

Controlling the MRI Image Quality

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Formation of MRI

- **Source of MR signals, RF excitation, signal detection**
- **Spatial encoding, image reconstruction**
- **Image contrast (PD, T1, & T2)**
- **How to get a good and clear image ?**

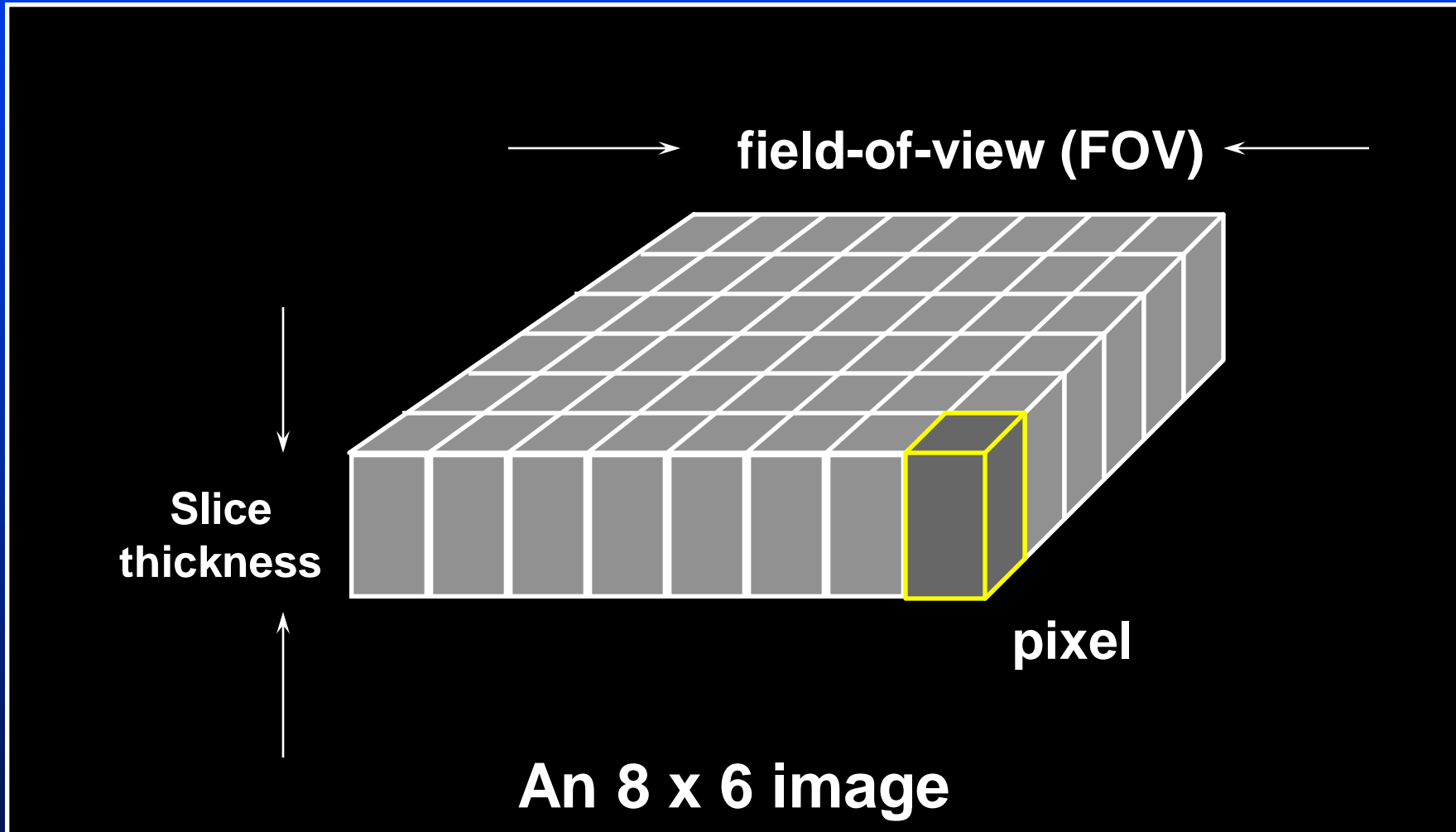
What Is a Good Image ?

- **Fine details -- high resolution**
- **Low noise -- high SNR**
- **Lesion depiction -- high contrast**
- **Unfortunately often mutually conflict !**

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Image Matrix Size and the Pixel



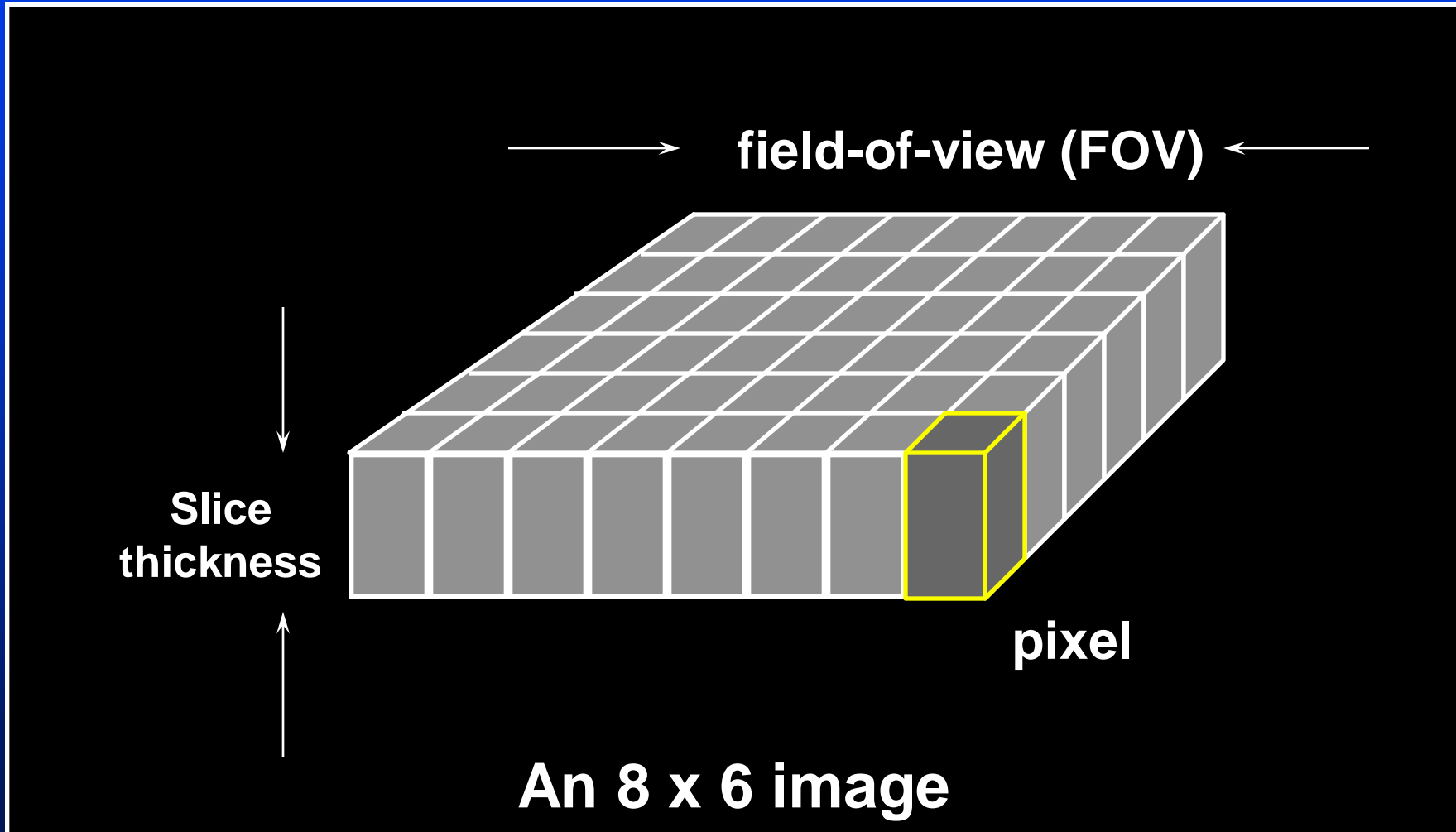
(Spatial) Resolution

- **Smallest tissue that can be differentiated**
- **Image composed of lots of pixels**
- **Resolution is higher if the pixels are smaller or more in number**
 - **256 x 256 → 1024 x 1024 ?**

Why Not 1024 Imaging ?

- **FOV = 24 cm → differentiate tissue as small as 0.24 mm !**
- **Noise becomes strong (lowered SNR)**
- **Scan becomes long (TR * 1024)**

Image Matrix Size and the Pixel



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What Is SNR ?

- **Relative strength of the signal**
- **Signal-to-Noise Ratio**
- **Signal intensity divided by noise intensity**
- **The larger the better**

SNR Determining Factors

- **Number of protons (voxel volume)**
- **TR and TE (T1 and T2)**
- **Number of sampling points**

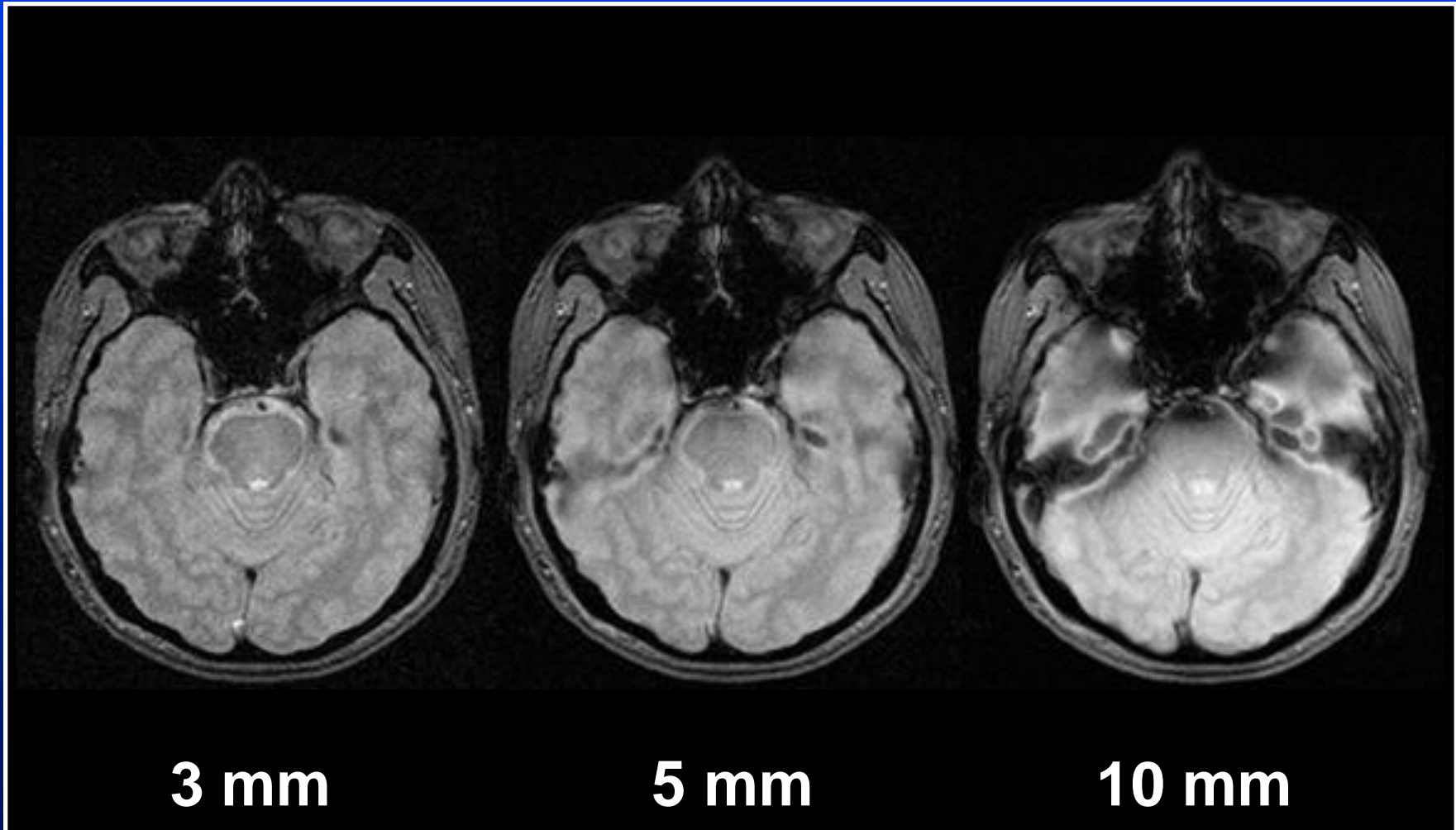
SNR Determining Factors

- **Number of signal averages (NEX)**
- **Usage of RF coil**
- **Sampling frequency (i.e., readout bandwidth)**

of Protons (Volume)

- **As slice thickness gets larger :**
 - **Voxel volume is larger, hence containing more protons**
 - **SNR becomes higher**
 - **Lowered resolution !**

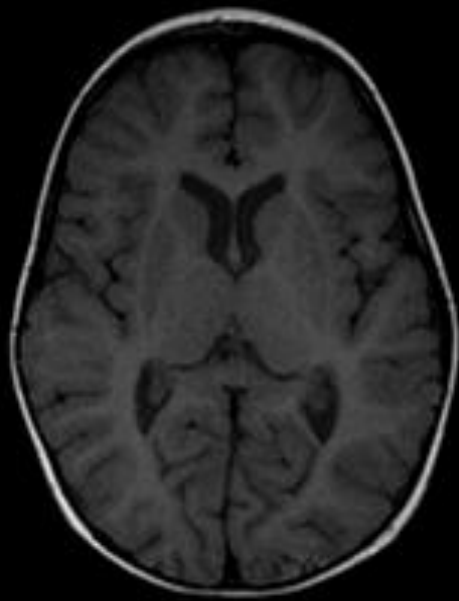
Effects of Slice Thickness



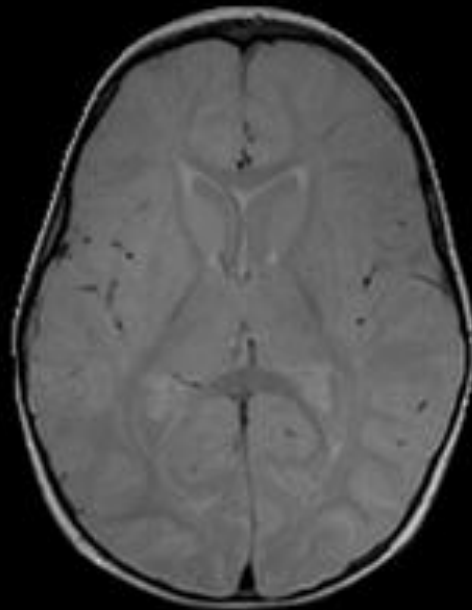
TR & TE (T1 & T2)

- **Longer TR → T1 recovery → higher SNR**
 - **Reduced T1 weighting; Longer scan**
- **Shorter TE → T2 decaying → higher SNR**
 - **Reduced T2 weighting**

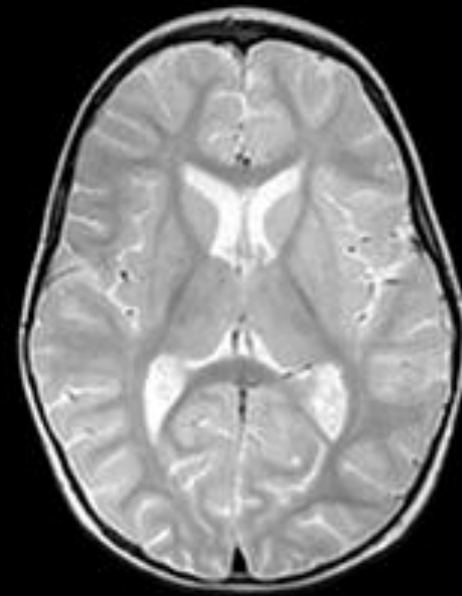
Effects of TR on T1 Contrast



TR = 600

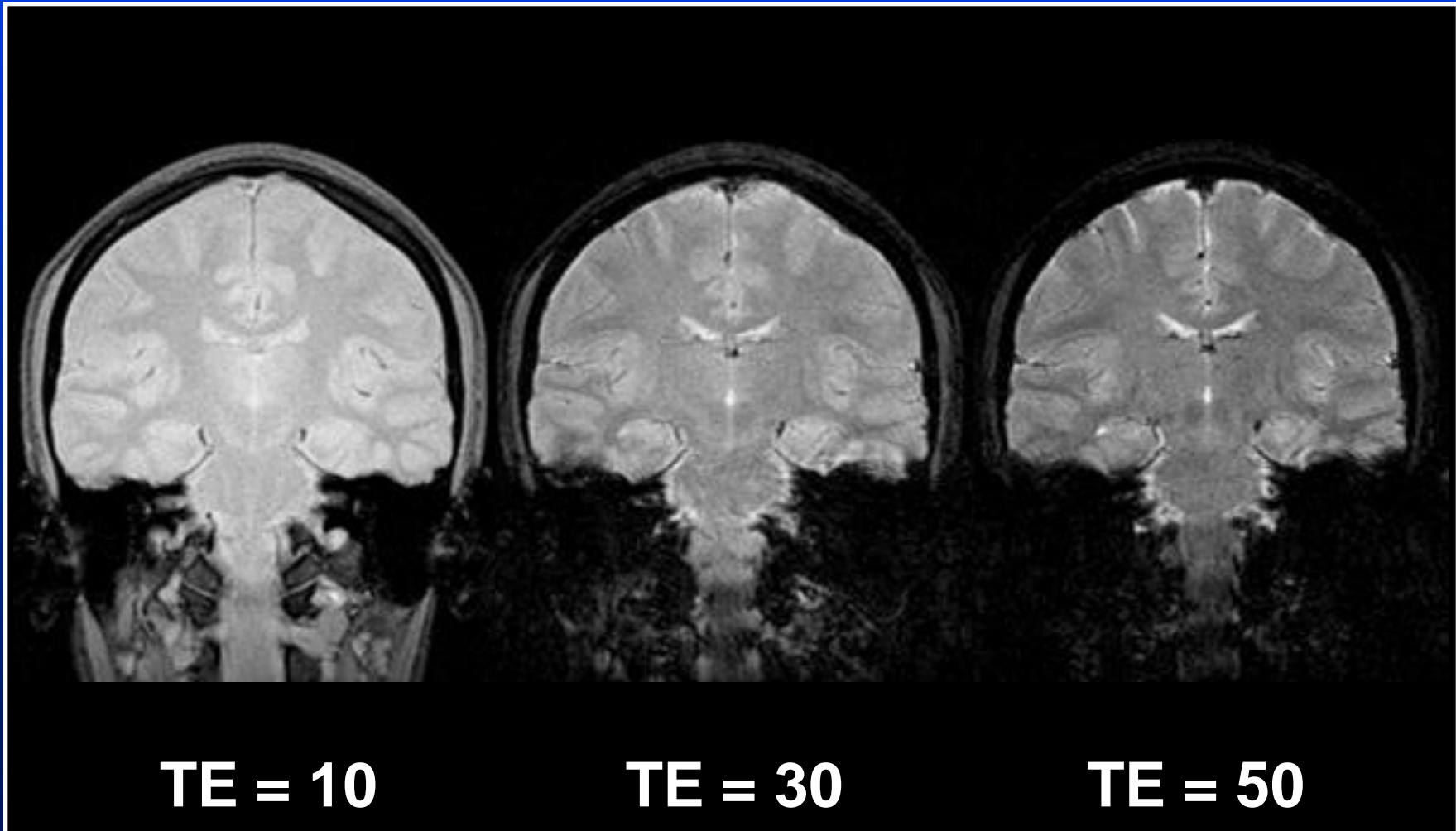


TR = 2400



TR = 4200

Effects of TE on SNR & T2* Contrast



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Image Matrix Size

- **The more you sample, the higher SNR**
 - **Also higher resolution if at fixed FOV**
 - **Lowered voxel volume also reduces image SNR !**
- **Needs thorough quanticonsideration**

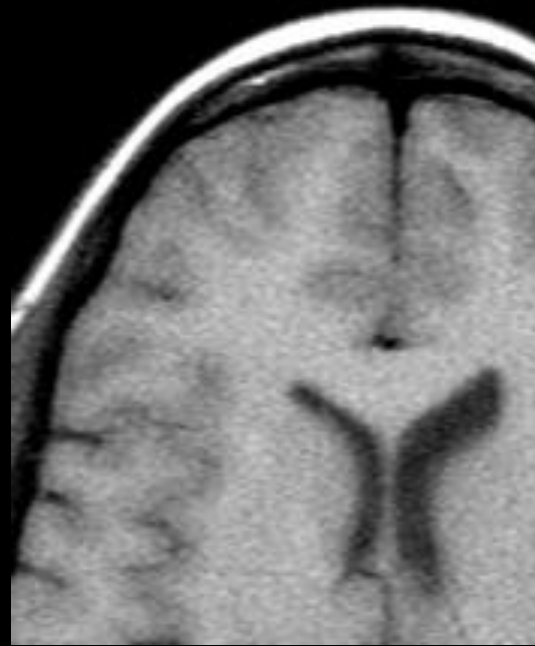
Example : FOV = 24 cm

- **256 x 128 → 256 x 256**
 - **2x sampling points → 40% SNR gain**
 - **Voxel volume reduced to half → 50% SNR loss**
- **Overall SNR reduced to 70% !**

Effects of Image Matrix Size



256x256



512x256



512x512

of Signal Averages

- **Doing it more times if unsatisfied**
- **More averages give higher SNR**
 - **Square root proportional**
- **Scan time increases proportionately**
- **Completely in vain if patient moves**

Usage of RF Coil

- **Smallest coil that can cover the tissue (wire as close to human body as possible)**
- **~ 80% volume filling factor**

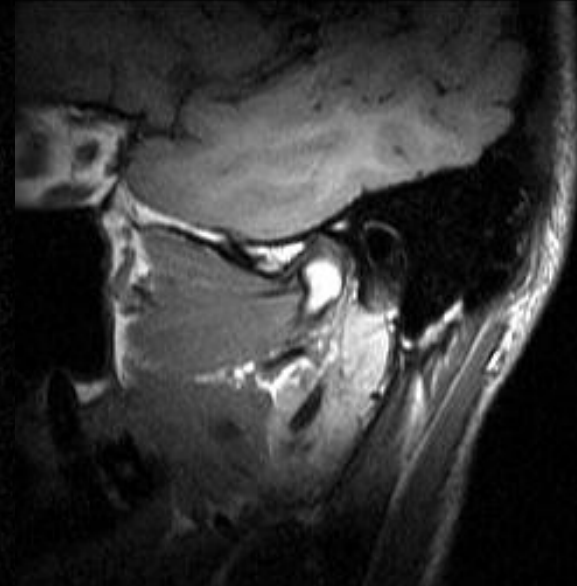
Effects of Coils on SNR



Body coil



Head coil



3-inch surface

Sampling Frequency

- Higher readout bandwidth allows receiving of more noise
- ... in addition to other subtle effects
 - Minimum TE, chemical shift artifacts ...
- Seldom changed by clinical technologists

In Summary ...

SNR proportional to :

number of protons

slice thickness

pixel width (2 directions)

$\sqrt{\text{matrix size (2 directions)}}$

$\sqrt{\text{\# of signal averages}}$

$1 / \sqrt{\text{readout bandwidth}}$

affected by T1, T2, TR, TE

affected by RF coil

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Lesion Contrast

- **Understand the relaxation properties of different lesions**
- **Proper choice of TR and TE**
- **Create other contrast (flow, diffusion ...)**
- **Usage of contrast agents**

Scan Time Consideration

- **(TR) x (phase encoding) x (NEX)**
- **Patient comfort**
- **Efficient scanner usage**
- **Motion artifacts**

Effects of Scan Time (already fast)

