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Magnetic Resonance Imaging (MRI)

Felix Bloch of Stanford University and Edward Purcell of Harvard University get the credit for discovering nuclear magnetic resonance (NMR). It is based on the fact that certain atoms behave like tiny spinning magnets. These images are mostly obtained from the resonance of hydrogen atoms. These atoms gather with respect to the magnetic force when placed in a magnetic field. Although the asymmetry of these atoms make them spin and wobble, the difference of atomic weight make the nuclei of different elements wobble at different frequencies. When radio waves are beamed across the atoms at right angle to the magnetic field, the spinning nuclei wobble synchronously. When the radio waves are turned off the synchrony induces a voltage (magnetic resonance) in the magnetic field. The different wobbling atoms are then located and analyzed by a computer to reconstruct image of the brain. MRI provides opportunity of structurally mapping the brain. Unlike CT scan, these images show the makeup and surroundings of cells.

Psychologists have also shown interest in the study of multiple sclerosis. In multiple sclerosis the immune system malfunctioning attacks the protective myelin cover leading to hard scar in the affected areas. This scar distorts normal conduction of nerve impulses along the axons. Ciccarelli et al (2000) used the MRI images for diagnosing multiple sclerosis and found isolated lesions around the lateral ventricles and in the white matter. Pyhtinen et al. (2006) have highlighted importance of MRI as a diagnostic tool for multiple sclerosis.

Although MRI does not provide information about the functioning of the brain, it does allow one to examine brain structure without exposing the client/ participant to radiation. However, the make-up of the machine is usually uncomfortable to claustrophobics.

MRI has been widely used by researchers to explore brain areas involved in the processing of affective stimuli (Leon-Carrion et al., 2006), near-threshold stimulus processing in the somatosensory system (Wühle et al., 2010), pitch discrimination in the auditory cortex (Brattico et al., 2009), and many other brain-behaviour studies. The conventional MRI scanner has been modified to study the functional brain. There are four main types of fMRI (functional magnetic resonance imaging)- BOLD -fMRI (Blood-Oxygen-Level-Dependent fMRI) which measures regional differences in oxygenated blood, Perfusion fMRI which measures regional cerebral blood flow, Diffusion–weight fMRI which measures random movement of water molecules, and MRI spectroscopy which measures certain cerebral metabolic activities.

Each of these types has their respective importance for psychological studies. BOLD -fMRI is based on differential magnetic properties of deoxy- and oxyhemoglobin. It has high temporal and spatial resolution. As it relies upon coupling of oxygenated blood flow and neuronal activity, it is best suitable for studying cognitive processes with rapid turning on and off property. Processes such as vision, hearing, movement, and memory belong to this category. Consequently it is not suitable for psychological processes that have slow and variable onset and also those that cannot be reversed quickly. Affective processes belong to this category.

Perfusion fMRI uses either intravenous Bolus-Tracking or arterial spin-labeling to measure cerebral blood flow. Intravenous Bolus-Tracking fMRI is based on differential regional cerebral perfusion of the magnetic compound and the coupling of blood flow and neural activities. On the other hand, in the arterial spin-labeling fMRI the hydrogen atoms are magnetically tagged through their course in the blood. It measures absolute blood flow. In Diffusion-weighted fMRI the amount of diffused water for a given pixel is calculated. This is known as Apparent Diffusion Coefficient (ADC). Areas with low ADC value appear more intense compared to those with high value. MRI spectroscopy identifies magnetic compounds by spectrographic peaks. It allows the study of non-water hydrogen containing molecules or molecules containing other magnetic elements.

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The contemporary research outcome in behavioral sciences is full of fMRI based studies. Once again we shall discuss only few of them here. D'Esposito et al. (1997) asked the participants to generate mental images of certain words (such as tree) from memory and recorded fMRI data to find the neural basis of visual imagery. Increased activation was recorded in the left posterior temporal occipital region corresponding to the fusiform gyrus (area 37) while visualizing concrete words. The finding corroborated Farah's hypothesis that in most people the left hemisphere specializes for image generation.

Holloway et al. (2000) used fMRI for imaging neural plasticity. fMRI and somato-sensory evoked potentials (SEPs) were recorded in hemisherectomy patients and normal participants. When the nerves of the limb opposite to the removed hemisphere were stimulated few patients showed SEPs in the normal hemisphere. A passive movement of the right hand was traced to the left sensorimotor cortex whereas passive movement of the left (hemiplegic) hand showed an abnormal ipsilateral pathway. The findings indicated injury induced reorganization in the brain, thus exhibiting neural plasticity.

Dierks et al. (1999) attempted imaging auditory hallucination in paranoid schizophrenia patients. Only those patients were included whose hallucinations could be monitored within one fMRI session. The images revealed that verbal hallucinations were rooted in the patients' inner language systems as the primary auditory cortex, Broca's area, and the speech zone in the posterior temporal cortex in the left hemisphere were activated. The researchers held that the activation of the auditory cortex guide the discernment that the sound is coming from an external source.

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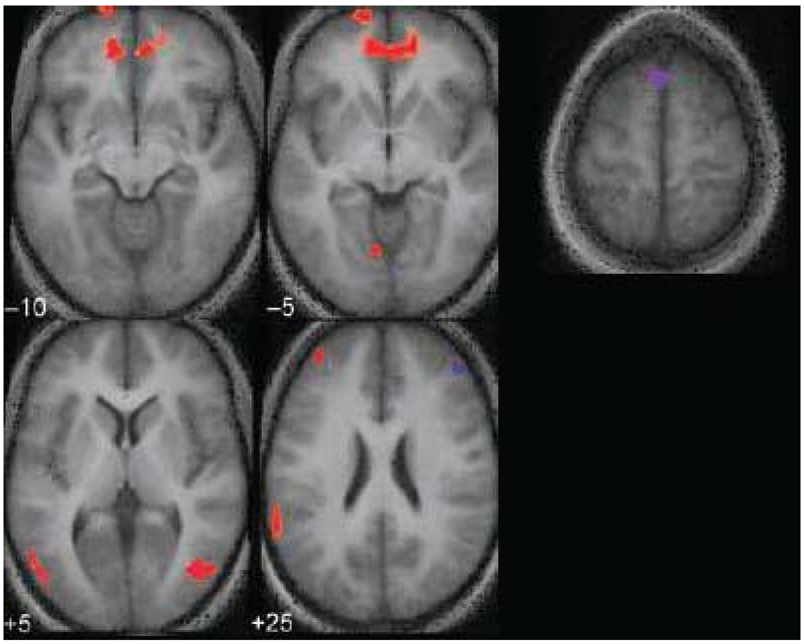
Module 2:Methods for understanding human psychophysiological activity

Lecture 11:Magnetic resonance imaging (MRI)

Functional imaging has been used by several researchers to find the locus of activation for a variety of psychological functions. For example, studies attempting frontal-lobe function have found activation in the dorsalateral area for self-ordering (Petrides, 2000), orbitofrontal area for encoding visual information (Frey & Petrides, 2000) and encoding unpleasant auditory information (Frey et al., 2000), inferior prefrontal area for f acial expression or recognition or both (Idaka et al., 2001), and medial and ventrolateral areas for a utobiographic memory (Svoboda et al., 2006). Given below are the fMRI images from a study by Borg et al. (2006). In this study fMRI was used to map the brain during moral judgment tasks. The red regions were activated more in moral scenarios whereas regions in blue were activated more in nonmoral scenarios.



fMRI images from Borg et al's (2006) study

The advantage of fMRI over PET is its better resolution besides being extremely sensitive to blood flow changes. This allows detection of even small changes in the brain and is therefore used by many researchers in the area of human behaviour.

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