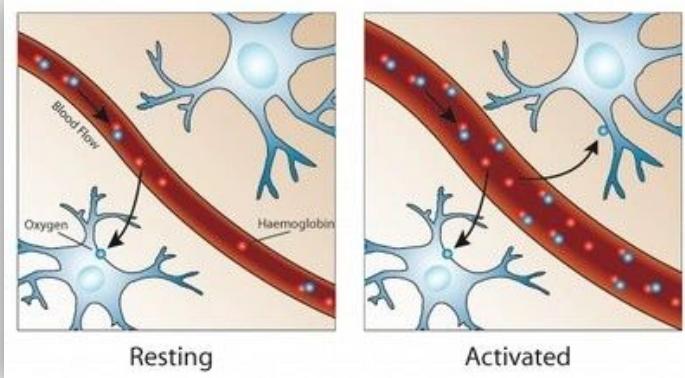
Blood Oxygenation Level Dependent



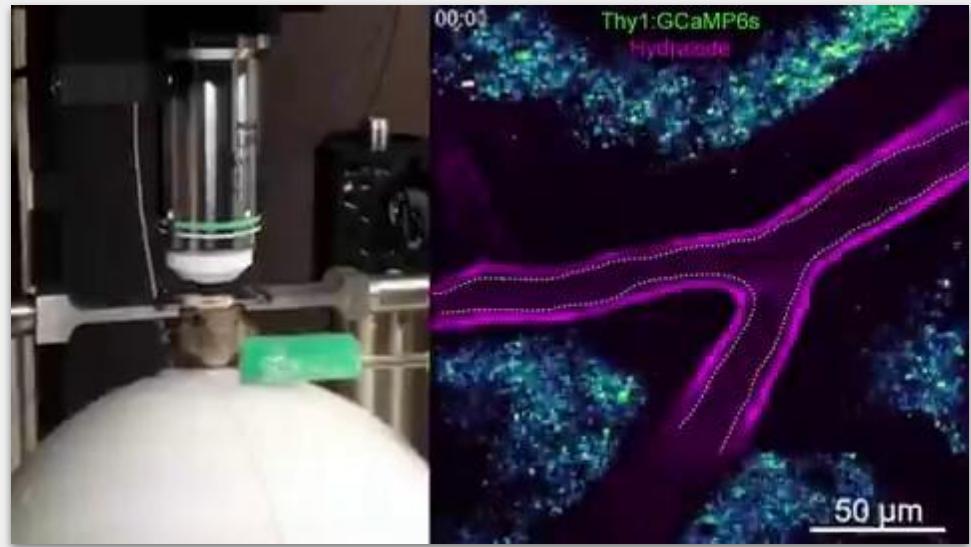
Ratio of **oxygenated** to deoxygenated
hemoglobin in the blood.

BOLD signal

Blood Oxygenation Level Dependent

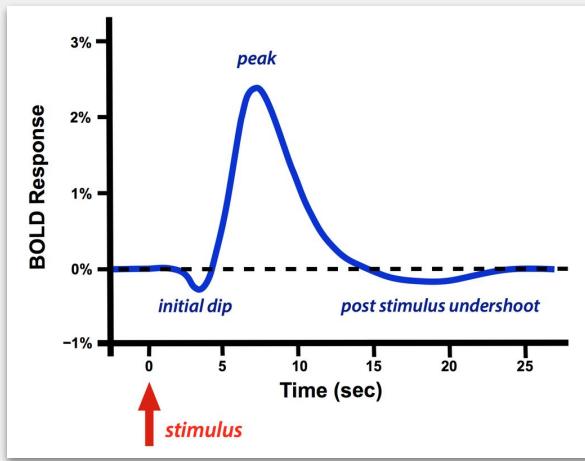


Ratio of **oxygenated** to deoxygenated hemoglobin in the blood.



Chow et al. (2020), *Nature*.

Haemodynamic response function



The change in BOLD signal that follows a brief period of neuronal activity.

Peak about 5 seconds after stimulation

Undershoot (returns to baseline in for at least 15-20 seconds)

The shape of HRF may differ in different brain areas or between subjects subjects.

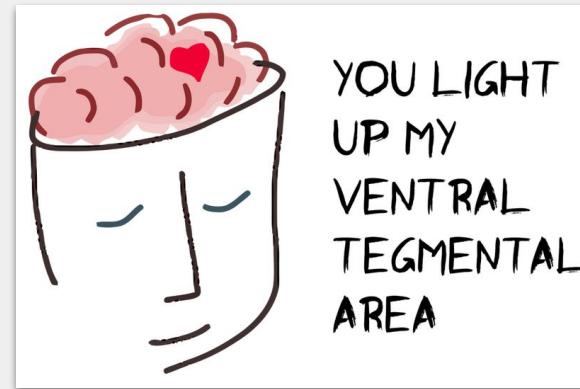
Cool stuff:

<https://www.slideshare.net/rnja8c/fmri-study-design>

Remember!

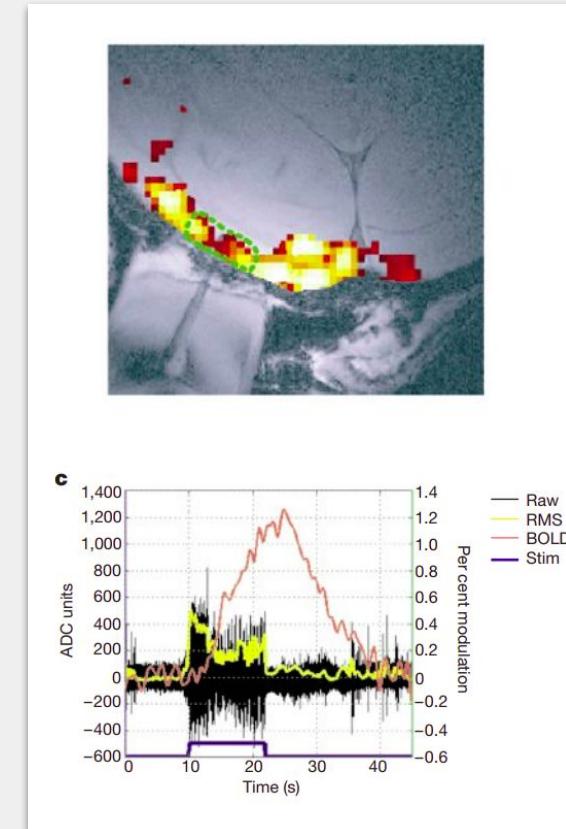
BOLD signal is not a direct measure of neuronal activity!

It measures **metabolic demands** of active neurons (oxygen consumption).



But...

BOLD signal corresponds closely to the local field potential - the electrical field potential surrounding group of neurons.



Logothetis et al. (2001), *Nature*.

Why we may want to analyze fMRI data?

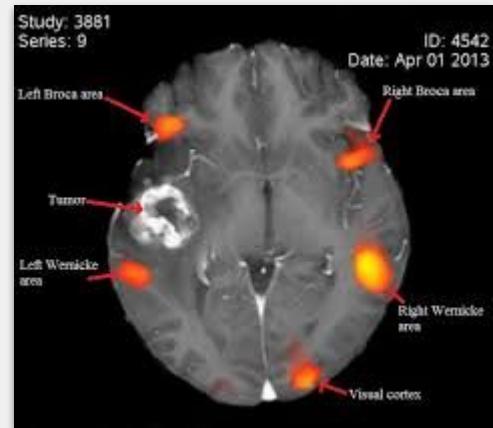


Why we may want to analyze fMRI data?

Understanding how the human brain works in health and disease.

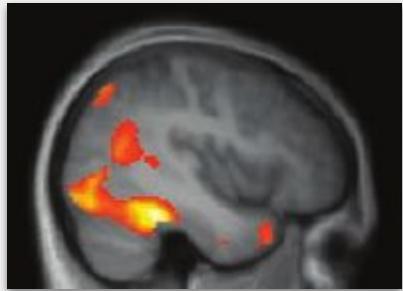
Example questions:

- How cognitive functions are organized in the human brain?
- How the human brain changes during learning?
- Can we diagnose psychiatric illness based on brain activity ?
- Can we predict neurodegenerative disorder based on brain activity?
- Can we use knowledge about how the human brain works to build more efficient artificial intelligence?



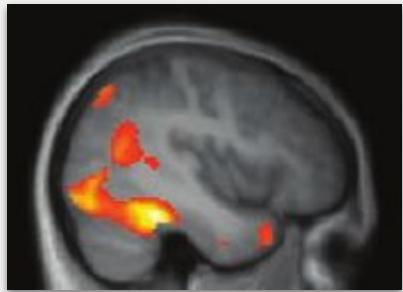
How we can look at fMRI data?

Brain activation

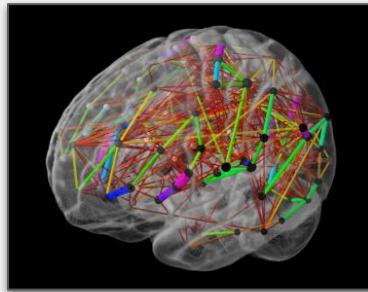


How we can look at fMRI data?

Brain activation

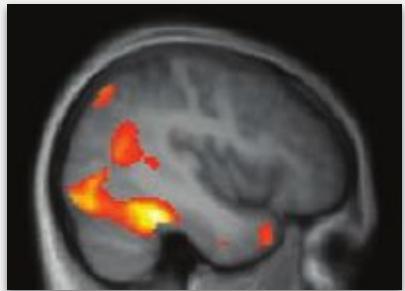


Functional connectivity

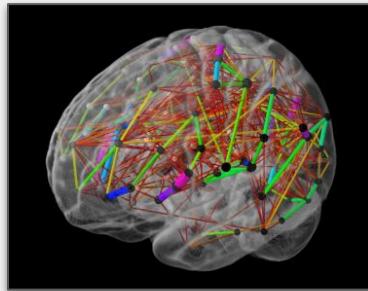


How we can look at fMRI data?

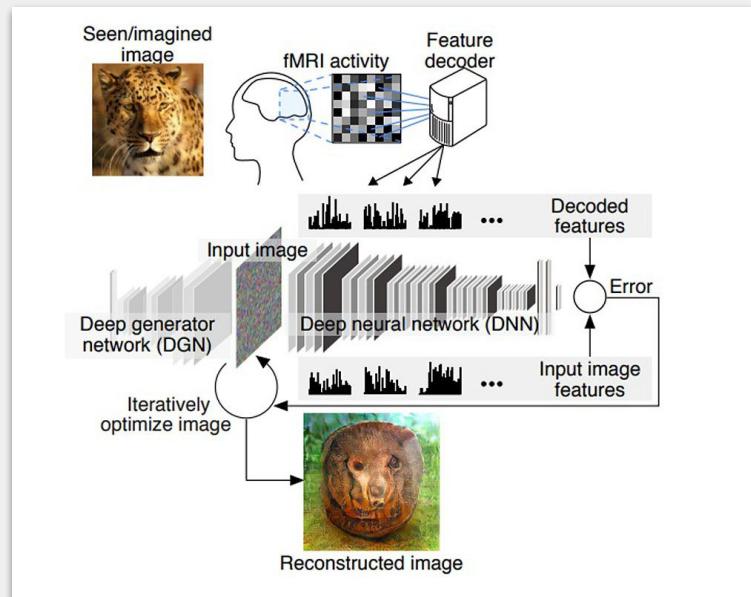
Brain activation



Functional connectivity



Machine learning



How fMRI study looks like?



How fMRI study look like?

Question & hypothesis

How fMRI study looks like?

Question & hypothesis



Designing experiment



How fMRI study looks like?

Question & hypothesis



Designing experiment



Collecting data



How fMRI study looks like?

Question & hypothesis



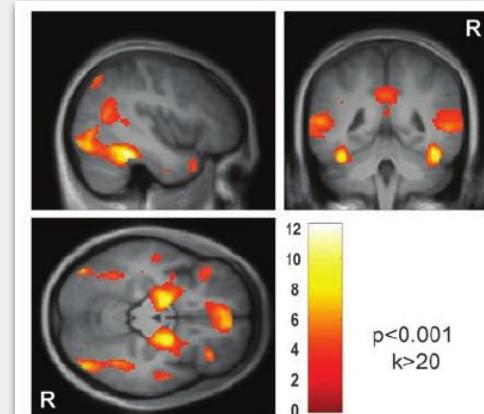
Designing experiment



Collecting data



Data analysis



How fMRI study looks like?

Question & hypothesis



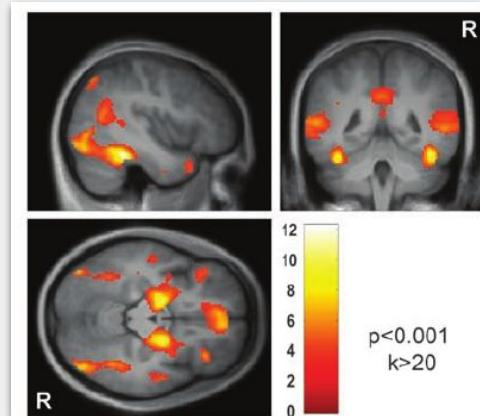
Designing experiment



Collecting data

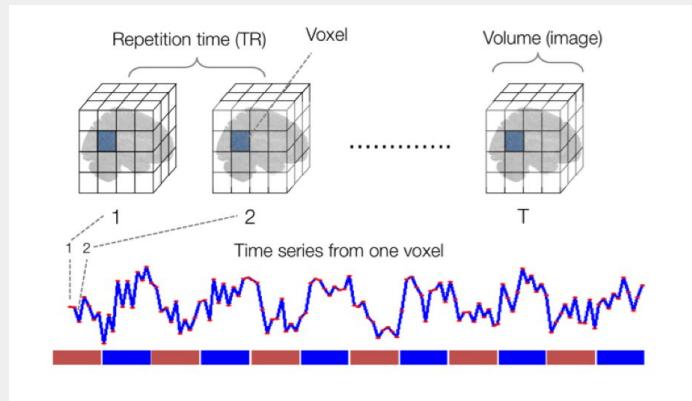
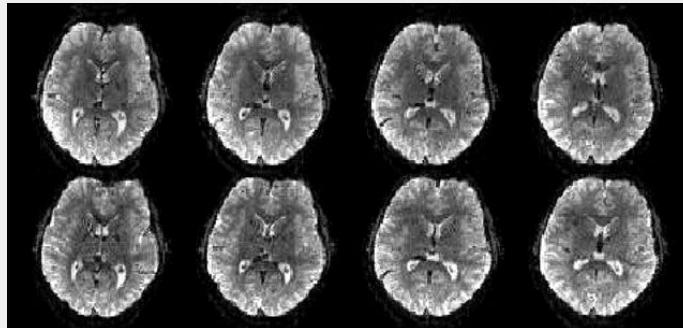


Data analysis

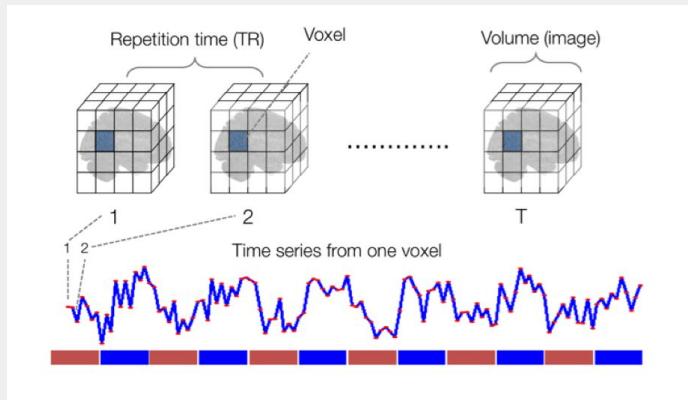
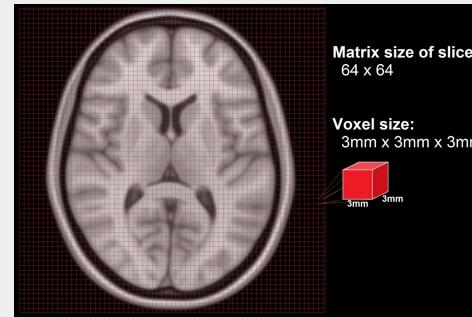
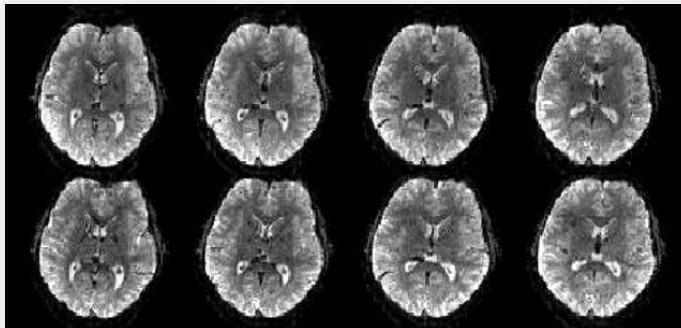


Reporting & interpretation

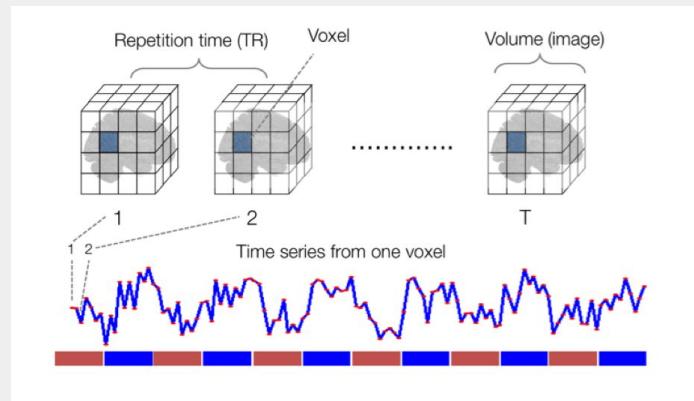
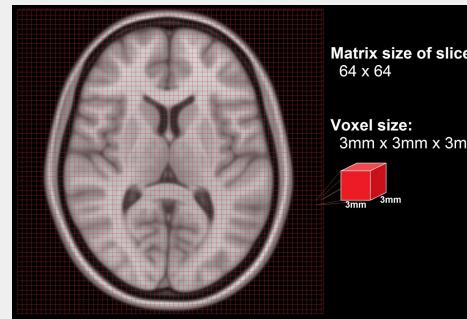
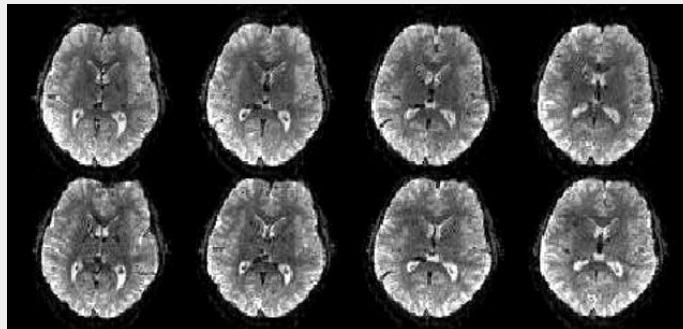
How fMRI data look like?



How fMRI data look like?



How fMRI data look like?

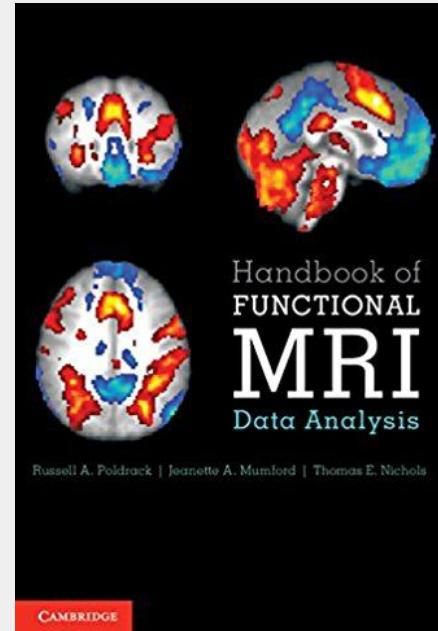


Challenges:

- Magnitude of signal changes is quite small - 0.5 - 5%
- Number of artifacts, head movement
- Variability within and between individuals
- High dimensionality of data

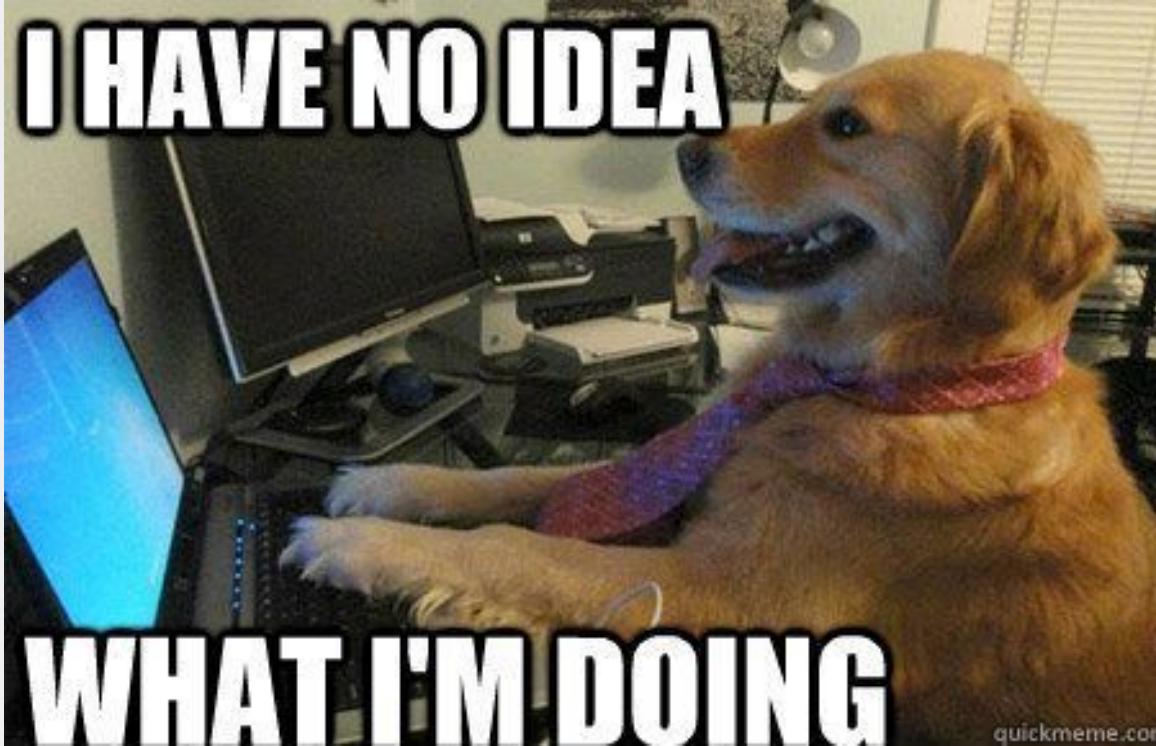
How to become an fMRI data analysis master?

1. Probability and statistics
2. Computer programming (Python/MATLAB)
3. Linear algebra
4. Magnetic resonance imaging
5. Neurophysiology and biophysics
6. Signal and image processing



... it can take many years!

I HAVE NO IDEA
WHAT I'M DOING



How to become neuro(i)magician?



Hogwarts approach

Study plan



BEFORE

Study plan



BEFORE



AFTER

Study plan

Open science &
neuroimaging



BEFORE



AFTER

Study plan



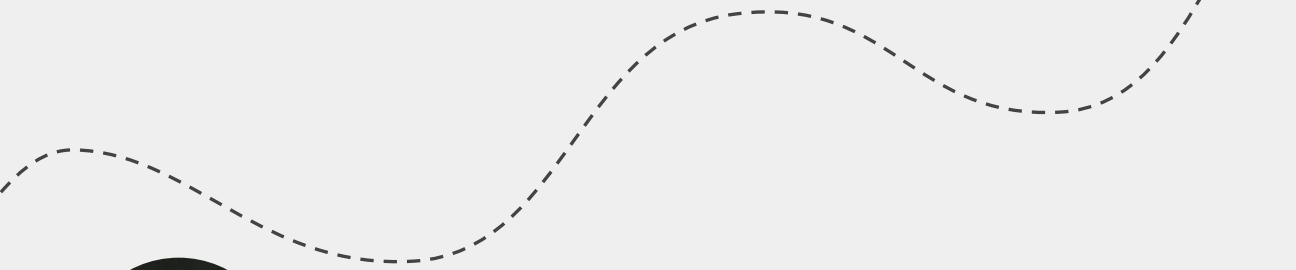
AFTER

Open science &
neuroimaging



BEFORE

Python language for
neuroimaging



Study plan

Open science &
neuroimaging



BEFORE

fMRI data
preprocessing



Python language for
neuroimaging



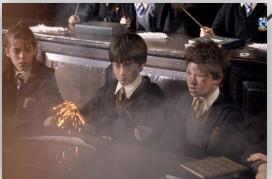
3



AFTER

Study plan

Open science &
neuroimaging



BEFORE

Python language for
neuroimaging



fMRI data
preprocessing



General
Linear Model



AFTER

Study plan

Open science & neuroimaging



BEFORE

Python language for neuroimaging



fMRI data preprocessing



3

General Linear Model



Functional connectivity



5



AFTER

Study plan

Open science & neuroimaging



BEFORE

Python language for neuroimaging



fMRI data preprocessing



3

Functional connectivity



5



4

General Linear Model



AFTER



6

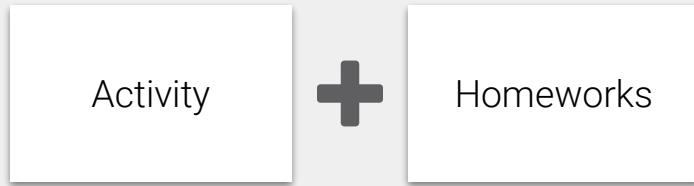
Machine Learning on fMRI data

Grading

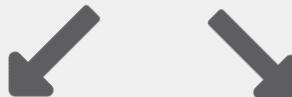
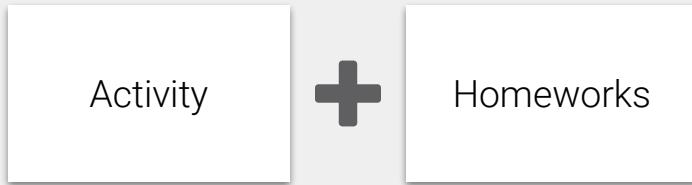
Activity



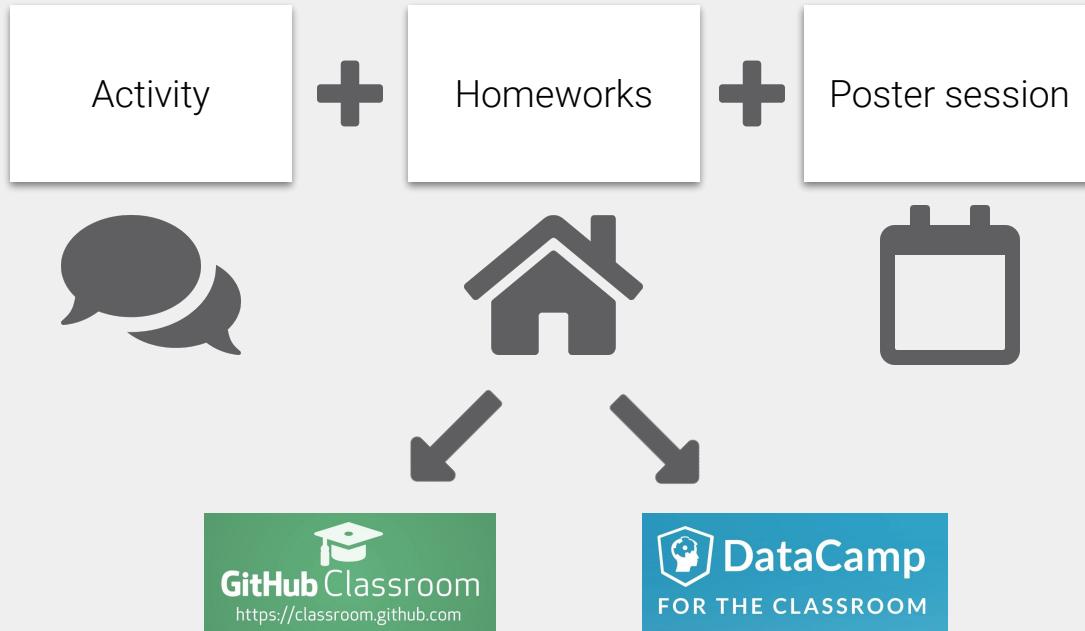
Grading



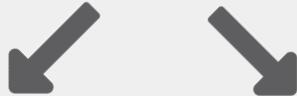
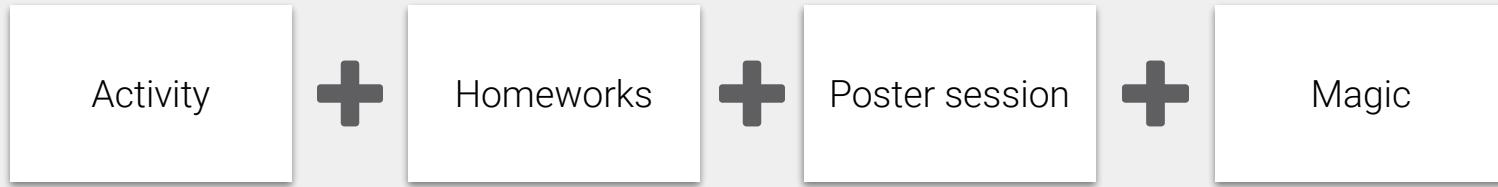
Grading



Grading



Grading



Rules & consultations

1 allowed absence

1 allowed missed homework

Consultations:

<https://finc.youcanbook.me>

ICNT, Room A.1.22

Email:

finc@umk.pl

