Bringing MEG towards clinical applications

Akademisk avhandling

Som för avläggande av medicine doktorsexamen vid Sahlgrenska akademin, Göteborgs universitet kommer att offentligt försvaras i hörsal Arvid Carlsson, Medicinaregatan 3, Göteborg

Fredagen den 14:e september 2018, klockan 13:00

av

Bushra Riaz Syeda

Fakultetsopponent:

Prof. Vittorio Pizzella, Physicist

Department of Neuroscience, Imaging and Clinical Sciences

University "G. d'Annunzio" of Chieti-Pescara

Chieti, Italy

Avhandlingen baseras på följande delarbeten

I. **B. Riaz;** J. J. Eskelin; L. Lundblad; B. G. Wallin; T. Karlsson; G. Starck; D. Lundqvist; R. Oostenveld; J. Schneiderman; M. Elam. Cortical predictors for stress-induced cardiovascular disease. *Manuscript.*

II. M. Xie; J. Schneiderman; M. Chukharkin; A. Kalabukhov; **B. Riaz;** D. Lundqvist; S. Whitmarsh; M. Hamalainen; V. Jousmaki; R. Oostenveld; D. Winkler. Benchmarking for on-scalp MEG sensors. *IEEE transactions on Biomedical Engineering* 2016: **64**(6), pp. 1270-1276.

III. **B. Riaz;** C. Pfeiffer; J. Schneiderman. Evaluation of realistic layouts for next generation on-scalp MEG: spatial information density maps. *Scientific Reports* 2017: **7**(1), 6974.

Department of Clinical Neurophysiology

Section of Clinical Neuroscience

Institute of Neuroscience & Physiology, Sahlgrenska akademin

UNIVERSITY OF GOTHENBURG

Bringing MEG towards clinical applications

Bushra Riaz Syeda

Department of Clinical Neurophysiology, Section of Clinical Neuroscience, Institute of Neuroscience and Physiology, Sahlgrenska akademin, University of Gothenburg, Sweden, 2018.

Abstract

Magnetoencephalography (MEG) is a passive, non-invasive functional neuroimaging technique for recording magnetic fields generated by neuronal currents in the brain. MEG provides a unique capability to map the electrophysiology of the brain with very high temporal resolution (below 1 ms) and fairly good spatial resolution (less than 1 cm). The advent of whole head MEG systems in the 1990s opened new perspectives in the understanding of the human brain. It has been used in the medical research setting for, among other things, understanding neurodegenerative diseases. However clinical applications of MEG are still few. One limiting factor is the sensors that are utilized in today's commercially available MEG systems: they operate only at extremely low temperatures. Liquid helium, an increasingly expensive and finite natural resource, is used to cool the sensors. Furthermore, thermal insulation that must be placed between the sensors and the subject limits system sensitivity. Modern sensor technologies operating at more moderate temperatures have led to developments towards principally new 'on-scalp' MEG systems. By eliminating the use of liquid helium and providing improved sensitivity via scanning closer to the brain, on-scalp MEG provides a promising future for MEG in clinical applications.

In this work, theoretical and experimental methods are detailed for on-scalp and conventional MEG studies of neural activations that are generally relevant to neuroscience research and clinical applications. As such, we bring MEG a step closer to becoming a routinely used clinical imaging modality.

The work is comprised of two main activities:

Activity I: Experimental support for utilizing MEG in a new clinical setting. We developed a MEG-based experimental approach for understanding the neural mechanisms and networks involved in modulating an individual's response to arousing stimuli. The aim is a non-invasive biomarker for identifying risk of developing cardiovascular disease. A MEG study was designed in line with previous microneurography studies that are known to reveal a distinct muscle sympathetic nerve activity (MSNA) response profile. This profile predicts the concomitant blood pressure trends associated with brief arousing stimuli and short periods of mental stress. In this thesis work, we investigated neural correlates of such MSNA response profiles in 20 subjects with MEG.

Activity II: Theoretical support for on-scalp MEG. We developed a framework for investigating realistic next generation MEG system designs. Our main metric is information capacity: a measure of the amount of information that can be extracted about brain activity with a given system. We use it to show the specific gains one can achieve by shifting to on-scalp MEG technology. This work furthermore contributed towards sensor array designs for full head MEG systems. The framework not only allows designing optimal arrays for MEG with new sensor technologies but also guides important sensor design parameters (such as pickup loop size, noise level, etc.) for on-scalp MEG systems.

In the future, these clinical and theoretical activities should be combined to develop a "custom on-scalp MEG" diagnostic procedure that includes improved sensitivity to cortical activations of clinical relevance.

ISBN 978-91-7833-103-1 (PRINT) http://hdl.handle.net/2077/56334
ISBN 978-91-7833-104-8 (PDF)