HST.583: Functional Magnetic Resonance Imaging: Data Acquisition and Analysis
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Human Subjects in fMRI Research

Outline

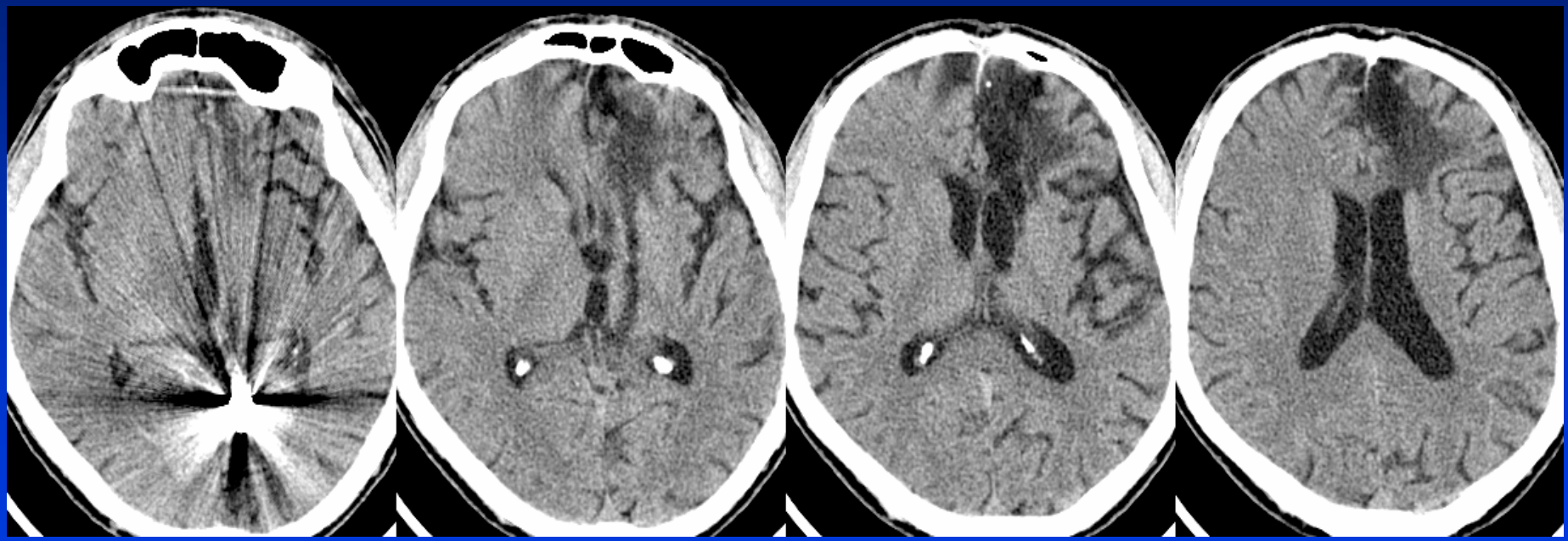
- ***fMRI Risks to Human Subjects***
  - Static B0 fields
  - RF B1 fields- tissue heating
  - Switched gradient fields- peripheral nerve stimulation
  - Acoustic Noise
- ***Practicing Safe Imaging- minimize risks***
- ***Minimizing Distress in the MR Environment***
- ***Ethical Conduct of fMRI Research involving Human Subjects***

Static B_0 Fields

- No established adverse health effects
- Projectile accidents
- Metallic object screening
- Magnetohydrodynamic effects

Static B_0 fields- Projectile Accidents

45 y.o. male 2+ years s/p altercation



RF B_1 Fields- Tissue Heating

- Ohmic heating of patient tissue is due to resistive losses from induced electric fields
- Greatest effect at periphery or surface
- Described in terms of Specific Absorption Rate (SAR)
- Scanner determinants: RF frequency, type of RF pulse, TR and type of RF coil
- Body determinants: thermoregulatory function

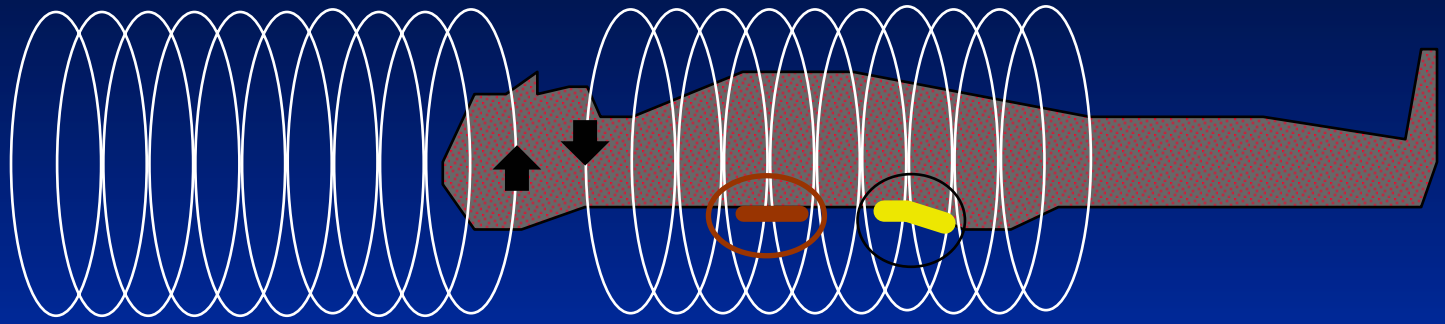
- Electrical Burns

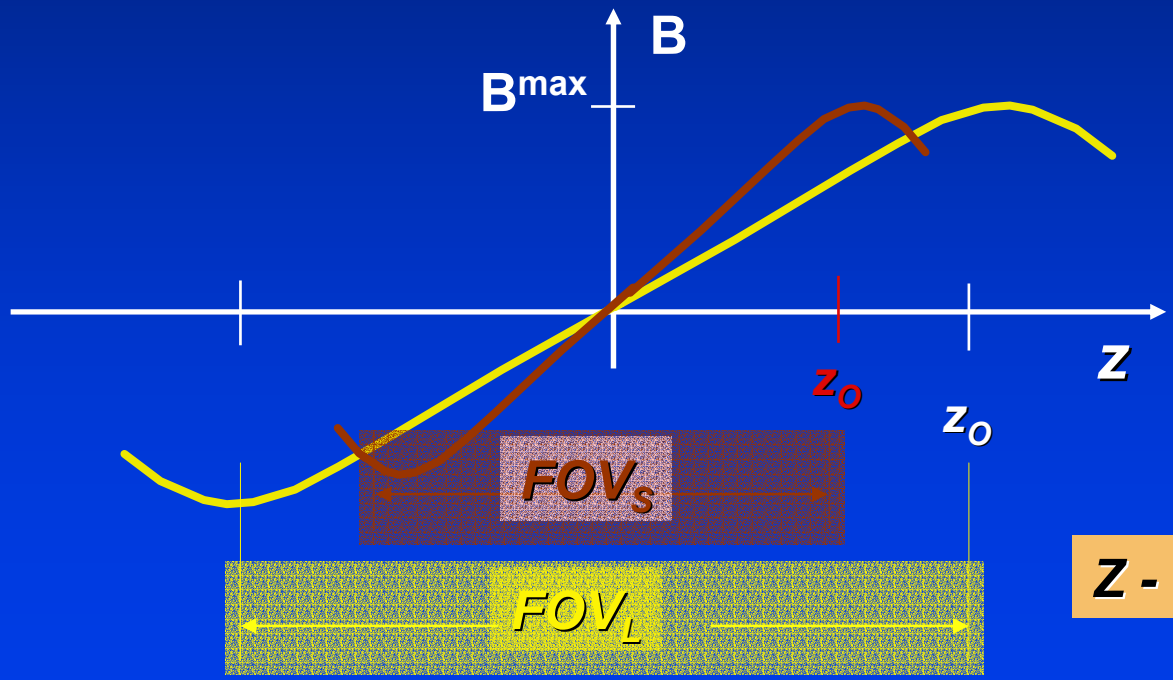
Switched Gradient Fields

- Peripheral Nerve Stimulation
- Metallic Taste
- Magnetophosphenes
- Skeletal Muscle Contractions

- By Faraday's Law of Induction exposure of conductive tissue to time-varying magnetic fields will induce an electric field.

Peripheral Nerve Stimulation

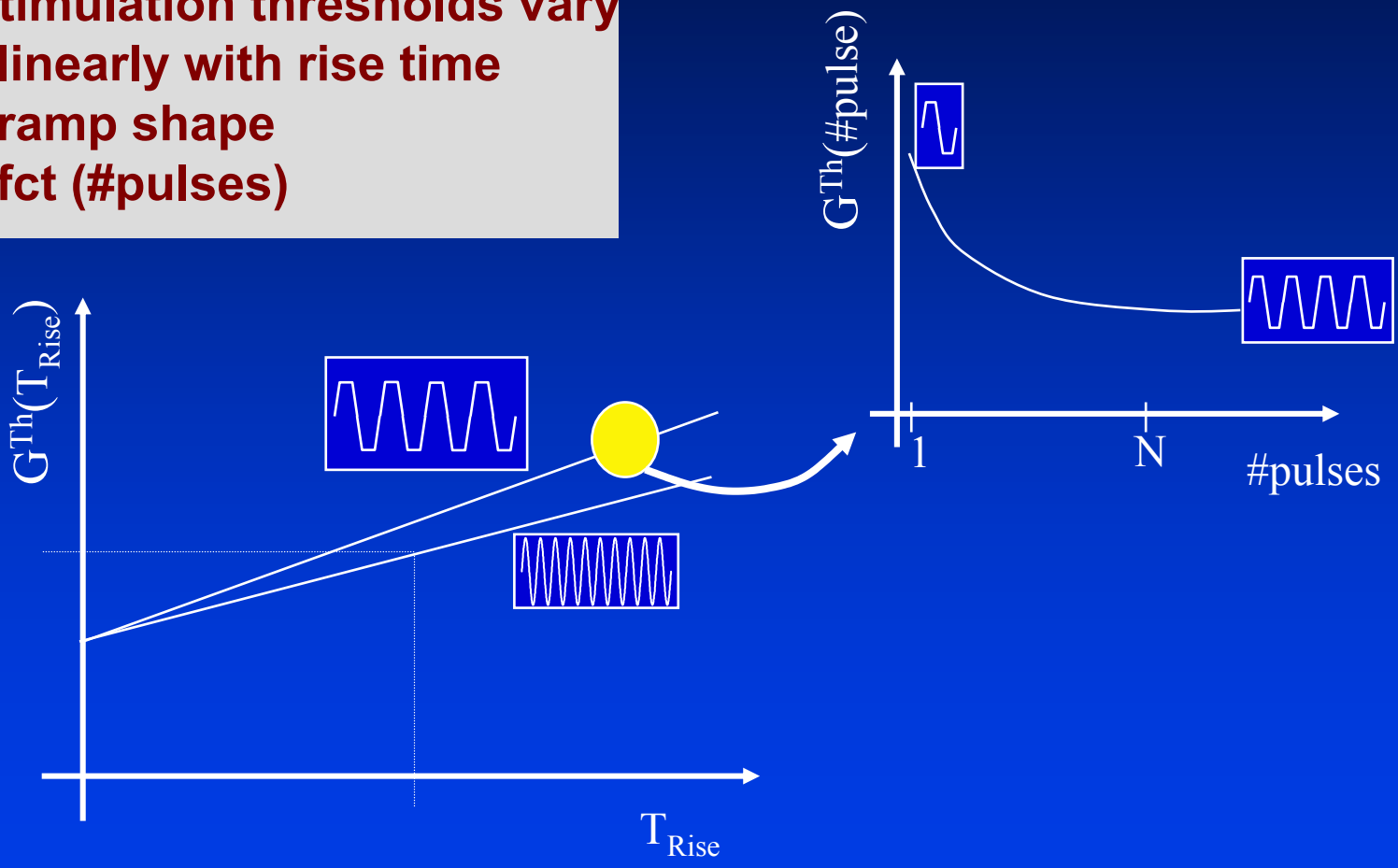




Z - gradient

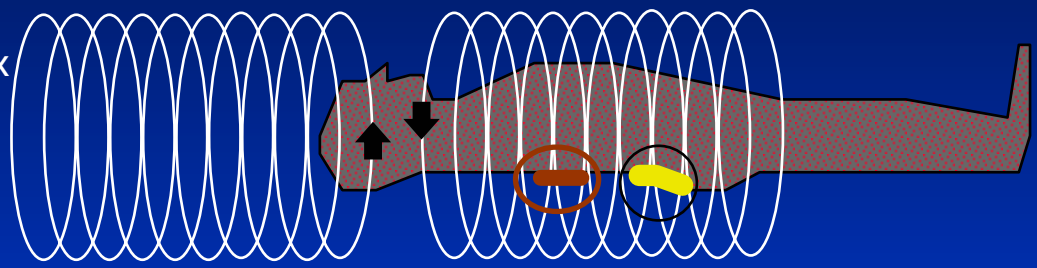
Stimulation Aspects(I)

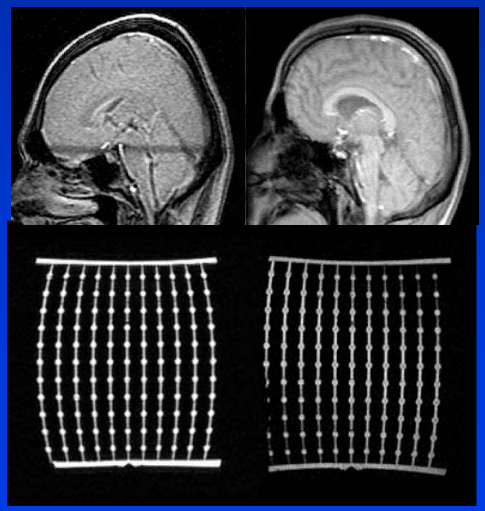
- Stimulation thresholds vary
  - linearly with rise time
  - ramp shape
  - fct (#pulses)



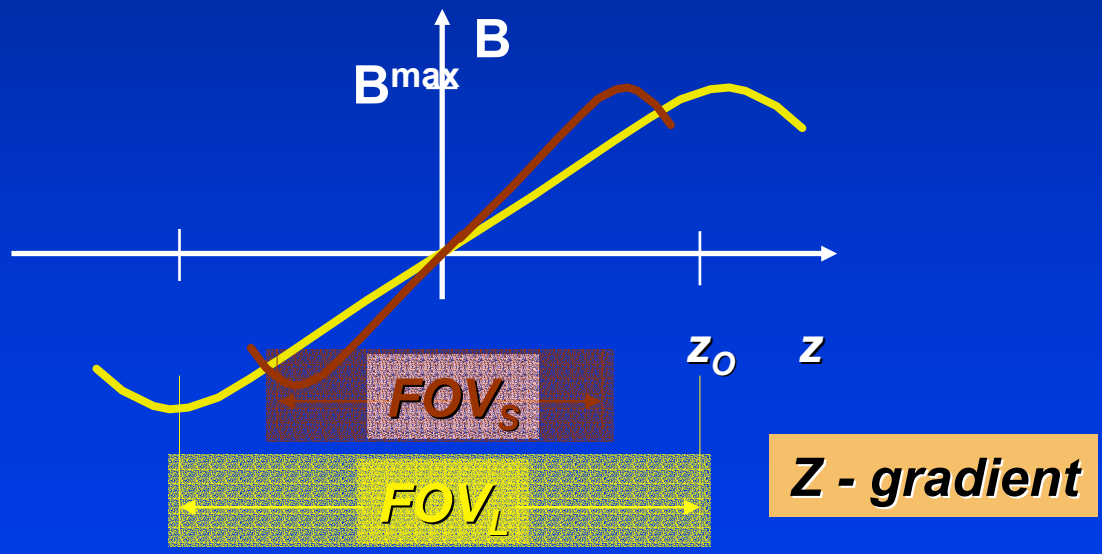
Faster & Stronger Gradients

- **"shorten" the gradient coil typically results in**
  - higher stimulation thresholds, when expressed in mT/m
  - lower inductance
    - i.e. higher SR, G^{max}
  - but more geometric image distortions

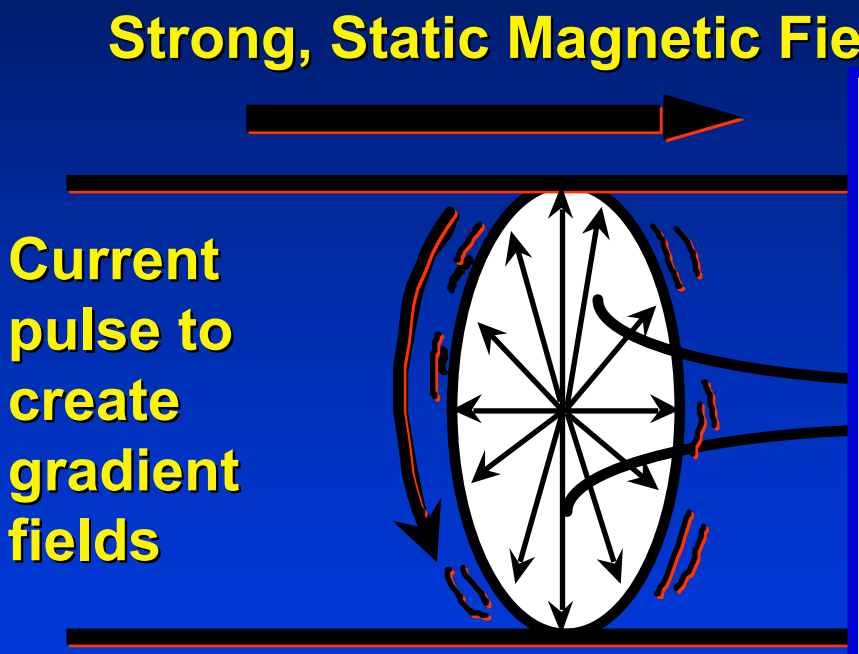




SR150 SR200



Why does EPI make so MUCH noise?

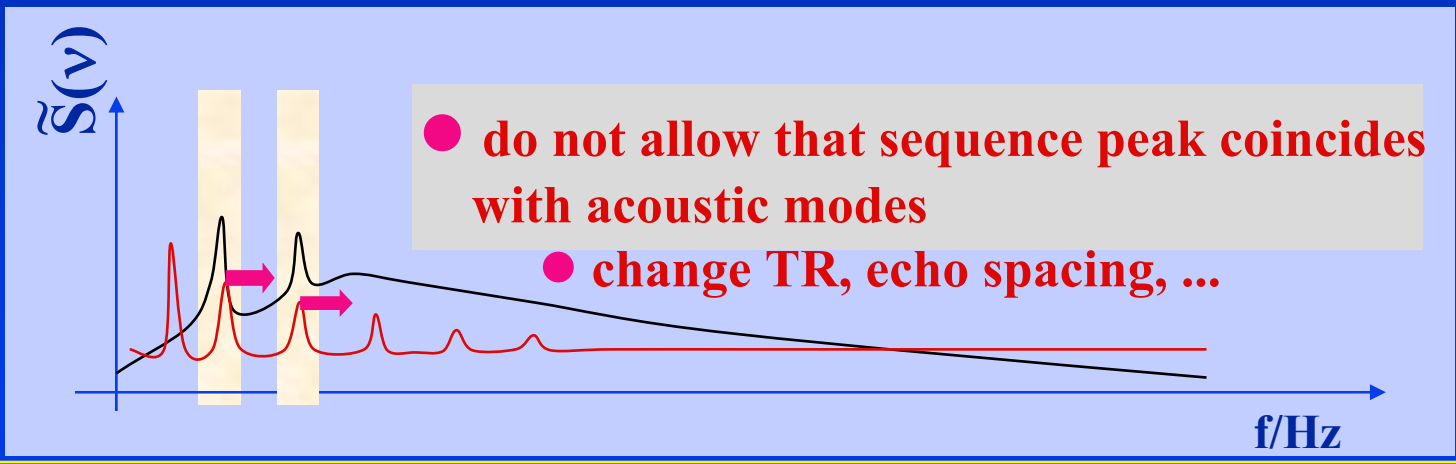


Together, these produce mechanical forces on the coils that create the gradient fields; so the coils move.

The result is acoustic noise.

Acoustic Noise .. and how to avoid?

- passive damping ~ 10 - 15 dB
  - acoustic insulation
  - more mass & stiffer
- encapsulation & vacuum ~ 20 - 30 dB
  - cooling
  - MRI system becomes longer
- “active” damping ~ 20 dB
  - avoid mechanical / acoustical resonance



Current FDA Criteria for Non-significant Risk

- Field strength < 4T
- SAR < 3 W/kg averaged over 10 minutes in head
- SAR < 8 W/Kg in any 1 cc of tissue in head averaged over 5 minutes
- Acoustic Noise <140 dB peak and 99 dB average with ear protection
- No painful or severe peripheral nerve stimulation

Subjective Distress in the MRI Environment

- Incidence of distress among clinical MRI is high
- Distress can be caused by may factors including: confined space, noise, restriction of movement
- Distress can range from mild anxiety to full blown panic attack
- Distress can result in subject motion and disrupt image quality

Minimizing Subjective Distress

- Careful screening
- Complete explanations
- Make them comfortable in the scanner
- Maintain verbal contact
- Give them the panic button

Safety is Your Responsibility

- **Become familiar with the material posted on your institution's Human Subjects web site**
- **Read**
  - Belmont Report
  - Title 45 Code of Federal Regulations Part 46 Protection of Human Subject
- **Review NIH presentation from the Office of Human Research Protection**

Human Subject Considerations

- Informed Consent
- Risk/Benefit Considerations