האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

The Hebrew University of Jerusalem

Syllabus

Human Neuroscience Methods - 76993

Last update 01-09-2024

HU Credits: 4

Degree/Cycle: 2nd degree (Master)

Responsible Department: Brain Science: Computation & Information Proc.

Academic year: 0

Semester: 1st Semester

Teaching Languages: English

Campus: E. Safra

Course/Module Coordinator: Dr. Aviv Mezer

Coordinator Email: Aviv.Mezer@mail.huji.ac.il

Coordinator Office Hours: By appointment

Teaching Staff:

Noa Guttman,
Dr. Aviv Mazer

Course/Module description:

In this course, we will explore the diverse methodologies used in human neuroscience research. Our focus will be on structural MRI, functional MRI, and EEG. We will delve into each technique's rationale, the types of signals it measures, and the specific research questions it can address. Critical to our discussion will be the analytical techniques, special statistical considerations, and notably, the limitations and potential drawbacks of each method.
Practical experience is a key component of this course. Students will engage in hands-on activities, including data collection and processing, leading to statistical analysis and inferences about the brain. This will involve visits to MRI and EEG labs for direct observation and participation, supplemented by TA-led experimental guidance sessions. Data analysis will be conducted using MATLAB or Python, thus prior experience in either of these programming languages is required for course participation.

Course/Module aims:

We aim to provide a comprehensive understanding of human neuroscience's main tools and equip students with the basic skills to conduct effective research starting from the research planning stage, through data collection, pre-processing, and statistical inference.

Learning outcomes - On successful completion of this module, students should be able to:

1. Grasp the fundamental methodologies in human neuroscience, encompassing signal types and principal analytical approaches.

2. Critically evaluate scientific literature that employs the discussed methods.

3. Select the most suitable methodology to investigate questions related to human brain structure and function.

4. Basic knowledge and hands-on experience in collecting and analyzing the data for each of the methods taught in the course

Attendance requirements(%):
80% (100% of the classes with hands on practice)

Teaching arrangement and method of instruction: Lectures and hands-on experience with data

Course/Module Content:
Unit 1 - MRI:
- The MR signal
- Neuroanatomy and microstructure with MRI
- Diffusion MRI
- Applications of structural MRI for neuroscience research

Unit 2 - fMRI:
- Physiology (Neurovascular coupling)
- BOLD, fMRI preprocessing, and experiment design.
- GLM and statistical inference
- Advanced application of fMRI in cognitive research

Unit 3 - EEG:
- EEG signal
- preprocessing (Artifact rejection, Filters, ICA)
- advanced processing and application of EEG in cognitive research

Required Reading:
Unit 1:

1.Miki Lustig (Berekely) Video introduction to MRI principles video. (In particular, the last 10 minutes describing the source of the MRI signal.)
2. Furt sections 8.1 and 8.2 (pages 137-141) in the book from picture to proton
3. "Studying neuroanatomy using MRI" by Lerch et al (2017).
4. Brian Hargreaves (Stanford) movie about MRI image formation (https://cdnapisec.kaltura.com/index.php/extwidget/preview/partner_id/1392761/uiconf_id/23332312/entry_id/0_s9ixgdf6/embed/dynamic)
5. Two videos about Diffusion: diffusion-weighted imaging (https://www.youtube.com/watch?v&eq;J_aamnpRJE8) and diffusion tensor imaging (https://www.youtube.com/watch?v&eq;twsV81UFFcE)

Unit 2:

1. http://mriquestions.com/functional-mribold---i.html- the first five topics include the advanced discussions.
a. Who invented fMRI.
b. How does fMRI work?
c. How is image contrast produced by BOLD fMRI?
d. Why does the BOLD signal increase during activation? It seems like it should decrease since more oxygen is being used up.
e. Does the BOLD response result from the firing of nerve cells?
2. Study design in fMRI: Basic principles (https://doi.org/10.1016/j.bandc.2005.11.009)
3. Representational similarity analysis – connecting the branches of systems neuroscience (https://doi.org/10.3389/neuro.06.004.2008)

Unit 3:
1. The origin of extracellular fields and currents — EEG, ECoG, LFP and spikes (https://doi.org/10.1038/nrn3241)
2. An Introduction to the Event-Related Potential Technique, second edition. Steven J. Luck

Additional Reading Material:
1. The book From Picture to proton
Chapters: 3- sequencing and tissue parameters, 4- basic concepts in MRI, 7- spatial encoding & k-space,8- basic MR, 9- MR equipment.
2. Lecture notes from Assaf Tal's MRI course at Weitzman Institute- https://www.weizmann.ac.il/chembiophys/assaf_tal/lecture-notes
3. https://mriquestions.com/index.html- A website that has great short answers and explanations for every question you can think of regarding MRI.
4. Youtube videos that show the spin dynamic during a spin-echo sequence, and an inversion recovery sequence (which is normally followed by a spin-echo).
5. A blog about MR relaxometry - https://qmrlab.org/blog.html.
6. Nikolaus Weiskopf (Max plank) lecture about "Characterizing Brain Microstructure using Magnetic Resonance Imaging: Toward in-vivo Histology"- https://www.youtube.com/watch?v&eq;FxcDM0QFP_Q

Grading Scheme:

Additional information: