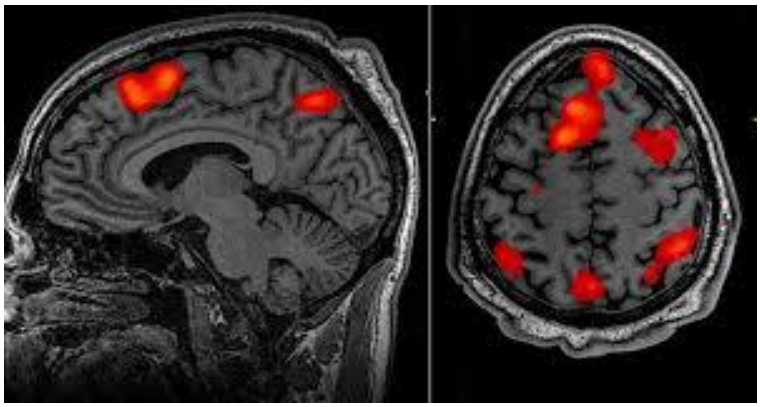
KREP 2025

KARNATAKA RADIOLOGY EDUCATION PROGRAM X

Functional MRI

Functional magnetic resonance imaging (fMRI) tracks brain function by detecting fluctuations related to blood flow. This technique operates on the idea that blood circulation in the brain is closely tied to neural activity. As a particular brain region becomes engaged, the blood supply to that area increases in response. fMRI is a non-invasive magnetic resonance method used to identify or locate brain regions involved in specific tasks. The patient is instructed to carry out a particular action, such as finger-thumb movement, while a T2*-weighted EPI sequence is conducted. The brain regions responsible for the action, like the sensory or motor cortex, will show an increase in signal intensity.

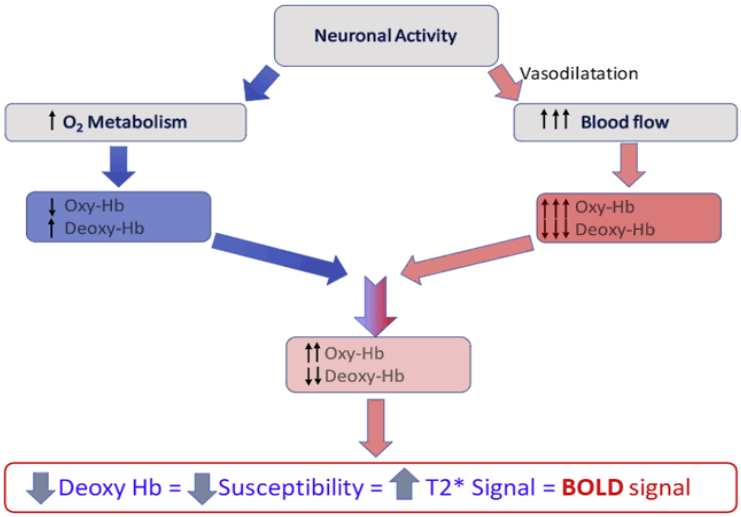


Functional magnetic resonance imaging (fMRI) is a method used to obtain functional data by visualizing cortical activity. It detects slight changes in blood flow as a response to stimuli or actions. fMRI is applied in two main areas:

1. **Clinical practice**
    - **Primarily used in presurgical patients**
    - **Aimed at identifying the eloquent cortex (such as areas responsible for speech and motor function)**
2. **Research**
    - **Often conducted on cohorts of patients, frequently healthy individuals**
    - **Focuses on uncovering novel neural networks**

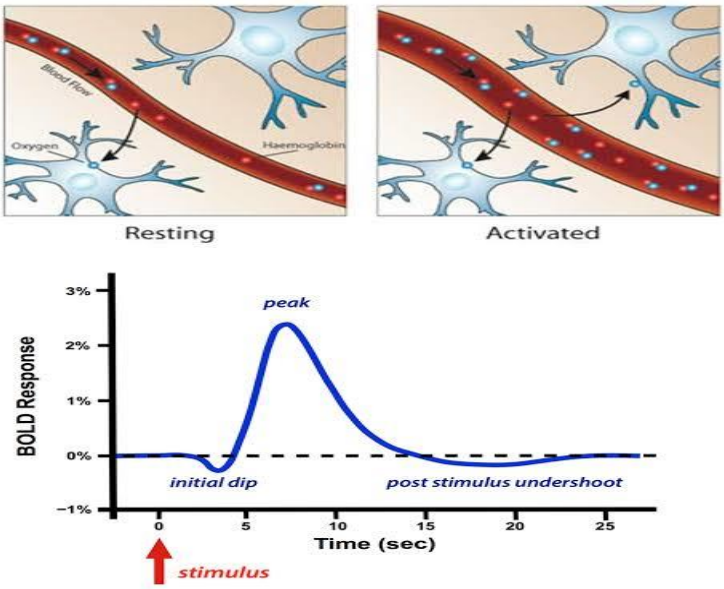
Principle behind fMRI

fMRI operates on the principle of Blood Oxygen Level-Dependent (BOLD) imaging. Deoxyhemoglobin is paramagnetic, whereas oxyhemoglobin is diamagnetic compared to surrounding tissues. The presence of deoxyhemoglobin leads to small variations in the magnetic field around the microvasculature, causing a signal decrease in T2 or T2*-weighted images.



Technique used in fMRI

When a specific brain region is activated by a task, blood flow to that area increases. This rise in blood flow exceeds the metabolic demand, resulting in a higher concentration of oxyhemoglobin and a lower amount of deoxyhemoglobin in the region. As a result, there is an increase in signal from the reduced deoxyhemoglobin. fMRI uses various paradigms or tasks to stimulate different brain areas. Active paradigms can involve motor, language, and cognitive tasks.



Technical Requirements for fMRI:

1. **1.5 T or higher field strength MRI**
2. **Excellent quality assurance**
3. **Appropriate software**
4. **Appropriate paradigms and ability to deliver visual and auditory stimuli, and record motor responses**
5. **Cooperative patients**

Study Design in fMRI

Two primary testing designs are commonly used in fMRI studies:

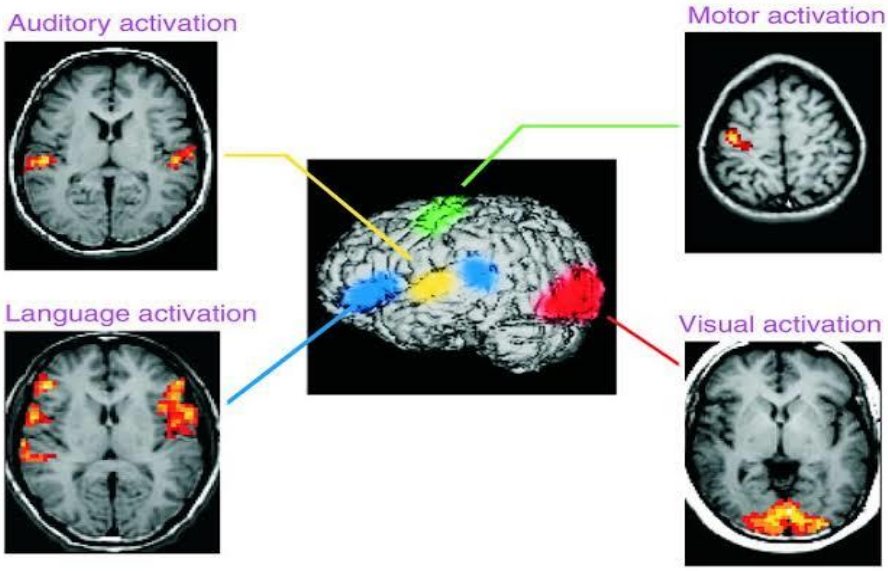
1. **Block Design**
    - **This design involves alternating periods of activity (paradigms) with periods of inactivity or alternative activity. It is the most frequently used design in clinical fMRI studies, as it allows for clear differentiation of brain activity during the task versus rest or other activities.**
2. **Event-Related Design**
    - **This design focuses on individual events rather than blocks. The events can be randomly distributed throughout the study, providing flexibility in the timing and presentation of stimuli. This design is particularly useful for studying specific, brief responses to stimuli or actions**

Paradigms in fMRI

A *paradigm* refers to the specific activity performed or stimulus presented to the patient, designed to provoke a particular cortical response. Various paradigms of different complexities have been developed. In clinical settings, four primary paradigms are typically sufficient for most indications, with modifications made according to the clinical situation:

1. **Visual Paradigm**
    - **Involves stimuli such as flashing lights, images, or patterns, aimed at activating the visual cortex.**
2. **Motor Paradigm**
    - **Includes tasks like hand movements, finger tapping, or leg motions to engage motor areas of the brain.**
3. **Speech Paradigm**
    - **Involves tasks such as speaking or listening to speech stimuli to activate language-related areas, particularly in the left hemisphere.**

4. **Memory Paradigm**
    - **Engages brain regions associated with memory by asking patients to recall words, objects, or perform tasks that involve memory retrieval.**



Clinical Applications of fMRI

In addition to ongoing research focused on understanding brain function and psychiatric disorders, fMRI has several clinical applications, including:

1. **Mapping the eloquent cortex in cases of intracranial tumors, seizure foci, and other lesions to assess surgical risk and determine the best surgical approach.**
2. **Estimating the risk of postoperative deficits; for example, if a functional area is more than 2 cm away from a tumor or lesion to be removed, the patient is less likely to experience postoperative deficits.**
3. **Determining hemispheric dominance for language.**

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