From Max Sutherland's weblog: www.sutherlandsurvey.com

Brain-Imaging Methods

Introduction:
There is a great deal of psychological interpretation involved in understanding the meaning of increased brain activation, i.e. in specifying what mental process is signified by an activation.

Most imaging studies report activations arising from the difference between two tasks.[1] As described by Robinson 2004 a typical experiment has the subject lying still for thirty seconds, then performs some task for thirty seconds, then lies still for thirty seconds. For each brain area, the signal during the task is compared to the signal at rest; those areas of the brain with stronger signals during the task are presumed to be processing the information.

A very recent breakthrough holds out eventual promise in the future of detecting the activity of an individual neuron. At this stage however the smallest brain area that can be represented (a voxel) is the size of a grain of rice and contains maybe tens of thousands of neurons. There are something like100 billion neurons in the typical brain but current fMRI resolution is only about 150,000 'voxels'. The changes in blood flow in a voxel indicate increased activity of not a single neuron but a huge pod of tens of thousands of neurons.

PET (Positron Emission Tomography)

Developed in the mid- 1970s, PET was the first scanning method to give functional information about the brain**.** Both PET and FMRI provide information about neural activity in different brain regions as indicated by the level of cerebral blood flow. (With FMRI, the magnetic consequences of blood oxygenation are measured whereas PET measures blood flow by first injecting people with radioactive water and measuring changes in radiation.[2])


PET Scanner

FMRI (Functional Magnetic Resonance Imaging)

MRI (Magnetic Resonance Imaging) requires no radioactive materials and produces images at a higher resolution than PET. MRI is like an X-ray, taken inside a giant doughnut magnet. Researchers realised that instead of taking snapshots of what injuries look like, they could use MRI machines to see which parts of the brain are doing specific tasks (such as perception, language and memory) – hence the term 'functional' MRI. It involves very rapid scanning of the brain to see which areas of the brain become activated. When neural activity increases and the blood oxygenation in a region increases, this changes its magnetic properties. Increased neural action draws a bigger blood supply to support its work, which shows up—millisecond by millisecond —on an fMRI scan as magnetic changes. So, what fMRI detects is not neural activity directly but magnetic changes that are blood-oxygen level dependent (BOLD). The method is non invasive so multiple scans can be done on the same subject. [Note: The blood flow changes between several hundred milliseconds and several seconds after the neuronal activity. Since changes in blood flow are linearly related to the amount of neuronal activity, it is theoretically possible to extrapolate back from the blood flow measurements to the time-course of neuronal activity. However, differences in the hemodynamic time-constants across individuals and across different cortical regions can limit the temporal resolution to about a second.]

MEG (Magnetoencephalography)

MEG's big advantage is that it can measure activity in the brain extremely quickly - every 1/1000 of a second, which is similar to the rate at which the brain works - essentially 'the speed of thought'. MEG is a very different brain scanning technique but used for similar purposes. It is closely related to electroencephalography or EEG, since they both try to measure the same neuronal currents. Electrical currents in the brain's neuronal circuitry give rise to very weak magnetic fields that can be picked up by superconducting detectors arranged around the outside of the head. People sit under a magnet that is not quite as daunting as an MRI scanner. The main disadvantages of MEG are that it is more expensive and not as good as fMRI at localising where precisely in the brain, activity is taking place.

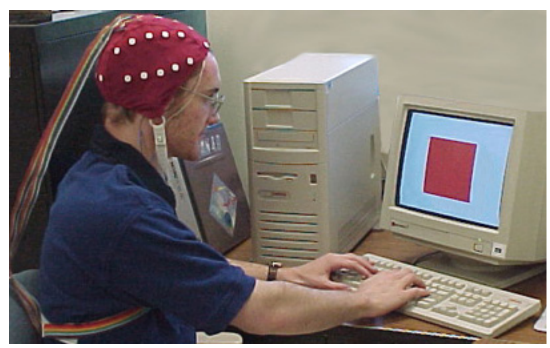
MEG Scanner

ERP – Event Related Potentials

(also called Evoked Response Potentials)

Electrodes on the scalp measure voltage fluctuations resulting from electrical activity in the brain. The "baseline" activity is then averaged out, leaving just the electrical responses evoked by each stimulus presentation. The location of where the activity is generated inside the brain has to be imputed mathematically. (In animal studies and patients undergoing brain surgery, another way to localize ERP sources is to place electrodes inside the brain.)

Event Related Potentials: Scalp electrode measurement.



Event Related Potentials: Electrode cap method.

SSPT (Steady State Probe Topography)

For monitoring activity during dynamic stimulus sequences, such as TV commercials only MEG and SSPT have the necessary temporal resolution. (FMRI and PET do not provide fast enough recording other than for relatively static stimulus presentations.) SSPT measures steady-state visually evoked potentials (SSVEP) and records at the rate of 13 times per second from 64 electrodes in a lightweight skull cap. (Subjects also wear lightweight goggles.)

SSPT cap & goggles

[1] Gabrieli J. D. E. (1998) Cognitive Neuroscience of Human Memory. In: *Annu*
49. Annual Reviews Inc, Palo Alto.
[2] Gabrieli J. D. E. (1998) Cognitive Neuroscience of Human Memory. In: *Annu*
49. Annual Reviews Inc, Palo Alto.