Neuroimaging introduction

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Disclosures

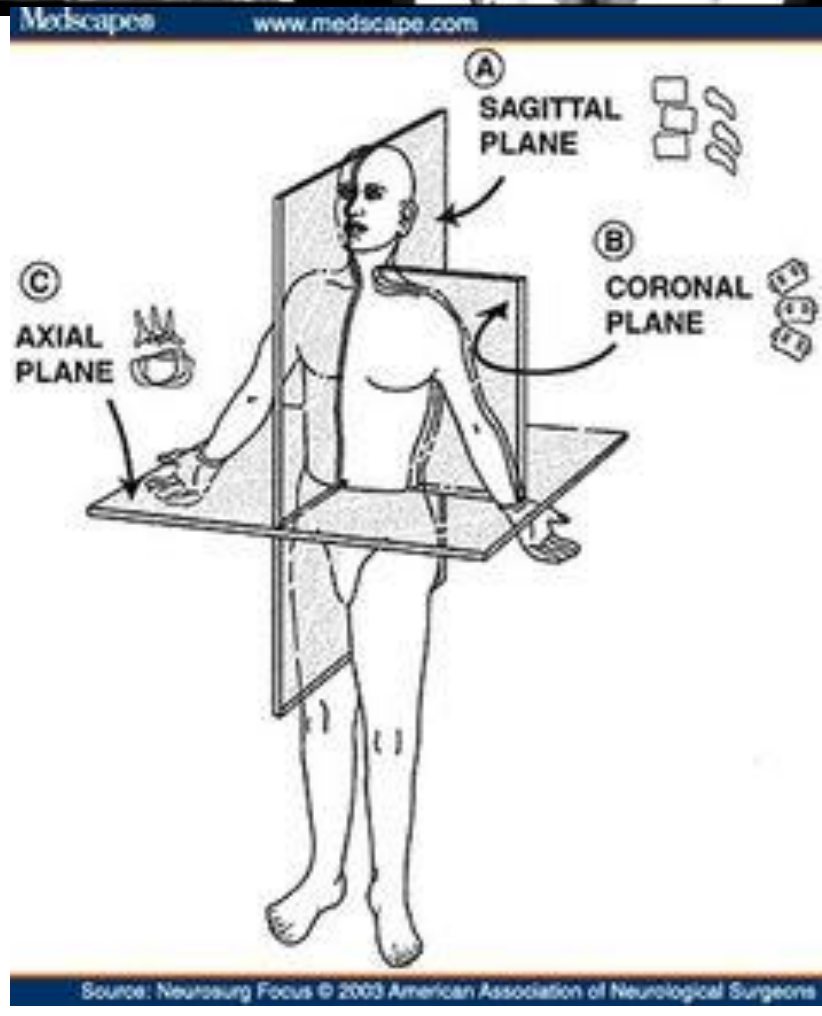
- FTE on Nihon Kohden America
- Presentation is vendor neutral

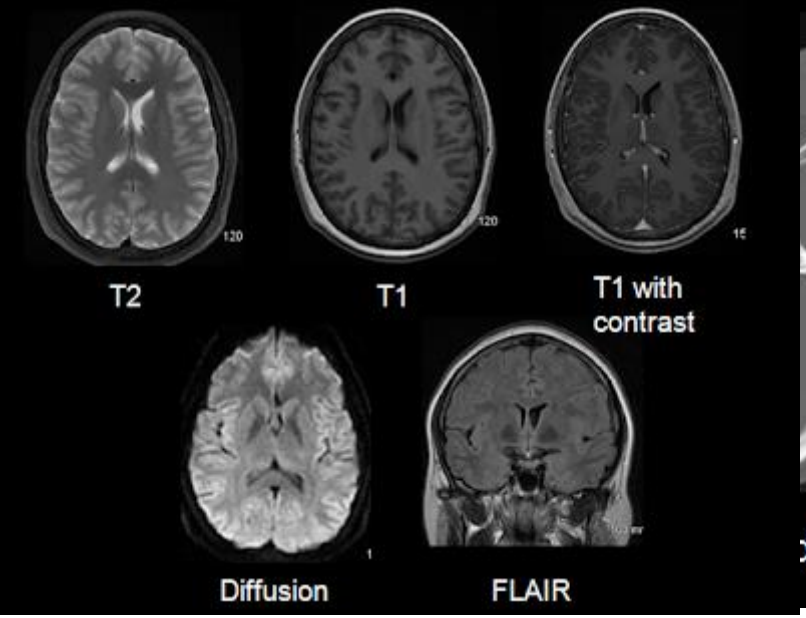
Objectives

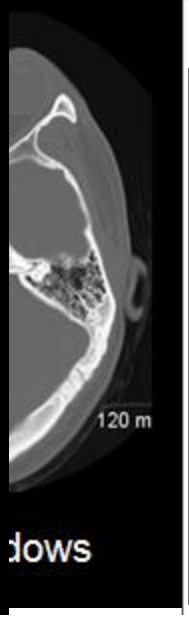
- Basic understanding of terminology
  - Slices
  - Orientation and view considerations
  - MRI vs CT
- Basic understanding of CT
  - Density
- Basic understanding of MRI
  - Intensity
  - T1, T2, FLAIR, diffusion
  - fMRI
- Nuclear imaging
  - PET
  - SPECT
- Understanding of how these factor into epilepsy evaluations, including what information it contributes
  - EEG findings with: CT, MRI, fMRI, PET, SPECT
  - Correlation of EEG to neuroimaging findings

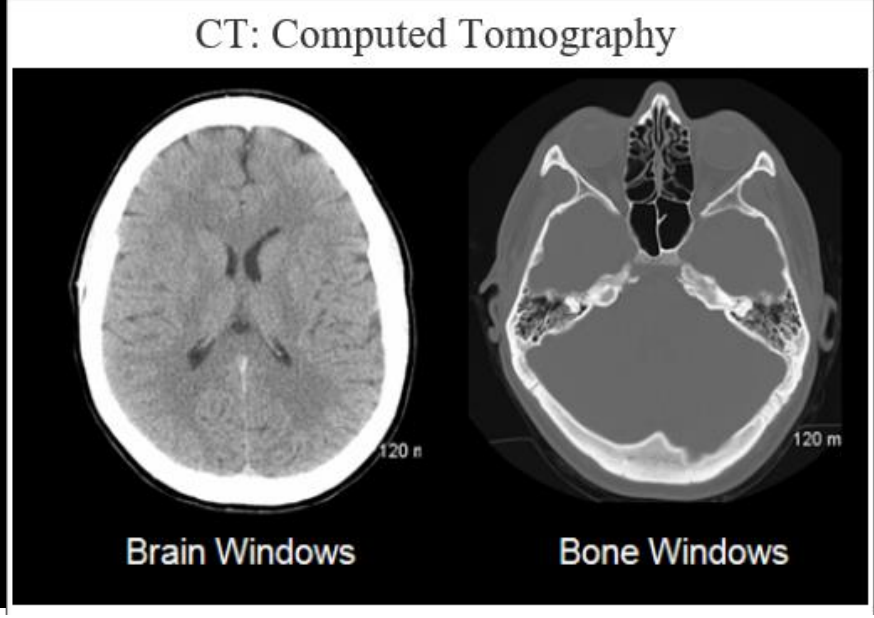
Terminology

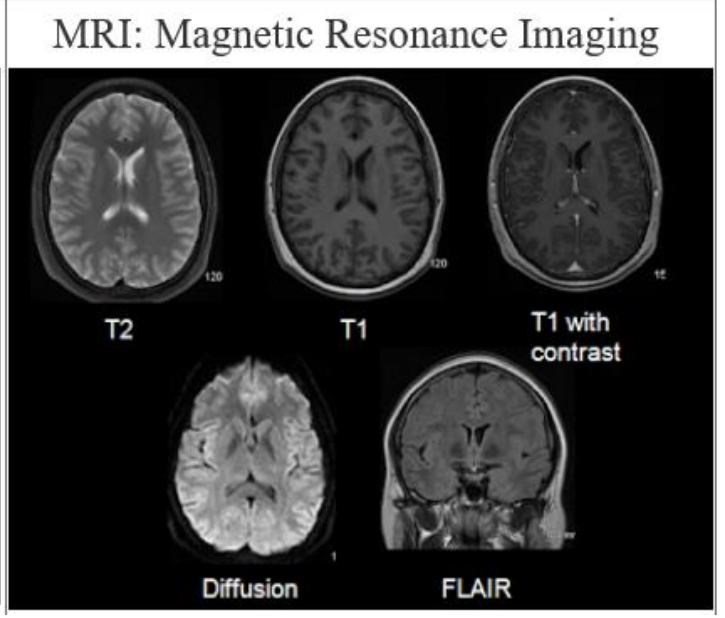
- Slice: A 2D image across a plane
- Series: A collection of slices from a test set, type of imaging parameters
- Axial: Across a horizontal plane
- Sagittal: “Side view” side to side
- Coronal: “”side view” back to front
- Oblique: angled from normal 3 plane (ie coronal oblique for hippocampi)











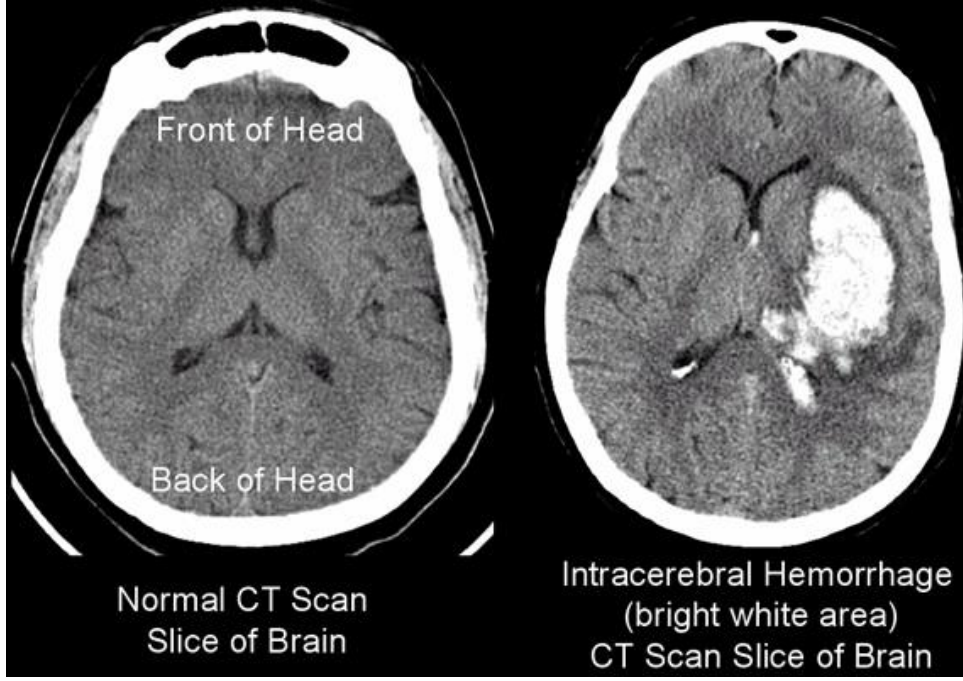
- CT
- Plane: Acquired in axial
- Windowing: Postprocessing adjustments that bring out certain structures (ie brain vs bone) **hit think of EEG filters
- Bright: X-ray so density based, hypodense and hyperdense

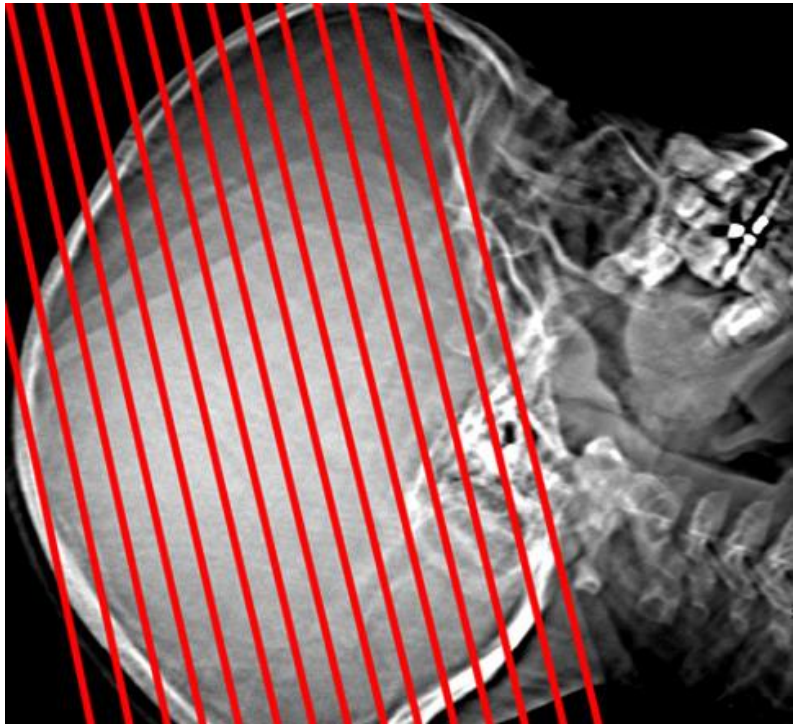
- MRI
- Plane: Can be in any plane
- Sequence: Based on parameters used to acquire different types of scan
- Bright: Type of scan highlights different material (ie tissue) types, hypointense and hyperintense

CT

CT

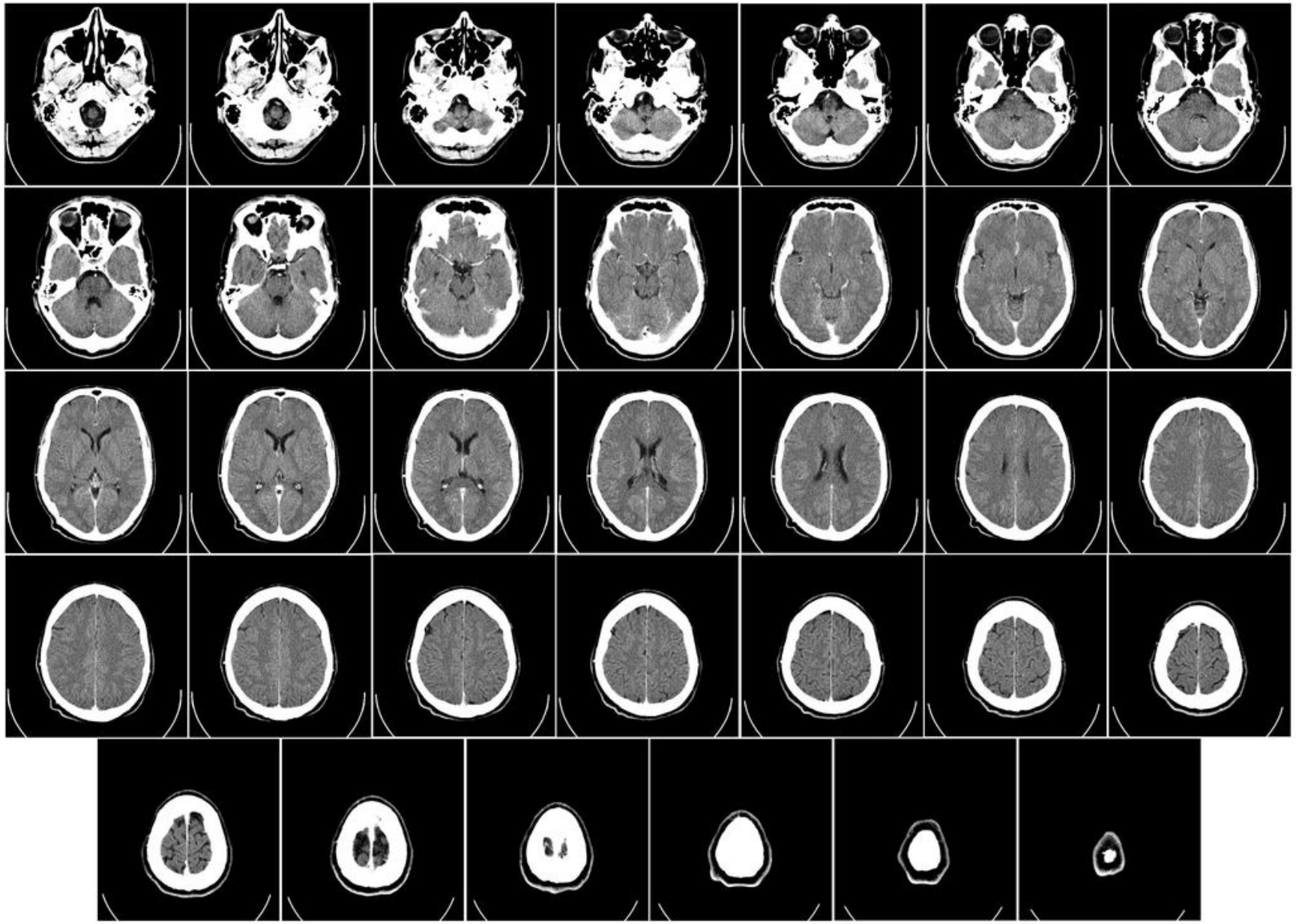
- CT
  - Computed tomography
  - Radiation, therefore density shows bright
  - Conceptually like multiple X-rays from different angles then reconstructed into 2D image “slices”
  - Some items that will show well
    - Bone vs soft tissue
    - Blood (new and old)





CT

A **CT scan**,[1] also known as **computed tomography scan**, makes use of computer-processed combinations of many X-ray measurements taken from different angles to produce cross-sectional (tomographic) images (virtual "slices") of specific areas of a scanned object, allowing the user to see inside the object without cutting.

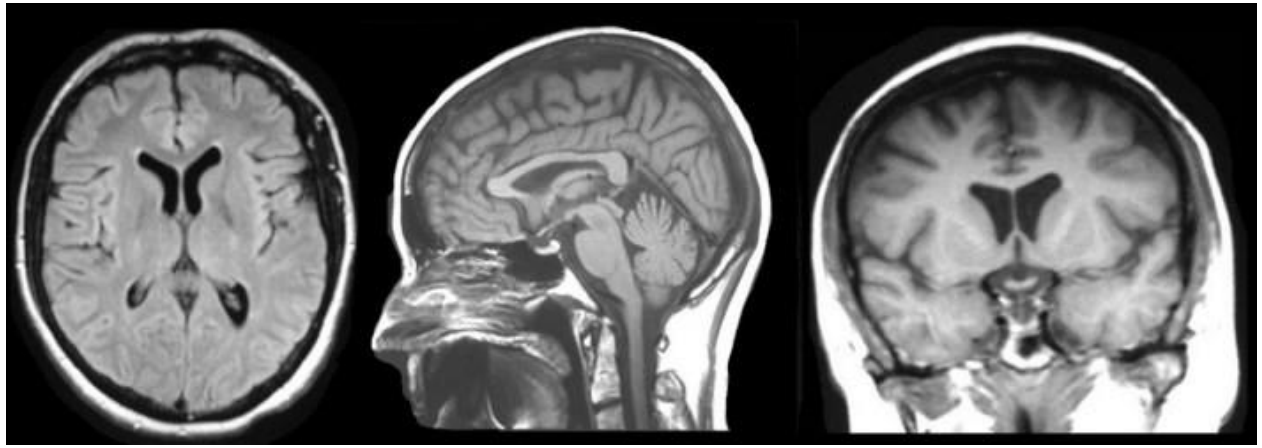


https://en.wikipedia.org/wiki/CT_scan

By Department of Radiology, Uppsala University Hospital. Uploaded by Mikael Häggström. - Radiology, Uppsala University Hospital. Uploaded by Mikael Häggström., CC0, https://commons.wikimedia.org/w/index.php?curid=3479321

Check up

- Orientation



- On a CT what things are bright vs dark

MRI

Magnet

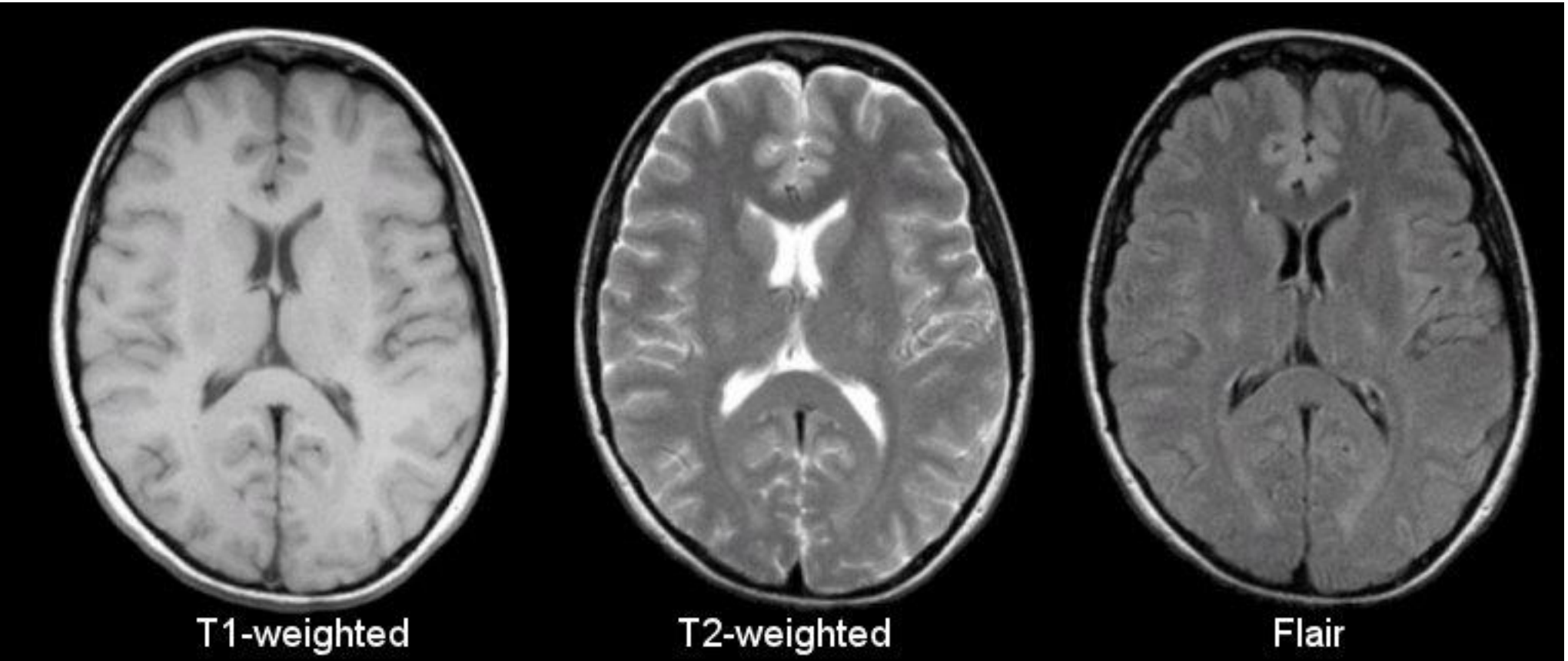
Bore

MRI

- Magnetic resonance imaging
- Basically, magnet aligns protons, RF signal introduced, as material/tissue returns to resting alignment, releases RF, different tissue-different characteristics and time course to realign
- T1 vs T2, amount of time between pulses (TR) and time from pulse to signal (TE).
- T1 short (500ms, 14ms), while T2 is longer (4000ms, 90ms)
  - Other types of scans (ie FLAIR) have different times (ie 9000ms, 114ms)

MRI

- Easiest to differentiate between T1 and T2 is look at CSF
- T1 dark, T2 bright (protein)



Quick check:
orientation?
Slice?
Left vs right?
Anterior vs posterior?

http://casemed.case.edu/clerkships/neurology/Web%20Neurorad/MRI%20Basics.htm

MRI

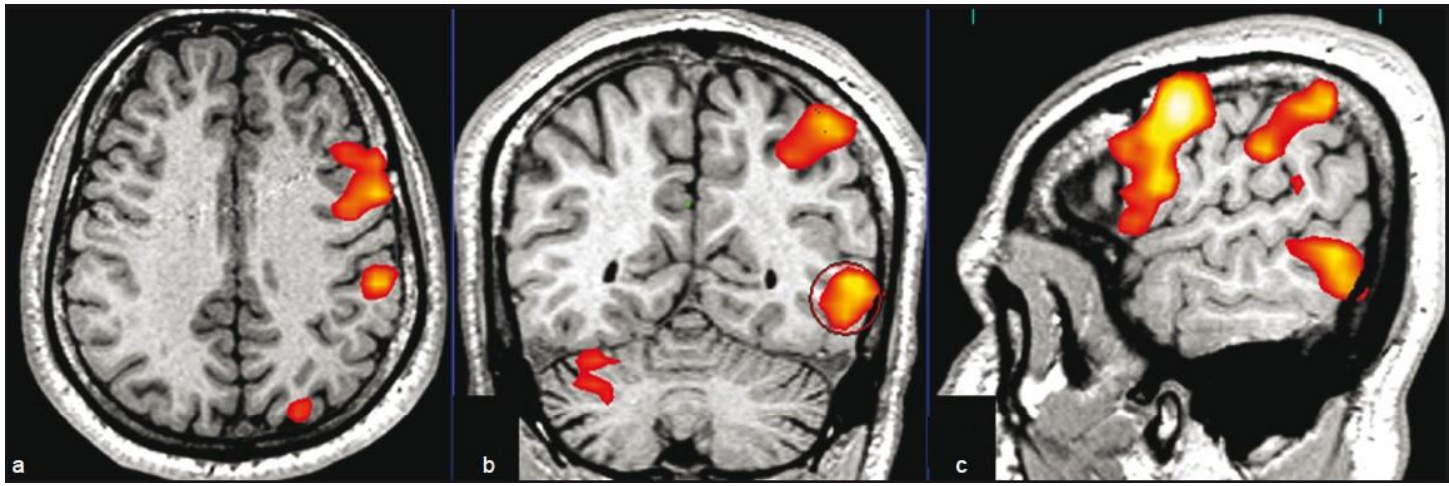
- T1; good to look at anatomy;
  - bone shows intense, white matter is light, cortex gray
- T2; good to look at some lesions (like MTS, demyleniation)
  - CSF and inflammation/infection/demylenation bright, white matter dark gray, cortex light gray
  - Can be difficult is CSF is near infection/demylenation (it MTS)
- FLAIR (Fluid Level Attenuated Inverse Recovery) ; good to look at T2 hyperintensities without CSF interference
  - CSF is dark, while inflammation/etc is bright
  - Similar to T2 but with CSF dark
- Diffusion; looks at movement of water, over time
  - Can be useful in stroke, ischemia, white matter tracts

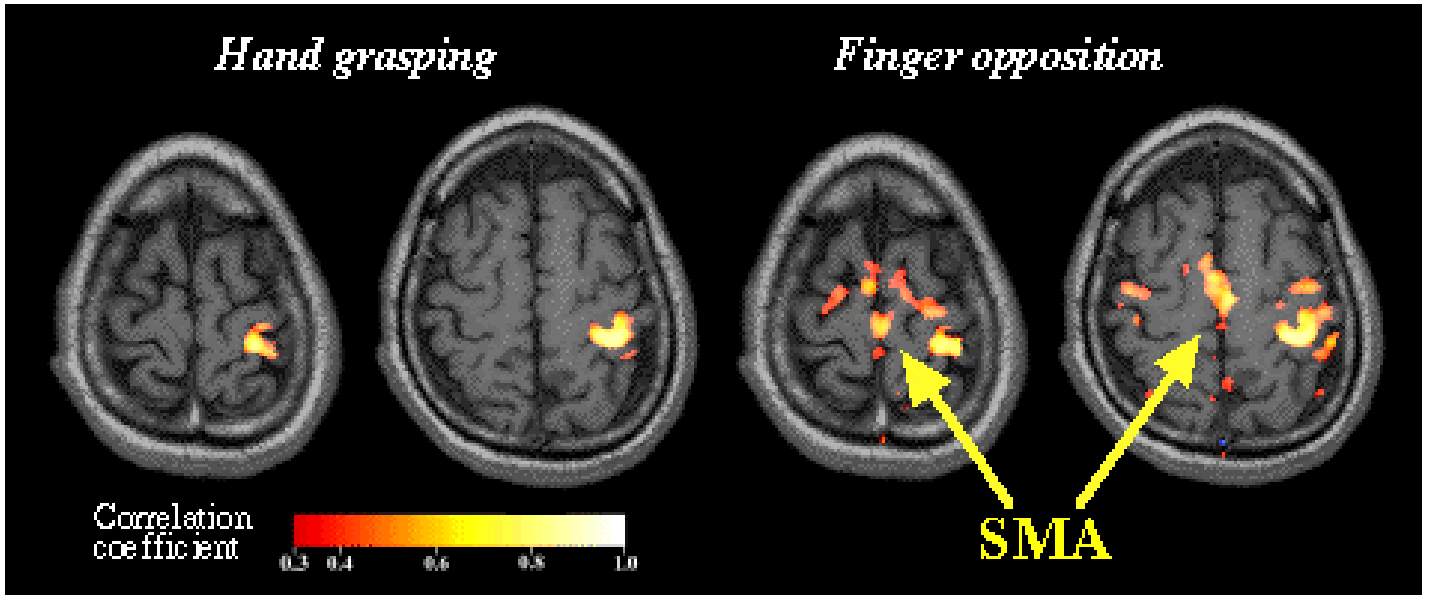
fMRI

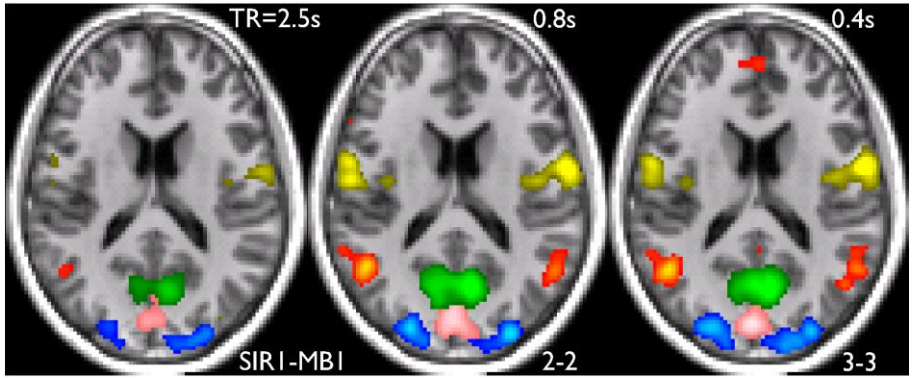
- Functional MRI
  - Like diffusion, looks at changes over time, though with fMRI looking at blood flow
  - With specific tasks compared to a resting state, can look at what areas of the brain use increased blood flow, hence more active
    - More active~involved in the processing and function
  - Some examples of typical tests might be
    - Language of different types (sentence completion, naming, etc)
    - Motor functions
    - Visual function

fMRI

- Red=more active
- Sometimes different colors to differentiate functional areas







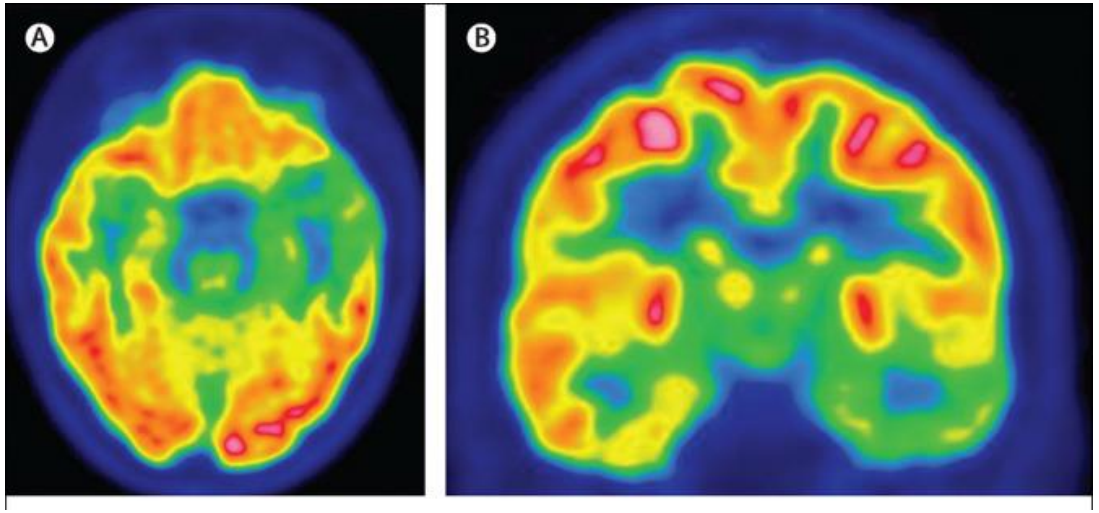
Check up-which is it

CT vs MRI vs fMRI	T1 vs T2 vs FLAIR	CT vs MRI vs fMRI
Type of tissue determines intensity	CSF bright	Stroke, cranial fracture
Blood flow color scale	CSF dark, inflammation bright	Lesion, MS
Density of tissue	Good to see anatomy	Language and motor function

Nuclear imaging

- Radioactive isotope used
- Looks at uptake (metabolism)
- After a period of time, post injection, scan to see what areas are more radioactive (hence had greater uptake)
- Usually coregistered with CT/MRI to visualize uptake with anatomy
- 2 main types we will look a PET and SPECT

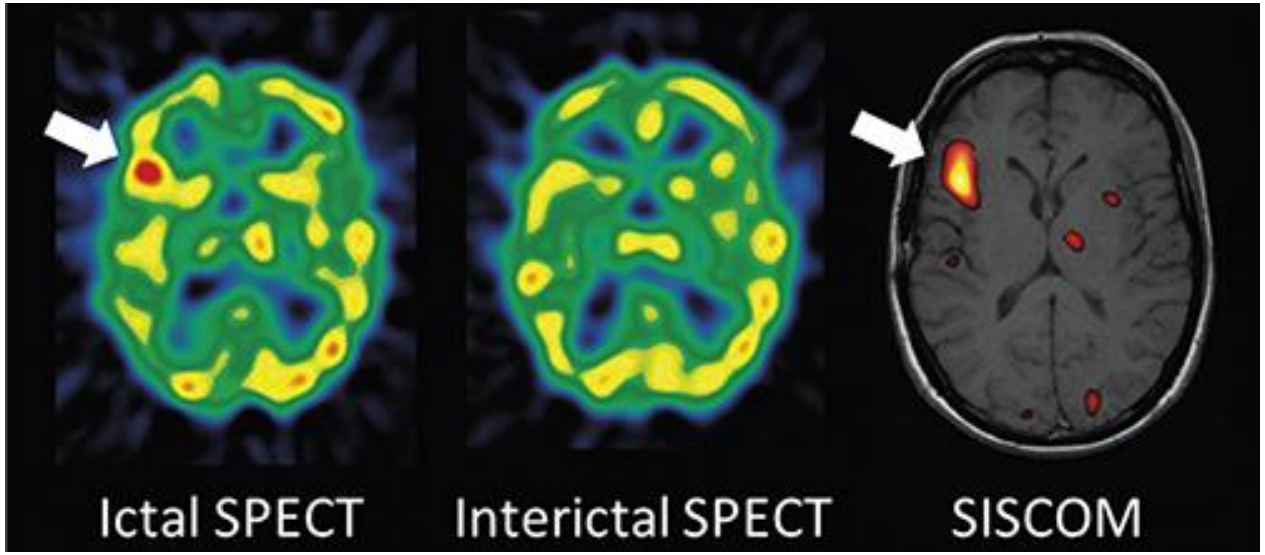
PET



- Glucose “tagged” with radioisotope
- Uptake over ~30 minutes, longer half life, to get wider time window
- Comparison of resting state metabolism to normal
- Dysfunctional areas show lower metabolism
  - In the axial and coronal view to the left, what area seems noticeably lower compared to other side?
  - Why is EEG monitored prior to and post injection?

SPECT

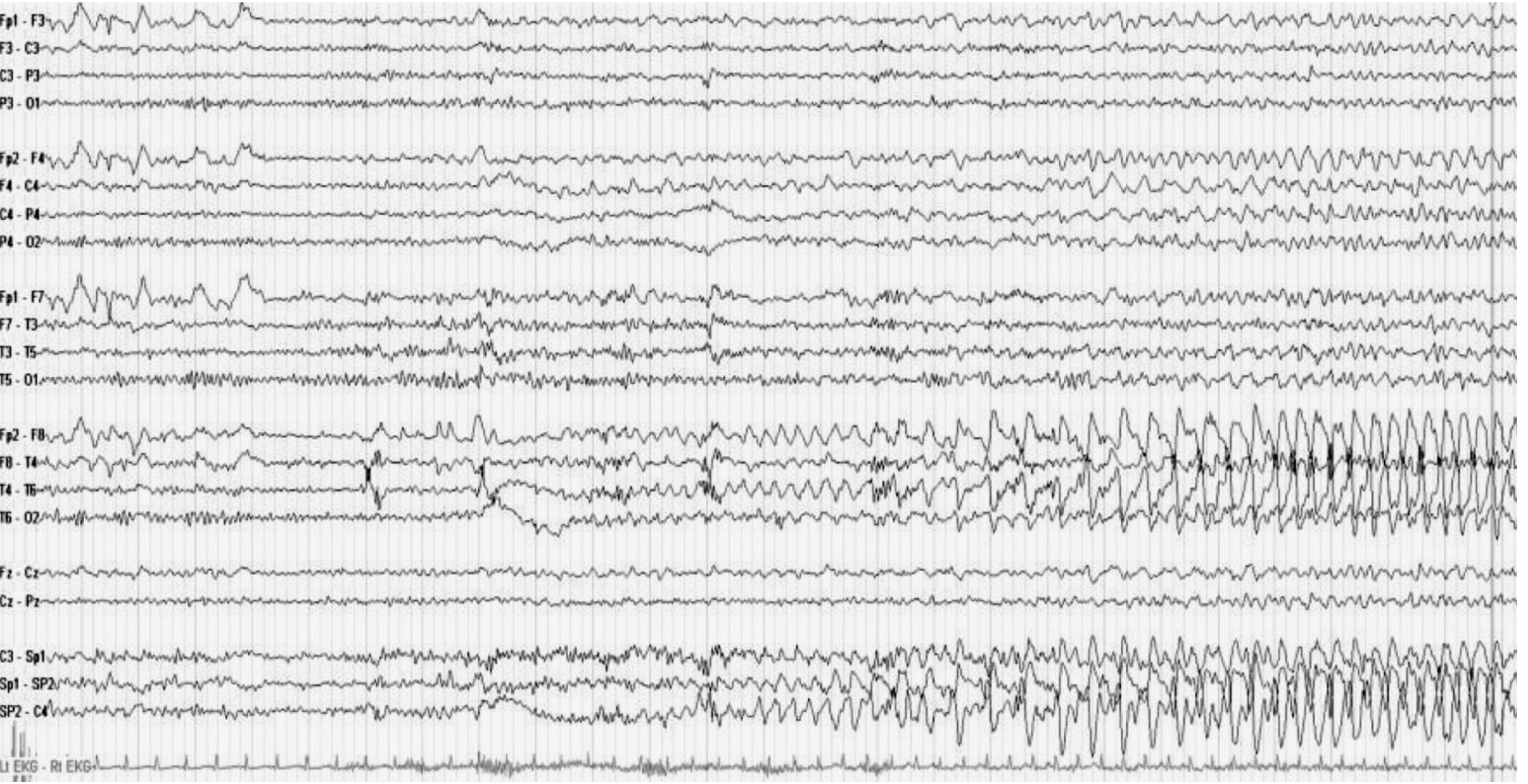
- Faster time window, short half life
- Radioactive isotope “tagged” oxygen
- Normal/resting state (interictal) can be compared to seizure onset (ictal) to determine focus
- Seizure would have acutely increased metabolism



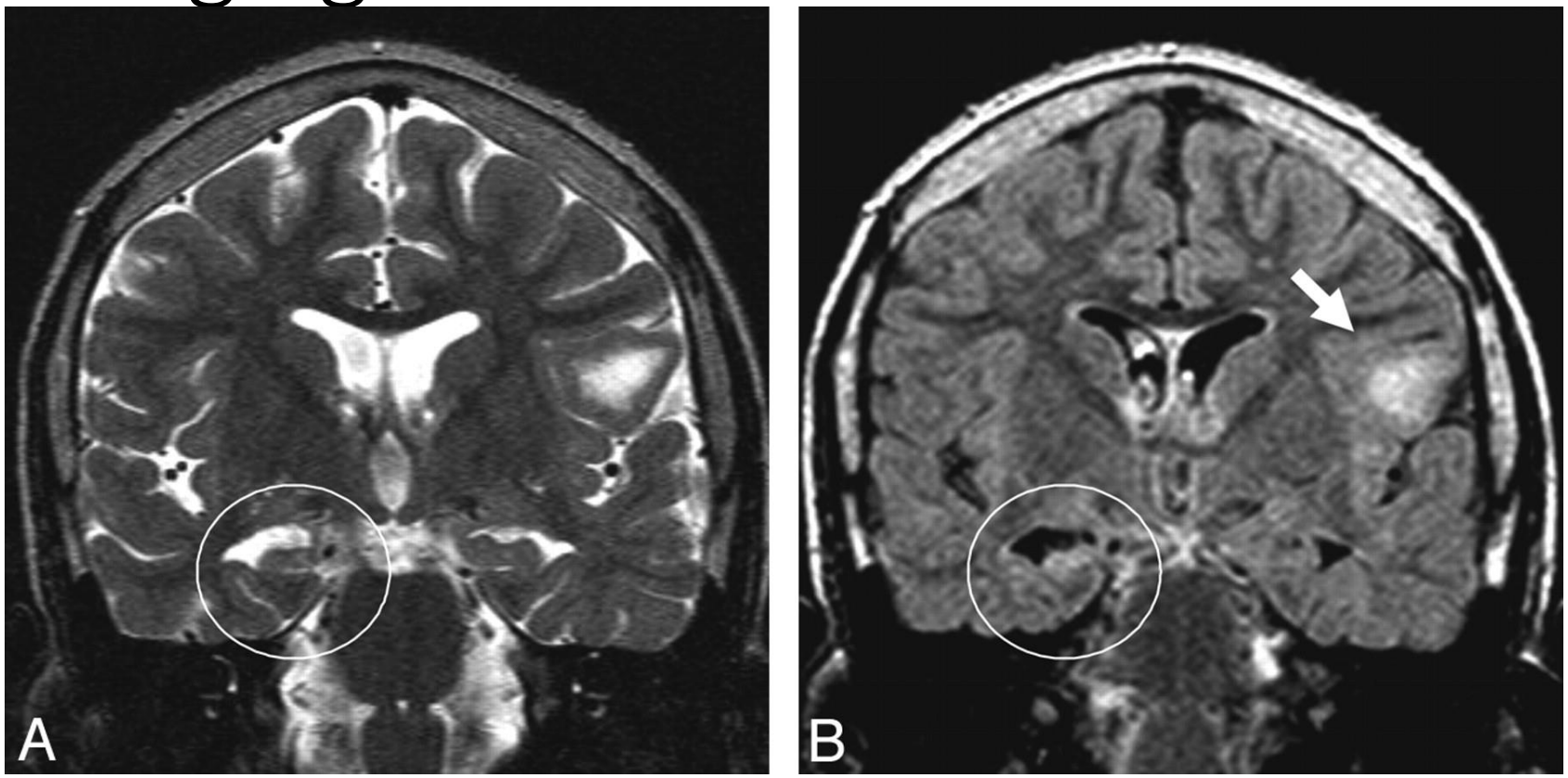
*SISCOM is subtractive method with ICTAL SPECT-INTERICTAL SPECT=ICTAL DIFFERENCE

Case study

- 32 year old with history of seizures, no history of head trauma
- Semiology: Hand automatisms followed by GTC
- Neuropsych shows some memory and language deficits
- EEG and imaging to follow

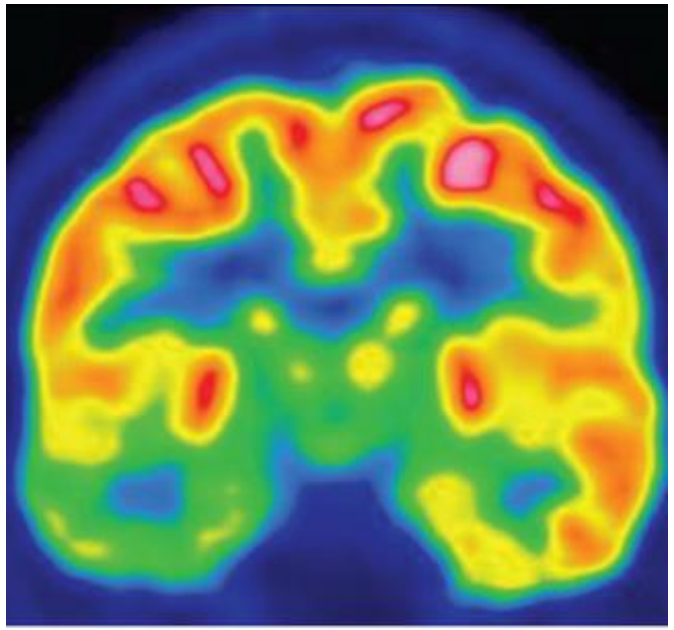

Fp1 - F3
F3 - C3
C3 - P3
P3 - O1
Fp2 - F4
F4 - C4
C4 - P4
P4 - O2
Fp1 - F7
F7 - T3
T3 - T5
T5 - O1
Fp2 - F8
F8 - T4
T4 - T6
T6 - O2
Fz - Cz
Cz - Pz
C3 - Sp1
Sp1 - SP2
SP2 - C4
Li EKG - Ri EKG

Imaging

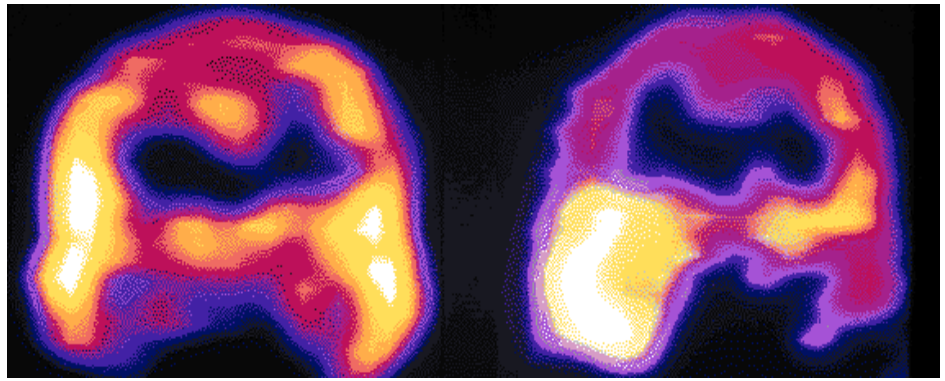


- Is this CT or MRI?
- What slice orientation?
- What types? How do you know?
- What other type might help?

Imaging

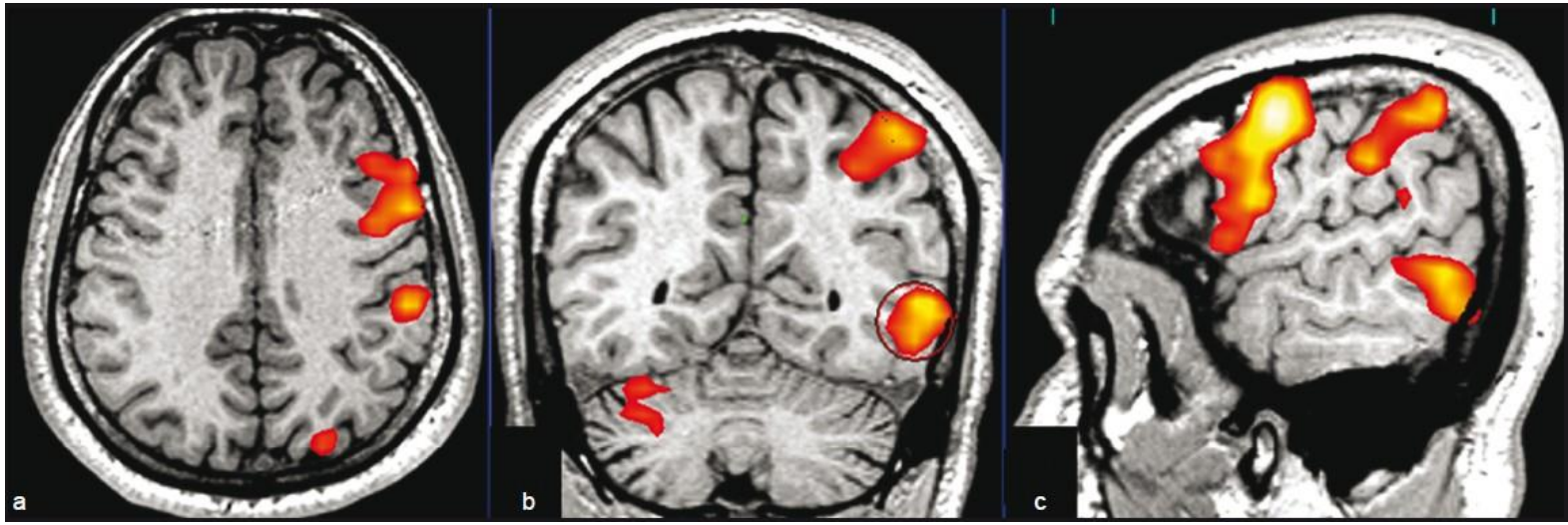


- PET scan
- What does PET show?
- What slice orientation?
- What part of the brain?
- Is there a side to side difference you can see?



- SPECT scan
- What does interictal-ictal SPECT show?
- What slice orientation?
- What part of the brain?
- Is there a side to side and ictal-interictal difference you can see?

fMRI



- Language task
- What does fMRI show?
- In this case, what dies it say about language?

How do these all factor in together?

- Clinical history and neuropsych?
- EEG?
- MRI?
- PET?
- SPECT?
- fMRI?

How do these all factor in together?

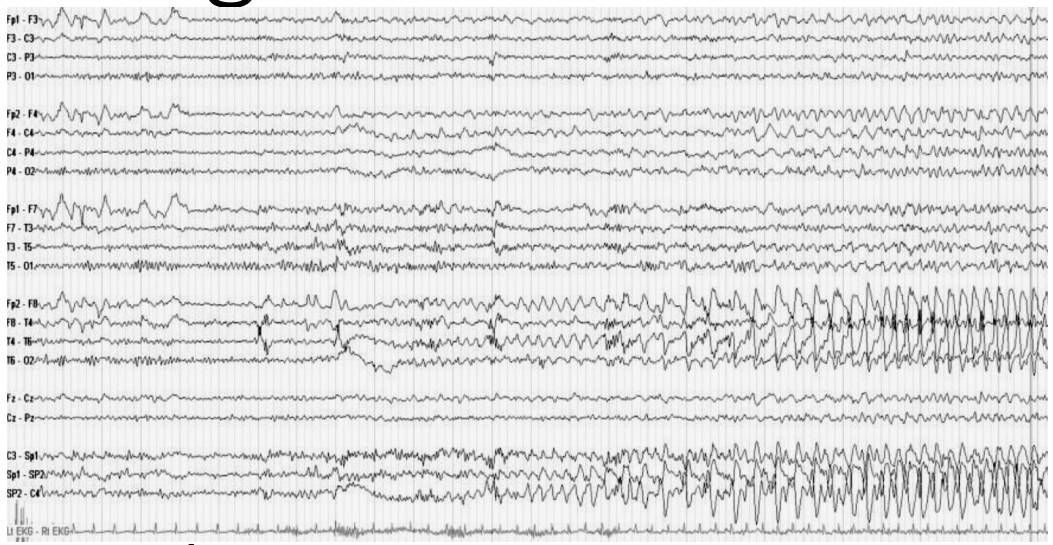
- **Clinical history and neuropsych?**
- EEG?
- MRI?
- PET?
- SPECT?
- fMRI?

- 32 year old with history of seizures, no history of head trauma
- Semiology: Hand automatisms followed by GTC
- Neuropsych shows some memory and language deficits

- **Focal, NS possibly temporal, risk of further deficits**

How do these all factor in together?

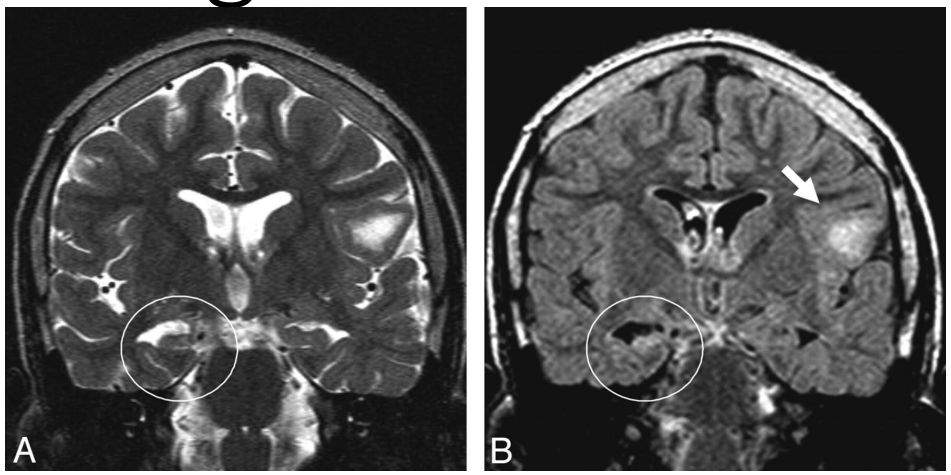
- Clinical Hx and NS: Focal, NS possibly temporal, risk of further deficits
- **EEG?**
- MRI?
- PET?
- SPECT?
- fMRI?



- Focal seizure
- Right temporal
- Sp2 focality
- **Right temporal (?mesial) seizure focus**

How do these all factor in together?

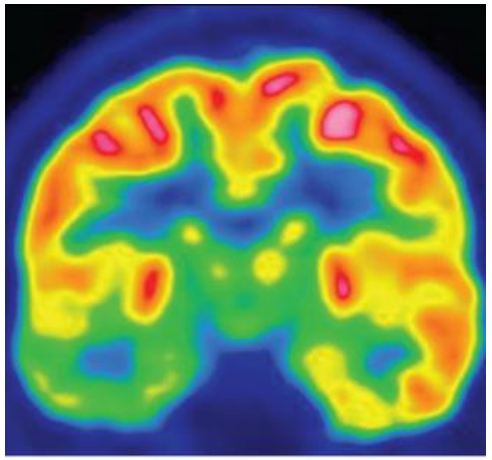
- Clinical Hx and NS: Focal, NS possibly temporal, risk of further deficits
- EEG: Right temporal (?mesial) seizure focus
- **MRI?**
- PET?
- SPECT?
- fMRI?



- Coronal MRI
- Hyperintensity on right hippocampuson T2
- Decreased volume of right hippocampus on T1
- **Right MTS**

How do these all factor in together?

- Clinical Hx and NS: Focal, NS possibly temporal, risk of further deficits
- EEG: Right temporal (?mesial) seizure focus
- MRI: Right MTS
- **PET?**
- SPECT?
- fMRI?

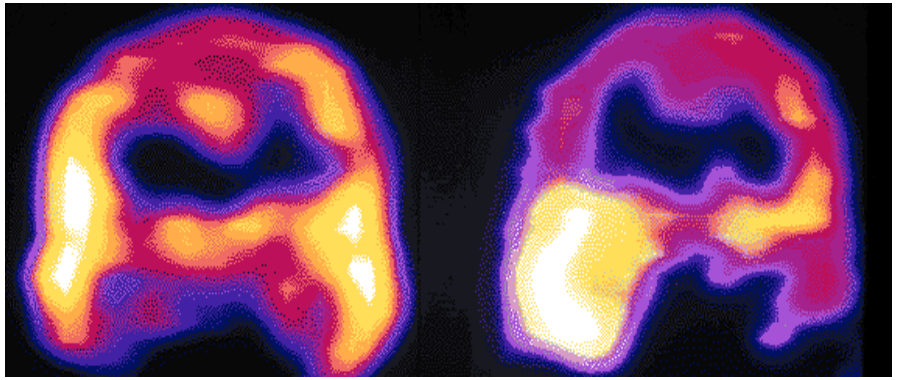


- Coronal-temporal
- Decreased uptake right temporal lobe

- **Right temporal hypometabolism**

How do these all factor in together?

- Clinical Hx and NS: Focal, NS possibly temporal, risk of further deficits
- EEG: Right temporal (?mesial) seizure focus
- MRI: Right MTS
- PET: Right temporal hypometabolism
- **SPECT?**
- fMRI?

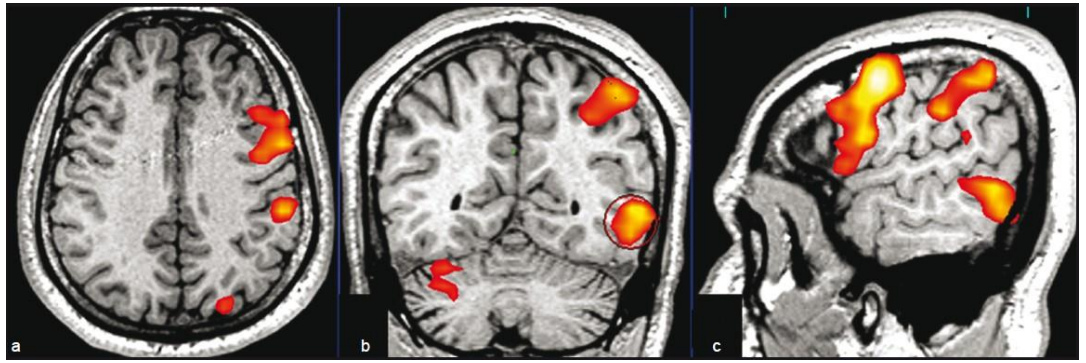


- Coronal ictal and interictal
- Interictal, decreased in right temporal lobe
- Ictal, increased in right temporal lobe

- **Ictal hypermetabolism in right temporal lobe**

How do these all factor in together?

- Clinical Hx and NS: Focal, NS possibly temporal, risk of further deficits
- EEG: Right temporal (?mesial) seizure focus
- MRI: Right MTS
- PET: Right temporal hypometabolism
- SPECT: Ictal hypermetabolism in right temporal lobe
- **fMRI?**



- Language task showing BOLD in left hemisphere
- Not right hemisphere or bilateral
- **Language dominance isolated to left hemisphere**

How do these all factor in together?

- Clinical Hx and NS: Focal, NS possibly temporal, risk of further deficits
- EEG: Right temporal (?mesial) seizure focus
- MRI: Right MTS
- PET: Right temporal hypometabolism
- SPECT: Ictal hypermetabolism in right temporal lobe
- fMRI: Language dominance isolated to left hemisphere

- **Bottom line?**
- discussion

Summary

- Describe what is a slice and what are axial, sagittal, coronal?
  - Which would not show side-side comparison well?
- CT vs MRI?
  - What is each, how can you tell difference?
  - What does fMRI show?
- Nuclear imaging?
  - What does it show, difference between PET and ictal SPECT