Lecture 12:Magnetoencephalography (MEG)

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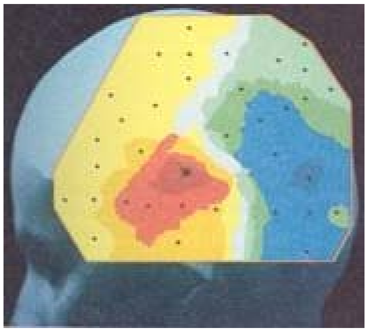
Magnetoencephalogram (MEG)

Physicist David Cohen was the first to measure the magnetic field present around the head in 1968. This magnetic field is an outcome of electrical activities of the brain. Though EEG and MEG both have to do with the electrical potential of the brain, EEG measures the average frequency with electrodes separated from the brain by thick skull. On the other hand MEG records the subtle magnetic field generated by the brain. The electrical signals generated by the neurons create weak magnetic field which is about one billionth the strength of the earth's magnetic field. The superconducting neuromagnetometer placed near a persons head picks up the magnetic field emerging from the brain and a computer maps it. The video demonstrates the process of MEG recordings. The MEG image of the brain is also given below.



MEG image of the brain (Source: Morris, C.G. (1993). Understanding psychology. Prentice Hall, New Jersey.)

See video on web

Elekta Video (Courtesy: Elekta Limited)

Although both MEG and EEG are sensitive to electrical flow in the brain MEG measures intercellular current while EEG measures volume extracellular current. Further, MEG primarily responds to tangential generators whereas EEG responds to tagential as well as ratial generators. Further, EEG signals get distorted because of the effect of the varying conductivity of the scalp. This makes precise localization of the source difficult or impossible. On the other hand, the scalp is transparent to the magnetic signals thus making it suitable for accurate localization. The advantage of MEG is its high resolution in space (2-3mm) as well as time (<1ms). However, it suffers a constraint as magnetic field decay very fast over distance. Although initially copper induction coil was used for MEG recordings, now-a-days superconducting material (SQUIDS) such as niobium is used. There has been a recent trend to use both EEG and MEG . CTF MEG /EEG system is used to have a relatively more accurate picture of the working brain.

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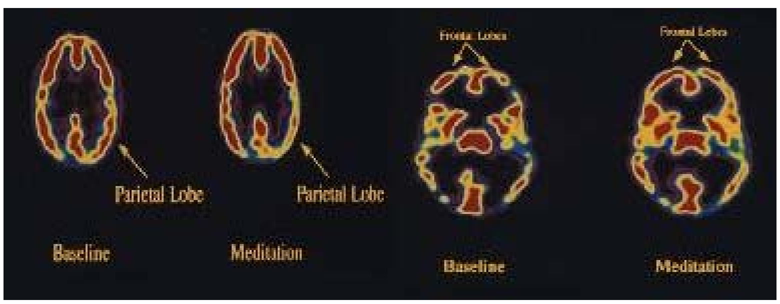
Single-Photon Emission Computed Tomography (SPECT)

SPECT helps us directly look at cerebral blood flow thus helping us indirectly infer about the brain activity (metabolism). It uses the scanning technology of CT scan reconstruction but instead of X-rays it detects gamma rays. A small amount of radioactive isotope is injected into the patient's vein which runs through the blood stream. The radioactive isotope is readily taken up by the cells in the brain. This isotope keeps degrading and at each step of decay it emits a gamma ray. Thereafter, the SPECT gamma camera rotates slowly around the head. The emitted rays are taken from multiple angles, usually encompassing 180° or 360° with the special crystals in the camera tracing them. Finally a supercomputer reconstructs 3-D images of the brain activity. The figure given below shows the SPECT image of veteran practitioners of Tibetan Buddhism. The image on the left shows decreased activity in the parietal lobe whereas the image on the right shows increased frontal activity. Parietal lobe is responsible for space and time orientation during meditation and frontal lobe is responsible for focusing attention and concentration



SPECT (Source: Davidson et al. (2003). Alterations in brain and immune function produced by mindfulness meditation. *Psychosomatic Medicine*, *65*, 564-570.)

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Çelik and Kaya (2004) performed SPECT to study Wernicke's encephalopathy in chronic alcoholics and found hypoperfusion of bilateral frontal and frontoparietal areas as well as right basal ganglia. SPECT has been used to study patients with partial epilepsy (Lee et al., 2011), frontotemporal lobar degeneration (Borroni et al., 2010), depression (Azuma et al., 2009) and several other issues that are important for psychologists. For instance, the study of hypoperfusion in patients with frontotemporal lobar degeneration by Borroni et al. (2010) is important for psychologists as the patients show impairment in their executive functions, behavioural disturbance and language deficit. Azuma et al. (2009) administered Wechsler Memory Scale–Revised (WMS -R) on patients with depression to investigate memory function and its relationship to brain perfusion in them. Using SPECT they found relationship between anterior cingulate cortex at rest, severity of depression and immediate memory scores.

Other alternatives

Besides these regional cerebral blood flow (rCBF) and event-related potential (ERP) are also the available technologies. In ERP the electrical activities of pre and poststimulus periods are correlated to refer to stimulus and response. In rCBF a scinitillation counter is put on the surface of the head to monitor the blood flow. Increased blood flow is an indicator of increased metabolic activity in the gray matter which in turn indicates increased neural activity in that area. Along with the imaging techniques and other physiological measures, cerebral involvement in a cognitive task can be studied with the help of functional measures such as dichhaptic measure, dichotic listening measure, lateral eye movement and split-field presentation.

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