## Cutting Edge of MEG and ECoG based BMIs

**Organizers: Masayuki Hirata**

**Room**: # 103

**Date and Time**: Monday, October3 / 17:00-18:00

**Cutting Edge of MEG and ECoG based Brain Machine Interfaces**
Brain machine interface (BMI) is a promising technology for functional restoration and neurofeedback. In this symposium, 4 leading researchers present the cutting edge of BMIs using MEG and ECoG, focusing on motor and cognitive BMIs. We will clarify common and different points between MEG and ECoG in terms of BMI. Both MEG and ECoG well estimate localized oscillatory modulation, which we can use as decoding features for BMIs. MEG is noninvasive but also has high spatiotemporal resolution. They are important and appropriate factors for neurofeedback. MEG has broader spatial coverage than ECoG. This is more appropriate to estimate transcortical connectivity, which may contribute to neural decoding of higher order brain functions. MEG is inferior in the sensitivity of high frequency oscillatory activity, which contains rich neural information. In contrast, ECoG enables accurate real time control of a robotic arm by detecting high frequency oscillation in a single trial basis. By fully utilizing and improving these properties, we may light up the future perspective of MEG and ECoG based BMIs.

**Speakers:**

- **Ole Jensen** (Radboud Univ., The Netherlands)
  "Alpha activity modulated by attention used for MEG brain-computer interfaces and neurofeedback"

  Oscillatory activity in the alpha-band is strongly modulated by spatial attention. We investigated if these modulation can be used to control a brain-computer interface (Horschig et al., 2015, Brain Topography) using a paradigm in which subjects, on their own will, attended left or right. This allowed them to control a simple interface. Eight of eleven subjects achieved classification rates significantly above chance level. We conclude that posterior alpha power can successfully be used as a control signal in brain-computer interfaces. Next we investigated whether real-time neurofeedback training of the alpha lateralization can cause subsequent changes in visual detection (Okazaki et al. 2015, Neuroimage). The experiment consisted of assessment before and after the neurofeedback. During neurofeedback, two face stimuli superimposed with noise were presented bilaterally. The visibility of the stimuli was varied according to the momentary degree of hemispheric alpha lateralization directed by attention. We found that hemispheric alpha lateralization increased with neurofeedback. Surprisingly, comparing pre- to post-training, detection performance decreased for stimuli presented in the un-attended hemifield during neurofeedback. Thus, neurofeedback training alters alpha lateralization, which in turn decreases performances in the untrained hemifield. Our neurofeedback could be of potential use for reducing distractibility in attention deficit patients.

- **Kyousuke Kamada** (Asahikawa Medical Univ., Japan)
  "ECoG-based BCI for motor functions"

  A brain-computer-interface (BCI) allows the user to control a device with brain activity. Most of today's BCI research focuses on analyzing EEG and MEG which provide only limited signal to noise ratio. Electrocorticographic (ECoG) signals allow the investigation of spatially highly focused task-related activation within the high gamma frequency band, making the discrimination of complex grasping tasks possible. Common spatial patterns (CSP) are used for BCI systems and provide a powerful tool for feature optimization. This work focused on the discrimination of (i) three complex hand movements, (ii) hand movement and idle state. Two subjects S1 and S2 performed single 'open', 'peace' and 'fist' hand poses and (iii) one subject S3 controlled a humanoid. Results showed for (i) an error rate of 7.22 % and 1.17 % for S1 and S2. For motor-imaginary to control the humanoid, (iii) S3 could perform such control over 4 sessions: 3 of those were performed over one day and the last one was performed two days afterwards. The performance of the classifier improved, reaching about 90% finally. This experiment showed that ECoG-based motor imagery performed well despite a short training period, providing future possibility for MEG-based BCI with higher sensitivity than present MEG sensors.

- **Jun Sic Kim** (Seoul Nat'l Univ., Korea)
  "Prediction of movement intention based on connectivity"

  In most of brain-machine interface (BMI) studies for movement, the prediction models have been optimized for kinetic states. This model may not be suitable in the idle state during resting. This potential maladaptation could lead to a sudden accident or unintended movement resulting from prediction error. Thus, prediction of movement intention is needed to build a reasonable BMI system. The kinetic movement is performed through the dynamic change of brain activity such as resting, movement selection, planning, preparation, and execution. The motor network including the primary motor cortex, premotor area, supplementary motor area, and the dorsolateral prefrontal cortex is involved in these movement states. Neuronal communication would increase within the motor network in the movement state. In this study, we investigated the temporal dynamics in the motor/sensory-related networks to predict movement intention, trajectory estimation, and sensory feedback using ECoG and MEG. Movement intention was successfully predicted by connectivity analysis, and the trajectory of arm movement was also well predicted by linear regression of brain activity from motor-related regions. Furthermore sensory-related cortex would also contribute to predict trajectory prediction as much as motor cortex. These results suggest that temporal dynamics in motor-sensory networks is an excellent approach for prediction of movement and its states.

- **Masayuki Hirata** (Osaka Univ. Medical School, Japan)
  "ECoG and MEG as neural signals for BMIs"

  Both ECoG and MEG are good signals for BMIs for motor and communication control. Using ECoG, we demonstrated high γ activity is useful to decode movement type and successfully controlled a robotic arm in real time. A tetraplegic patient with ALS was able to his communication support device using ‘γ switch’: his high γ activity in the motor area.
  High γ activity is subtle but more focally distributed and better reflect functional localization than α and β activity. ECoG can stably detect this subtle high γ activity in single trial basis. This high sensitivity of ECoG in the high frequency band enables ECoG-based BMI accurate decoding. Using MEG, although its performance as a BMI signal is inferior to that of ECoG, low frequency components or powers of magnetic fields offer higher decoding accuracy than high γ activity. Low frequency components are clear and large enough to be stably detected by MEG. This robustness of low frequency components enables MEG accurate decoding. However, present MEGs are insensitive to detect high γ activity in single trial basis. Improvement of sensitivity of MEG in the high frequency band will not only improve the performance of MEG-based BMIs but also open new research fields such as cross frequency coupling between low and high frequency oscillations.