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Information processing by the brain involves electric current flow in neurons. This allows us to couple to the dynamics of the brain by electromagnetic means. On can measure the neuronally generated electric and magnetic fields outside the head; similarly, one can trigger or dampen signaling in the brain by externally applied electric or magnetic fields. Although the technology is already quite sophisticated, huge advances are still possible; breakthroughs in electromagnetic probing of the brain can be expected.

Magnetoencephalography (MEG) is the recording of magnetic fields produced by neuronal currents in the brain. When a magnetic-field detector (superconducting quantum interference device or SQUID) is placed over the skull, it measures the electric currents that flow within its sensitivity region. Since the time-averaged electric current distribution of a neuron is spatially relatively stable and roughly proportional to the neuronal firing frequency, an array of SQUID detectors measures (approximately) a projection of the firing-frequency vector of the human brain.

Transcranial magnetic stimulation (TMS) is the opposite of MEG: a magnetic pulse to the brain induces electric currents in the target area, changing transmembrane voltages and thereby giving rise to action potentials, the information-carrying neuronal signals.

We have built a hybrid multichannel helmet-shaped prototype capable of ultra-low-field magnetic resonance imaging (ULF MRI) and MEG using the same SQUID sensors. The main benefit of concurrent MEG and MRI is superior registration and thereby improved source localization accuracy and reliability. In addition, ULF MRI offers quiet operation and improved safety; also conductivity imaging may be possible.

We are also developing methods for multi-locus TMS (mTMS) combined with electroencephalography (EEG). We use so-called navigated brain stimulation (NBS), which allows very accurate targeting of the neuron-stimulating electric field. When the TMS-evoked EEG is recorded, one obtains direct measures of cortical excitability and time-resolved area-to-area connectivity. One can also monitor changes in excitability and connectivity in the course of treatment, medication, or rehabilitation.

The new technology will offer great opportunities for more sophisticated experimentation, diagnostics and therapy, including improved possibilities to take into account *a priori* information, the benefits of which will be more significant as the signals and geometrical data will become more reliable. The challenge is to develop algorithms and software to take advantage of the emerging technology. What are the ultimate limits of MEG/EEG/TMS and how will we reach them? How should brain dynamics be studied?