Program

Moscow, 2013

The classes will be held at the **Department of Higher Nervous Activity of Lomonosov Moscow State University (MSU), April 16 - 17, 19, 27, 29-30**

The classes will be held at the **Moscow State University of Psychology and Education (MSUPE), April, 18, 20-26**

April 16, Tuesday, MSU

12:00 -18:00 - *Alexandra Litvinova, PhD., Poxana Salikhova, Alexey Pospelov* "MatLab for beginners/ FreeMat environment" *practical lessons*

April 17, Wednesday, MSU

12:00 -18:00 – *Alexandra Litvinova, PhD., Poxana* Salikhova*, Alexey Pospelov* "EEG Lab for beginners" *practical lessons*

April 18, Thursday, MSUPE

10:00-13:00 - *Olaf Hauk, PhD*, "Source estimation and design of optimal spatial filters for time-series and connectivity analysis of EEG/MEG data"

14:00-17:30 - *Karim Jerbi, PhD,* "Connectivity analysis and cross-frequency coupling in MEG source space: From theory to application in real MEG data and perspectives for psychiatric disorders"

April 19, Friday, MSU

10:00-17:00 - *Professor Alexander Kaplan, Arina Kochetova, PhD., Daniel Kiryanov (postgraduate)*

"Neurocommunikative technology: Achievements and Prospects" *Lecture* (2 hours)

"Neurocomputing interface" *Workshop* (3 hours)

The prospects of the brain in the postindustrial world *Roundtable* (2 hours)

In lecture will be presented the basic theoretical background of creating technologies of neurocommunication and examples of their practical applications. In addition to the lectures the limits of technology and the adaptive capabilities of the brain included in the contours of the direct control and neurocommunication in the way of analysis and interpretation of the electroencephalogram will be discussed. At practical training, the opportunity to experience the efficiency of neurocomputer communication, for example, in the technology of typing or device management by focusing attention on external objects or internally will be given to the students. The round table will be devoted to discussion of the brain to adapt to the digital world technology with an intensive flow of information, and its multimodal network structure.

April 20, Saturday, MSUPE

10:00-17:00 - *Vladimir Litvak, PhD*, SPM course for EEG/MEG (lecture and practice)

April 21, Sunday, MSUPE

10:00-15:00 - *Vladimir Litvak, PhD*, SPM course for EEG/MEG (lecture and practice)

April 22, Monday, MSUPE

10:00-12:30 - Joachim Gross, PhD, **"Principles of spectral analysis in MEG"**

I will give a basic introduction to spectral analysis for MEG data. I will motivate the need for spectral analysis, discuss the differences between evoked and induced brain activity and introduce basic signal processing techniques that can be used to process MEG data. The talk will cover Fourier transform and wavelets and explain the principles behind time frequency analysis. The more theoretical part will be complemented with a presentation of several studies that highlight the benefits of spectral analysis.

13:30-15:00 - **Jan-Mathijs Schoffelen, MD PhD,** "Principles of source reconstruction in MEG"

Although MEG is a technique that is unrivalled in temporal resolution, sensor-level readings are difficult to interpret in terms of the spatial origin of the activity due to the ill-posedness of the inverse problem. To improve these interpretation problems, source reconstruction techniques aim at unmixing the sensor-level data into the constituent neuronal sources. This lecture aims at providing an overview of the most common methods used for source reconstruction and their strengths and weaknesses. Also, in the beginning of the lecture I will deal with the solution to the forward problem, which describes the mixing of neuronal sources to the sensor level, and which is a necessary ingredient to all biophysically inspired source reconstruction methods.

15:30-17:00 - **Jan-Mathijs Schoffelen, MD PhD,** "Promises and pitfalls in the analysis and interpretation of connectivity using MEG"

Connectivity analysis using electrophysiological techniques is very relevant, because these techniques allow to study the brain’s activity at time scales relevant for cognition. The researcher interested in estimated connectivity from electrophysiological data is faced with a multitude of connectivity metrics that can be used to quantify the interaction between brain regions. This lecture will provide an overview and some insights into a few connectivity measures that are commonly used in the field (coherence and its relatives, as well as frequency-resolved Granger causality). It also addresses some important issues related to connectivity analysis based on non-invasively obtained data. The most important issue is the problem of electromagnetic field spread, which seriously affects the interpretability of the estimated connectivity and which requires the researcher to perform the analysis at the level of the underlying sources, rather than at the sensor-level. However, even at the source level (apart from the fact that the source reconstruction adds a level of complexity to the analysis) one needs to be careful with the interpretation of the results.

17:30-19:00 – **Students' Poster session**

April 23, Tuesday, MSUPE

11:00-12:00 - **Andrey Zhdanov, PhD**, "Decoding mental states from magnetoencephalographic signals";

"Brain reading" - inferring personal mental state from neuropsysiological signals - is an increasingly popular approach to brain research. Historically, it was most extensively pursued in the field of EEG-based brain-computer interface (BCI) design with the earliest works dating back about 40 years.

More recently this approach has been increasingly gaining traction in the mainstream functional neuroimaging research, especially in the field of functional Magnetic Resonance Imaging (fMRI) [3]. One particularly interesting possibility is using this technique for investigating bistable perceptual states. Bistable perceptual states (Necker cube and Rubin's vase being among the most prominent examples) are characterized by person's percept spontaneously alternating between two possible interpretations of the same stimulus. Thus they provide a unique opportunity for decoupling physical properties of the stimulus from the subjective experience. Application of the "brain reading" methodology to the investigation of such states has already yielded some interesting results.

With very few exceptions all of the "brain reading" studies employ some form of machine learning techniques for extracting the information about the mental state from the brain data. Employing machine learning techniques for this kind of data analysis poses a unique set of challenges such as the demand for robust performance on a noisy high-dimensional data with a limited number of samples and the requirement for interpretability of the resulting models in a physiologically meaningful way.

In my presentation I survey the current progress in application of machine learning techniques in the field of "brain reading" and describe our own experiments in applying regularized Fisher Linear Discriminant Analysis to the problem of inferring the mental state from magnetoencephalographic (MEG) signals. I discuss the motivation for our experiment, the way we address the high dimensionality of data with Tiknonov regularization, and the interpretability of the resulting classifiers.
The research described in the presentation was carried out at the Functional Brain Imaging Unit at Tel Aviv Sourasky Medical Center and the School of Computer Science of Tel Aviv University, in collaboration with Prof. Nathan Intrator, Prof. Talma Handler and Prof. Leslie Ungerleider.

13:00-16:30 - Tim Mullen, PhD, **"The Dynamic Brain: Modeling Neural Dynamics and Interactions from M/EEG.";** EEGLAB training - Functional Connectivity Measures (Phase-Locking Value, Phase-Amplitude Coupling, Coherence)

A significant challenge in contemporary neuroscience lies in modeling the temporal dynamics of frequency-dependent cortical interactions posited to play critical roles in cognitive state maintenance, information processing and motor control. The first part of this lecture will survey contemporary computational approaches for analyzing oscillatory system dynamics and synchronization/information flow (functional and effective connectivity) in electrophysiological time-series data including the basic theory and practical issues surrounding estimation of functional connectivity measures, such as coherence, phase-locking value, and phase-amplitude coupling, as well as Granger causality and related effective connectivity measures. I will discuss important theoretical and practical issues such as the use of channel versus source-reconstructed data, bivariate versus multivariate methods, and the use of priors and constraints, such as smoothness and sparsity, in improving dynamical system identification. I will demonstrate recent work by our center applying these methods in studies of cognitive information processing, seizure dynamics, and brain-computer interfaces using scalp EEG and intracranial EEG (ECoG). In the second part of the lecture, I will present an overview and practicum of the Source Information Flow Toolbox (SIFT), a publicly available EEGLAB-compatible MATLAB-based toolbox for analysis and visualization of time- and frequency-dependent functional and effective connectivity in multivariate electrophysiological data, preferably following source reconstruction. Here, we will explore five of SIFT's modules: (1) Data Preprocessing, (2) Model Fitting, Validation, and

Connectivity Estimation, (3) Statistical Analysis, (4) Visualization, and (5) Simulation.

17:00-18:00 - **Jyrki Mäkelä, PhD**, "Aspects of MEG data analysis important in clinical MEG"

Presurgical evaluation in patients with intractable focal epilepsy to identify and localize areas of epileptiform activity, and identification of eloquent cortex in presurgical evaluation of brain tumors and vascular malformations have been identified as valid indications of clinical MEG studies. The individually useful results have been obtained by using equivalent current dipoles as source models of relevant activity.

MEG may also provide tools to improve diagnostics of neurodegenerative disorders. In these conditions, detection of functional disconnection between brain regions will be crucial. MEG is a useful tool to identify a “signature” of altered functional connectivity that can distinguish pathological processes from normal cognition. This should help to direct the development of treatment strategies (e.g., as an endpoint in clinical trials), and in the tracking of disease progression. As MEG is sensitive to dendritic activity at the synaptic level, it may detect pathology even before there is evidence of other “positive” neuroimaging biomarkers. New, interesting MEG analysis methods depicting cortico-cortical spatial, phase-related and temporal correlations of spontaneous MEG networks in signal or source spaces may produce robust markers of disease in individual patients.

The present connectivity analysis methods require relatively long recordings of high-quality signals for providing meaningful results. Exquisite experimental setups are needed to avoid problems related to varying vigilance. Moreover, sophisticated movement correction and artifact suppression are required for complete realization of their clinical value. The complex methods used in data mining and complicated statistics associated with these new methods may be relatively impenetrable for clinical users. To further the integration of clinical MEG results into routine patient flow, the analyses also need to be fast and understandable to the clinical teams using them. The hypotheses and presumptions underlying the modeling need to be clear, and the effects of various details of the models required for the completion of the final results need to be thoroughly understood. Clinical decision making is seldom based on one methodology only. Nevertheless, developers of new analysis methods for such purposes may benefit by placing themselves into the clinical situation, i.e., as a target for the planned procedures, or to consider their willingness to use preventive medication for the next 20 years, based on data analysis results conducted by a technician. Although solving such usability problems is not necessarily attractive for researchers in basic neuroscience, it is highly important in clinical research and particularly in MEG clinical applications.

April 24, Wednesday, MSUPE

10:00-18:00 - Francois Tadel, MSc, Elizabeth Bock, Msc, **Brainstorm Software (lecture and practice);**

10:00-11:00: Brainstorm overview; Introduction; Software architecture; Typical data workflow
11:00-11:30: Hands-on training begins
11:45-13:00: Hands-on training
14:00-18:00: Hands-on training resumes (coffee & refreshments served)

April 25, Thursday, MSUPE

10:00-12:00 - Alex Ossadtchi, PhD, **"Inferring Spatio-temporal Network Patterns from event-related EMEG Data"**

12:15-13:15 - Pantelis Lioumis, PhD, **"Navigated transcranial magnetic stimulation in assessment of cortical network properties-Examples of combination with MEG"**

Our studies demonstrate the way to combine navigated transcranial magnetic stimulation (nTMS) with electrophysiological techniques, such as electroencephalography (EEG) and magnetoencephalography (MEG). This technical and neurophysiological possibility allows the assessment of cortical excitability and connectivity with the advantage of high spatiotemporal resolution. Investigation of these cortical network properties can lead in deeper understanding of sensorimotor and speech networks and bridge the gap between basic research and clinical applications by means of TMS. First, we examined whether nTMS–EEG can be used as a marker of cortical excitability changes by investigating the reproducibility of EEG after TMS. We showed that reproducibility is a feature of TMS-evoked EEG responses if the parameters of the stimulation and coil orientation are kept the same. Utilization of navigation is crucial for such test–retest paradigms. For the second study, we analyzed the effect of neuronal state prior to TMS on cortico–cortical excitability. We demonstrated modulation of excitability of not only of the contra- but also of the ipsilateral hemisphere during preparation and execution of unilateral movements. We also tested the methodology to measure the time onset of cortical activation by grading the levels of its modulation with TMS–EEG. Next, we utilized MEG to detect sensorimotor cortical sources. nTMS was used to target these sources and modulate their activity during a motor task after a sensory stimulation. We demonstrated that stimulation of secondary somatosensory cortex can influence the primary one and amplify somatosensory processing. By this study, we set also the methodological standards on how to use nTMS and MEG in mapping sensorimotor cortex. Therefore, we applied our experience in presurgical mapping of epileptic patients before cortical resection. By combining the nTMS and MEG advantages, we created a noninvasive methodology to map sensorimotor cortex. The results were as accurate as electrical cortical stimulation in most patients. Thus, it may be possible to replace costly invasive standard procedures, which pose a high risk for the patient, when the epileptic focus is near sensorimotor cortex and accessible to MEG. This motivated us to create another nTMS paradigm for mapping speech-related areas. We combined an object naming paradigm and repetitive TMS to find cortical sites sensitive to interference during the task. We recorded video of the experiment to evaluate the effect of TMS on the subjects' performance. The results show that this method may map speech-related areas successfully. All in all, we show that recent advances in TMS set new standards in basic research and clinical applications, such as preoperative work-up and test–retest pharmacological studies. Cross-modal nTMS applications open new avenues in studying cortical network parameters.

14:30-17:00 - Dirk J. A. Smit, PhD, **"M/EEG as Endophenotype: from Simple Power to Graph Analysis."**

17:30-18:30 - Aleksander Valjamae, PhD, **"Non-visual and multisensory BCI systems: present and future"**

During the past decade, brain-computer interfaces (BCIs) have rapidly developed, both in technological and application domains. However, most of these interfaces rely on the visual modality. Only some research groups have been studying non-visual BCIs, primarily based on auditory and, sometimes, on somatosensory signals. These non-visual BCI approaches are especially useful for severely disabled patients with poor vision. From a broader perspective, multisensory BCIs may offer more versatile and user-friendly paradigms for control and feedback. This chapter describes current

systems that are used within auditory and somatosensory BCI research. Four categories of noninvasive BCI paradigms are employed, P300 evoked potentials, steady-state evoked potentials, slow cortical potentials, and mental tasks.

Comparing visual and non-visual BCIs, we propose and discuss different possible multisensory combinations, as well as their pros and cons. We conclude by discussing potential future research directions of multisensory BCIs and related research questions

April 26, Friday, MSUPE

10:00-11:30 - Risto Ilmoniemi, PhD, "New opportunities and challenges for MEG/EEG data analysis"

12:00-14:00 - *Lauri Parkkonen, PhD*, "Employing advanced signal processing and machine learning techniques in the analysis of MEG data"

15:00-16:30 - *Arthur Chih-Hsin Tsai, PhD*, "Multi-Subject Spatiotemporal Independent MEG/EEG Source Imaging"

April 27, Saturday, MSU

*10:00-14:00 – Larisa Mayorova, M.D. S*PM: analysis of fMRI data, practical lessons

April 29, Monday, MSU

15:00-16:30 – Professor Valery Shulgovsky "Neurobioligy of human saccadic system"

16:45-18:15 - *Maria Slavutskaya, Dr.Sci.* "Cognitive functions and eye movement programming"

18:30-20:00 - *Elena Mikhailova, Dr.Sci.*, "Strategies of evaluation of spatial characteristics for visual environment in human"

April 30, Tuesday, MSU

15:00-16:30 – Professor Risto Naatanen, "The mismatch negativity (MMN): a universal index of cognitive decline in different neuropsychiatric, neurological, and neurodevelopmental disorders"

16:45-18:15 - *Professor Alexander Latanov*, "Psychophysiology of reading"

18:30-20:00 - *Professor Alexander Latanov*, "Eye movements in reading: effects of linguistic variables"