MEG-TMS Combination

Organizer: Jyrki Mäkelä

Room: # 105

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Combining MEG and Navigated TMS

Magnetic fields can be used both to obtain information from the brain function in MEG studies, and to modify the brain electric activity in transcranial magnetic stimulation (TMS). Knowledge about physical properties of the magnetic fields in the brain has enabled development of navigated TMS (nTMS), in which the location and strength of TMS can be calculated based on the model of the individual's brain. This extension has opened new clinical uses of nTMS in diagnostics as well as in therapy of neurological conditions. This symposium aims at studying the possibilities of combination of the two methods in obtaining benefits for the neurological patients and to study the questions regarding modeling of the magnetic fields relevant to both methods.

Speakers:

- **Andrew Papanicolau** (The Univ. of Tennessee, USA)
  "Combining MEG and nTMS in epilepsy surgery planning"

  Presurgical evaluation for most pediatric epilepsy and tumor patients has been carried out until recently by means of invasive procedures such as the Wada procedure for determining hemispheric dominance for language and memory and Cortical stimulation mapping for localizing the language-related cortex and another subset of patients undergo additional cortical mapping through recording of high gamma activity from subdural electrodes. Currently, however, in many neurosurgery centers, including ours, patients also undergo MEG, fMRI, and nTMS for the same purposes. The results of all the above brain mapping methods are then correlated with the ultimate aim of establishing the compatibility of the invasive and non-invasive mapping procedures and the relative efficiency of each of the non-invasive ones. In this presentation, our experience with nTMS as an efficient procedure of functional mapping (if it were to be used alone), as a procedure for securing complementary information to that of the other functional imaging procedures, especially MEG, and as a substitute for direct cortical stimulation mapping will be discussed with the aid of a series of surgical cases.

- **Jyrki Mäkelä** (HUS Medical Imaging Center, Finland)
  "Cortical excitability estimated by MEG and nTMS in evaluating cortical recovery and effects of rehabilitation"

  The motor system is a dynamic network of cortical and subcortical areas interacting through excitatory and inhibitory circuits and modulated by somatosensory input. The network balance is disturbed in several neurological disorders including stroke, chronic pain and Parkinson's disease. Modifications of cortical excitability enable recovery and reorganization of the motor areas both in animal models and in humans. Transcranial magnetic stimulation (TMS) and magnetoencephalography (MEG) have both been applied in neurological patients to reveal cortical excitability changes. This presentation studies the possibilities of combined MEG and nTMS recordings in evaluating the effects of recovery and effects of therapies, including navigated rapid-rate TMS, in neurological disorders.

- **Matti Stenroos**
  "Improving modeling of the magnetic fields to enhance usability and precision of MEG and nTMS"

  To focus TMS-induced electric field to a region of interest and to estimate the cortical source of a MEG map, we need a forward model. In nTMS, the head has been modelled locally spherical, while in MEG, either spherical or simple layered models are used. Recent studies are in favor of realistically-shaped models.
  In this work, I apply computer simulations to assess the roles of a) level of detail of head model and b) accuracy of TMS coil model on TMS focusing, aiming at fast-to-solve models that are suitable for clinical nTMS use. I will also assess the possible coupling between the errors in TMS and MEG models: if the aim is to study the effect of TMS on brain activity as measured by MEG, how much will a detailed MEG model help, if nTMS is done using a simple model?

  The reference computations are done using an accurate coil model and a boundary-element head model that contains the brain, realistic CSF, skull, and scalp, and test models apply various simplifications to both the head and the TMS coil model. The first results suggest that, given proper implementation, realistically-shaped models are computationally tractable in nTMS setting.