האוניברסיטה העברית בירושלים
THE HEBREW UNIVERSITY OF JERUSALEM

The Hebrew University of Jerusalem

Syllabus

Advanced (Human) Electrophysiology Methods - 76919

Last update 15-03-2021

HU Credits: 4

Degree/Cycle: 2nd degree (Master)

Responsible Department: Brain Science: Computation & Information Proc.

Academic year: 0

Semester: 2nd Semester

Teaching Languages: English

Campus: E. Safra

Course/Module Coordinator: Ms. Gal Vishne

Coordinator Email: gal.vishne@mail.huji.ac.il

Coordinator Office Hours: By appointment

Teaching Staff:

Ms. Noa Rahamim,
Ms. Gal Vishne

Course/Module description:

The course will discuss several modern analysis methods for field potential recordings, and the non-invasive parallels EEG and MEG.
The course will provide mathematical background, hands-on practice and a theoretical background on the relation of these methods to theories in neuroscience and cognitive science.

Course/Module aims:

The course will provide students with essential tools for analysis of field potential recordings, and the non-invasive parallels EEG and MEG. In recent years there has been an "explosion" of new data analysis methods in the research fields using these recordings, inspired by advanced in machine learning and digital signal processing. Without knowledge of these tools researchers are highly limited with regard to what they can do with the data they collected, and will face many obstacles in tackling the recent literature.

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

The course will provide students with a comprehensive toolkit of advanced analytical approaches for research using large scale electrophysiological recordings. While the course was designed with human electrophysiology in mind, the techniques are applicable to any LFP recording, and may also transfer to analyses of other complex functional datasets (fMRI, spikes).

Attendance requirements(%):

Teaching arrangement and method of instruction: 1) Mathematical background (talk)
2) Hands-on practice in the TA and HW
3) Getting to know the relevant cognitive & physiological methods

Course/Module Content:

1) Background (one week):
a. Signal origin.
b. Preprocessing, artifact rejection and correction (e.g. ICA)
c. Classical analysis methods (ERP analyses)

2) Analysis in the frequency domain (two weeks):
a. Filters (“dos and don’ts”)
b. Time-frequency analysis – including STFT, wavelet analysis and Hilbert transform.

c. Novel analysis methods: separating rhythmic signals from non-rhythmic background “noise”, techniques for analyzing non-sinusoidal signals.
3) Cross-frequency-coupling (one week): detection and possible caveats
4) Multi-variate analysis methods (four weeks):
a. Background and comparison to conventional statistical approaches
b. Important techniques from the world of machine-learning (and specifically – getting to know several important classifiers).
c. Decoding problems
d. Encoding problems – including regression methods to deal with signal overlap
e. Representational Similarity Analysis
5) Advanced statistical methods (one week):
a. Permutation methods with an emphasis on cluster permutations
b. Circular statistics
6) Functional connectivity (two weeks): time and frequency measures, and connection to advanced analyses in the frequency domain.
7) (if possible) Source localization

Required Reading:
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Additional Reading Material:
Parial list (updated during the semester):

Frequency domain:
- de Cheveigné and Nelken "Filters: when, why, and how (not) to use them." Neuron, 2019
- Widmann, Schröger and Maess. "Digital filter design for electrophysiological data–a practical approach." Journal of neuroscience methods (2015)
- Donoghue et al. "Parameterizing neural power spectra into periodic and aperiodic components." Nature neuroscience (2020)
- He "Scale-free brain activity: past, present, and future." Trends in cognitive sciences (2014)
- Gao, Peterson and Voytek. "Inferring synaptic excitation/inhibition balance from field potentials." Neuroimage (2017)
- Bruns "Fourier-, Hilbert-and wavelet-based signal analysis: are they really different approaches?" Journal of neuroscience methods (2004)
- Cole and Voytek “Brain Oscillations and the Importance of Waveform Shape.” Trends in cognitive sciences (2017)
- Cole and Voytek. "Cycle-by-cycle analysis of neural oscillations." Journal of neurophysiology (2019)

- Canolty and Knight. "The functional role of cross-frequency coupling." Trends in cognitive sciences (2010)
- Gerber et al. "Non-sinusoidal activity can produce cross-frequency coupling in cortical signals in the absence of functional interaction between neural sources." PloS one (2016)

Multivariate analyses
- Grootswagers Wardle, and Carlson. "Decoding dynamic brain patterns from evoked responses: A tutorial on multivariate pattern analysis applied to time series neuroimaging data." Journal of cognitive neuroscience (2017)
- King and Dehaene. "Characterizing the dynamics of mental representations: the temporal generalization method." Trends in cognitive sciences (2014)
- Haufe et al. "On the interpretation of weight vectors of linear models in multivariate neuroimaging." Neuroimage (2014)
- Kriegeskorte and Kievit. "Representational geometry: integrating cognition, computation, and the brain." Trends in cognitive sciences (2013)
- Naselaris et al. "Encoding and decoding in fMRI." Neuroimage (2011)
- Dimigen and Ehinger. "Regression-based analysis of combined EEG and eye-tracking data: Theory and applications." Journal of Vision (2021)
- Liu, Cable and Gardner. "Inverted encoding models of human population response conflate noise and neural tuning width." Journal of Neuroscience (2018)
- Sprague et al. "Inverted encoding models assay population-level stimulus representations, not single-unit neural tuning." Eneuro (2018)
- Gardner and Liu. "Inverted encoding models reconstruct an arbitrary model response, not the stimulus." Eneuro (2019)
- Kragel et al. "Representation, pattern information, and brain signatures: from neurons to neuroimaging." Neuron (2018)

Statistics, functional connectivity and more
- Combrisson and Jerbi. "Exceeding chance level by chance: The caveat of theoretical chance levels in brain signal classification and statistical assessment of decoding accuracy." Journal of neuroscience methods (2015)
- Maris and Oostenveld. "Nonparametric statistical testing of EEG-and MEG-data." Journal of neuroscience methods (2007)
- Sassenhagen and Draschkow. "Cluster-based permutation tests of MEG/EEG data do not establish significance of effect latency or location." Psychophysiology (2019)
- Bastos and Schoffelen. "A tutorial review of functional connectivity analysis methods and their interpretational pitfalls." Frontiers in systems neuroscience (2016)
- van Diepen and Mazaheri. "The caveats of observing inter-trial phase-coherence in cognitive neuroscience." Scientific reports (2018)
- VanRullen. "How to evaluate phase differences between trial groups in ongoing electrophysiological signals." Frontiers in neuroscience (2016)

Course/Module evaluation:

End of year written/oral examination 0 %
Presentation 0 %
Participation in Tutorials 0 %
Project work 0 %
Assignments 30 %
Reports 0 %
Research project 70 %
Quizzes 0 %
Other 0 %

Additional information:
There may be changes in the course assessment.