EEG Dipole Localization of Human Brain Functions

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A depolarizing neuron generates current loops around it, and its electric property is identical with a small electric current dipole. When many neurons in a limited volume of the brain cortex are depolarized almost simultaneously, their electric activity is well approximated by a single equivalent current dipole.

The dipole currents of many activated neurons produce measurable amount of electric potentials on the scalp. Mathematically,the equivalent dipole position and strength (dipole moment)are estimated from the scalp potential distribution. This is called an "inverse problem" because the cause is estimated from its result.

The scalp potentials are measured at 21~32 electrode sites simultaneously at every 1 ms or so, and time evolution of the scalp potential distribution is recorded. Every time the scalp potential is measured an equivalent dipole is derived. This technique is named by us as "Dipole Tracing"method or DT method because we can the trace process of information processing in the brain.

The DT method was applied to tracing of cognitive processes in the brain for readable and unreadable symbols ; for readable letters activation of the primary visual cortex was followed by activation of the visual association area, angular gyrus, left posterior inferior temporal area and the Wernicke-auditory boundary area. The signal processing times differ significantly from subject to subject. In this fashion the cognitive processing can be traced for visual and auditory stimuli. The dipole moment of the equivalent dipole is proportional to the number of active neurons which are related to this dipole. Therefore, we can monitor the time change of the number of active neurons.

In the DT method, a real head shape is measured for the inverse calculation, and the effect of the skull is corrected mathematically afterward. The computing time in finding the equivalent dipole ranges from 0.3s to 2 s. The maximum error of the estimated dipole location is less than 4 mm except for the basal region where the bone structure is complicated. We have developed the "SSB Head model" in which the head model is composed of three compartments with uniform electric conductivity corresponding to the scalp, skull and brain. The error estimation was done in collaboration with the group of the department of clinical neurophysiology, University Hospital, Uppsala, Sweden for four years by generating artificial current dipoles with implanted subdural electrodes of which positions were estimated by the SSB/DT. The maximum error of the estimated dipole position on this model was 2~5mm including the basal region. Position of epileptic focus is well estimated by this method beause it is localized in a small volume.

The present talk refers to basic concept of the DT method and then some important results will be described.