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The Role of Magnetoencephalography in Neurology and Neurotechnology

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Magnetoencephalography (MEG) is the detection of magnetic fields produced by the neuronal activity in the cortex [1]. The magnetic field measurable outside the head is produced by intracellular current flow in the active neurons. The main contributors to MEG and electroencephalography (EEG) signals are considered the dendrites of pyramidal neurons aligned in parallel. The EEG is determined by the distribution of extracellular volume currents, generated by the intracellular currents [2]. The analysis of brain function by positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) is based on the change of cerebral blood flow induced by neural activity, whereas that of EEG and MEG on the electric potential and magnetic changes induced by neural activity. Both EEG and MEG are characterized by higher temporal resolutions than PET and fMRI in measurements of brain activity. The major advantage of MEG over EEG is that MEG has higher localization accuracy. This is due to the fact that the different structures of the head influence the magnetic fields less than the volume current flow that causes the EEG. MEG has higher spatial density of recording points than EEG. The magnetic fields are less distorted than electrical fields, because of the distorting effect of the skull, which acts as a low-pass filter for electrical potential. Furthermore, inaccuracies in estimating the conductivities of the skull and other tissues of the head affect the elucidation of electrical much more than magnetic sources.

In order to detect and measure very weak magnetic fields it is necessary to use a magnetically shielded room and a very sensitive and sophisticated magnetic field detector called SQUID from the initials of the four words (Superconductive QUantum Interference Device). The introduction of whole-scalp MEG instruments in 1993 has been a major advance in patient studies. These instruments make possible simultaneously recording of magnetic activity over the entire head surface [3]. The monitoring of brain activity by MEG requires particularly sensitive sensors made superconductive by liquid helium and data acquisition in shielded rooms cutting out the ambient magnetic fields in order to obtain the best quality signals. The strengths of the detected signals measured are in the order of magnitude of picotesla (pT) or femtotesla (fT) [4-6].

Furthermore, transcranial magnetic stimulation (TMS) with suitable characteristics (magnetic field in the order of pT and frequency the α-rhythm of the patient (8-13 Hz)) has been applied in our laboratory to patients with CNS disorders [7]. The MEG recordings after the application of TMS have shown a rapid attenuation of the abnormal MEG activity followed by an increase of the low frequency components and the α-rhythm of the patients. Further signal analysis indicated that the application of the TMS strongly influenced the underlying brain dynamics with beneficial effects on the clinical condition of the patients with CNS disorders [8-10].

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