IDENTIFYING MUTUAL INFORMATION TRANSFER IN THE BRAIN WITH DIFFERENTIAL-ALGEBRAIC MODELING: EVIDENCE FOR FAST OSCILLATORY COUPLING BETWEEN CORTICAL SOMATOSENSORY AREAS 3B AND 1

Jens Haueisen[1], Lutz Leistritz[2], Thomas Süsse[2], Gabriel Curio[3], Herbert Witte[2]

[1] Institut für Biomedizinische Technik und Informatik, Technische Universität Ilmenau, Germany
[2] Institut für Medizinische Statistik, Informatik und Dokumentation, Klinikum der Friedrich-Schiller-Universität Jena, Germany
[3] Klinik für Neurologie, Universitätsklinikum Benjamin Franklin, Berlin, Germany

Jens.Haueisen@tu-ilmenau.de

Understanding information transfer in the brain is a major challenge in today's neurosciences. Commonly, information transfer between brain areas is analyzed with the help of correlation measures for electrophysiological data. However, such approaches cannot distinguish between mutual coupling and other mechanisms of creating correlations between responses, such as common input from other sources [1]. Functional coupling is mandatory for information transfer. Here we propose to analyze coupling between active brain areas with the help of models described by a system of differential-algebraic equations. Comparing models with various degrees of coupling, we show that mutual information transfer can be distinguished from one-way information transfer for activated cortical areas estimated by source localization techniques. We exemplify the technique with fast oscillatory activity found in both cortical areas 3b and 1 after peripheral nerve stimulation.
Electrical stimulation of peripheral somatosensory nerves evokes two types of early brain activity in two distinct frequency ranges that can be detected with electroencephalography (EEG) or magnetoencephalography (MEG) [2]. An oscillatory brain activity with a mean frequency around 650 Hz is overlaying the initial low-frequency (up to 250 Hz) cortical responses at latencies of 18 to 30 ms after stimulus (N20, P25). In most subjects this fast oscillatory activity consists of two distinct components originating from the same cortical areas as the N20 and P25 (Brodmann areas 3b and 1, respectively) [3]. We use simultaneous measurements of EEG and MEG in ten healthy volunteers to differentiate between both activities on source level. Our results indicate that for the fast oscillatory activity under analysis, the model including mutual coupling represents the brain activation best and therefore hints to a mutual information transfer between cortical areas 3b and 1.

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