Applications of CT and MR

KAIST Research Group of Future Emerging Technology on Medical Imaging

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CNI & CGV

Cognitive Neuroscience and Neuroimaging

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Computer Graphics and Visualization

CT Imaging

- Using the principle of X-ray imaging, CT scan forms several slices to construct 3D image
- CT scans can show
  - Bones tissues
  - Muscles
  - Blood vessels

CT Imaging - pros

- Widely available: can show many parts listed before
- Quick procedure: around 30 seconds
- Cheap: KRW 50,000 ~ 100,000 (medical insurance available!)
- Has strong point on angiography and bone imaging

CT Imaging - cons

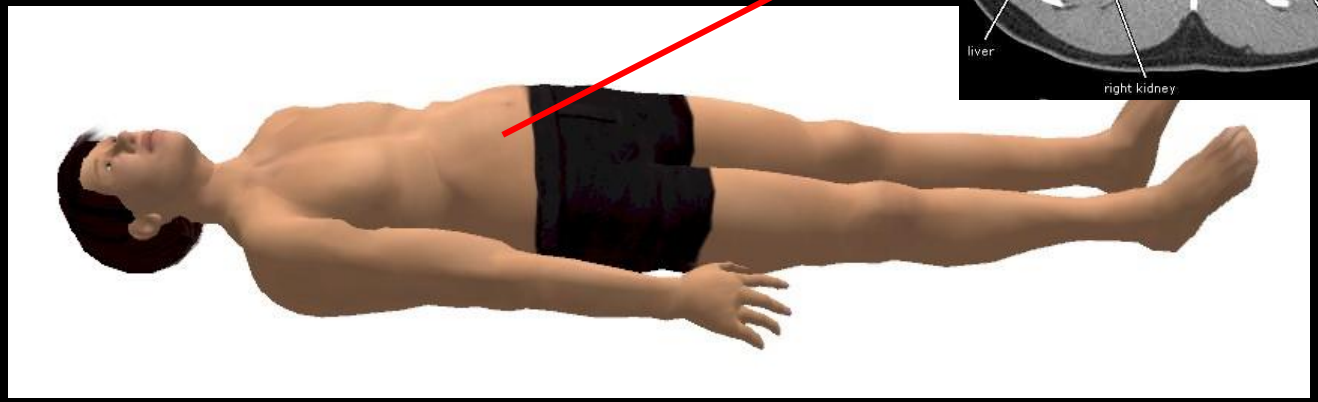
- Radiation dose
  - 0.001mSv (X-ray Extremity) to 25mSv (PET/CT)
- Allergic reaction to contrast material
- Metal artifacts

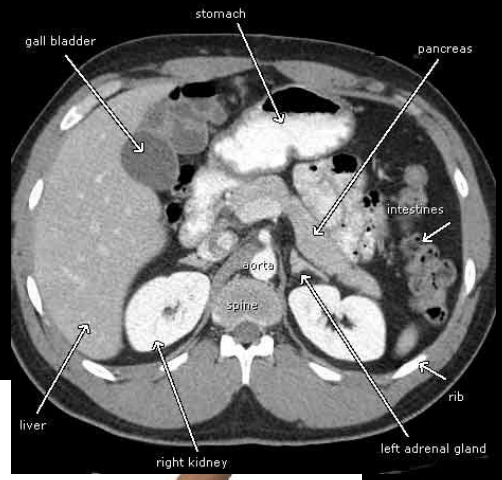
CT Imaging

- How can we use these principles in better way?
  - Weight-bearing CT
  - Dual Energy CT

Weight-bearing CT

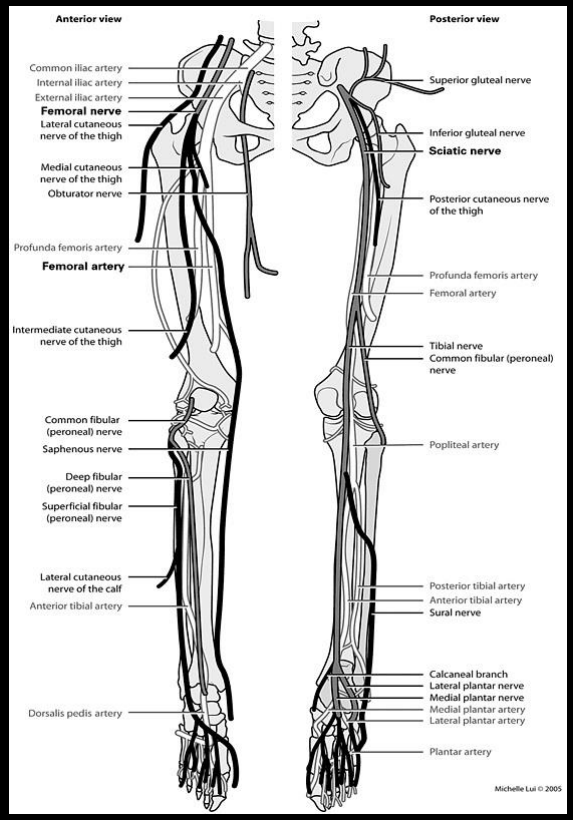
- Normal CT scans
  - Supine position





Weight-bearing CT

- Lower extremities
  - Most of the “weight-bearing” joints are placed
  - Weight-bearing situation
    - Bone shape does not change
    - Cartilages are compressed
    - Overall pose changes



Weight-bearing CT

- Foot-ankle CT
  - Foot-ankle joint: has very complex structure

supine CT 영상자료

Supine CT

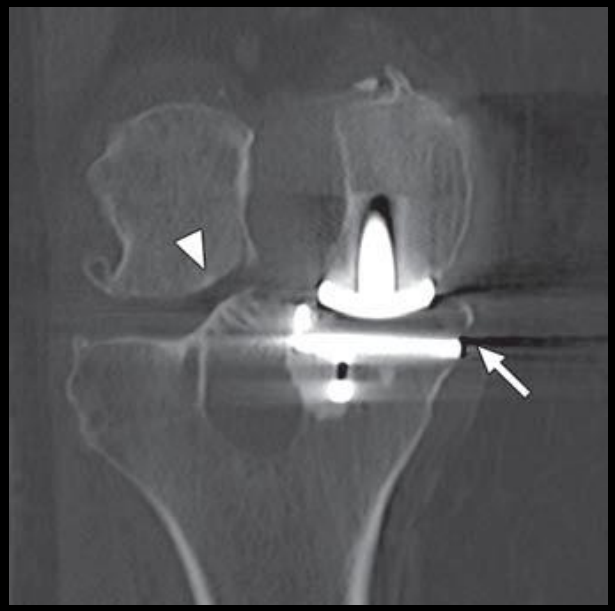
Standing X-ray

Weight-bearing CT

- CT scan in standing position
  - simple, but effective idea
  - no additional radiation dose
  - has many clinical applications

Weight-bearing CT

- Knee



Supine CT

Weight-bearing CT

Weight-bearing CT

- Ankle

Supine CT

Weight-bearing CT

Weight-bearing CT

- Lisfranc joint

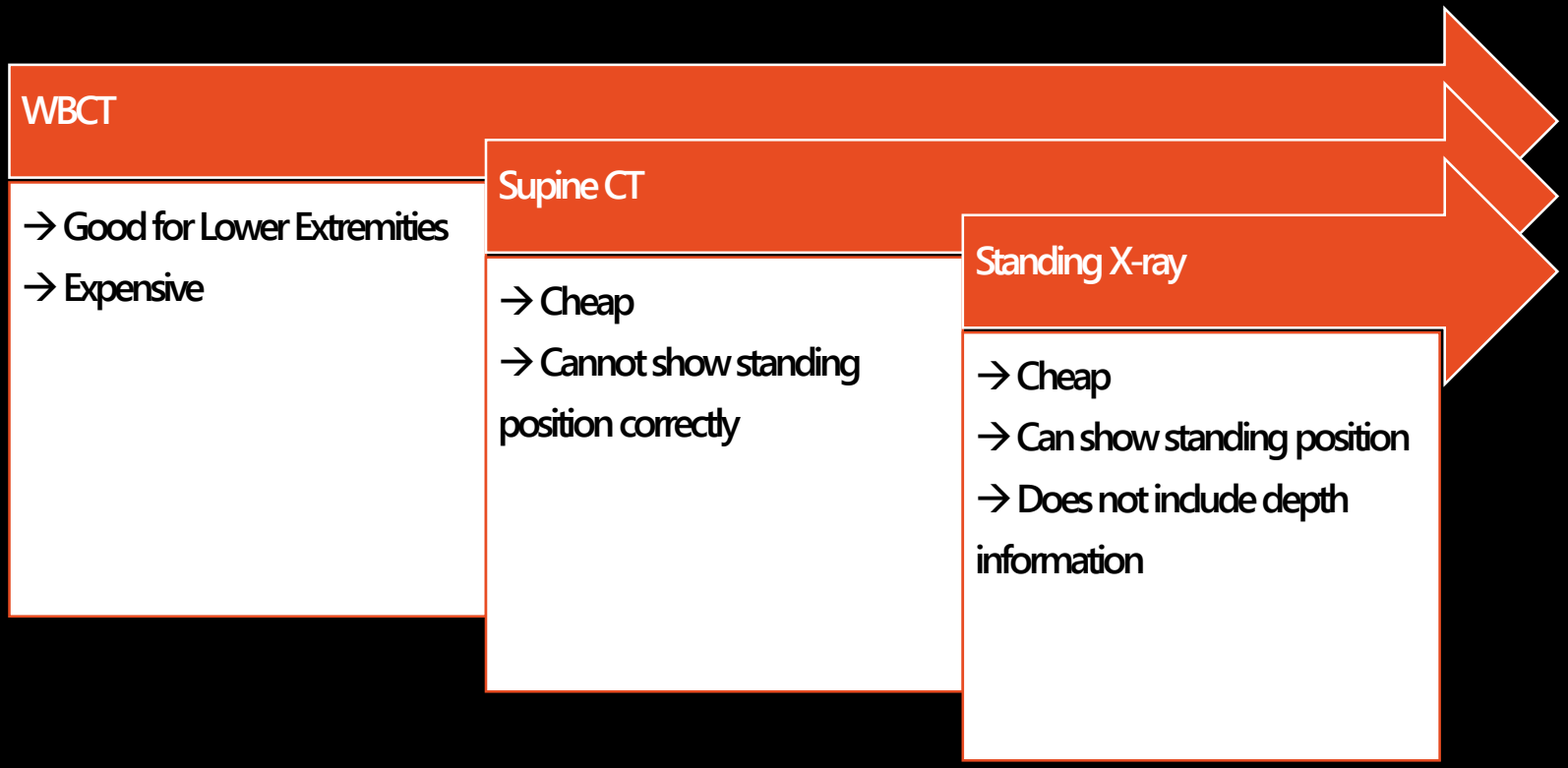
Supine CT

Weight-bearing CT

Weight-bearing CT

- Limitations
  - Instrument is expensive
  - Some patients can’t even stand

Weight-bearing CT in CS



Weight-bearing CT in CS

supine CT 영상자료

Simulates 3D WBCT

Weight-bearing CT in CS

CT 3D modelling 자료

- Measurement
  - Bone angle
  - Distance
  - etc
- Diagnosis

Better to deal with SW

Dual Energy CT

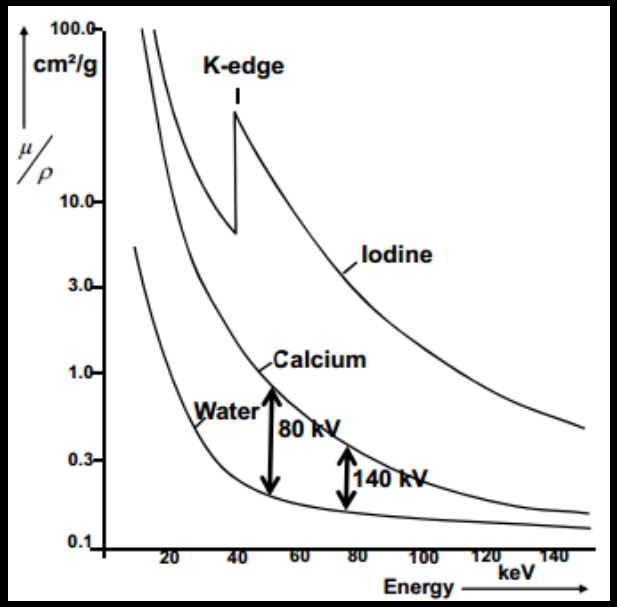
- Dual Energy Computed Tomography (DECT)
  - Exploit different mass attenuation coefficients of different materials as a function of energy

- Take 2 CT images at once
  - With additional tissue parameters
  - Not spectroscopic features

Recent product of Siemens

Dual Energy CT

- Mass attenuation coefficients: Coefficients as a function of energy

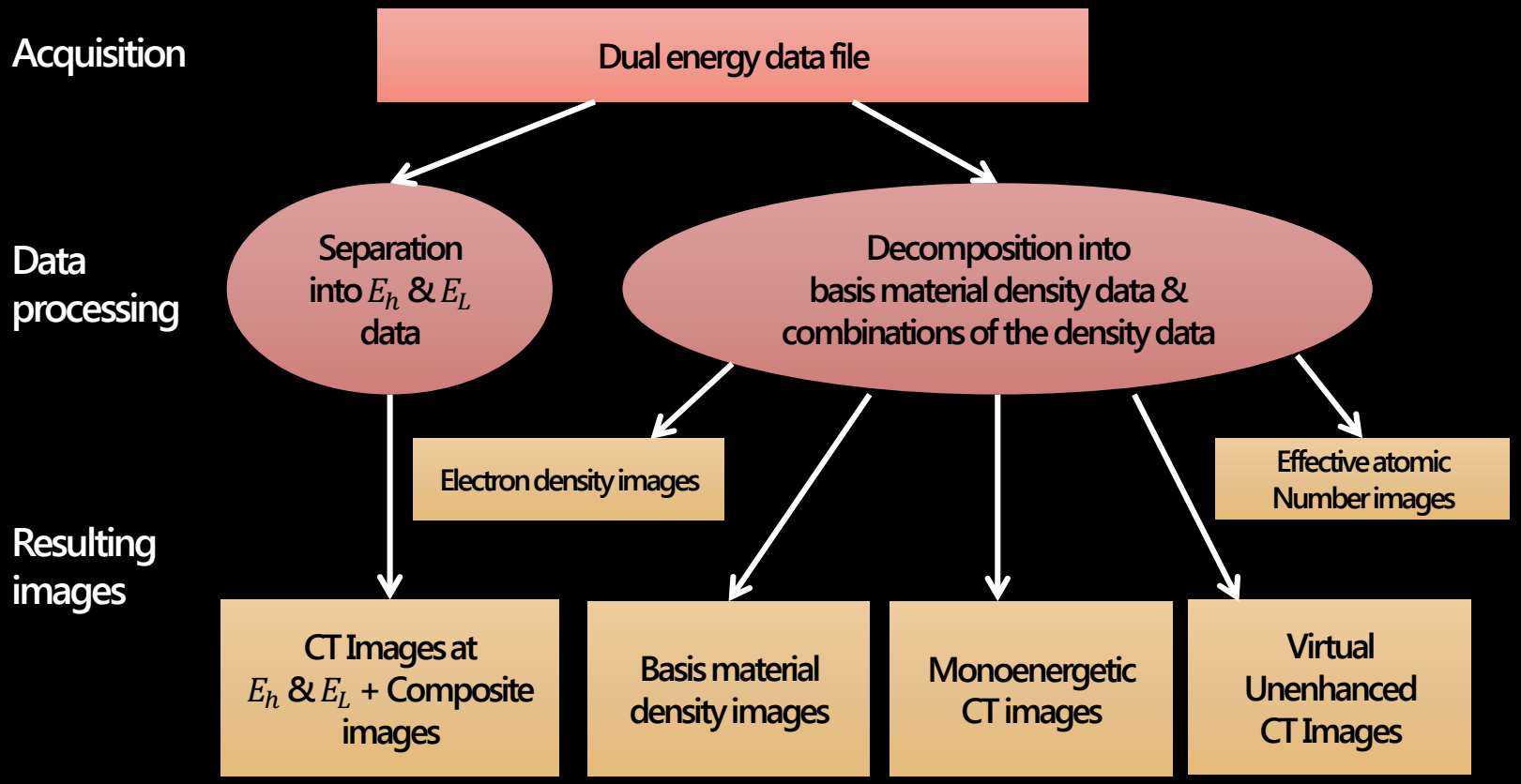


Energy	Mass attenuation coefficient		
keV	cm^2/g		
	Water	Calcium	Iodine
30	0.371	3.971	8.45
40	0.267	1.804	22.10
60	0.205	0.651	7.55
80	0.183	0.361	3.49
100	0.171	0.254	1.94
150	0.150	0.167	0.71

Dual Energy CT – basics

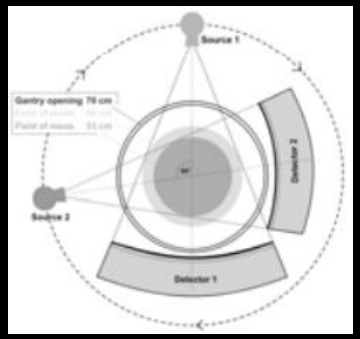
- Energy subtraction
  - A weighted subtraction of images taken at two different energies
- Basic material decomposition
  - Decomposition of the measured data or images into contributions due to the two so-called "basis materials"

Dual Energy CT – pipeline

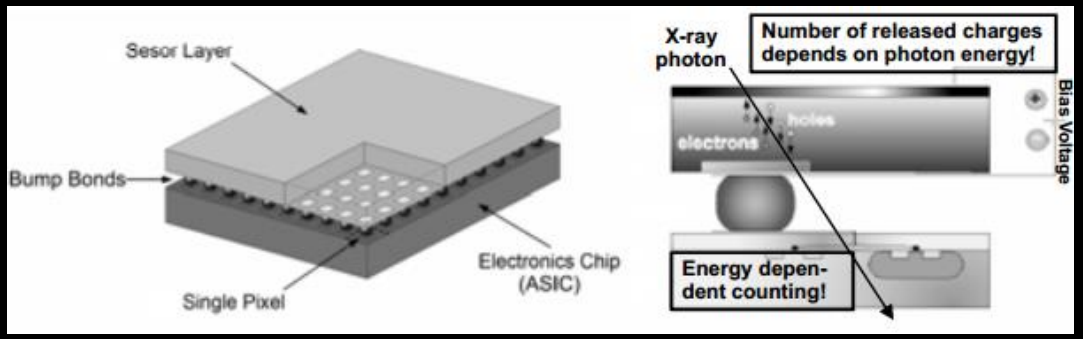


Dual Energy CT – History

- 1970s: Two separate scans
- 1980s: Rapid kV-switching
- 1990s: Novel detectors
- 2000s: Dual source CT
- 2010s: Spectral CT



Dual source CT



Spectral CT

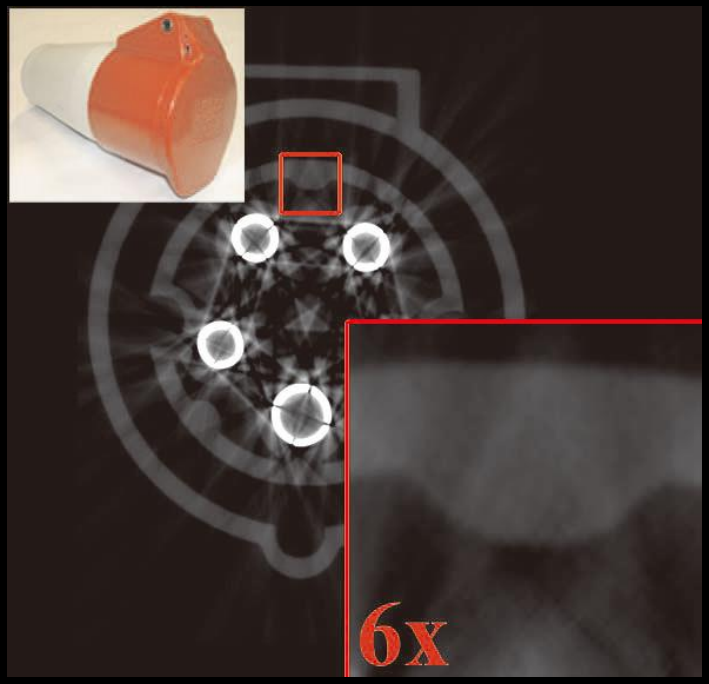
Dual Energy CT – applications

- Direct Bone Removal

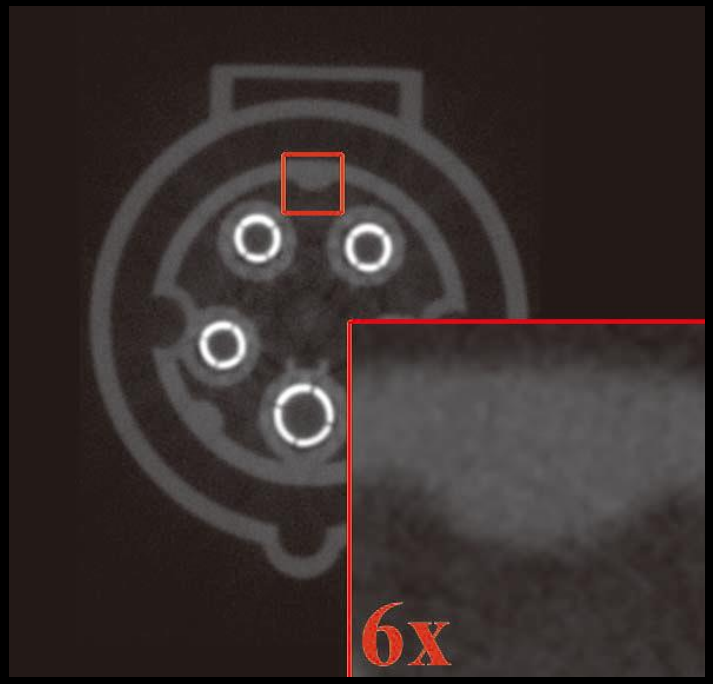
Dual Energy CT – applications

- Distinguish different kinds of tissues automatically

Dual Energy CT in CS

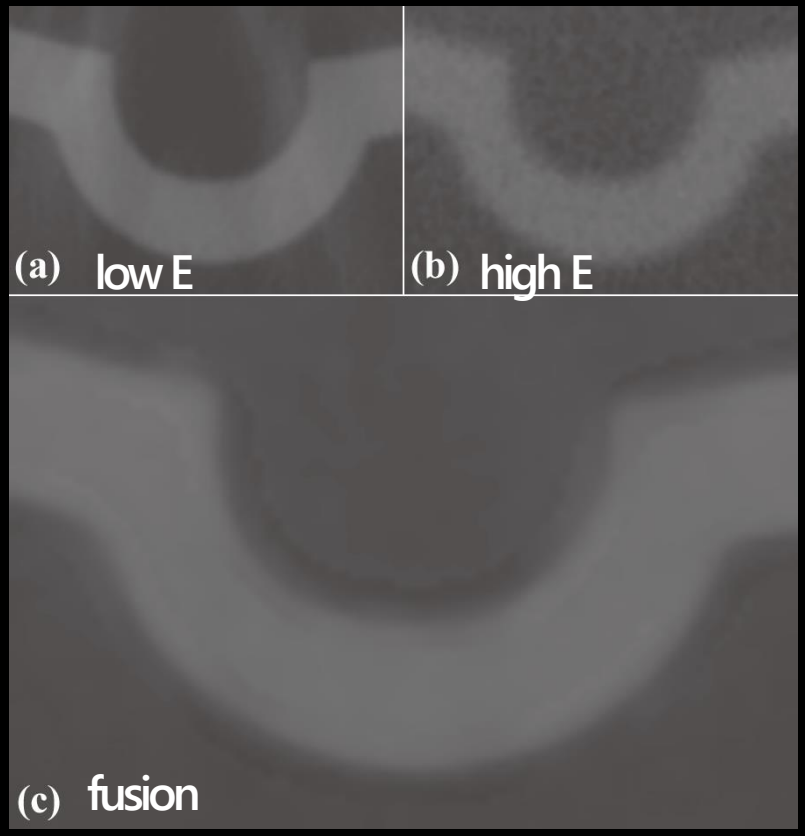


Low Energy CT

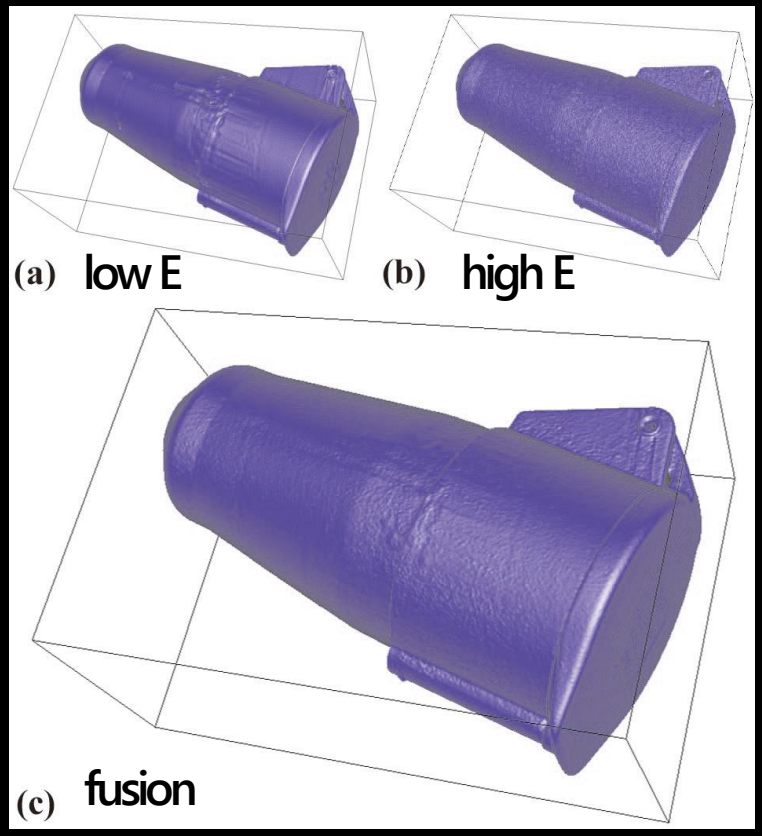


High Energy CT

Dual Energy CT in CS

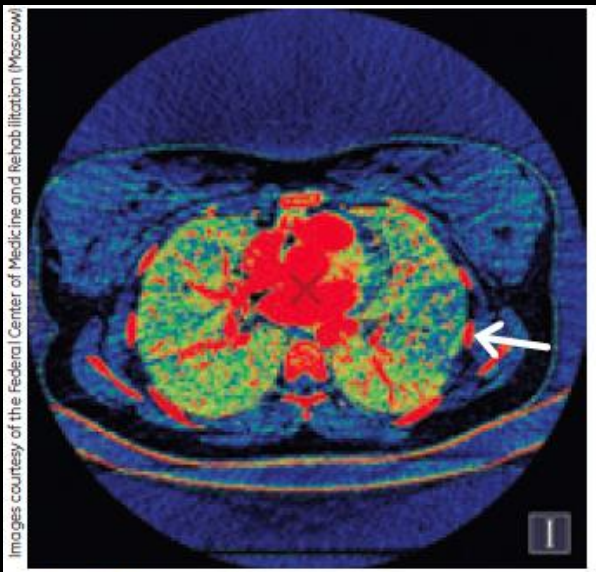


Removing artifacts



Surface reconstruction

Dual Energy CT in CS



Images courtesy of the Federal Center of Medicine and Rehabilitation (Moscow)

Figure 1A. A GSI iodine map depicts a wedge-shaped perfusion defect in the 9th segment of the left lung.

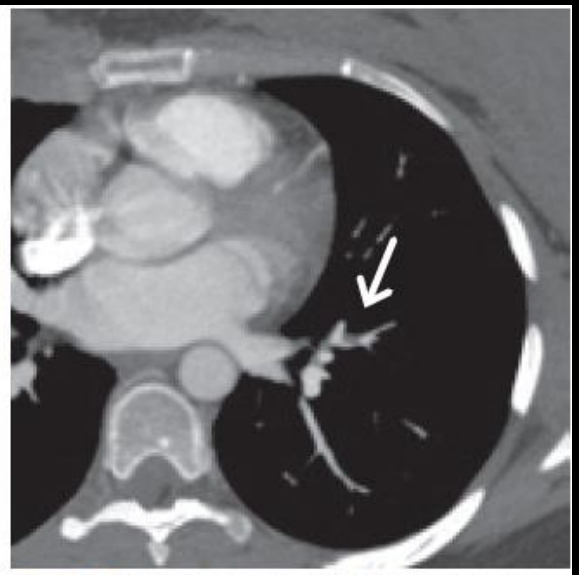


Figure 1B. A small embolus inside the corresponding segmental branch of the left pulmonary artery can be seen with GSI.

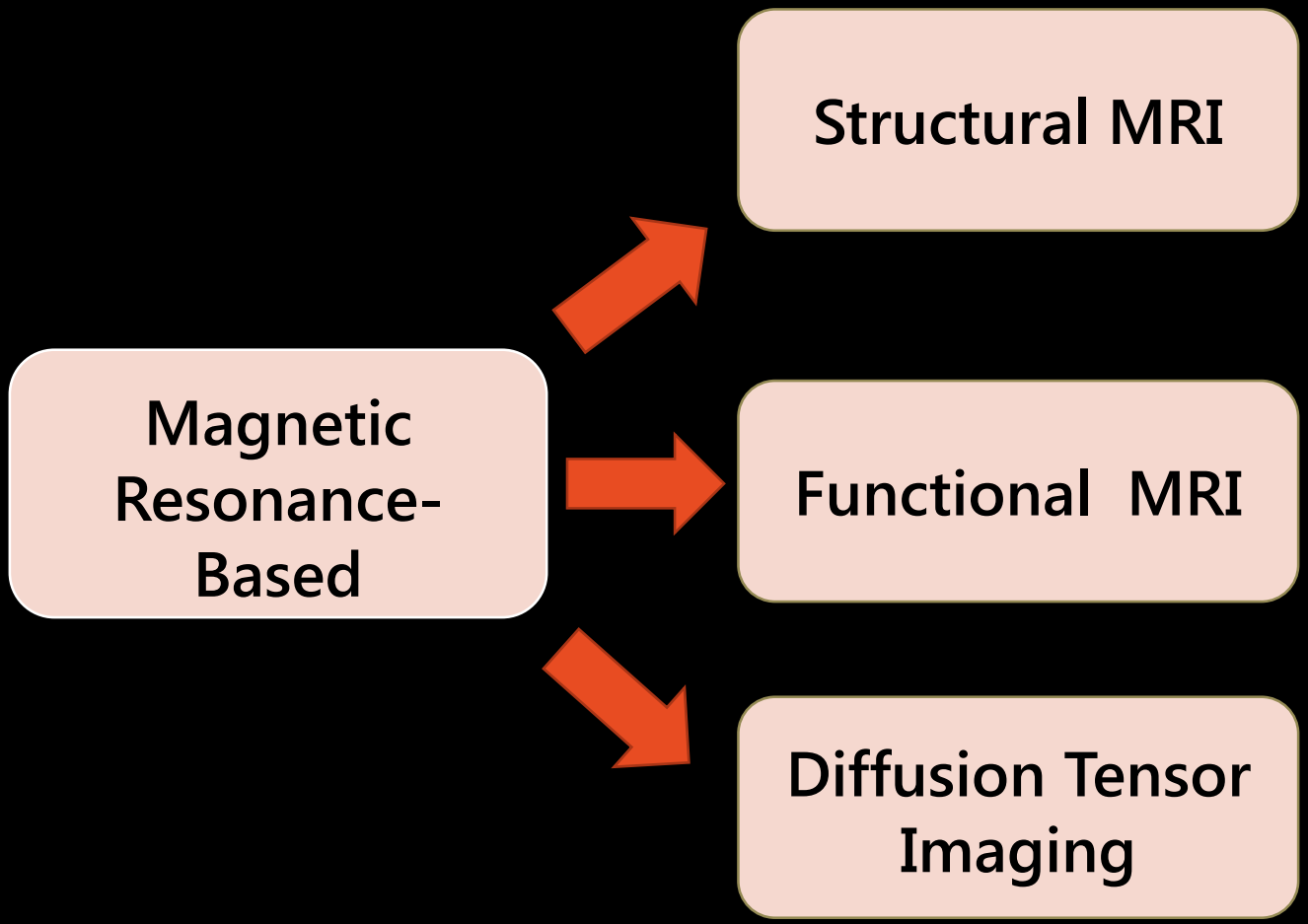
Tissue characterization for diagnosis

CT Imaging

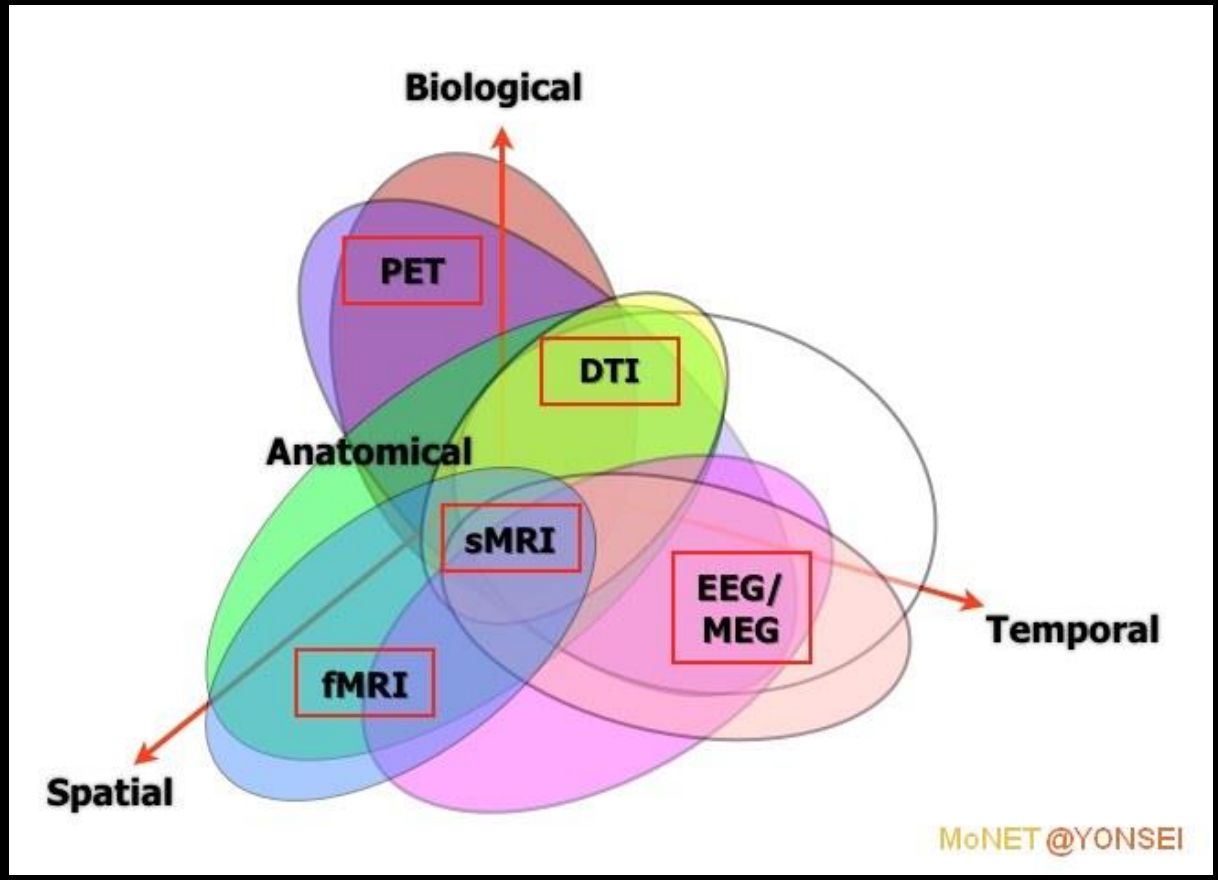
- Brain imaging?

brain CT – good for checking cerebral hemorrhage
but some other thing could do better in most cases

Brain Imaging Modalities



Brain Imaging Modalities



MRI – pros

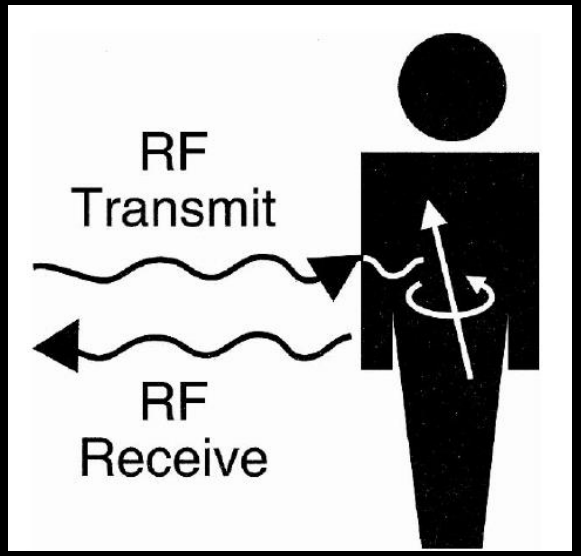
- Good resolution of brain anatomic structure
- Contrast manipulation between different soft tissues
  - X-Ray and CT cannot
- No exposure to ionizing radiations

MRI – cons

- Increased complexity
- Expensive
- Long scan times
  - Uncomfortable for patients
  - Susceptible to patient motion

Principles of MRI

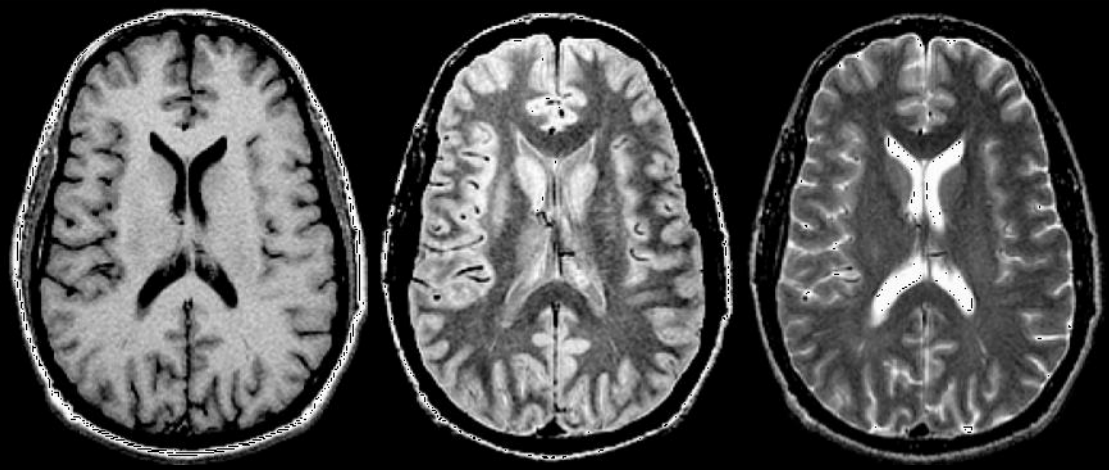
- Protons placed in a B field



- Signal strengths are modified
  - properties of microenvironment
  - the local inhomogeneity of the B field

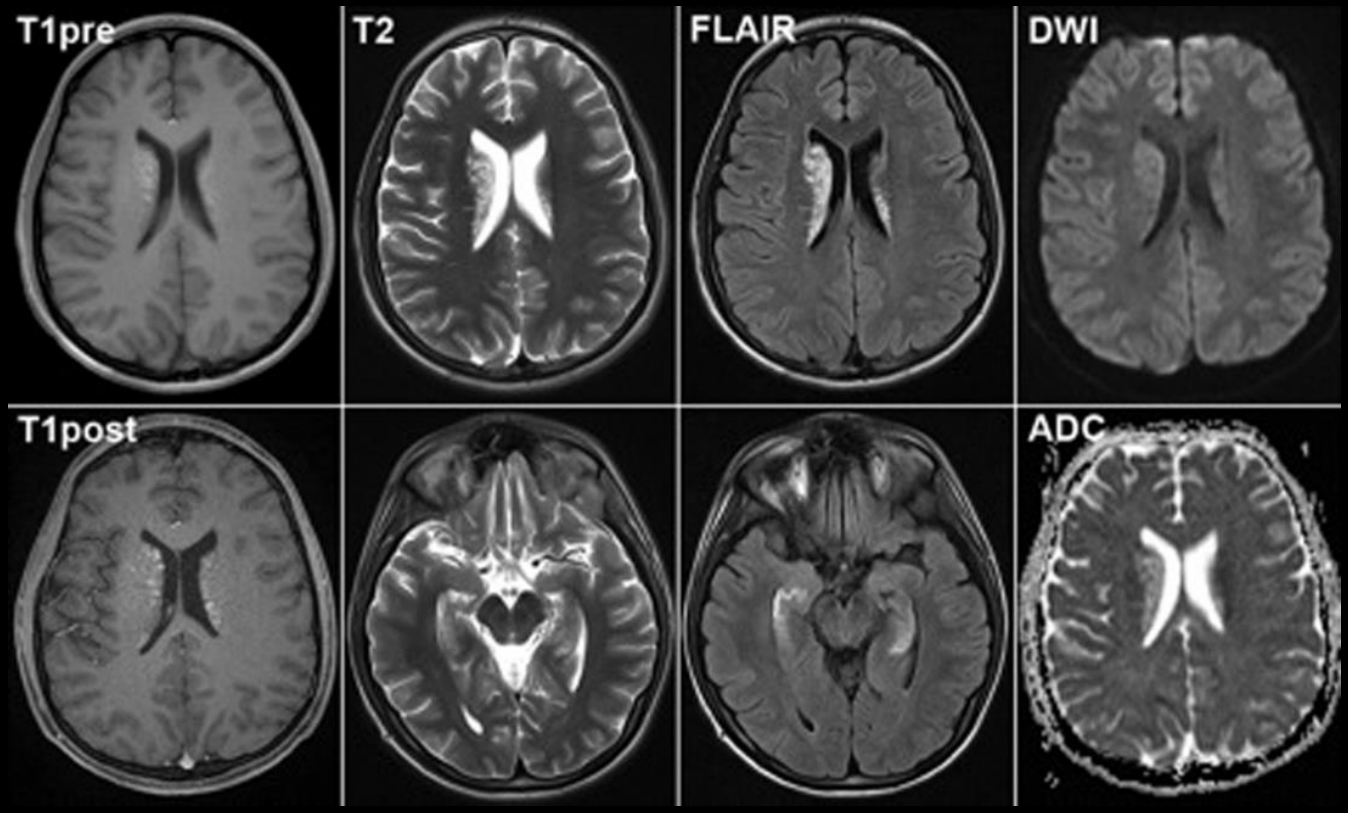
Principles of MRI

- MR signal can be "weighted" to accentuate some properties



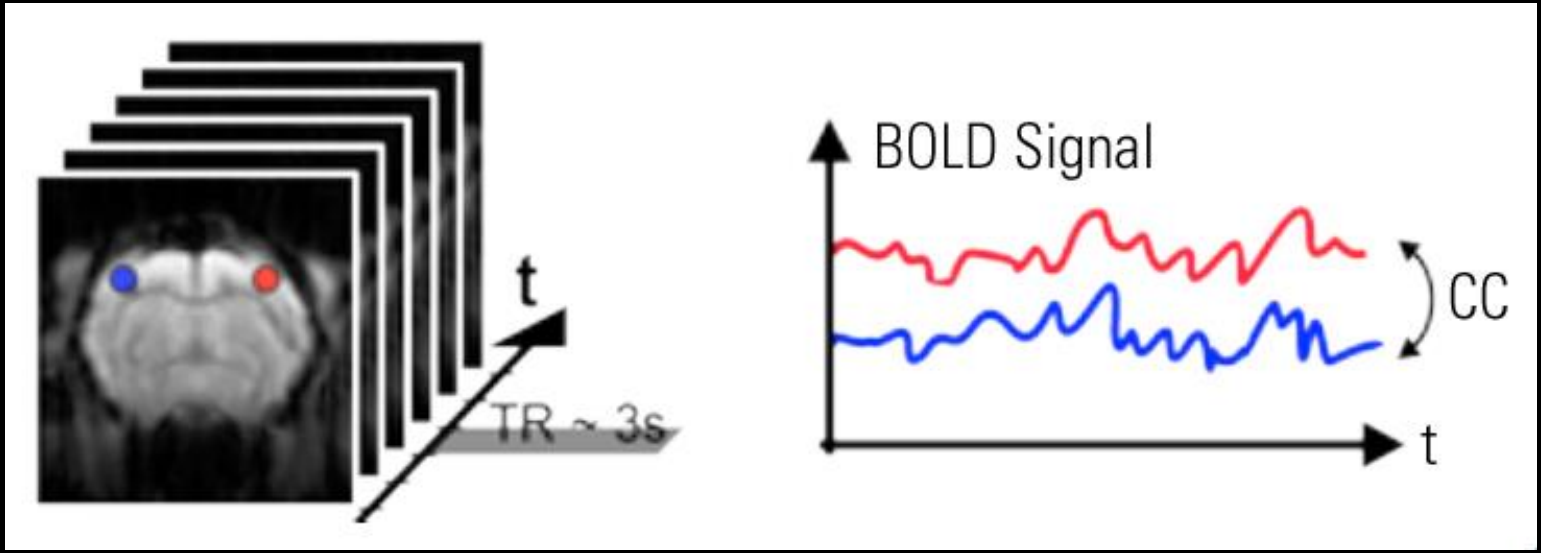
Structural MRI Techniques

- Images with different contrast are used for different (clinical) purpose

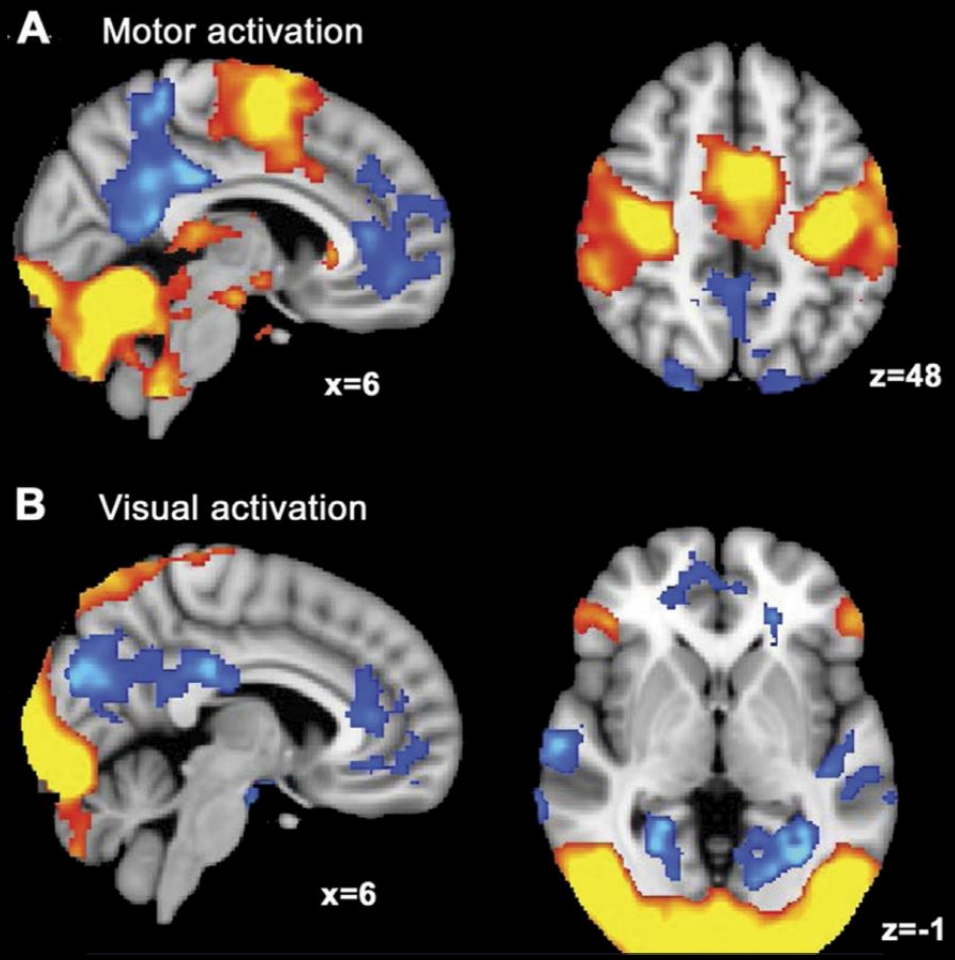


What is fMRI?

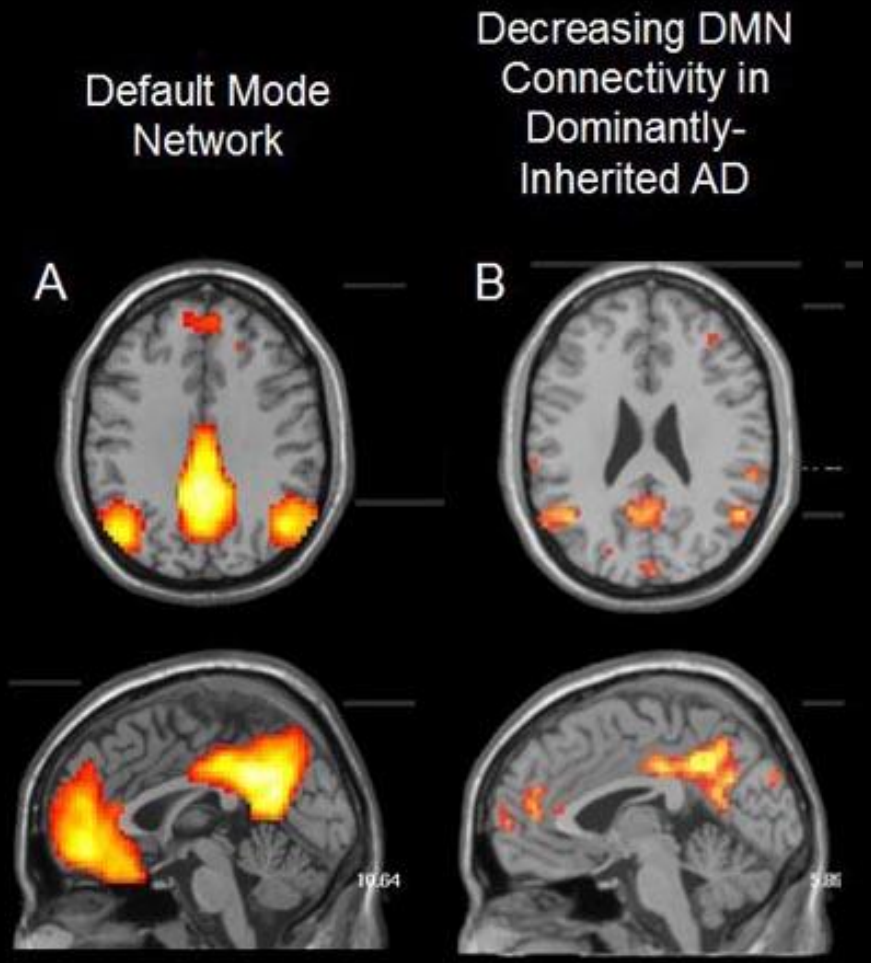
- Images of brain "activity" changing over time



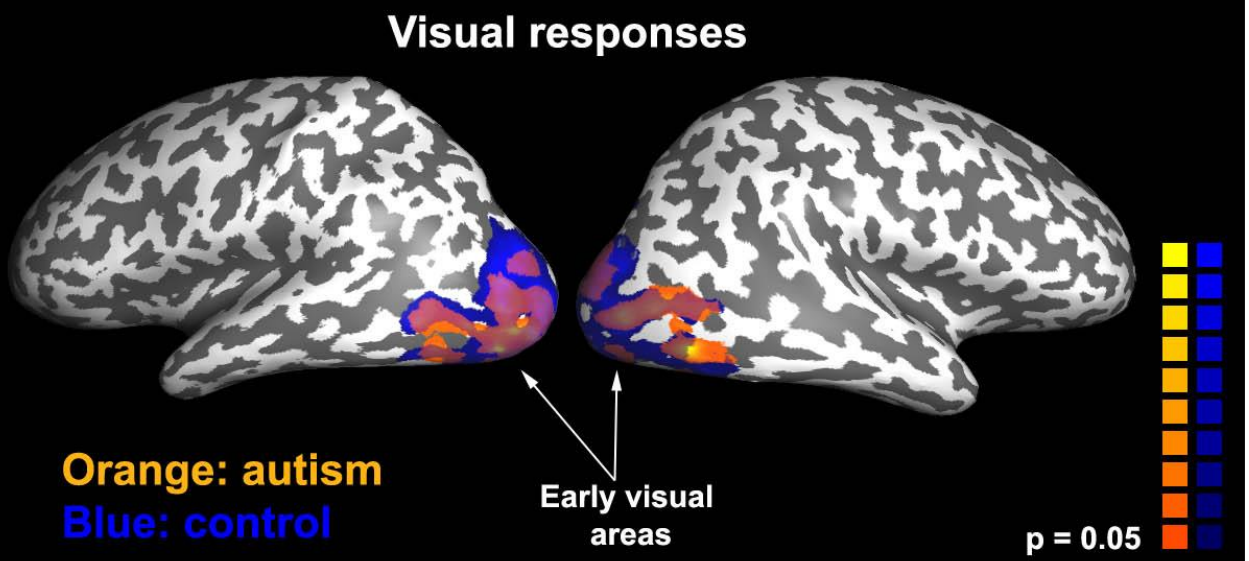
Applications of fMRI

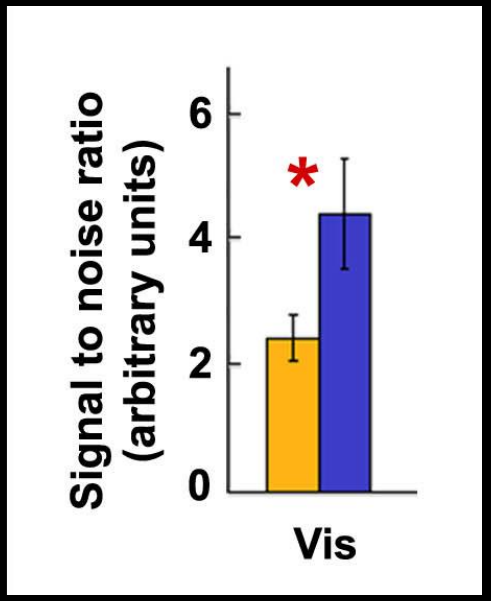


Applications of fMRI



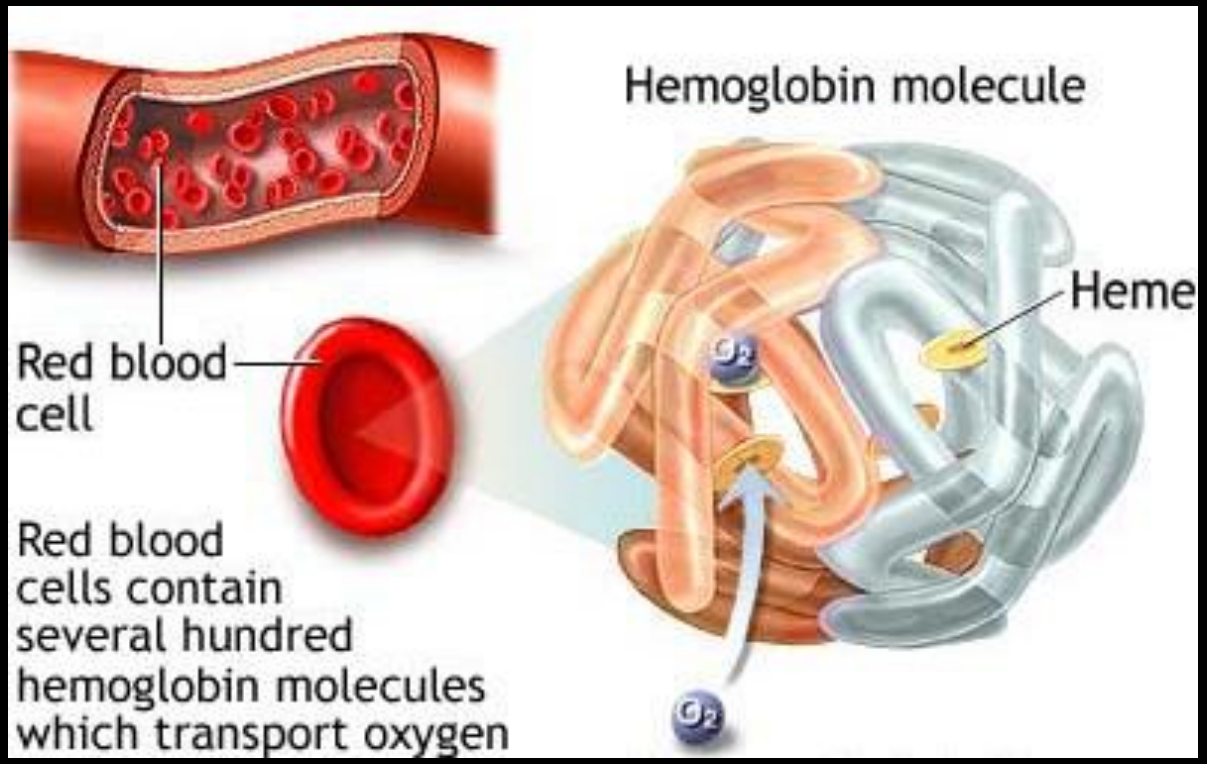
Applications of fMRI



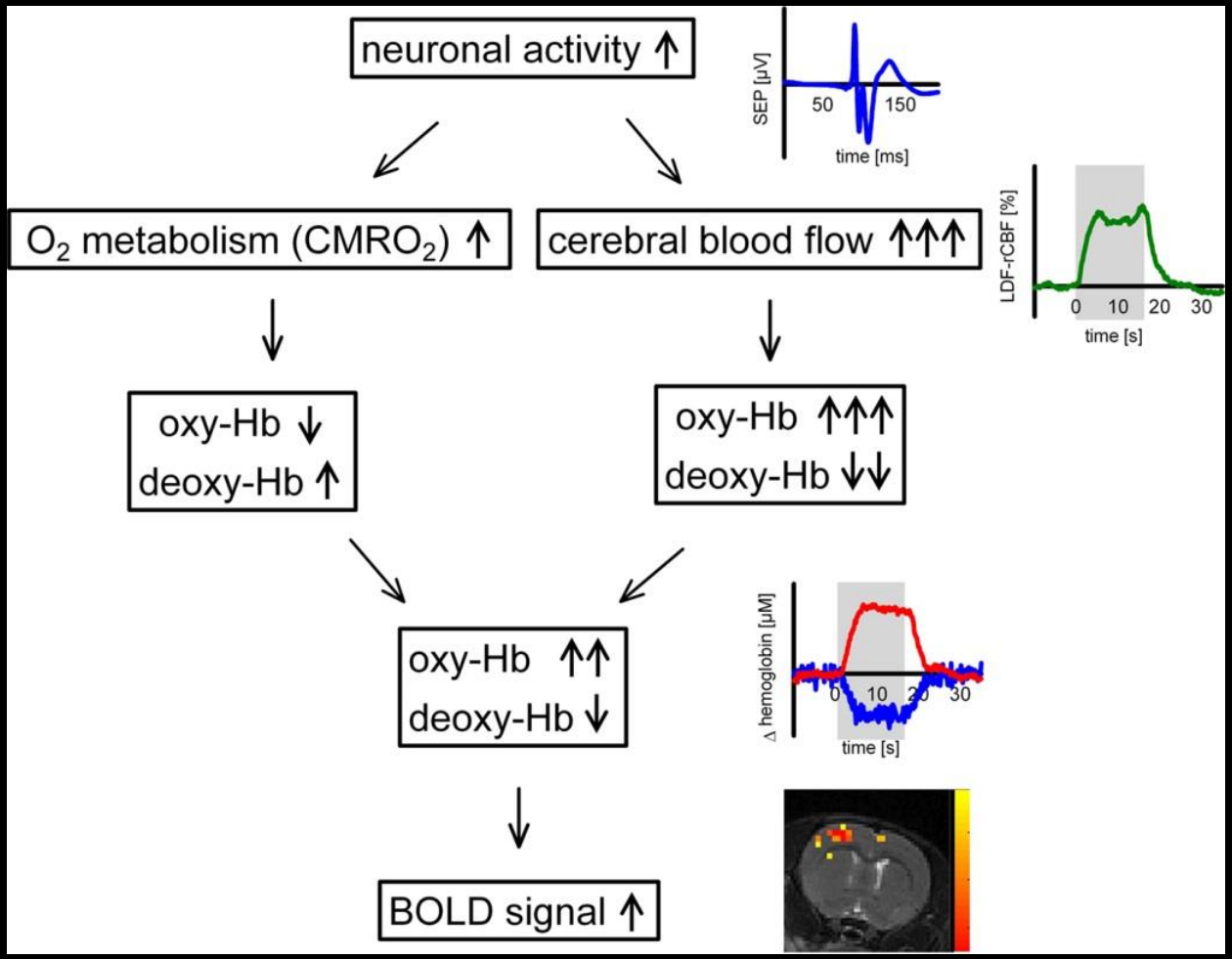


Blood Oxygen Level Dependent (BOLD) signal

- DeoxyHb decreases the MR signal



Principle of fMRI

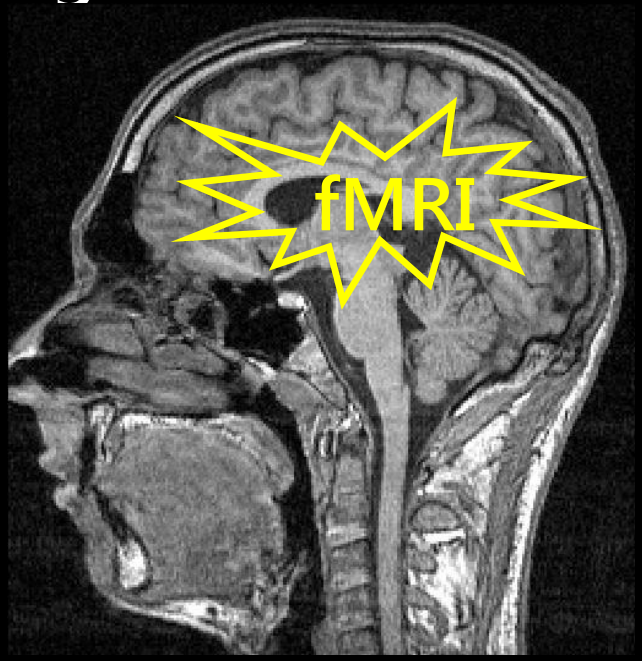


Task-based fMRI

- Disambiguate task-dependent patterns of neuronal activity

- Active brain regions are different in different tasks

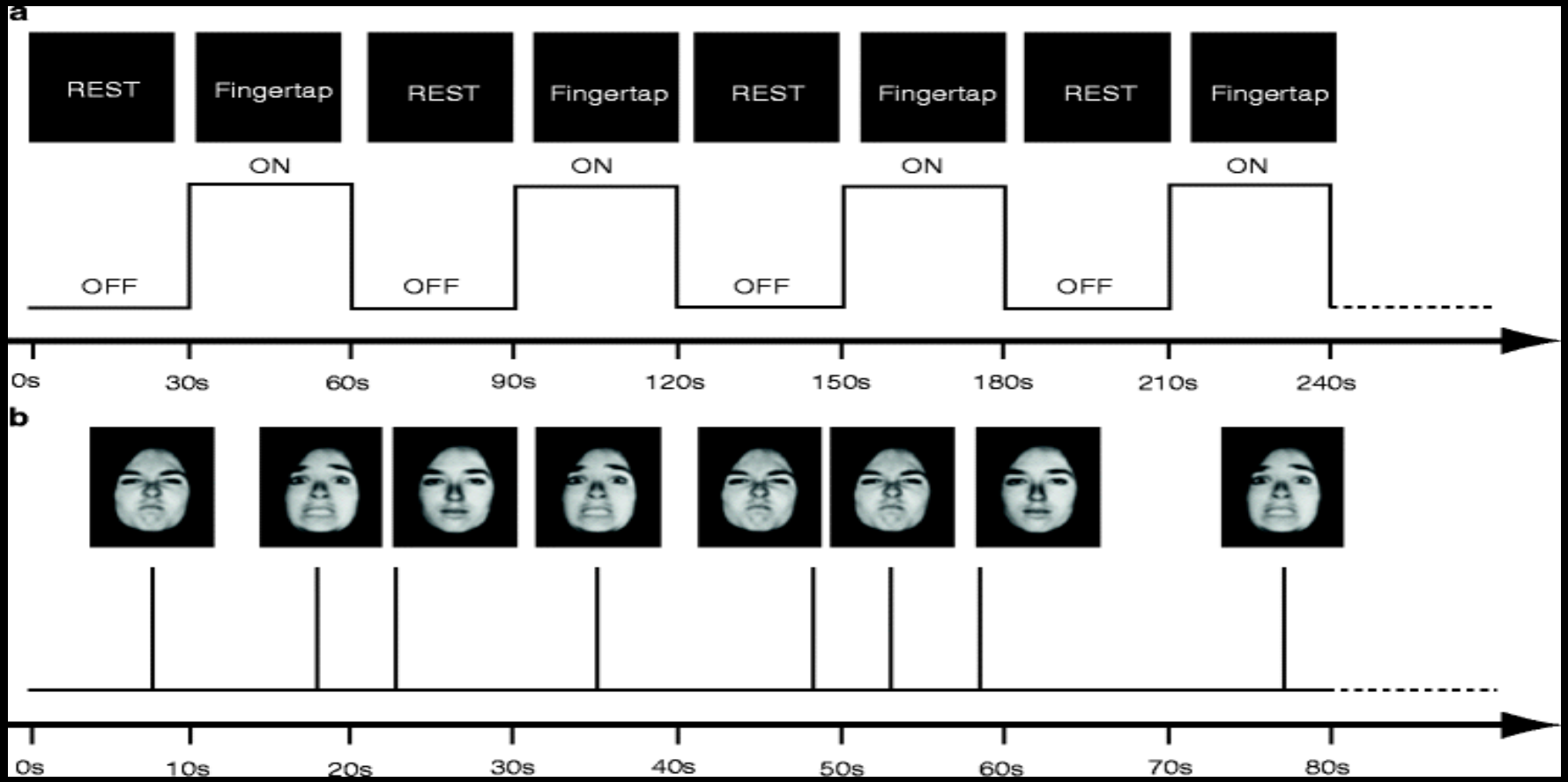
Task



Task-based fMRI

- Block design
  - Block stimulate(series of similar stimulus)
- Event-related design
  - Single stimulus

Task-based fMRI

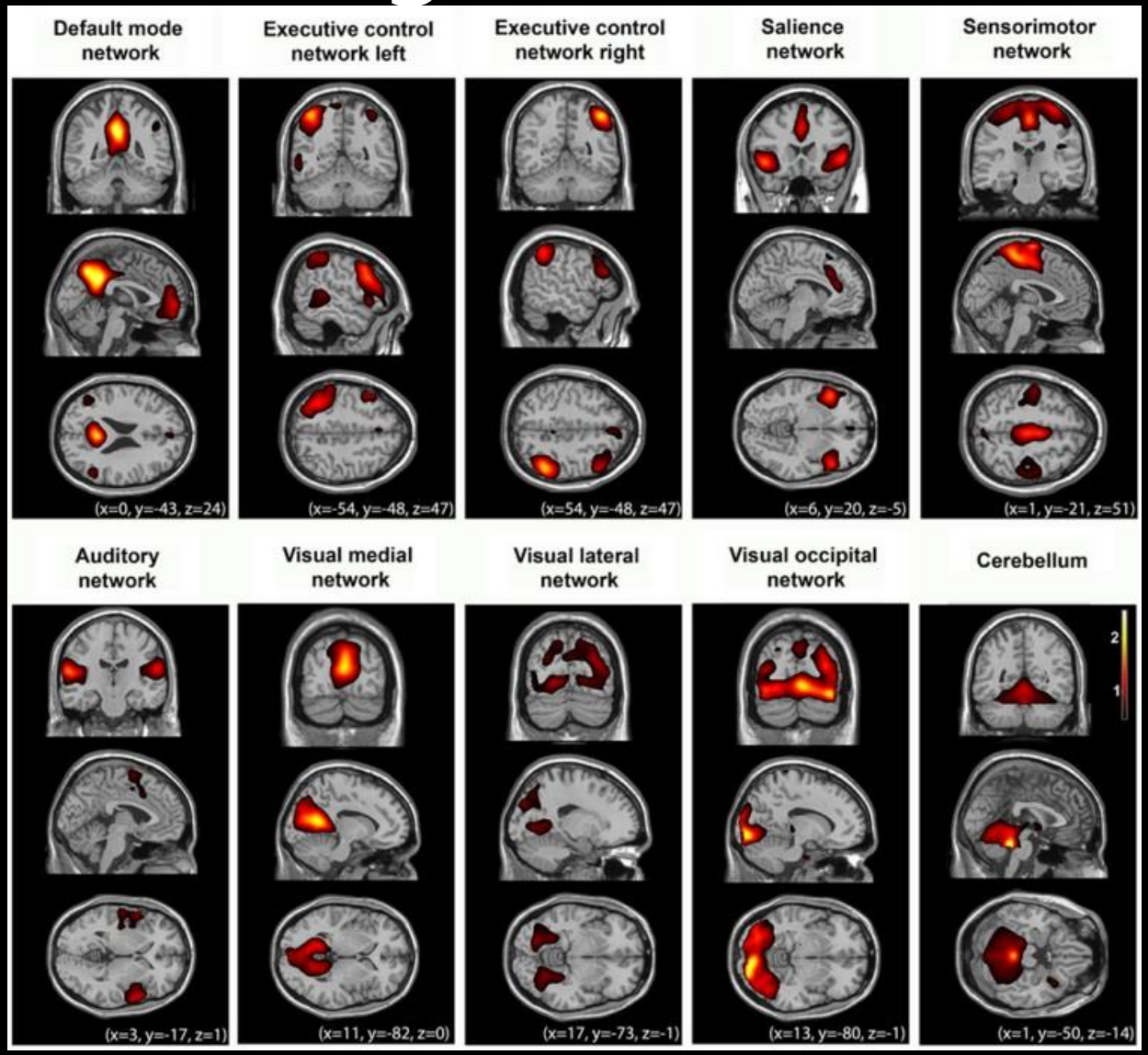


Task-based fMRI

- Block design
  - Can detect general brain region across the particular block stimulus
  - simple to implement

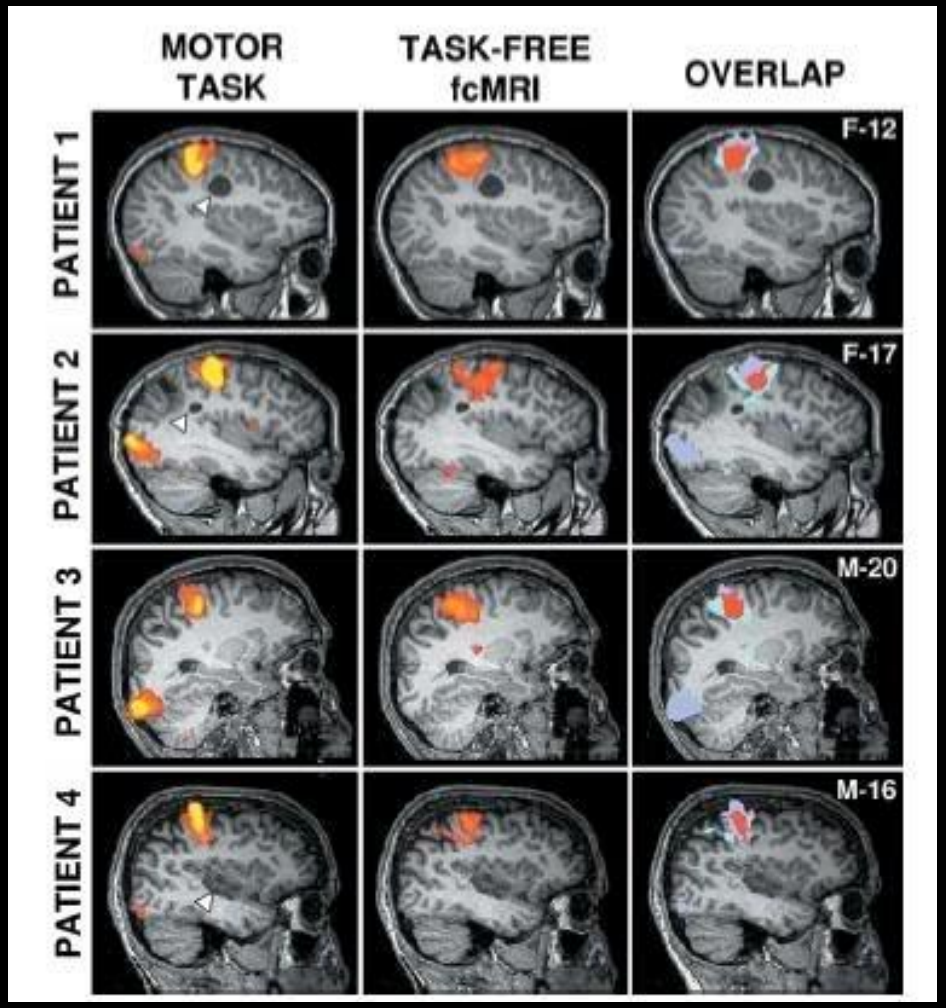
- Event-related design
  - Can detect dynamic responses to varied stimulus categories
  - Also get temporal characteristics of responses

Resting State Networks

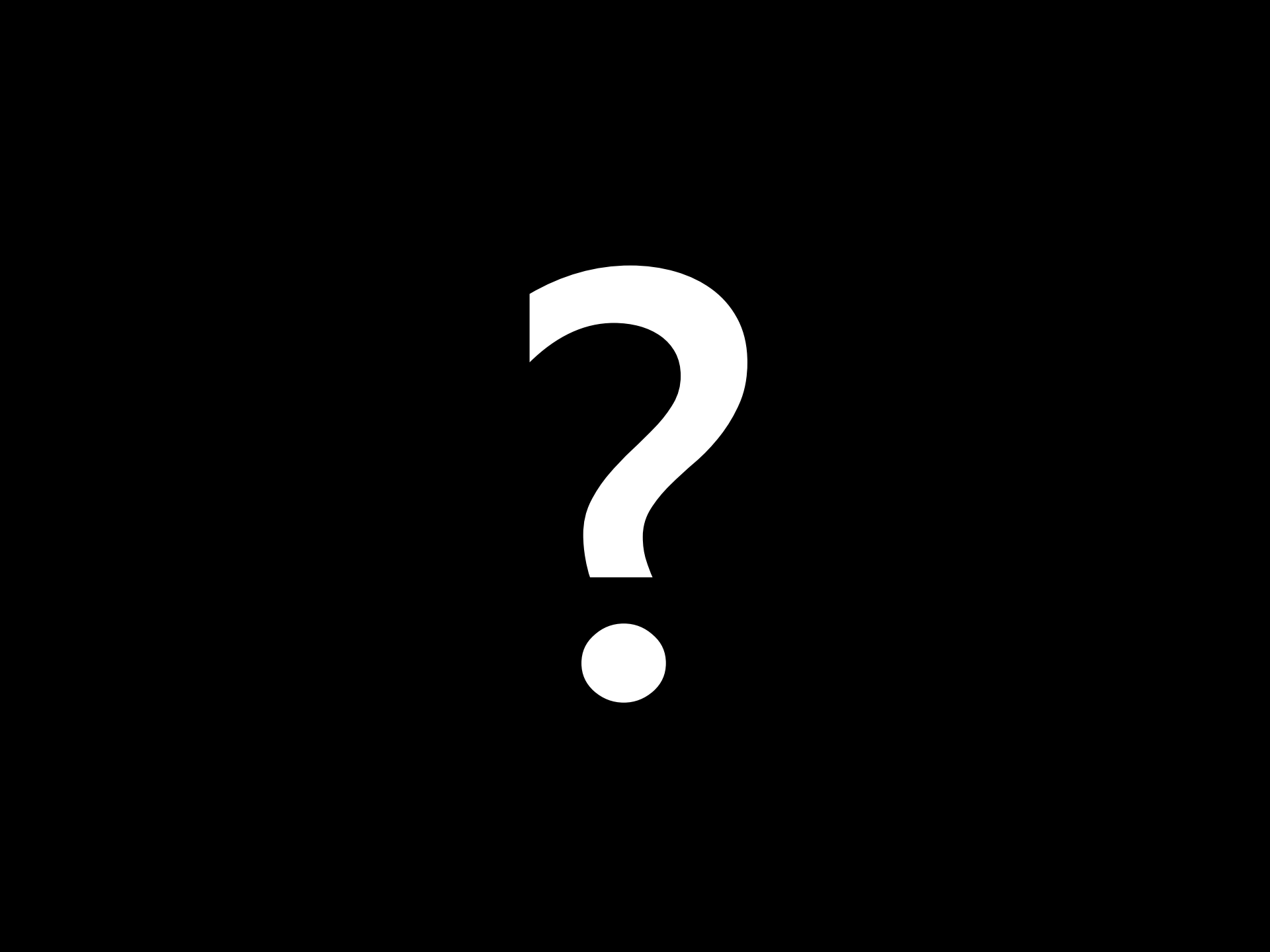


- Resting-state

Resting State Networks



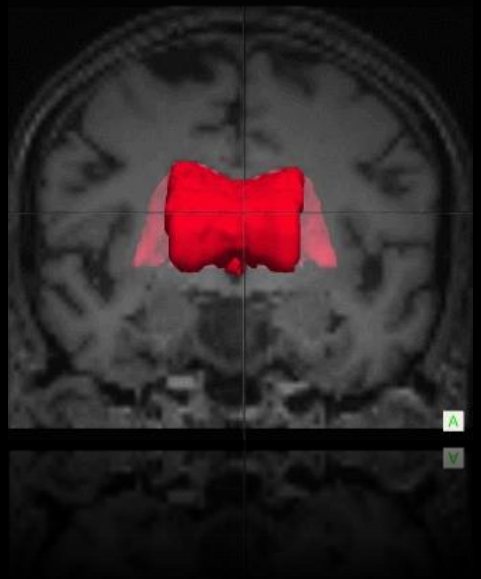
- A record of previous use
- Organize / coordinate neuronal activity

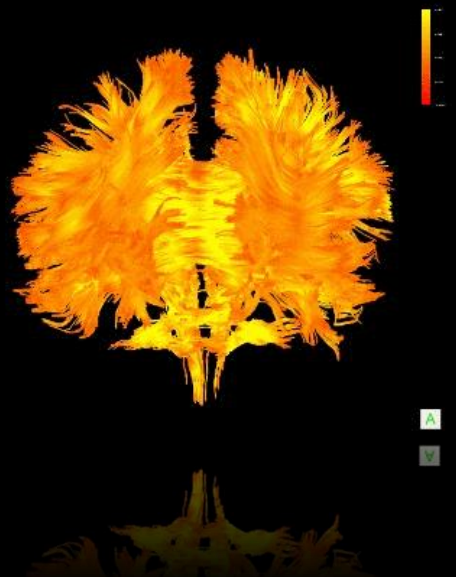


The Brain Structure

- CGV_MRI
  - Magnetic Resonance Imaging
- Ventricular System
- Volumetric Enlargement
- 3D Shape Modeling

- CNI_DTI
  - Diffusion Tensor Imaging
- Fiber tracts
- Fractional Anisotropy
- Graph Theory





만든 사람들

CGV 연구실

김태호

류호진

김의태

CNI 연구실

이재현

정진용

임이삭

Thank you
& See you in July!