

Structural MRI Module

MRI Artifacts

Jason Rock



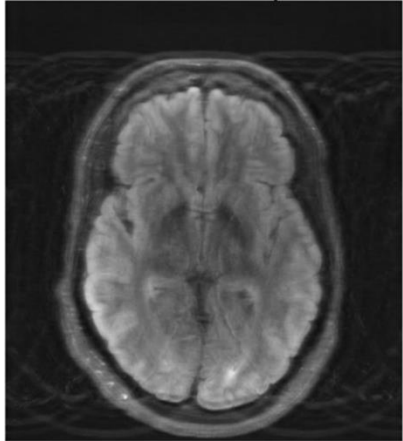
Sunnybrook
RESEARCH INSTITUTE



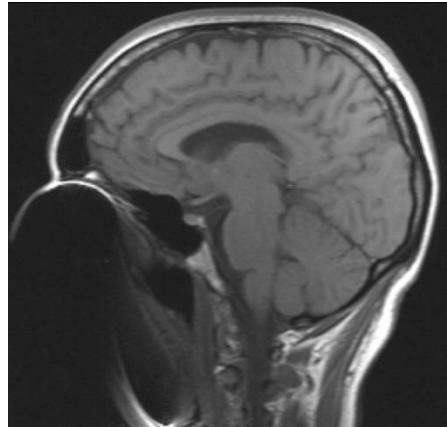
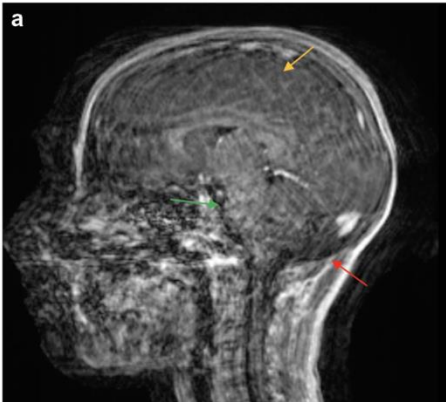
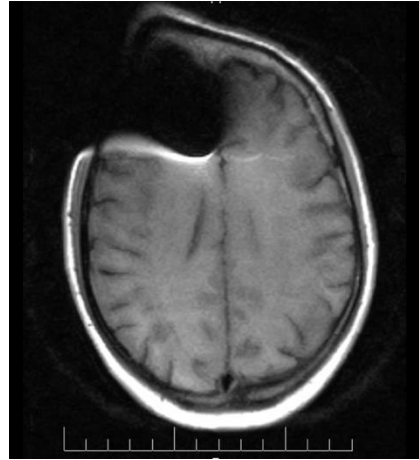
Medical Biophysics
UNIVERSITY OF TORONTO

Subject Dependent Artifacts

Motion

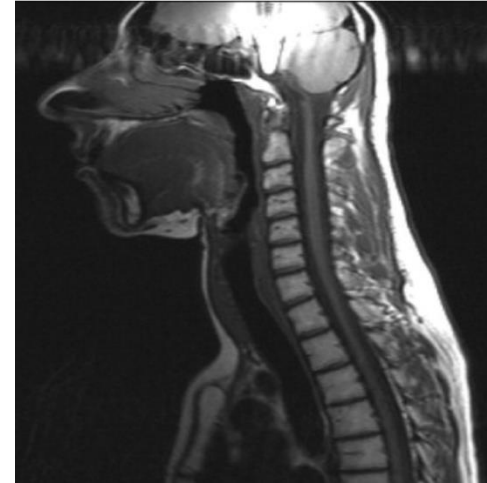


Susceptibility

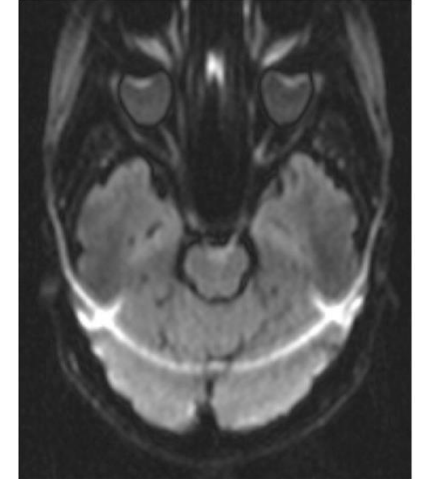


Hardware Dependent Artifacts

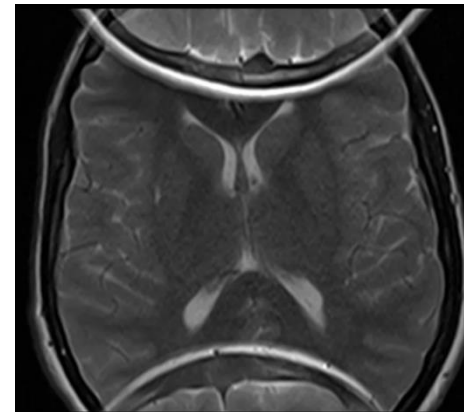
Gradient Distortion



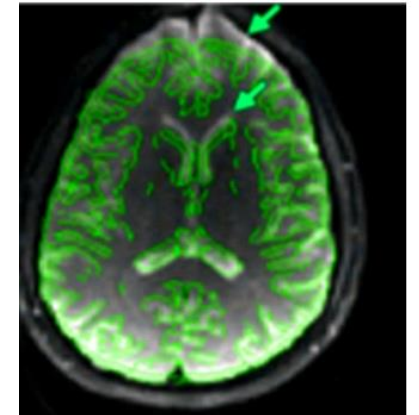
Chemical Shift



Aliasing



Poor Shimming



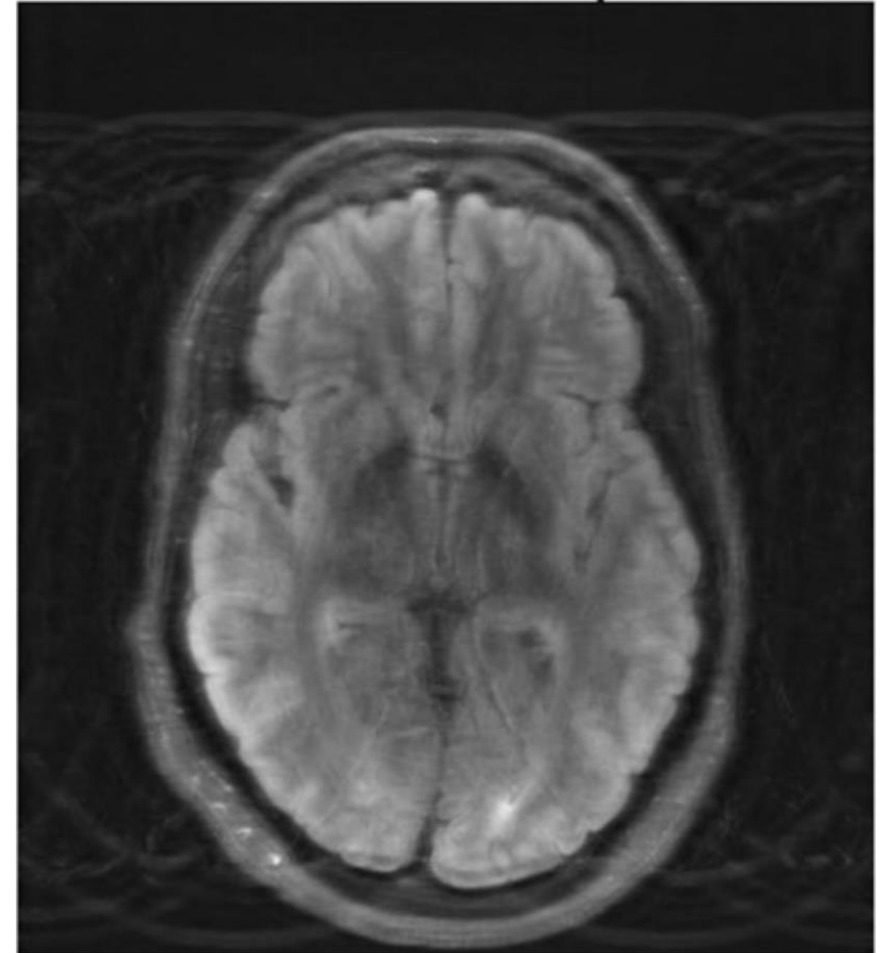
Motion

MR imaging sequences take $\sim 1 - 10$ minutes to acquire data

- Any movement during this time will result in **motion artifacts**
- Common in the brain (rigid motion), jaws, eyes

What it looks like

- Ghosting, duplication, blurring



“MIT researchers combine deep learning and physics to fix motion-corrupted MRI scans” 2023

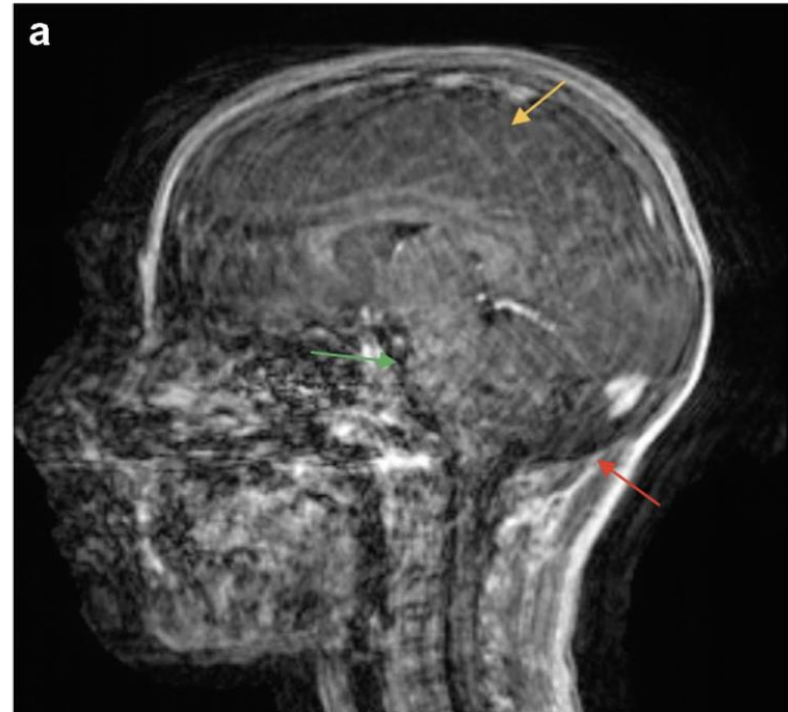
Motion

Commonly seen in

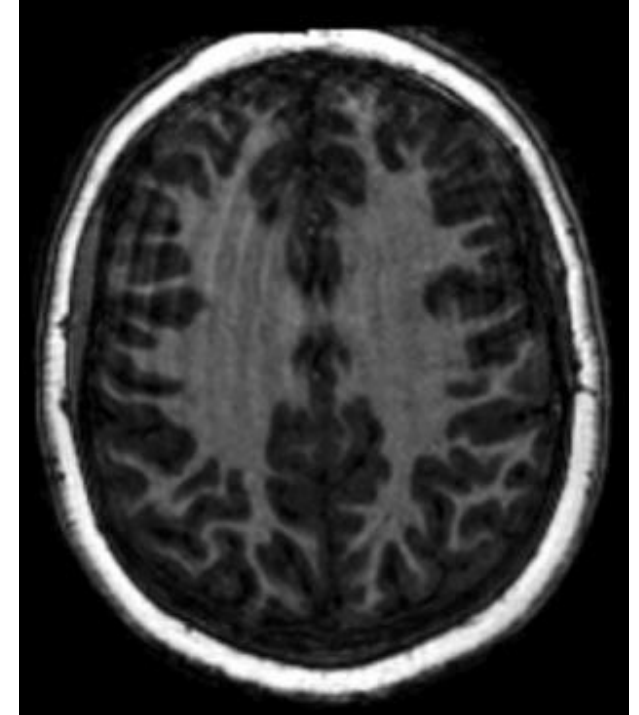
- Paediatrics
- Patients with movement disorders
- Patients with cognitive disorders, often forgetful (Alzheimer's, MCI)

Prospective and retrospective techniques are being developed to correct

- Real-time motion tracking
- Deep learning



Azadeh Tabari, et al. Clinical evaluation of scout accelerated motion estimation and reduction (SAMER) for brain MRI in non-sedated children: initial clinical experience. *Pediatric Radiology* 2025



Ben A Duffy, et al. Retrospective motion artifact correction of structural MRI images using deep learning improves the quality of cortical surface reconstructions, *NeuroImage* 2021,

Susceptibility

Susceptibility artifacts occur at an air-tissue or metal-tissue magnetic field mismatch

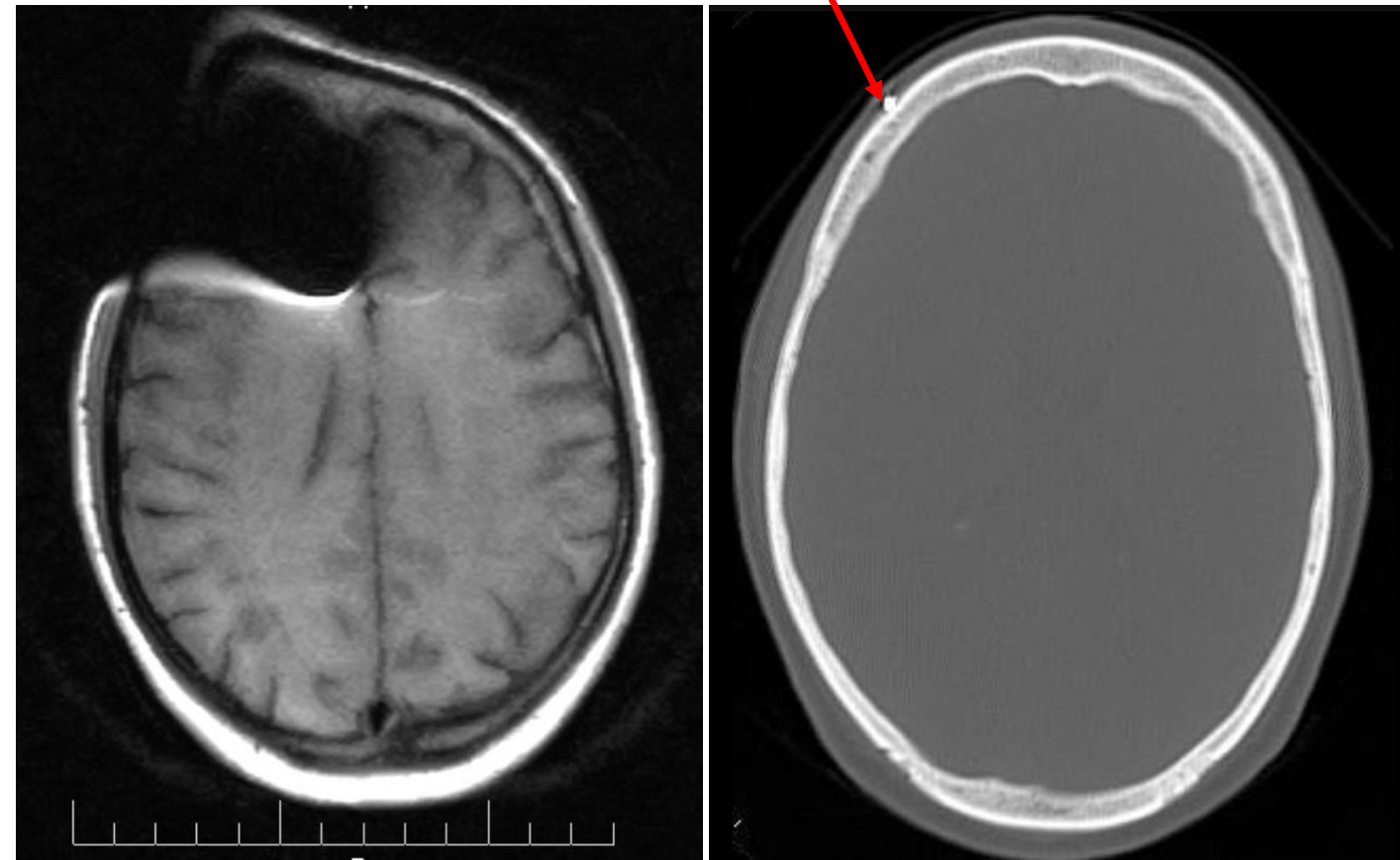
- Think of Snell's law but for magnetic fields

MRI is a precise frequency-spatial mapping of tissues

- If resonant frequency of tissue changes, a miss-mapping can occur

Occurs for patients with

- Braces
- Surgical clips
- Metallic implants
- Certain hair products



Radiopaedia, Magnetic susceptibility artifact

Susceptibility

Susceptibility artifacts occur at an air-tissue or metal-tissue magnetic field mismatch

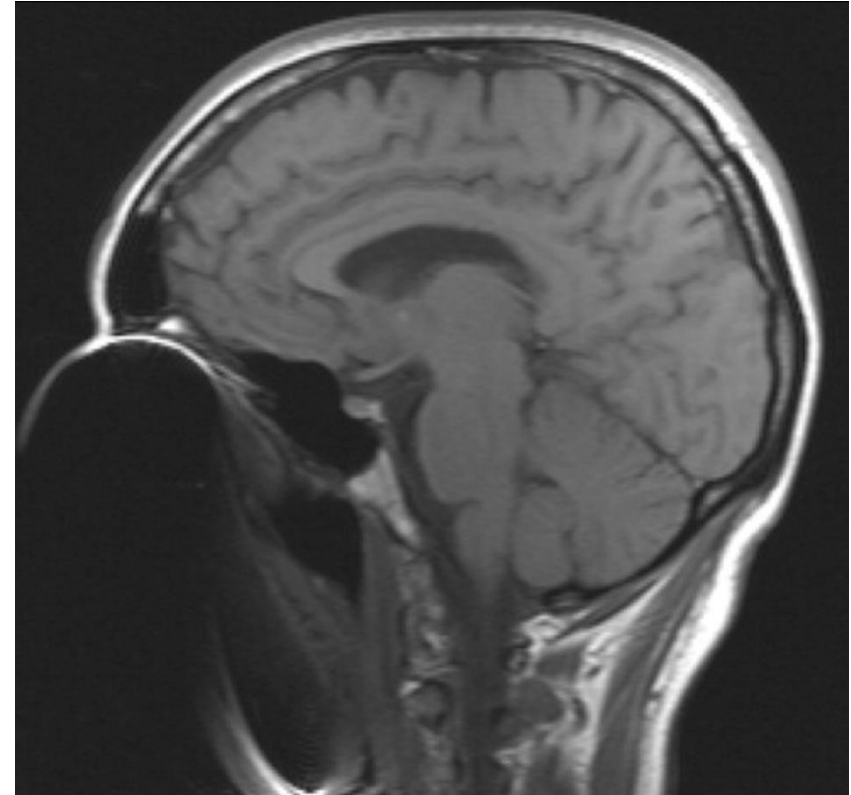
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Effect of braces



Radiopaedia, Magnetic susceptibility artifact

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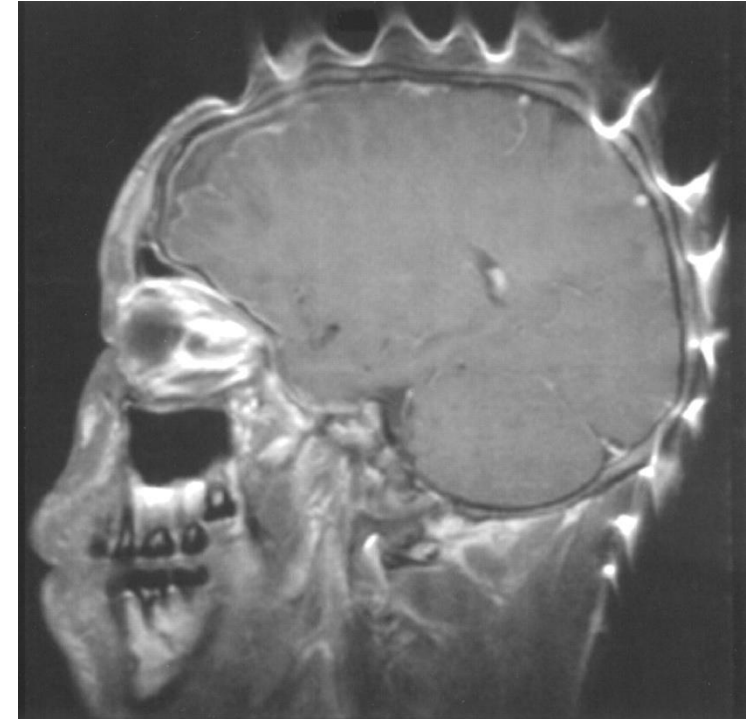
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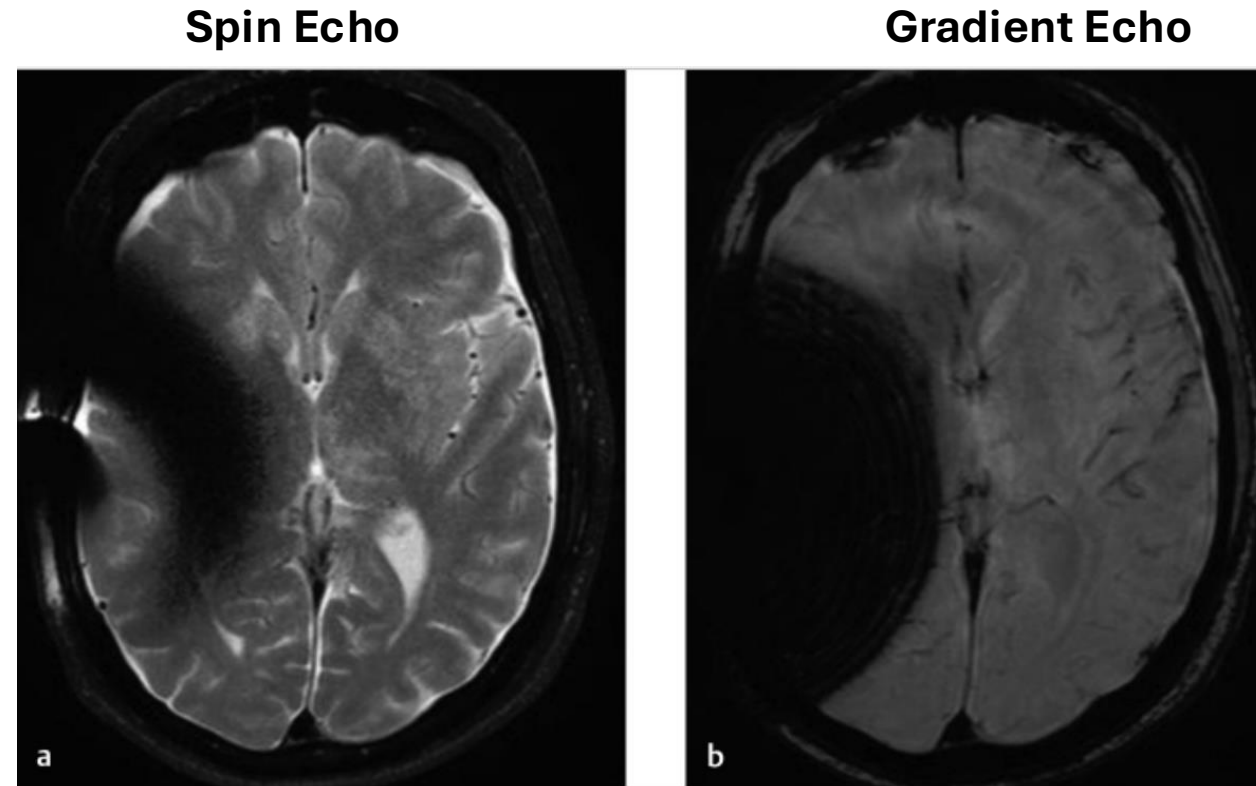
Effect of hair products containing iron oxide



Duncan IC. The "aura" sign: an unusual cultural variant affecting MR imaging. (letter) AJR 2001; 177:1487

Susceptibility

The imaging protocol used can highly influence the outcome of susceptibility artifacts



Westmark, Kaye D. et al.: 2020, Magnetic Susceptibility-Related Artifacts on MRI

Aliasing

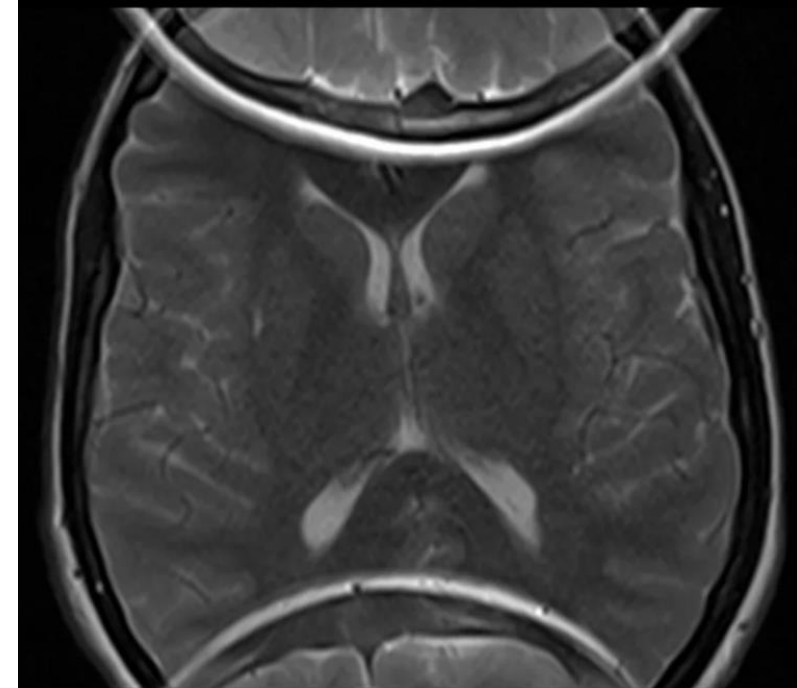
Anatomy appears on wrong side of image

- when the FOV is smaller than the actual object being imaged
- The MRI system assumes that all signal is coming from within the FOV

Mitigation

- Change direction of phase encoding
- Oversample data collection

“Problem for MR technologist to deal with”

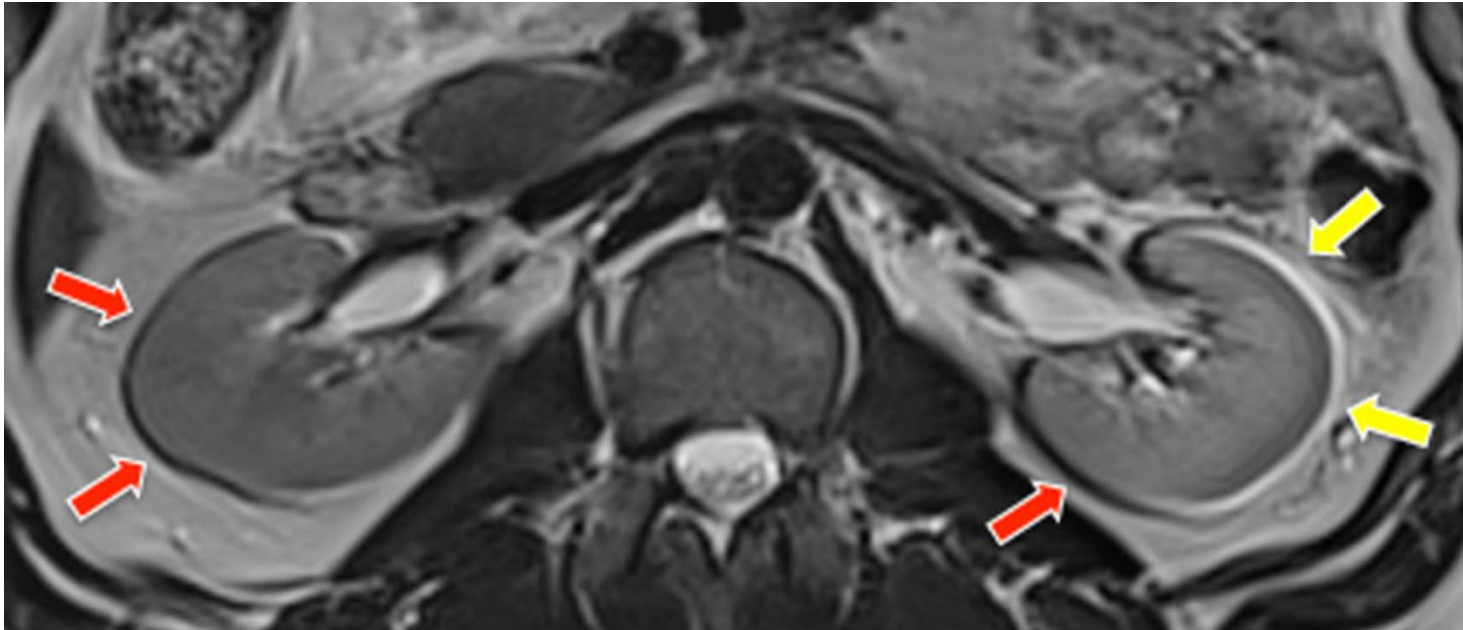


<https://mrimaster.com/aliasing-wrap-around/>

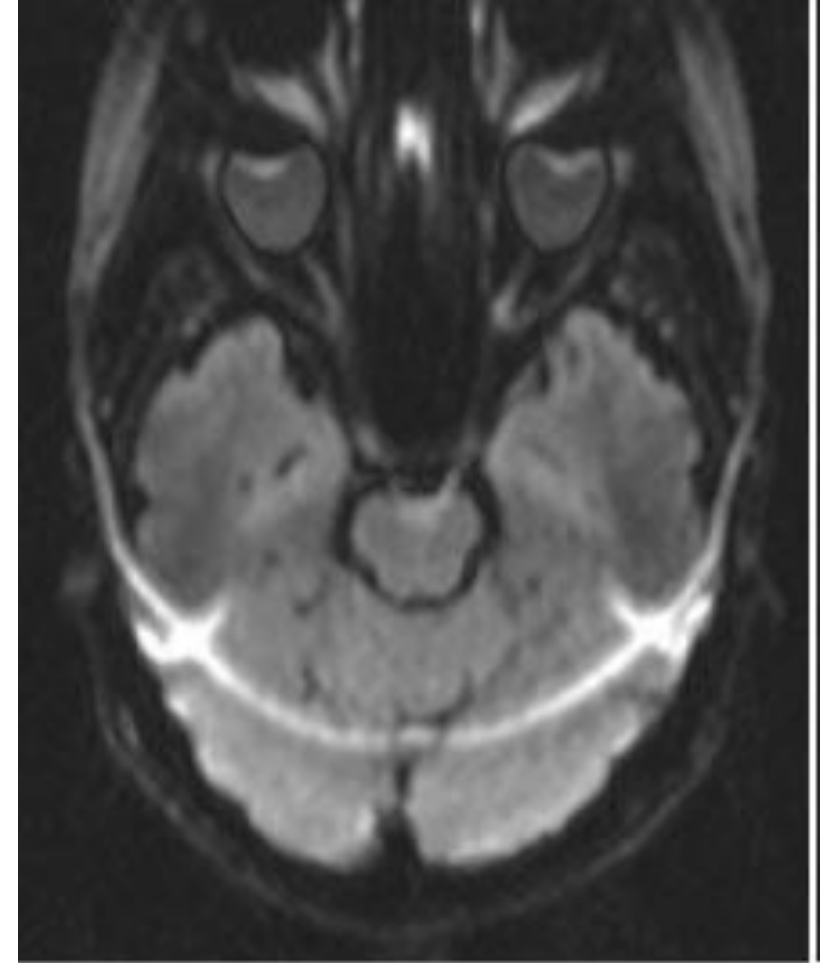
Chemical Shift

Fat and water precess at slightly different frequencies

- spatial mismapping of tissues



<https://www.mriquestions.com/chemical-shift-artifact.html>

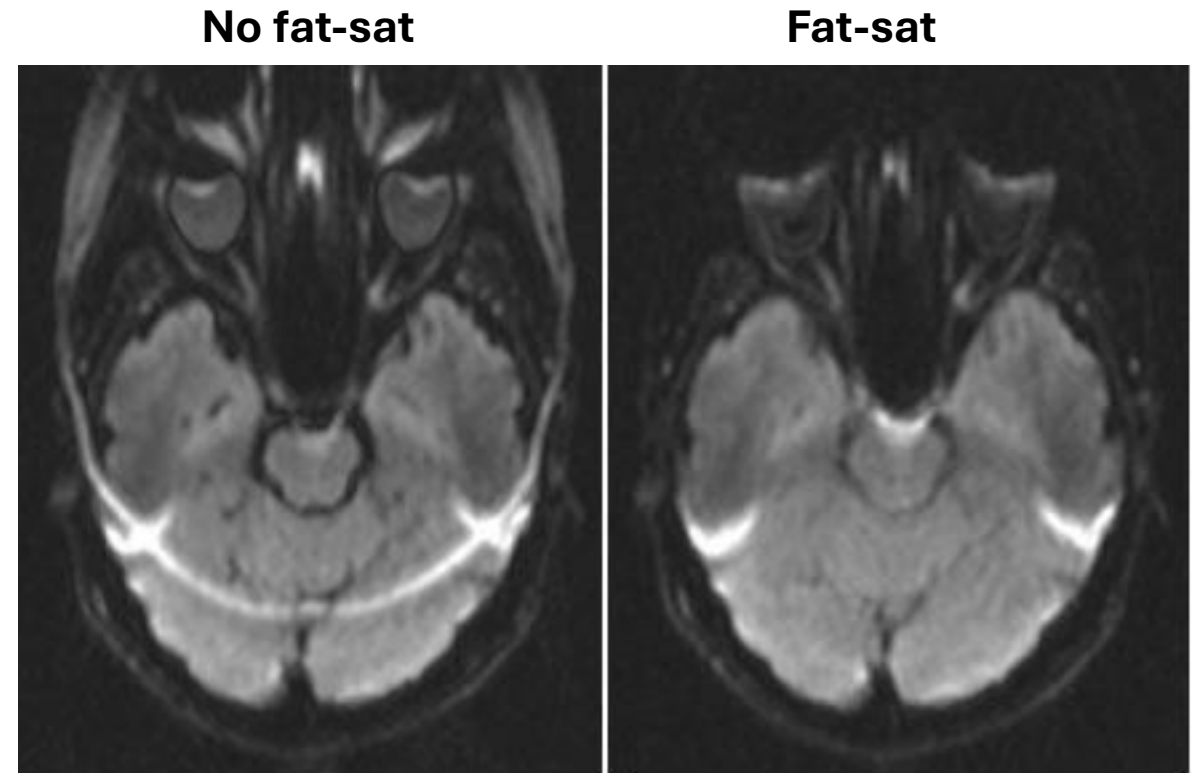


Zhu J, Gullapalli RP. "AAPM/RSNA Physics Tutorial for Residents: MR Artifacts, Safety, and Quality Control." *RadioGraphics* 2006; 26:275-297.

Chemical Shift

Mitigation

- Fat-saturation imaging
- Frequency-selective imaging (Dixon)
- Increase receiver bandwidth
 - Number of allotted frequencies per pixel



Zhu J, Gullapalli RP. "AAPM/RSNA Physics Tutorial for Residents: MR Artifacts, Safety, and Quality Control." RadioGraphics 2006; 26:275-297.

Poor Shim

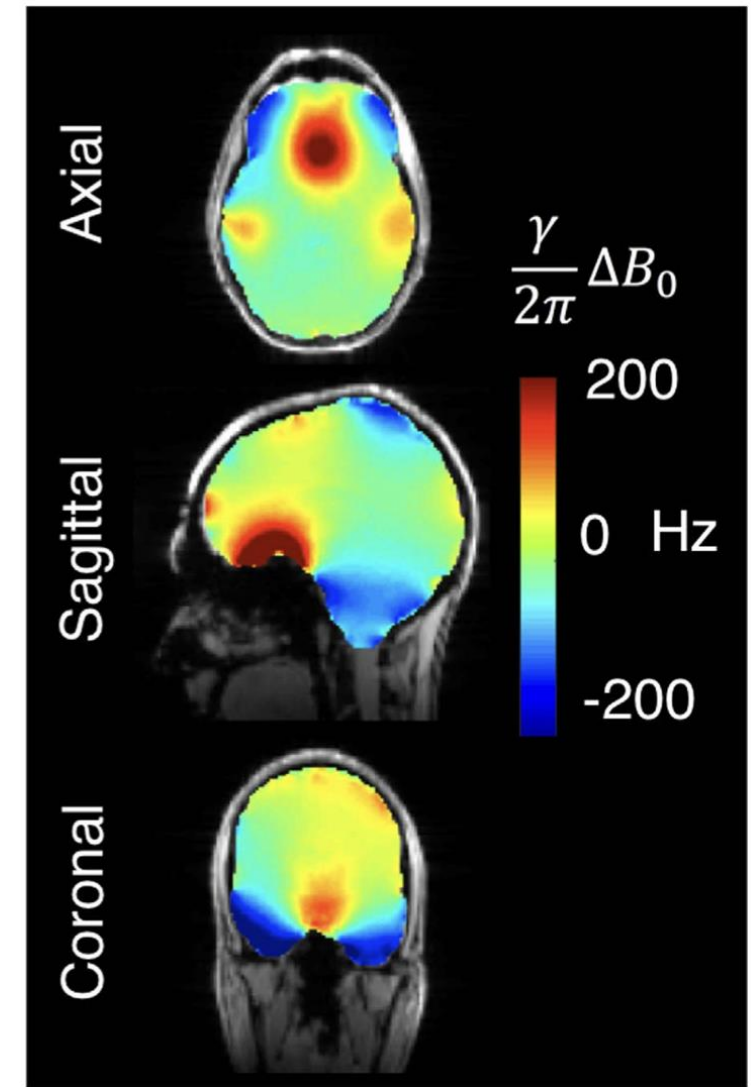
Even with no metallic implants, air-tissue interfaces affect field homogeneity

- An MRI shim attempts to “iron out” the field inhomogeneity

Magnetic Field Boundary Equations

$$\mu_1 H_{n1} = \mu_2 H_{n2}$$

$$H_{t1} = H_{t2}$$



Jason P. Stockmann, Lawrence L. Wald, In vivo B0 field shimming methods for MRI at 7T, NeuroImage

Poor Shim

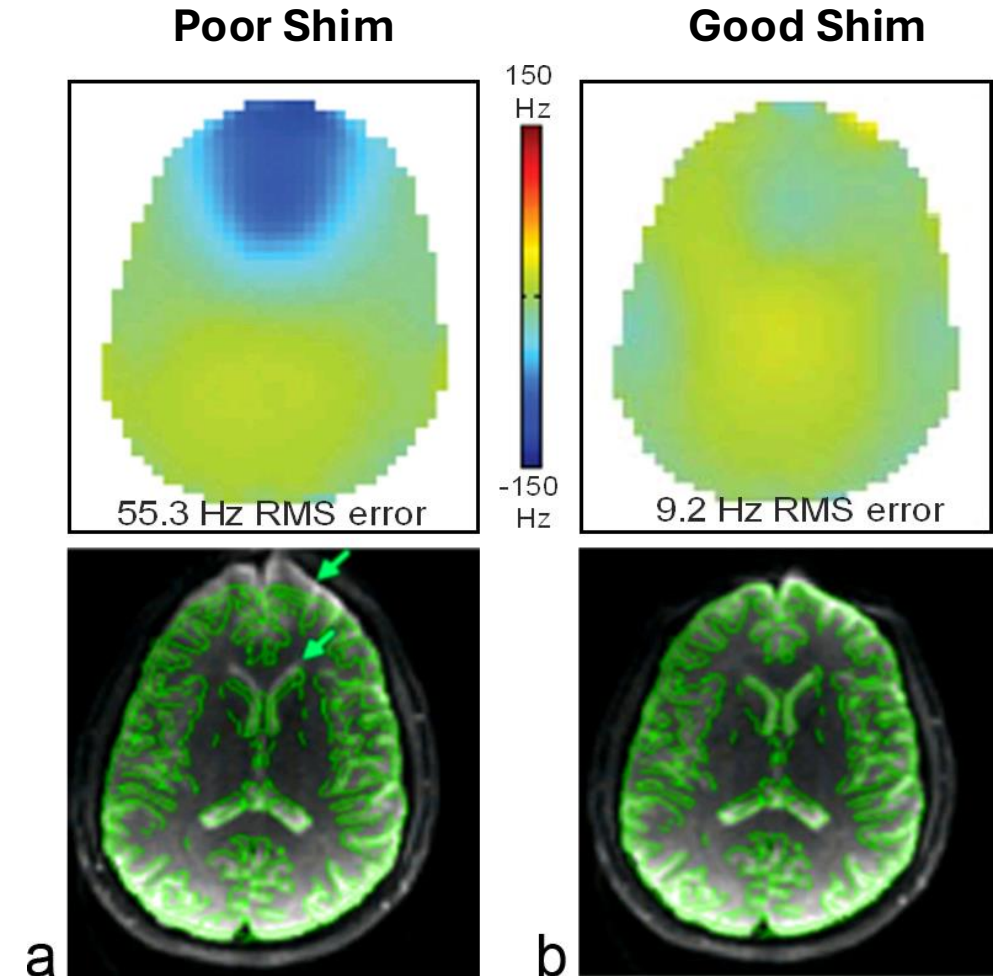
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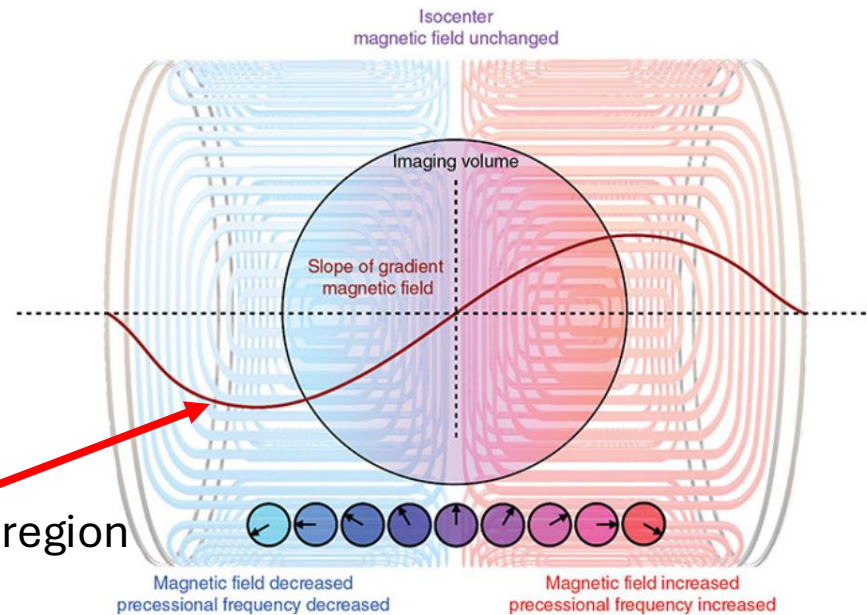
$$H_{t1} = H_{t2}$$



Gradient Distortion

Gradient fields become non-linear for extended FOV imaging

- Not common for neuro-imaging
- Once again, due to spatial mismapping of tissues



J Zhou, R Gullapalli. MRI Artifacts, Safety, and Quality Control. Radiographics 2006

Gradient Distortion

Vendor supplied correction algorithm



Uncorrected

