Module 10: Approaches in Neuroimaging

Arnold Bakker
Department of Psychiatry and Behavioral Sciences
Division of Psychiatric Neuroimaging
Johns Hopkins University School of Medicine

Approaches in Neuroimaging

Neuroimaging uses various techniques to directly or indirectly image the central nervous system

Categories:

- Structural imaging (anatomy, pathology or injury)
- Functional imaging (metabolic, pharmacologic or cognitive)

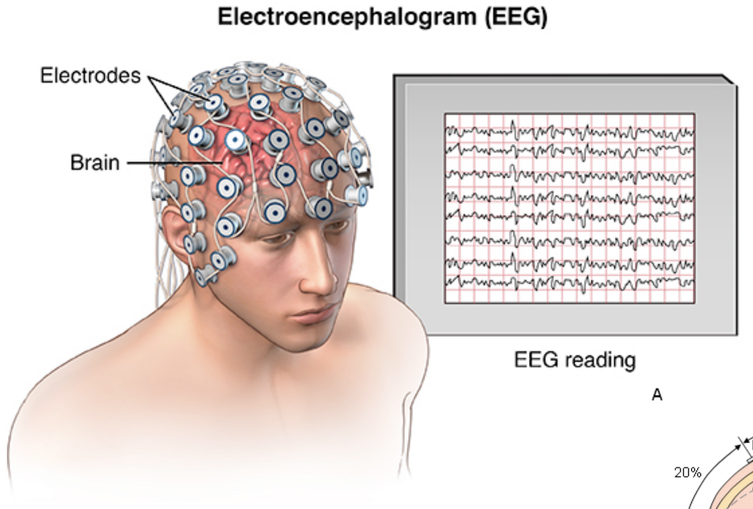
Techniques:

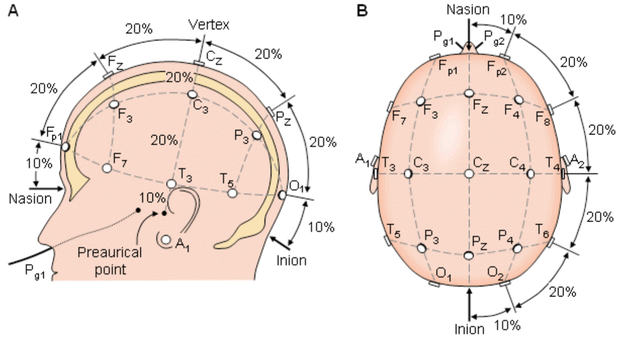
- Electroencephalography (EEG)
- Computed axial tomography (CT)
- Single-photon emission computed tomography (SPECT)
- Positron emission tomography (PET)
- Magnetic resonance imaging (MRI)
- Functional magnetic resonance imaging (fMRI)
- Diffusion Tensor imaging
- Spectroscopy imaging

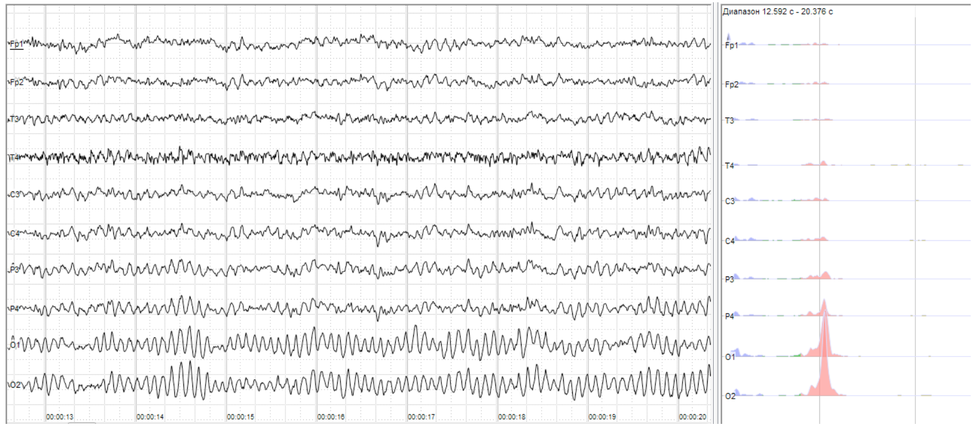
Electroencephalography

Electroencephalography

- Measures electrical activity in the brain through electrodes placed on the scalp
- Measure activity at rest or during presentation of a stimulus
- Assess localized brain response or brain networks through temporal and spatial correlations



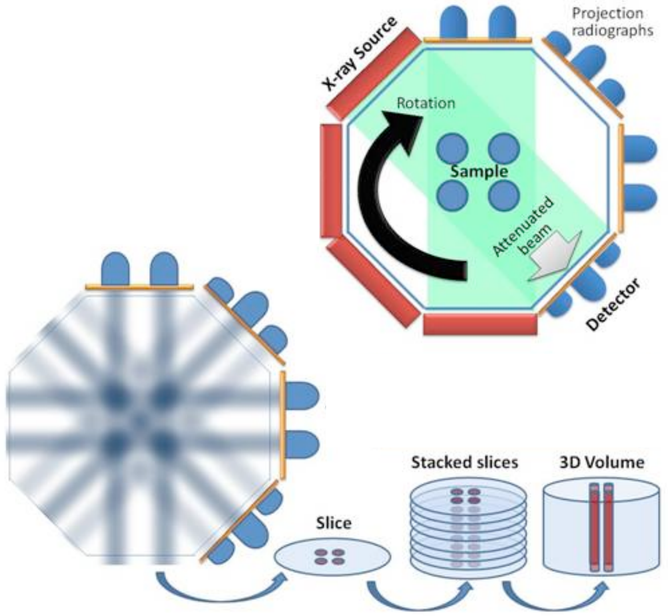


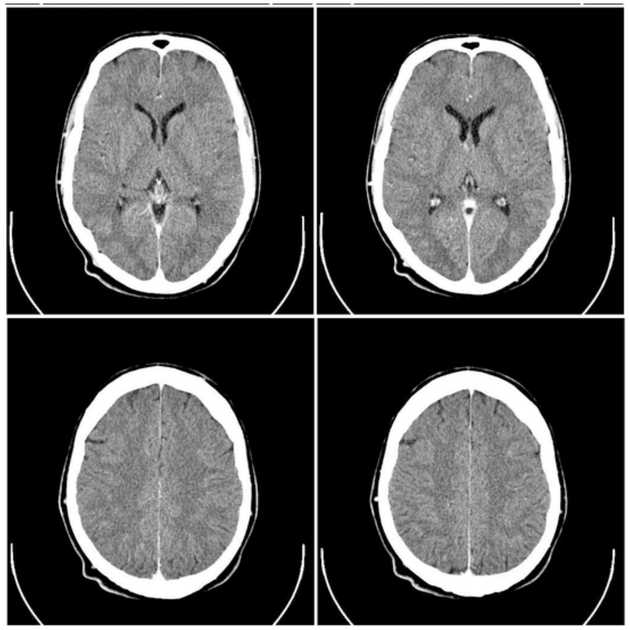


Computed Axial Tomography

Computed Axial Tomography

- Series of x-rays
- Measures amount of x-ray absorption
- Series of cross sections or reconstructed to a 3D volume
- Fast, widely available but involves moderate radiation

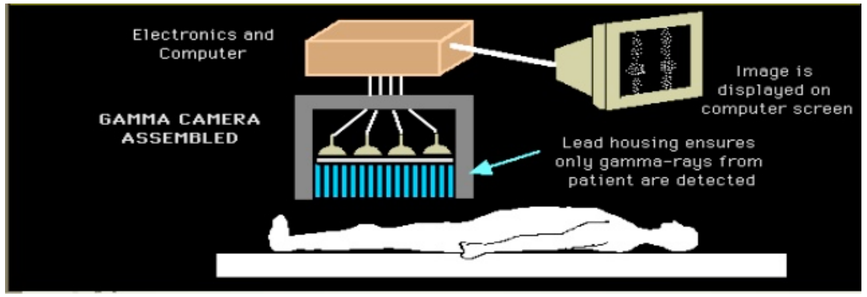


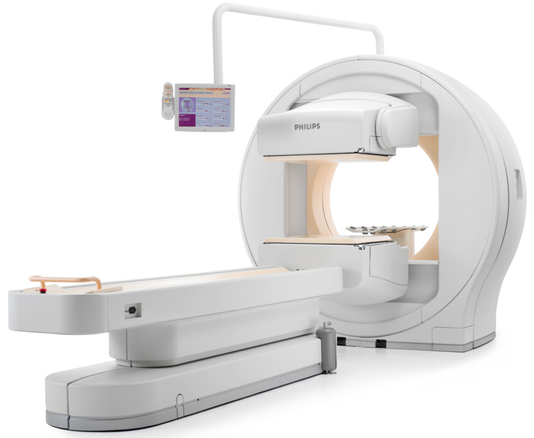


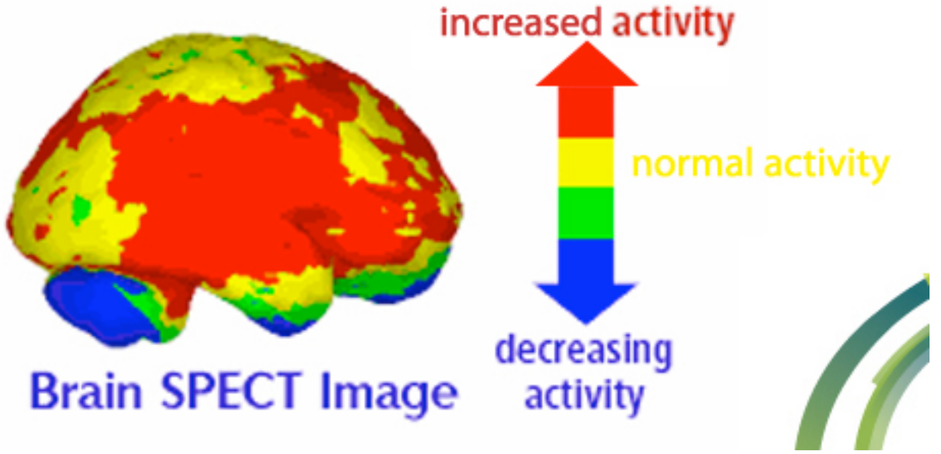
Single Photon Emission Tomography

Single Photon Emission Computed Tomography

- Nuclear imaging technique
- Uses a gamma emitting tracer injected intravenously
- Either as soluble ion or attached to a ligand
- Measures gamma rays in a series of 2D images from multiple angles



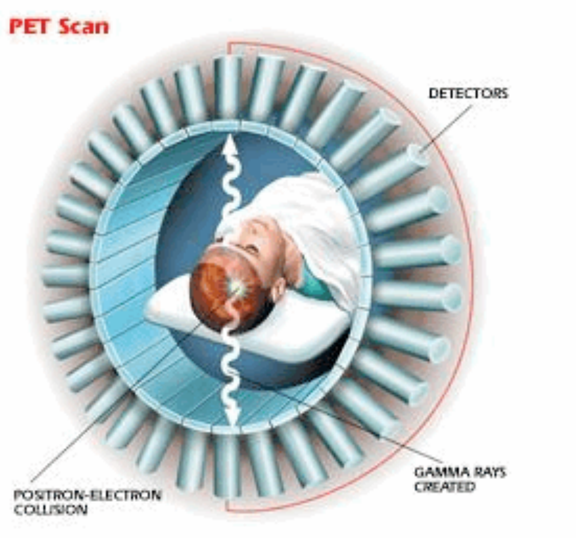


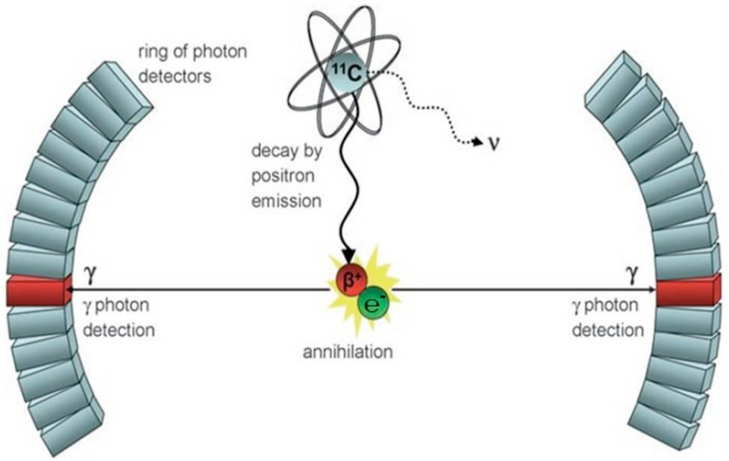


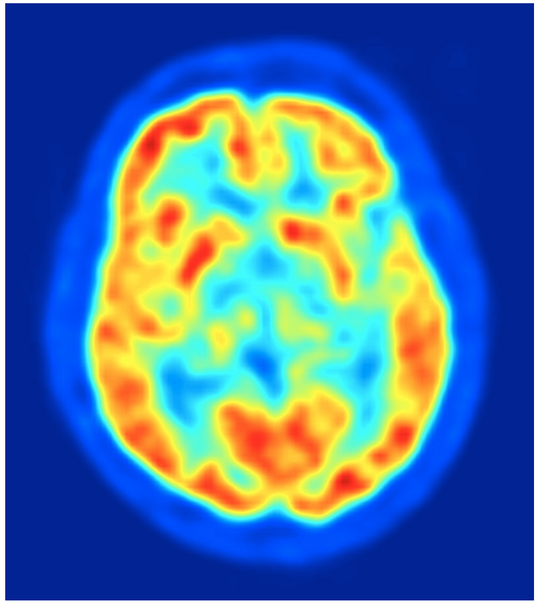
Positron Emission Tomography

Positron Emission Tomography

- Nuclear imaging technique
- Uses a positron emitting radionuclide attached to a biologically active molecule
- Scanner detects pairs of gamma rays emitted to construct 3D image
- Generates image of active molecule binding



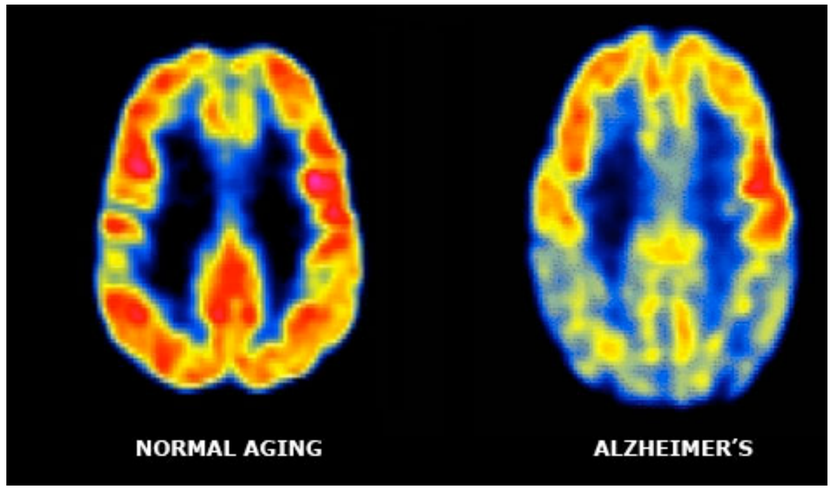


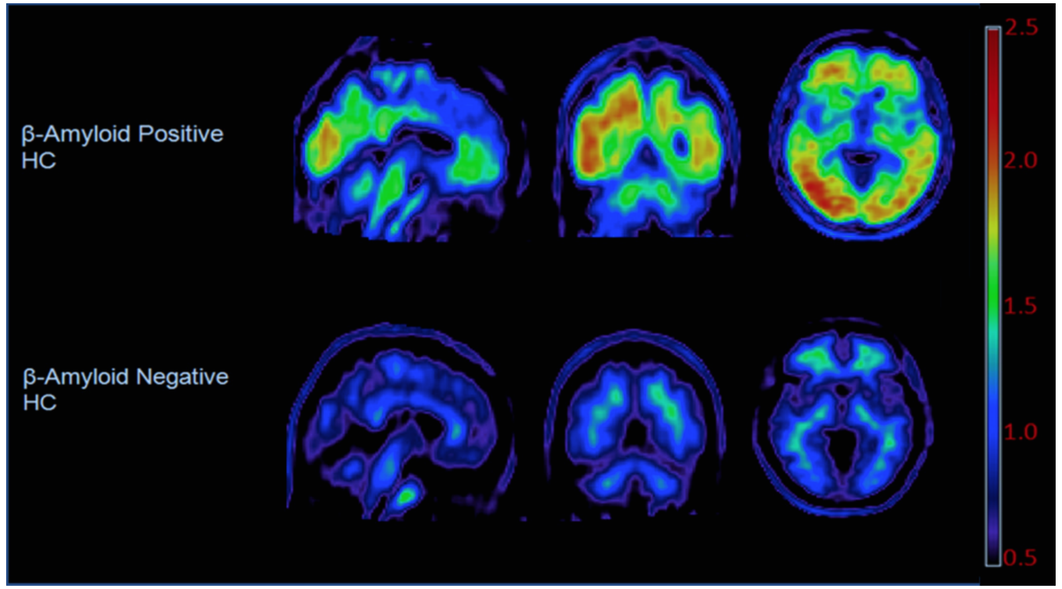


Positron Emission Tomography

Positron Emission Tomography

- Flurodeoxyglucose (FDG-PET) is a marker for uptake of glucose (tumors, Alzheimer's disease
- Florbetapir F18 (18F-AV-45 PET) is a marker for beta amyloid accumulation (Alzheimer's disease)
- [11c]PBB3 Tau is a marker for Tau accumulation (Alzheimer's disease)

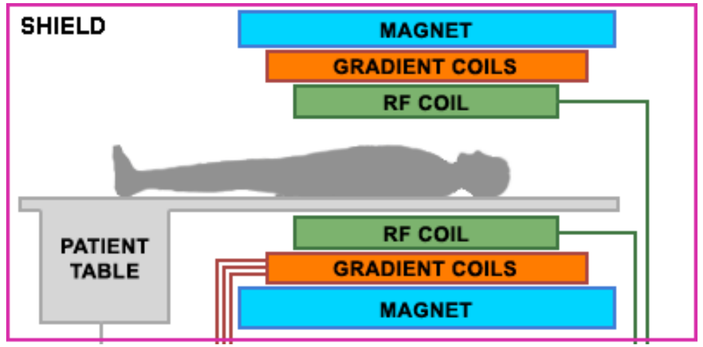




Magnetic Resonance Imaging

Magnetic Resonance Imaging

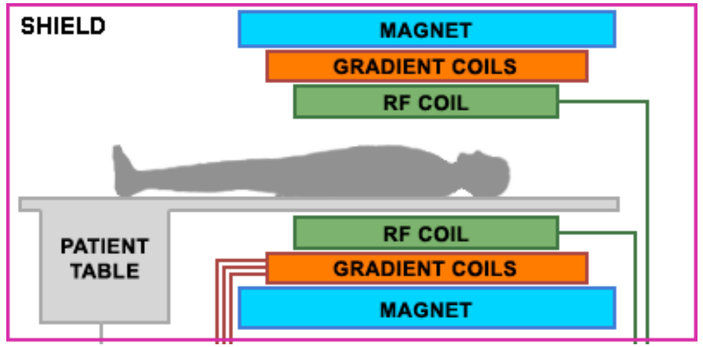
- Nuclear imaging technique
- Uses static and variable magnetic fields to perturb hydrogen atoms
- Resulting magnetic resonance is measured by radio frequency receivers
- Different pulse sequences can be used to generate different contrasts between tissue types



Magnetic Resonance Imaging

Magnetic Resonance Imaging

- Magnetic field is very strong
- Dangerous to have any metallic objects in the vicinity
- No radiation and no known side effects
- High resolution possible. Good temporal resolution



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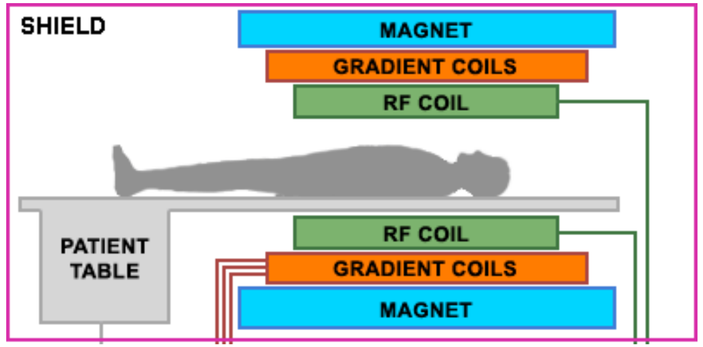
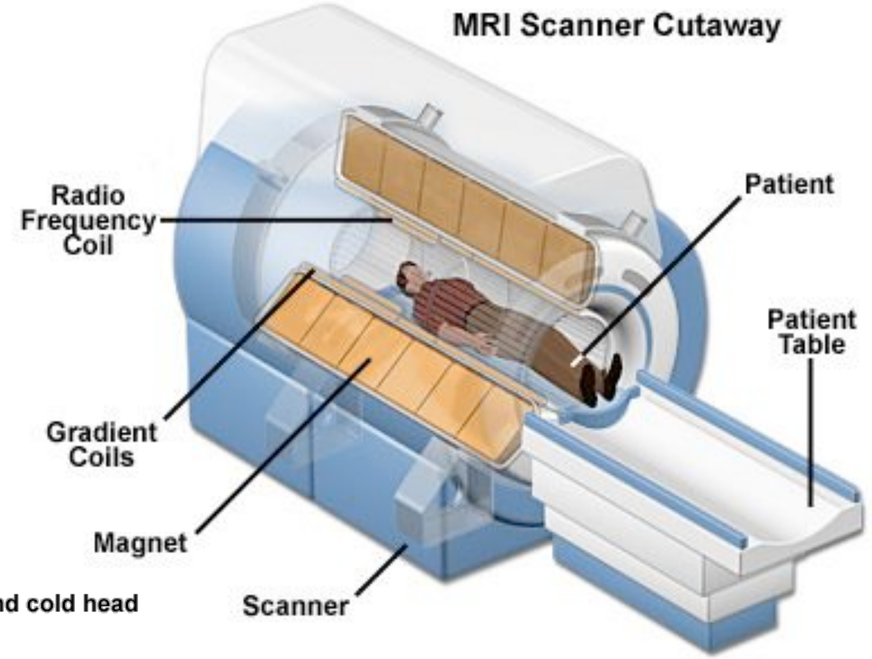
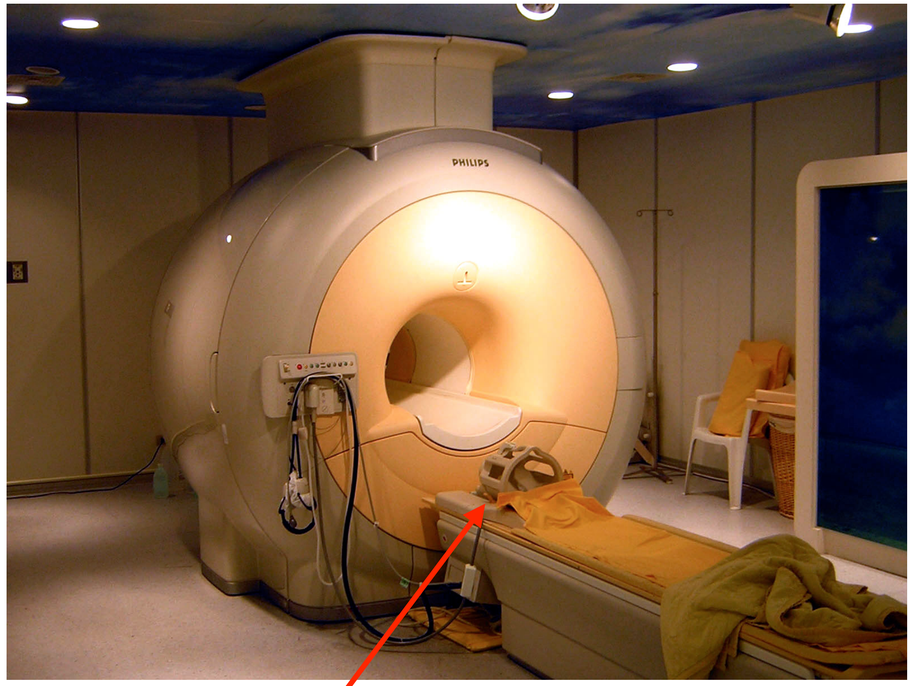
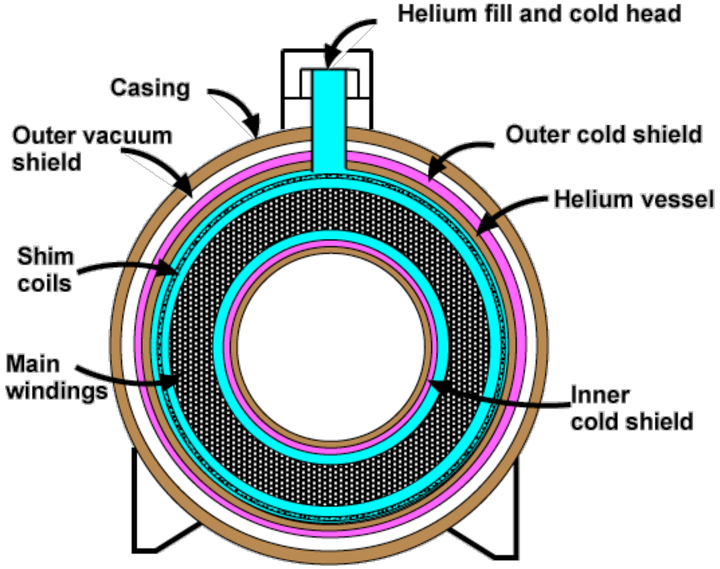
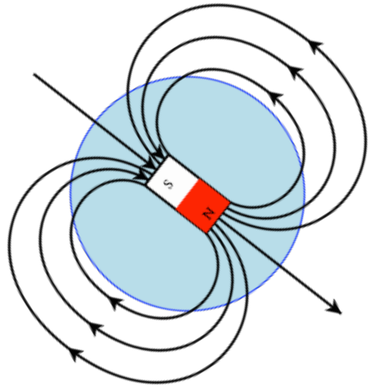


Magnetic Resonance Imaging





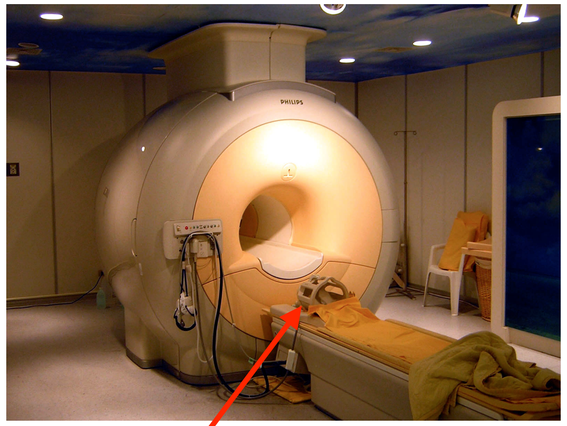


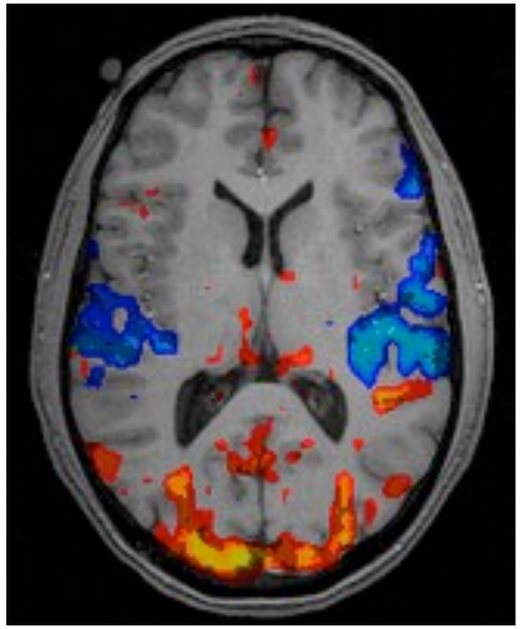


Functional Magnetic Resonance Imaging

Magnetic Resonance Imaging

- Refined application of Magnetic Resonance Imaging
- Magnetic resonance from oxygenated versus non-oxygenated blood is measured
- Used to assess localized brain function

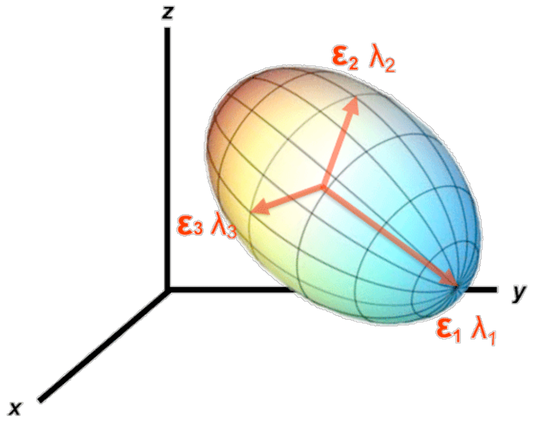


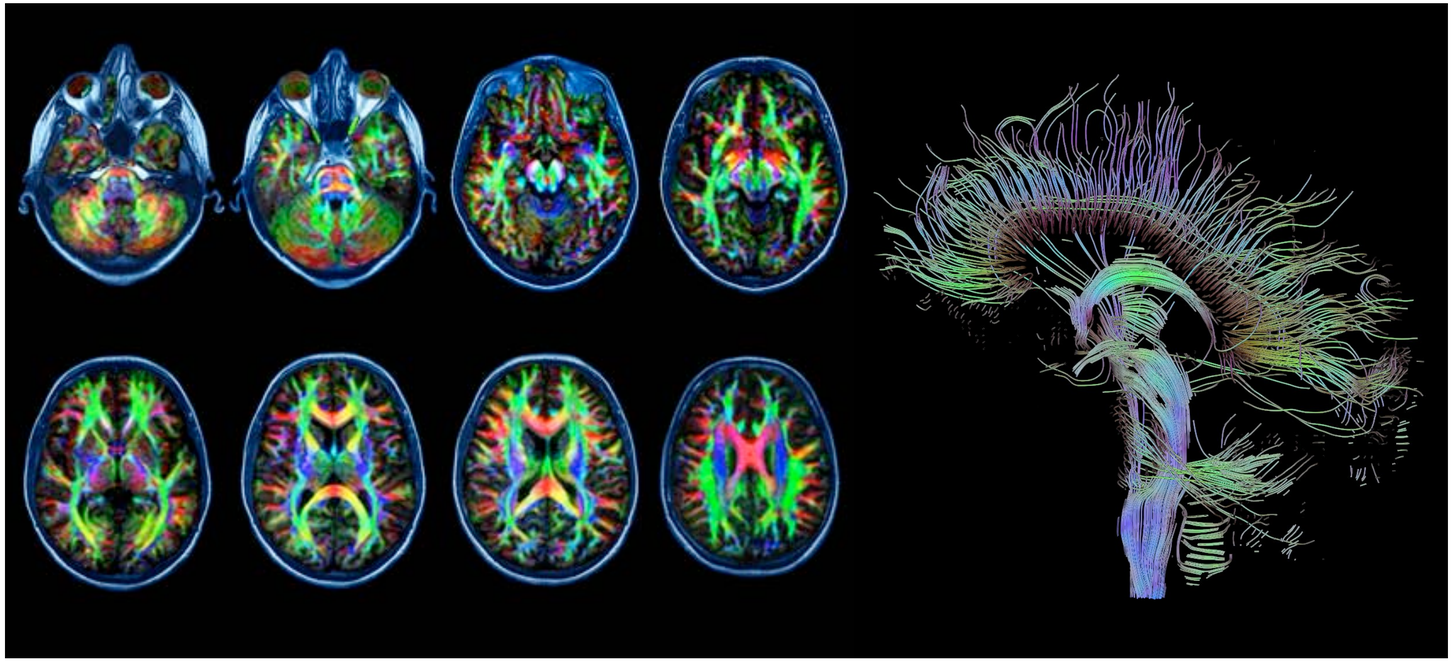


Diffusion Tensor Imaging

Diffusion Tensor Imaging

- Refined application of Magnetic Resonance Imaging
- Measures directionality of water molecules to generate image
- Used to assess fiber projections and white matter integrity

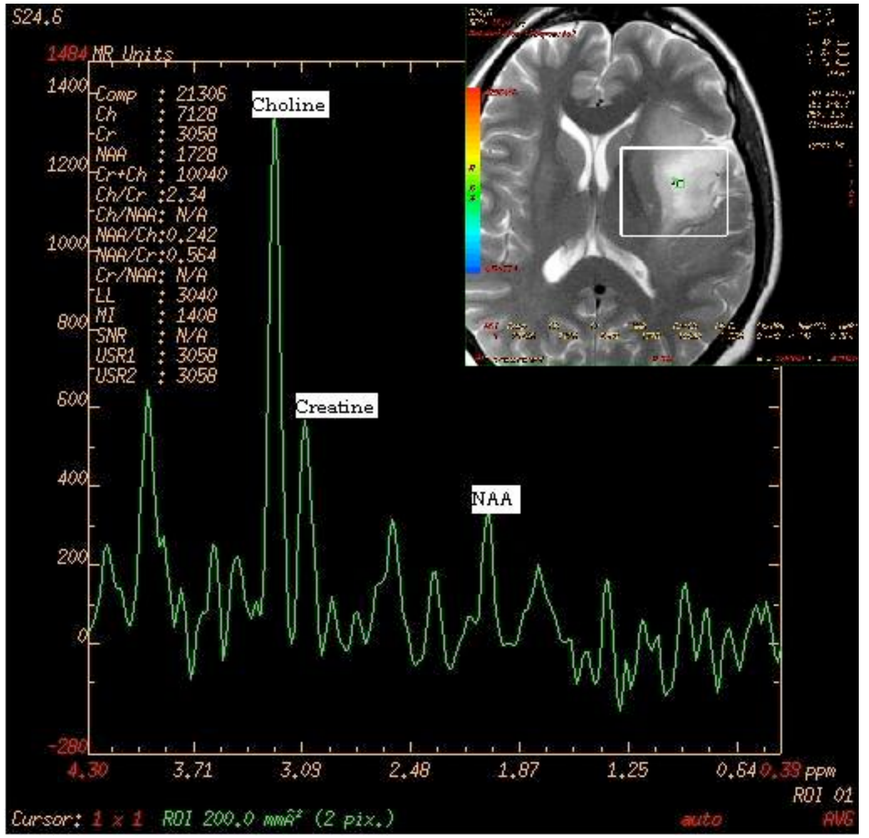




Spectroscopy Imaging

Spectroscopy Imaging

- Refined application of Magnetic Resonance Imaging
- Measures magnetic signatures of various metabolites in the brain
- Creates a frequency distribution of metabolites for a defined location



Observable Proton Metabolites

ppm	Metabolite	Properties
0.9-1.4	Lipids	Products of brain destruction
1.3	Lactate	Product of anaerobic glycolysis
2.0	NAA	Neuronal marker
2.2-2.4	Glutamine/GABA	Neurotransmitters
3.0	Creatine	Energy metabolism
3.2	Choline	Cell membrane marker
3.5	*myo*-inositol	Glial cell marker, osmolyte hormone receptor mechanisms