Introduction to Transcranial Magnetic Stimulation

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***Abstract*—Transcranial magnetic stimulation (TMS) is a method for activating neurons in the brain by an electric field (E-field) induced by externally applied magnetic fields. Typically, a multi-turn figure-eight-shaped or a round coil (diameter 5–10 cm) is placed over the scalp above the target area and a pulse of current (several kA) is fed through the coil windings from a large capacitor. The LC-circuit formed by the capacitance and coil inductance define the pulse duration, which is on the order of 0.1 ms. The magnetic field strength needed is on the order of one tesla. The E-field (~100 V/m) causes a brief flow of current in the neuronal tissue, changing transmembrane voltage and thereby triggering highly synchronously action potentials in a large number of neurons in the target site. By measuring the local response with electroencephalography (EEG), one can study cortical excitability; by measuring elicited brain activation at more distant areas with EEG or muscle activity with electromyography (EMG), one can study connectivity in the brain or between the brain the periphery. TMS provides information about excitability, connectivity, as well as plasticity of the cortex as repeated stimulation can change the neuronal network, apparently by the causing long-term potentiation (LTP) or long-term depression (LTD). TMS and its combination with EEG, NIRS, PET or fMRI is used increasingly also in clinical trials. Recently, the targeting of TMS has been made accurate by combining TMS with individual patients' magnetic resonance images (MRIs), achieving what is called navigated TMS (nTMS). Recently, TMS has been increasingly used also for therapy of depression, stroke, pain and other conditions; it is effective also as a probe of pharmaceutical efficacy. Future will bring further improved accuracy of targeting and ease of use as well as computerized TMS–EEG systems.**

Keywords—transcranial magnetic stimulation, TMS, cortex, brain, excitability, connectivity, TMS-EEG