

Part I

MRI

The basic operation and its applications

After the first meeting on "MRI"
the students were asked to prepare a presentations,
emphasizing also the T1 and T2 encoding, used on:

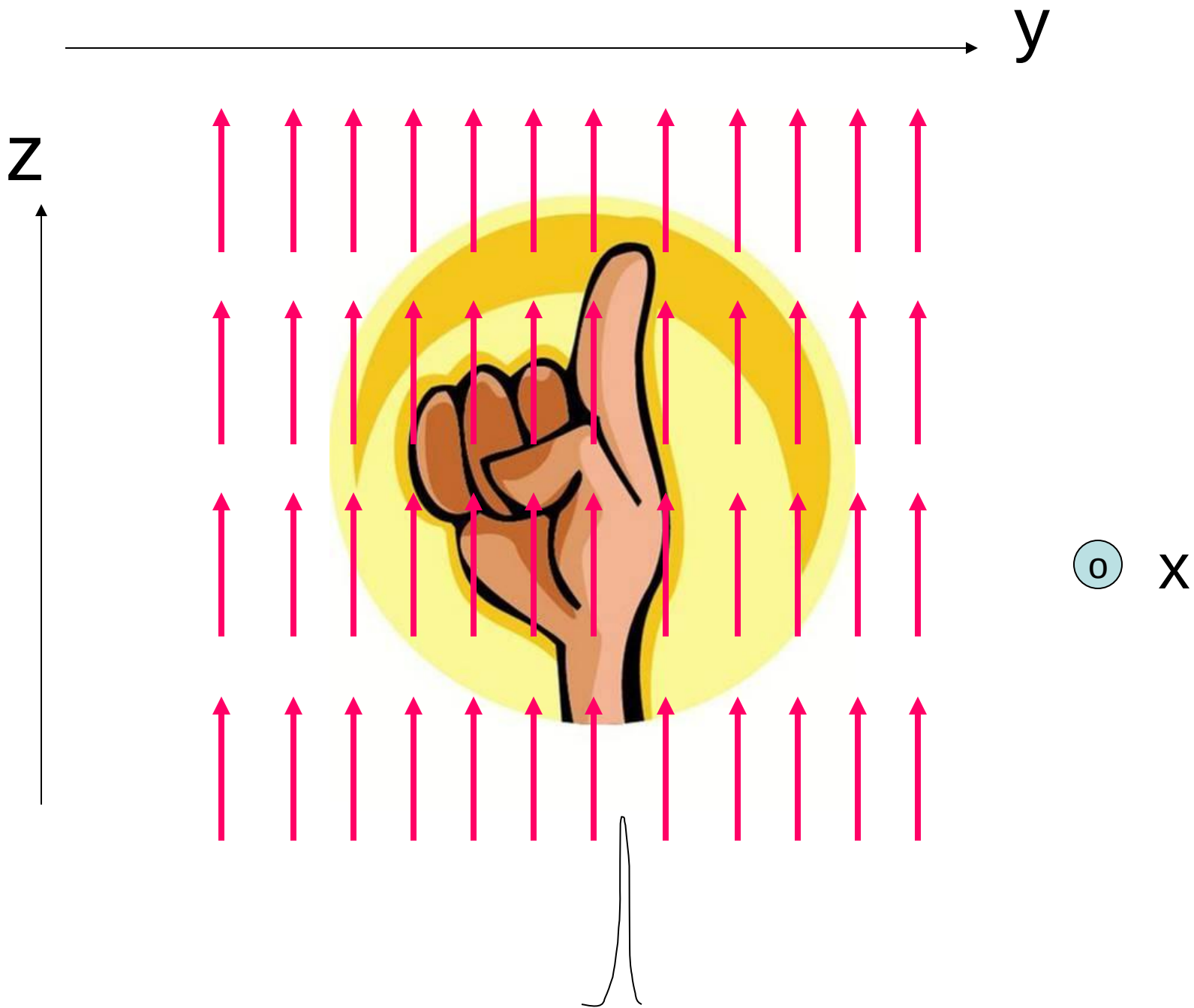
5-8 slides:

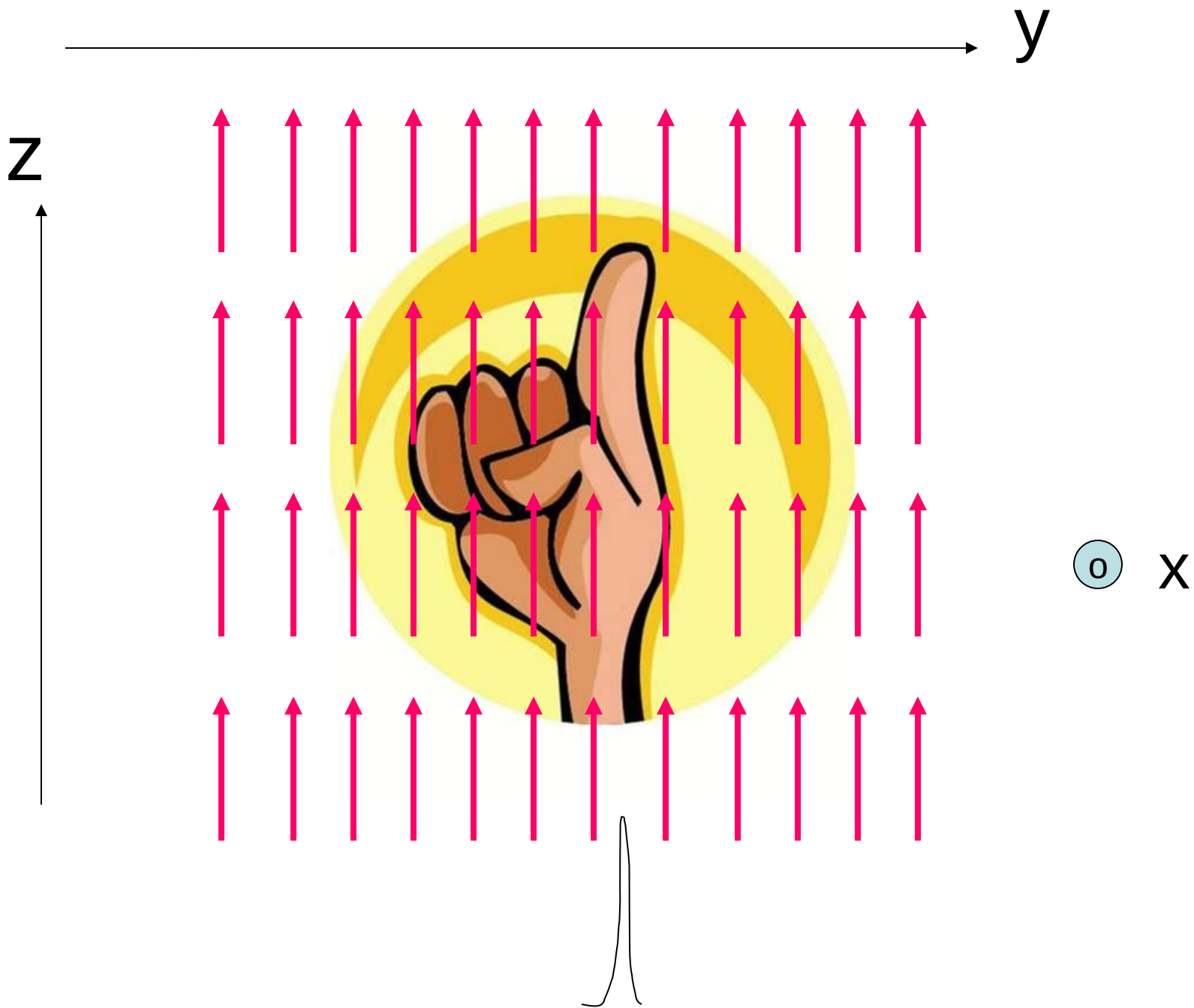
I : Breast Imaging

II : Knee Imaging

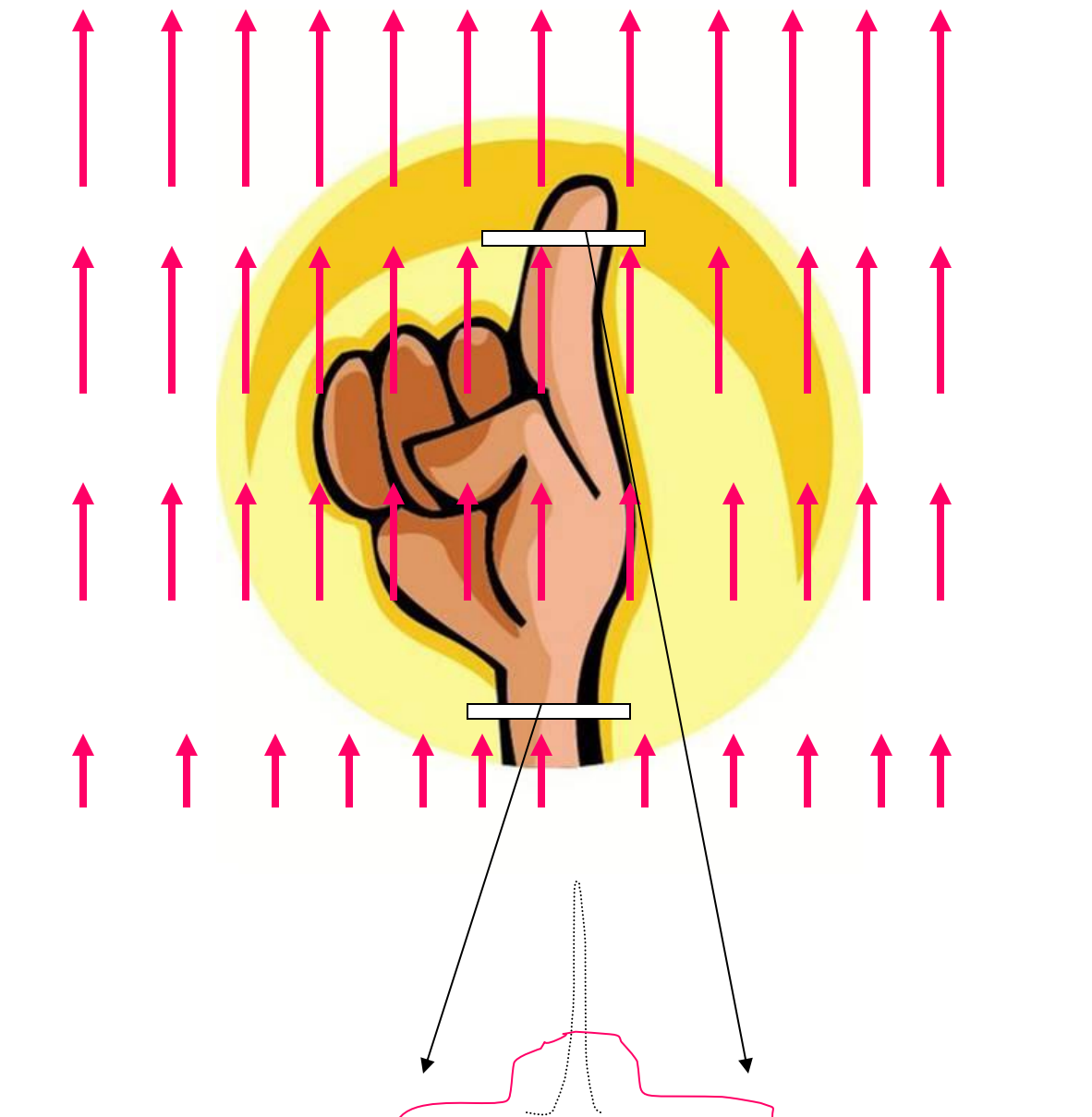
III: Head

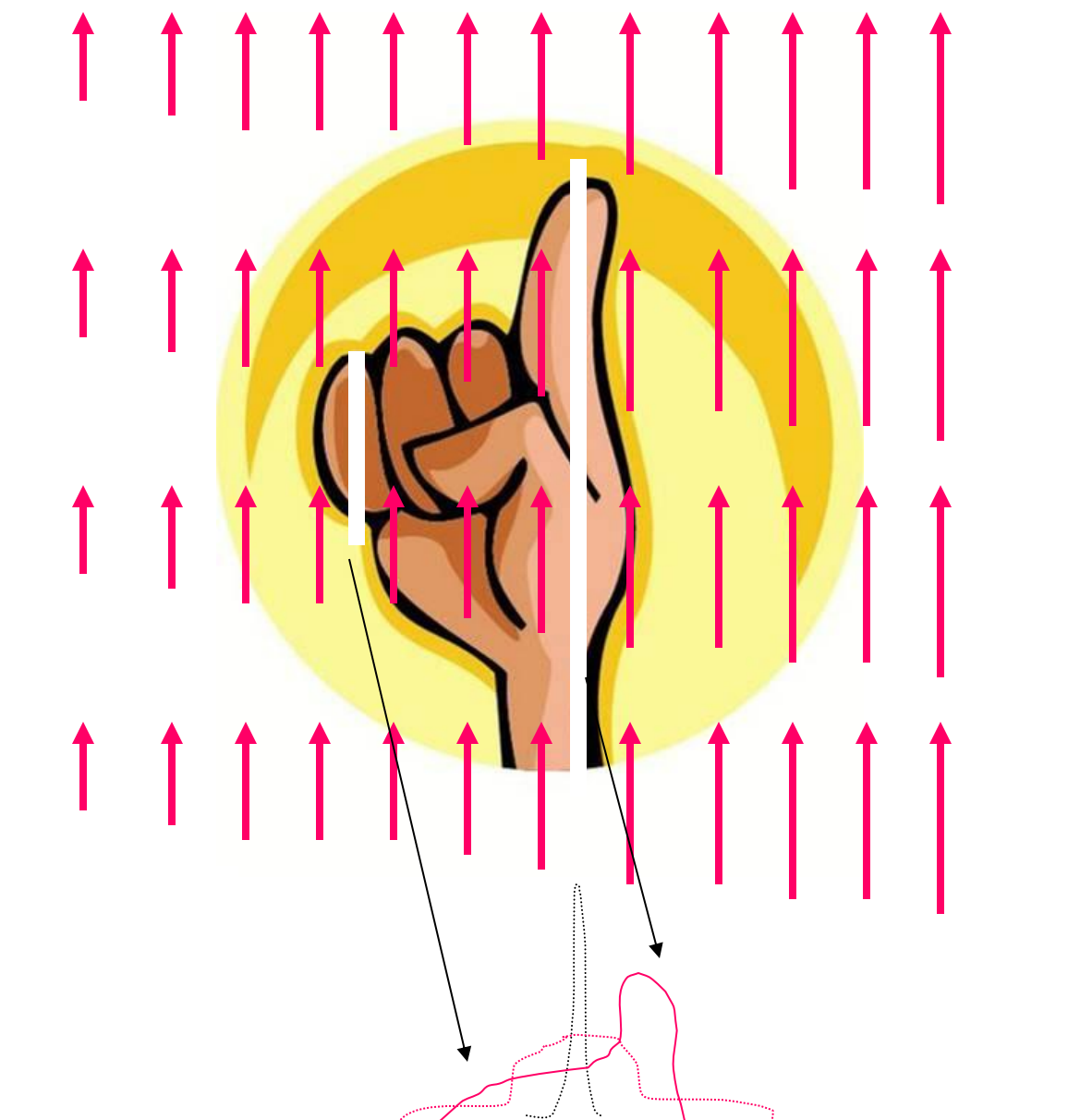
VI : fMRI





H_0



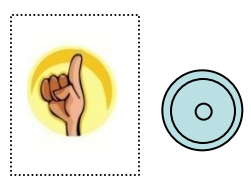
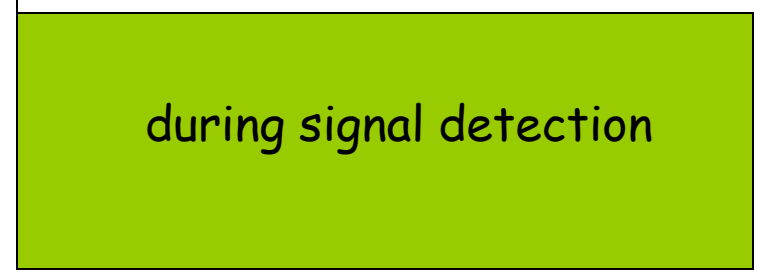
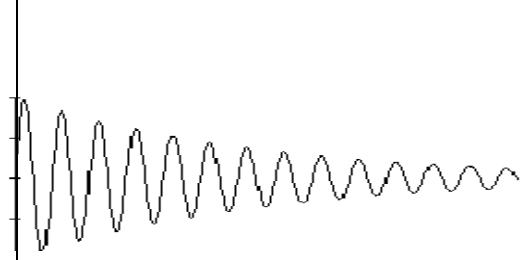


Time¹

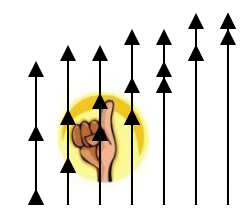


T_E -delay

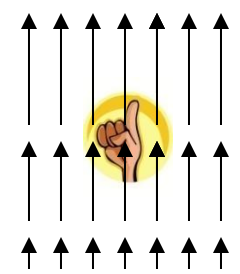
Time²



z-gradients



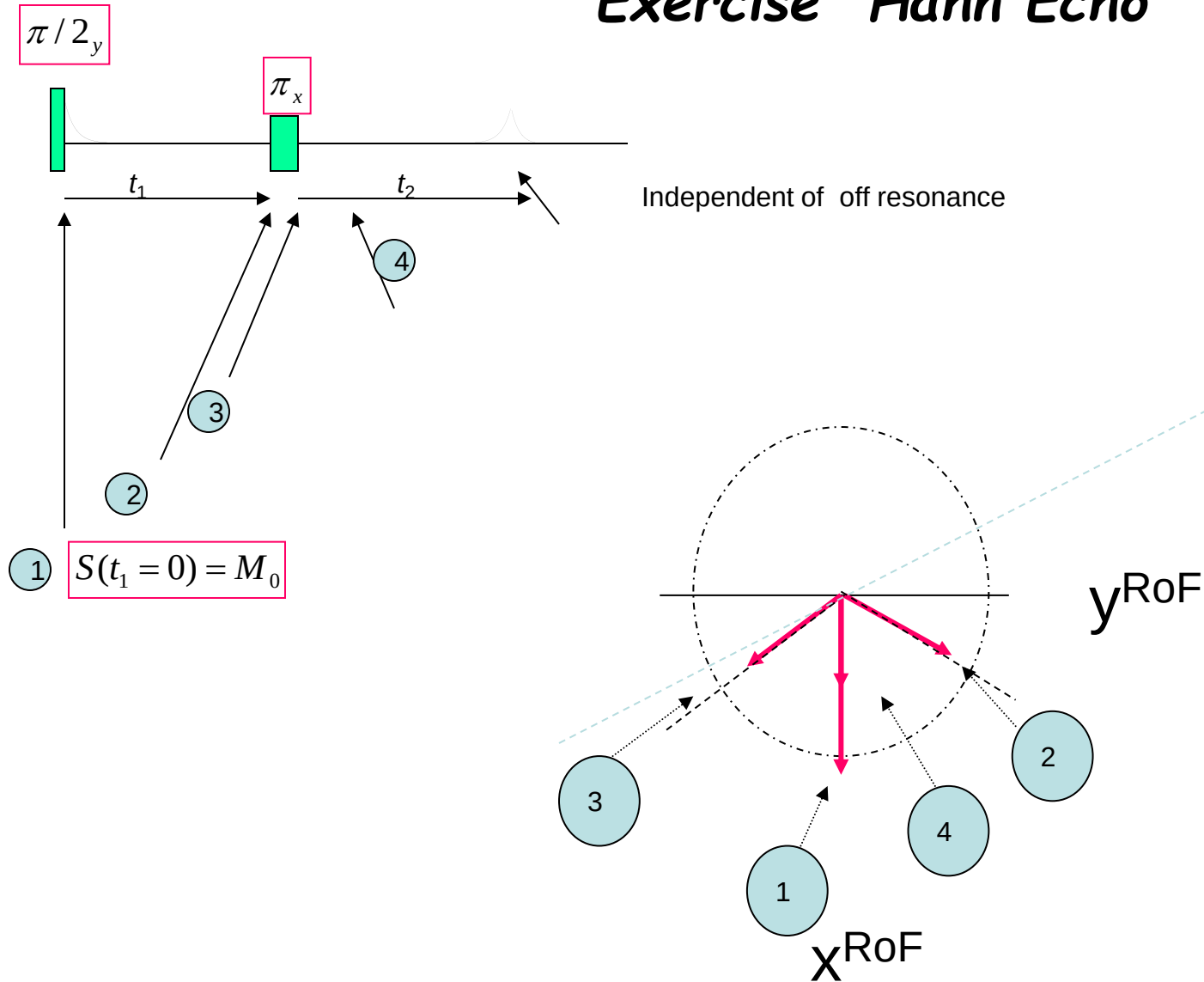
incrementing
y-gradients



x-gradients

from projection reconstruction to "two dimensional spectroscopy"
an joint exercise at the round table

Exercise "Hahn Echo"

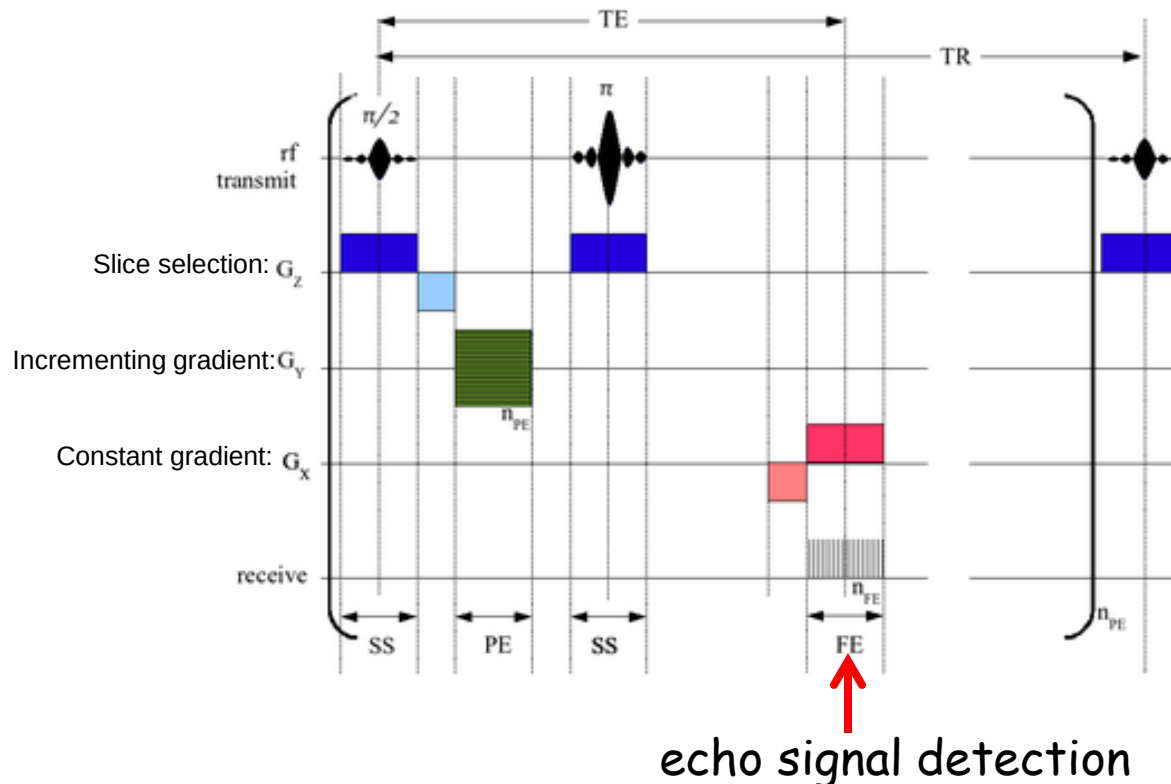


an joint exercise at the round table

The basic MRI sequence

After z-slice selection we perform 2D-FT NMR experiment

1. slice selective excitation and inversion to create echo
2. during time PE an incrementing y-gradient is applied
3. during the echo detection an x-gradient is applied
4. acquisition starts at the top of the echo



TE is the echo time in which T_2 determines the echo amplitude

TR is the repetition time in which T_1 determines the starting signal

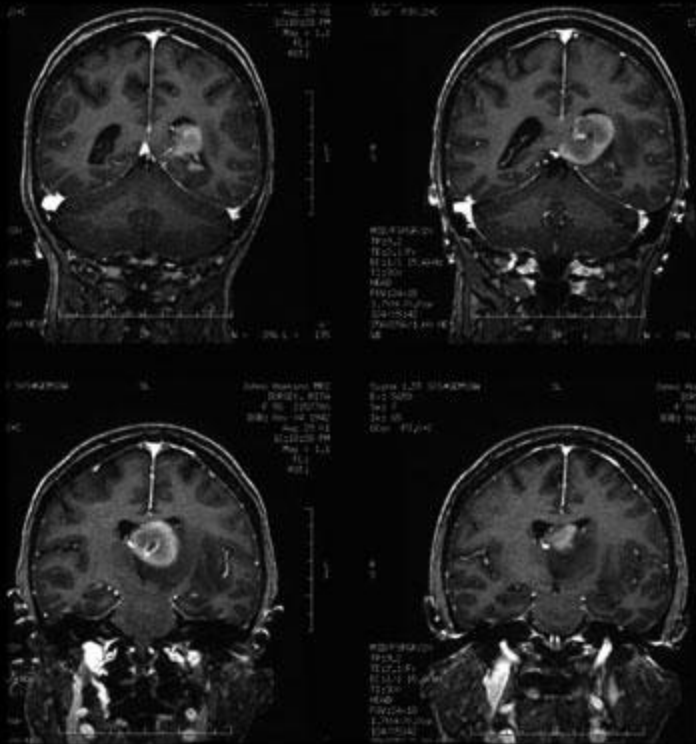
t_{PE} is fixed and t_{FE} evolves

Frequency “z”



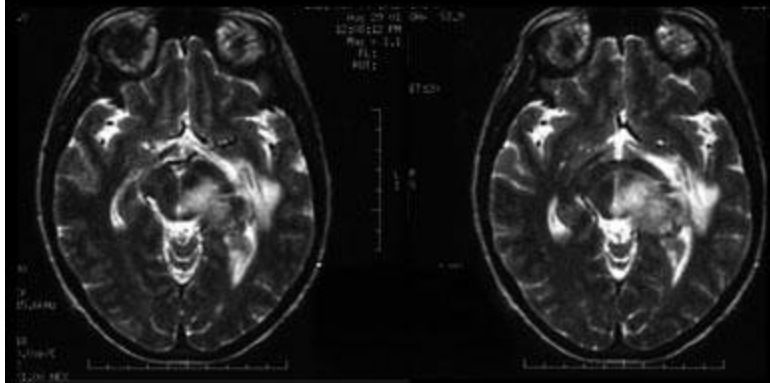
Frequency “y”

MRI: Coronal T1+Gad

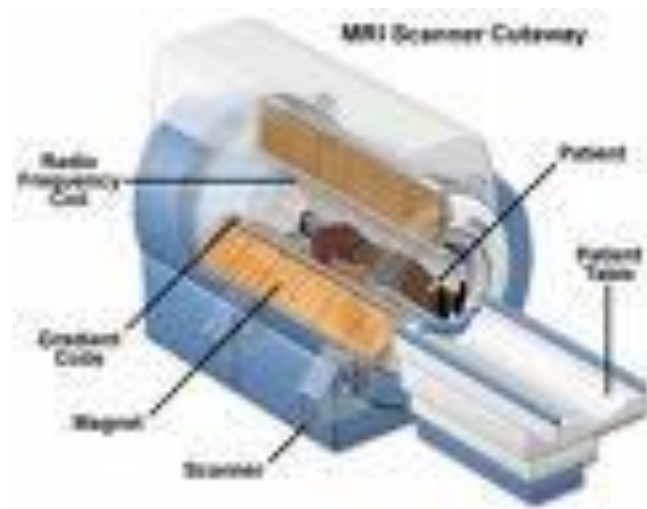


TR < T1

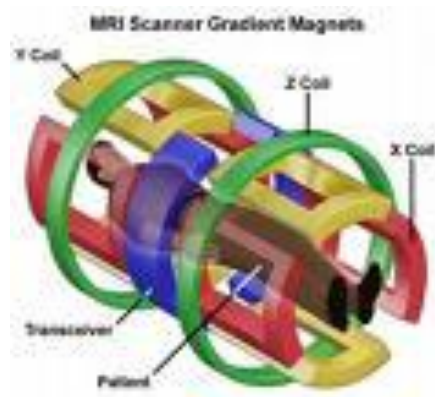
MRI: Axial T2

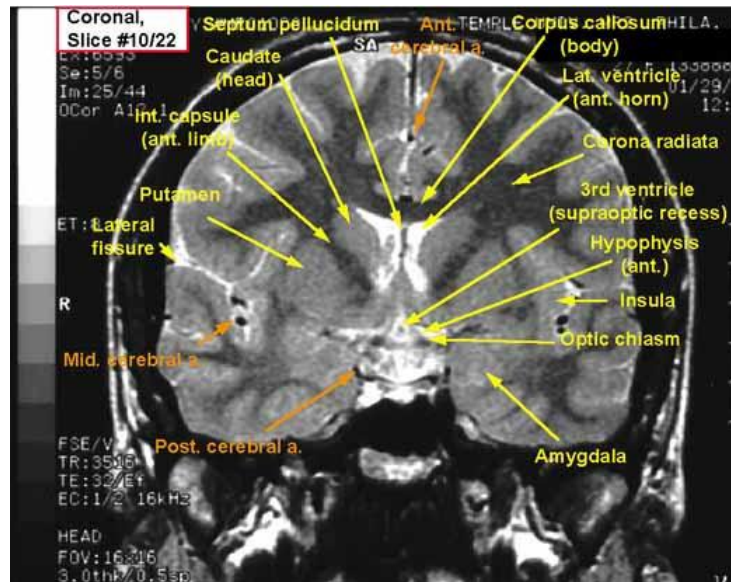


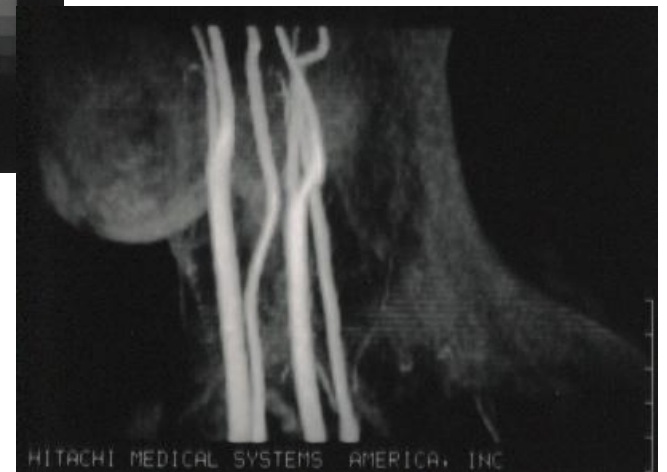
TE ~ T2

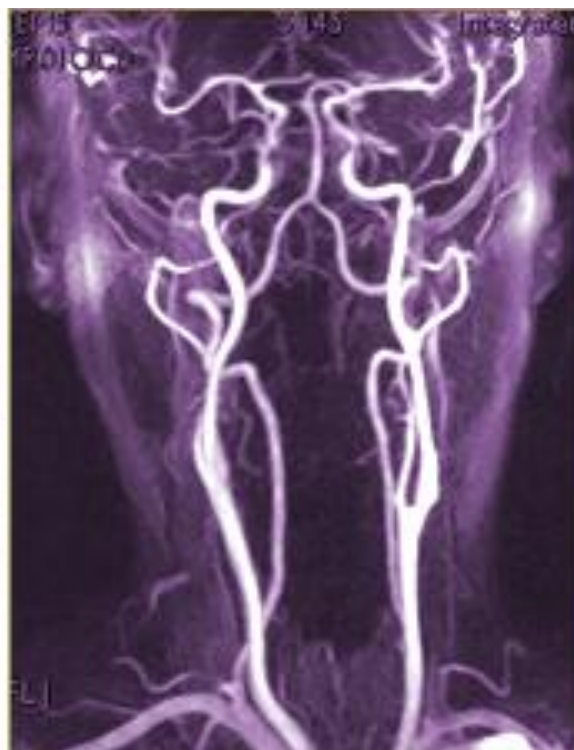


1.5 and 3 T =







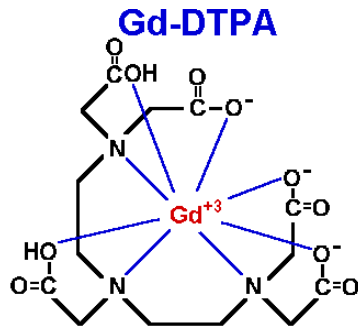


Gd-DTPA.

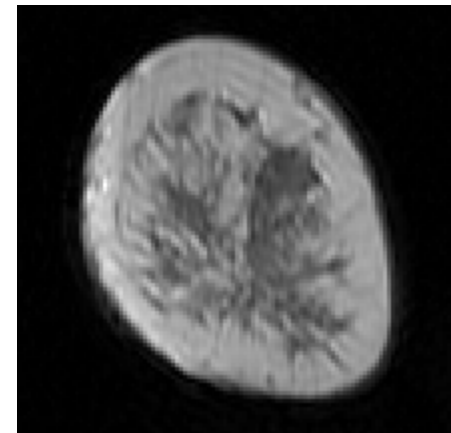
The effect of this agent is to shorten T2 of local spins causing a decrease in signal on T2-weighted images and an increase on T1-weighted images.

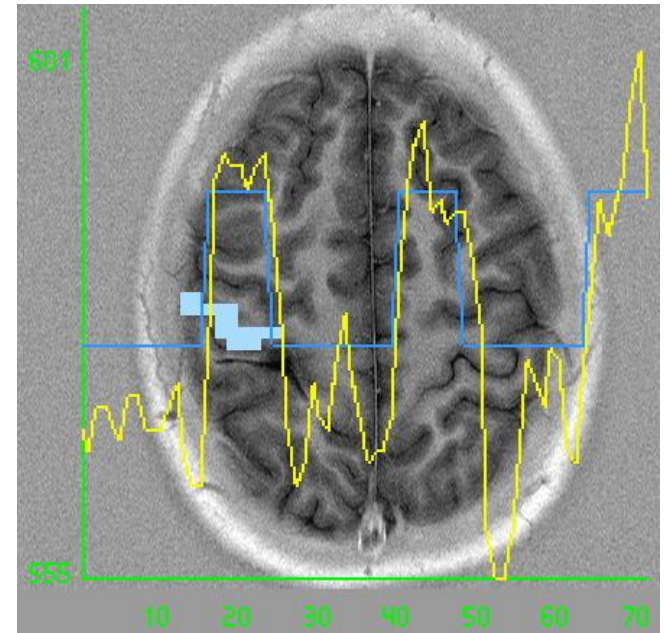
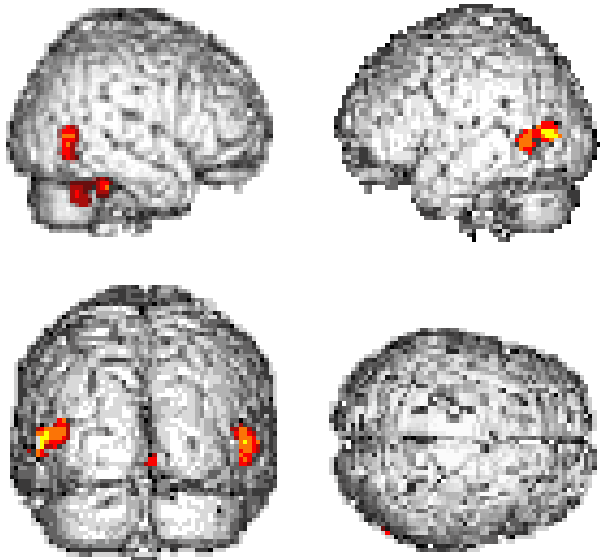
An example: Brain images both before and after contrast allow disruptions in the blood-brain barrier to be investigated.

The increased vascularity of tumours produces a preferential uptake. Furthermore if MR scans are repeatedly acquired following the contrast injection. An example of *dynamic contrast-enhancement* is shown here for the [breast](#). Superparamagnetic iron-oxide is used in the liver.

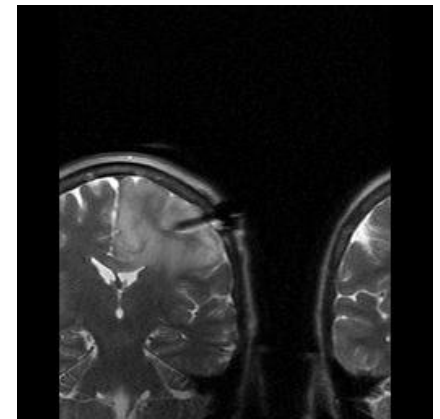


Complex of Gd^{3+} with a chelating agent,
diethylenetriamine penta-acetic acid

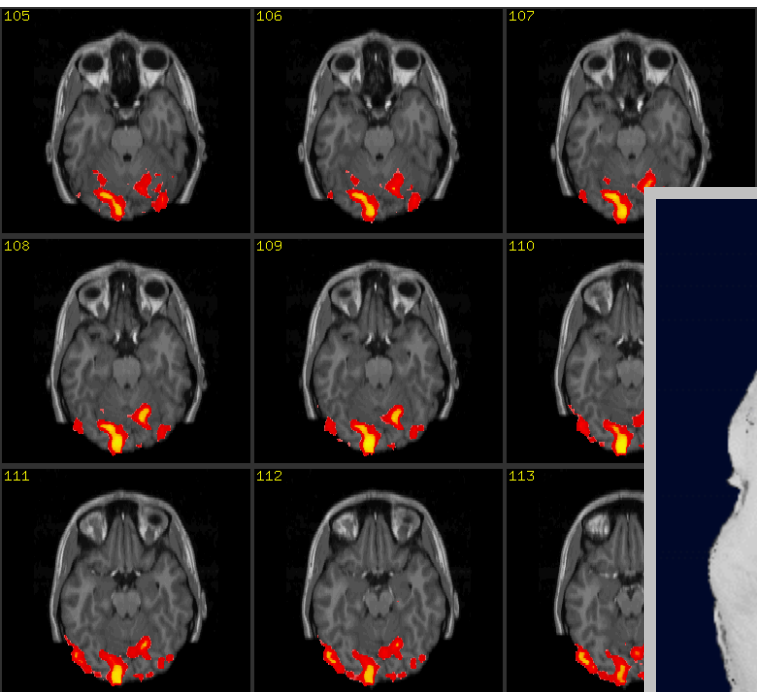




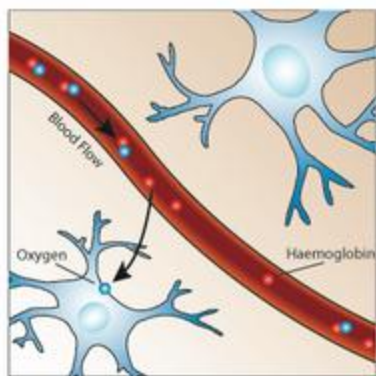
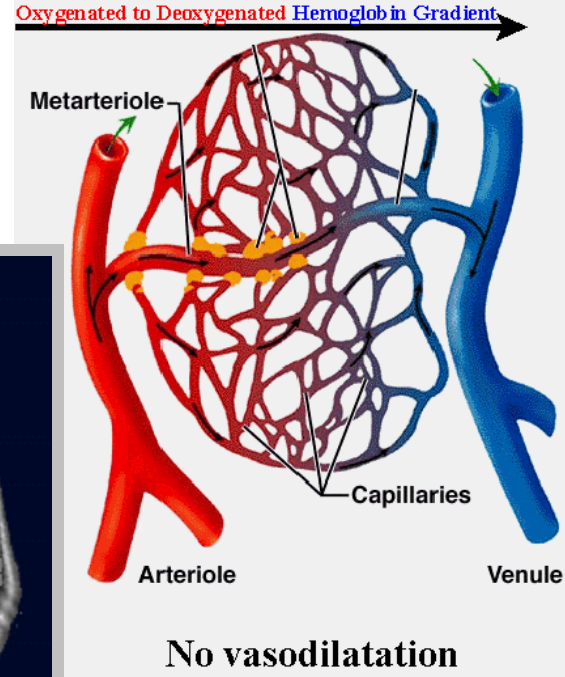
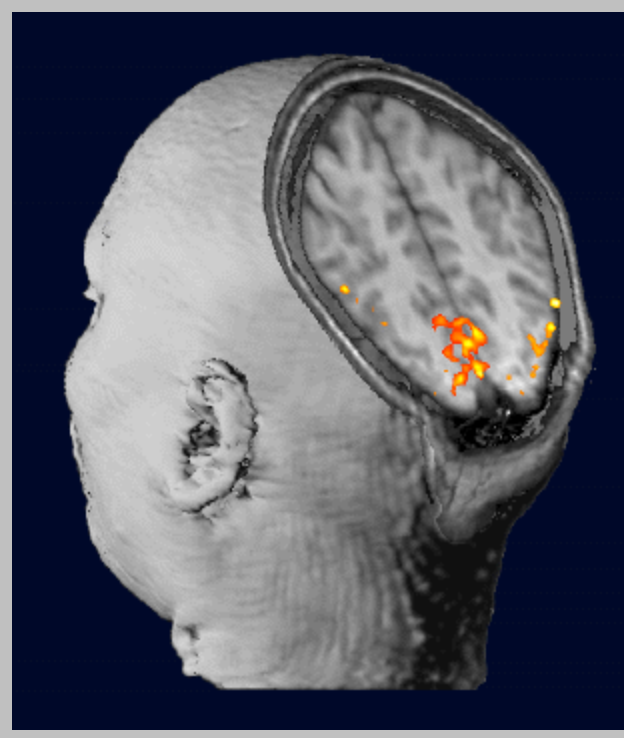
Functional MRI



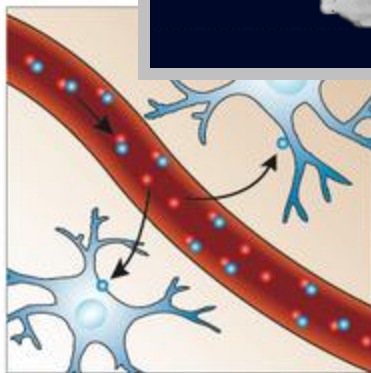
MRI guidance



Functional MRI

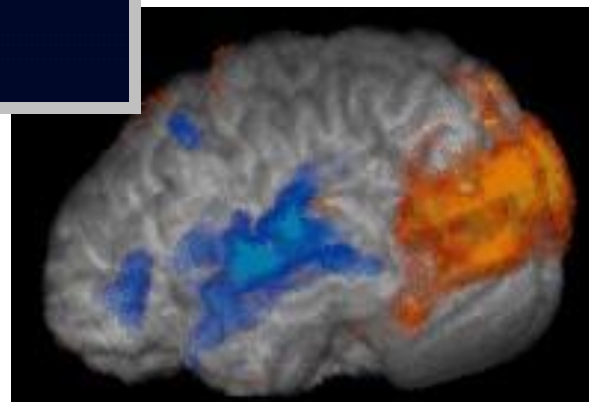


Resting

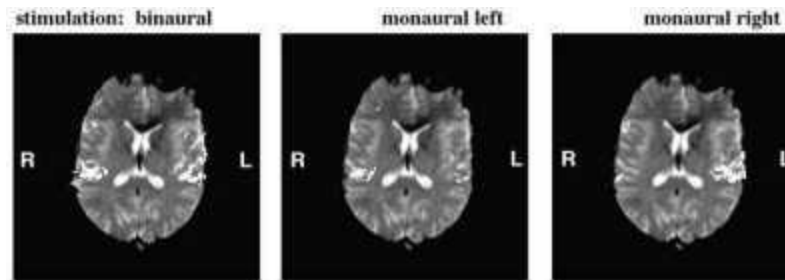


Activated

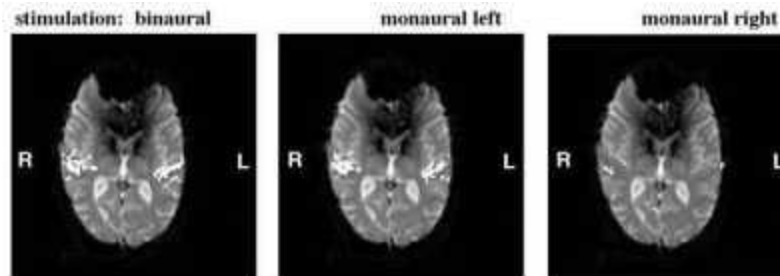
BOLD effect



normal hearing



anormal hearing



Presentations

I : Breast Imaging

II : Knee Imaging

III: Head

VI : fMRI

Project I:

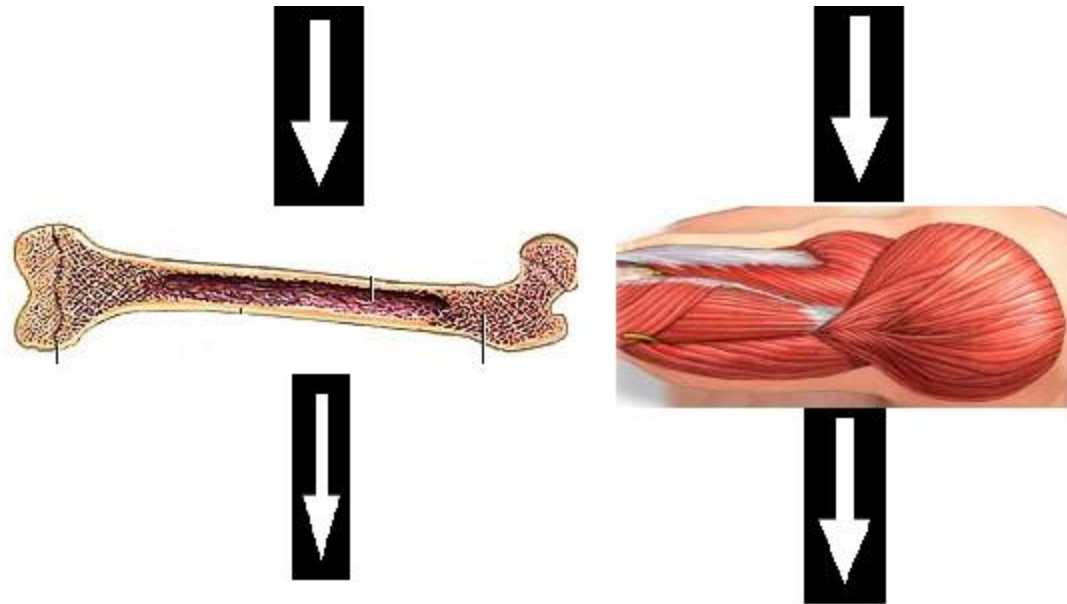
MRI & Breast Cancer

Screening voor borstkanker

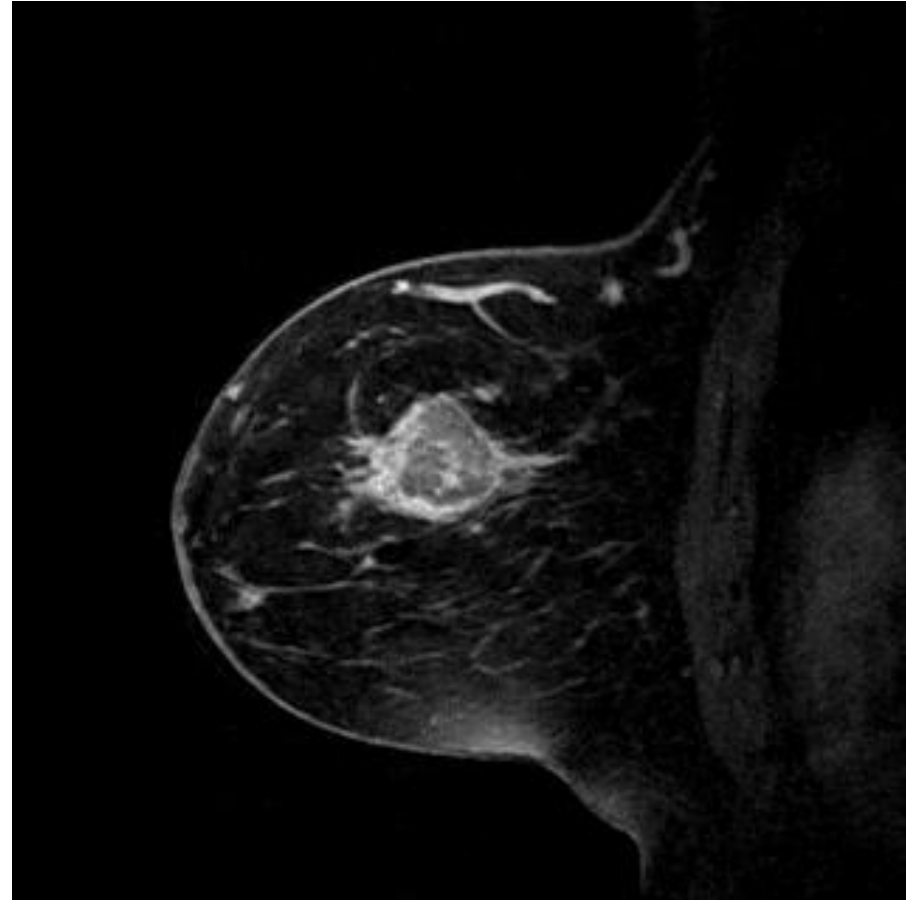
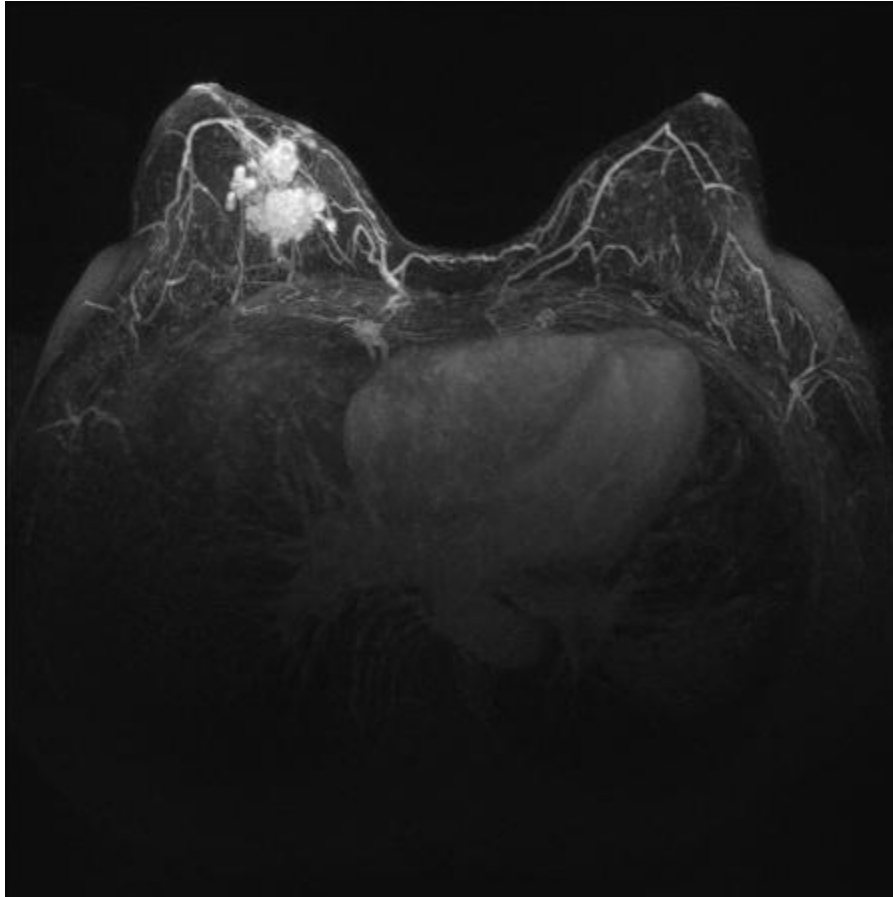
- Vrouwen ouder dan 40 hebben verhoogde kans op borstkanker
- Vrouwen met erfelijke aanleg hebben al voor hun 40^{ste} verhoogde kans op borstkanker
- Bij vrouwen van 50 tot en met 75 jaar, die opgeroepen worden voor het bevolkingsonderzoek.
- Screening d.m.v. mammografie (X-ray) & MRI

Oorspronkelijk: mammografie

- Afbeelding door middel van röntgenstraling
- Tumoren en cysten van de borstklier opsporen
- Absorptieverschillen in samenstelling en
- Stralingsenergie 15-30 keV



MRI



MRI vs Mammografie

- Erasmus Medisch Centrum
- 1909 high-risk vrouwen
- Elke 6 maanden mammogram + MRI scan
- Na 4 jaar 50 tumoren gevonden
- 32 gevonden door MRI, waarvan mammografie er 22 niet zag
- 18 gevonden door mammografie, waarvan 8 niet zichtbaar op MRI scan
- MRI detecteert ander soort tumor dan mammografie

MRI vs Mammografie

- Kosten:
 - MRI: 1000 – 1500 dollar
 - Mammografie: 100 – 150 dollar
- Naast de hoge kosten detecteert de MRI ook veel dingen die niet kanker zijn, waardoor veel onnodige vervolgpcedures volgen

Bron: American Cancer Society

http://www.cancer.org/docroot/NWS/content/NWS_1_1x_MRI_Finds_Breast_Cancer_in_High-Risk_Women.asp

Project II: MRI in knieën en benen



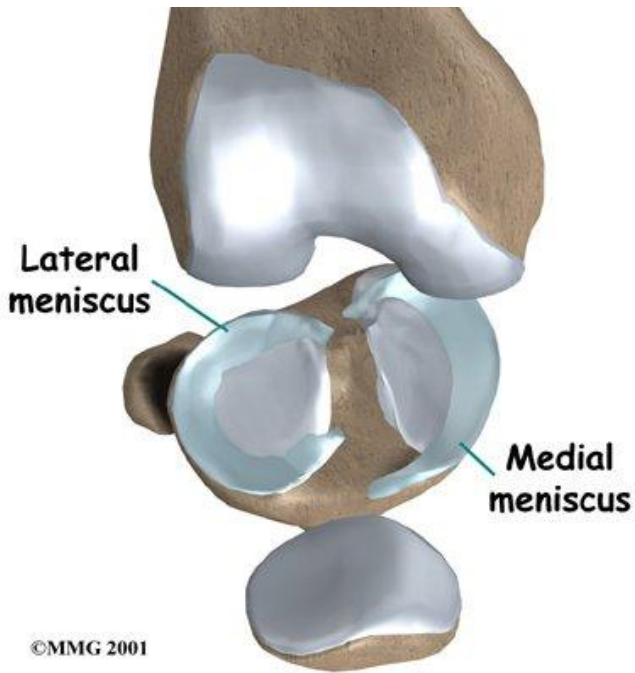
Waarom?

- Veel zichtbaar
- Naast MRI ook andere methodes
- Onderzoek

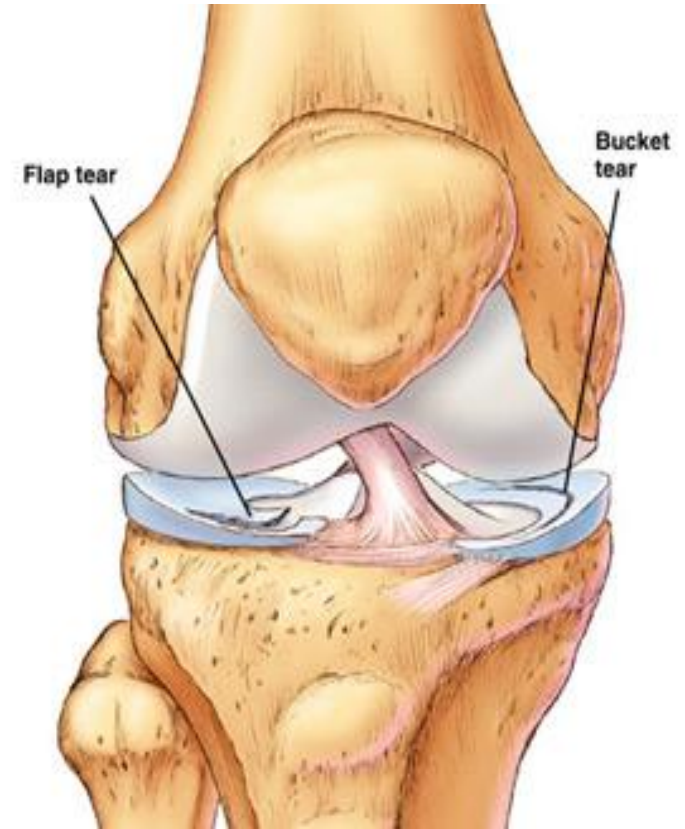
Knieproblemen

- Meniscus
- Ligamenten
- Botbreuken
- Pezen

Meniscus



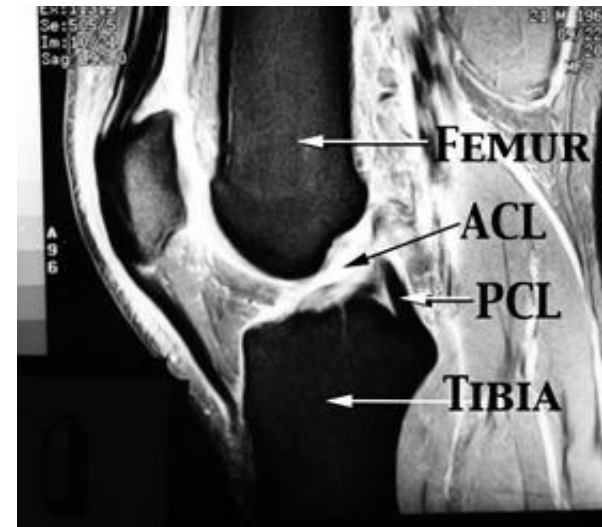
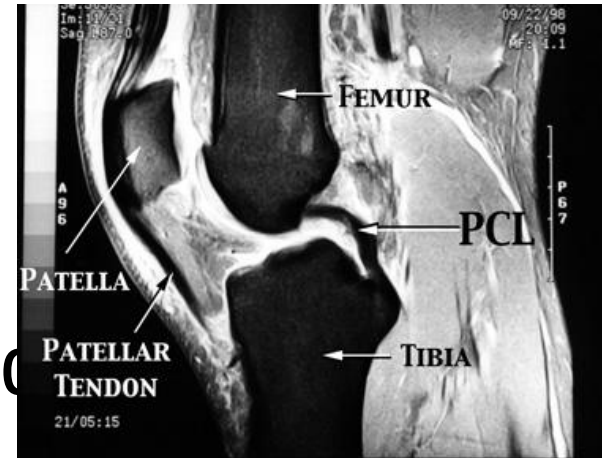
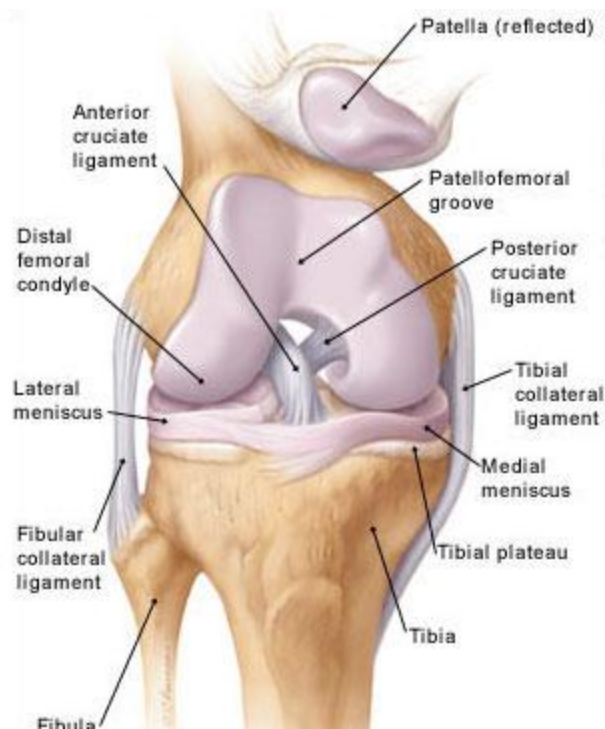
- Kraakbeen
- Ondersteuning
- Scheur





Ligamenten

- PCL & ACL
- Kruisbanden
- 3 graden van ernstigheid



6844
26-JUN-1983
15:23
24-AUG-2009
IMAGE 140
SER 1-8

H

EXPERT
F-SP VB33G
+ : F A L

AL

35

TR 820.0
TE 22.9/1
TA 03:31
AC 1

SP 78.2
SL 3.0
FoV 160*160
256*256
Sag>Cor 8

M 1184
C 1532

left

Laterale & mediale collaterale ligamenten

- Kniebanden
- Zwellingen





5A



5B



5C



5D

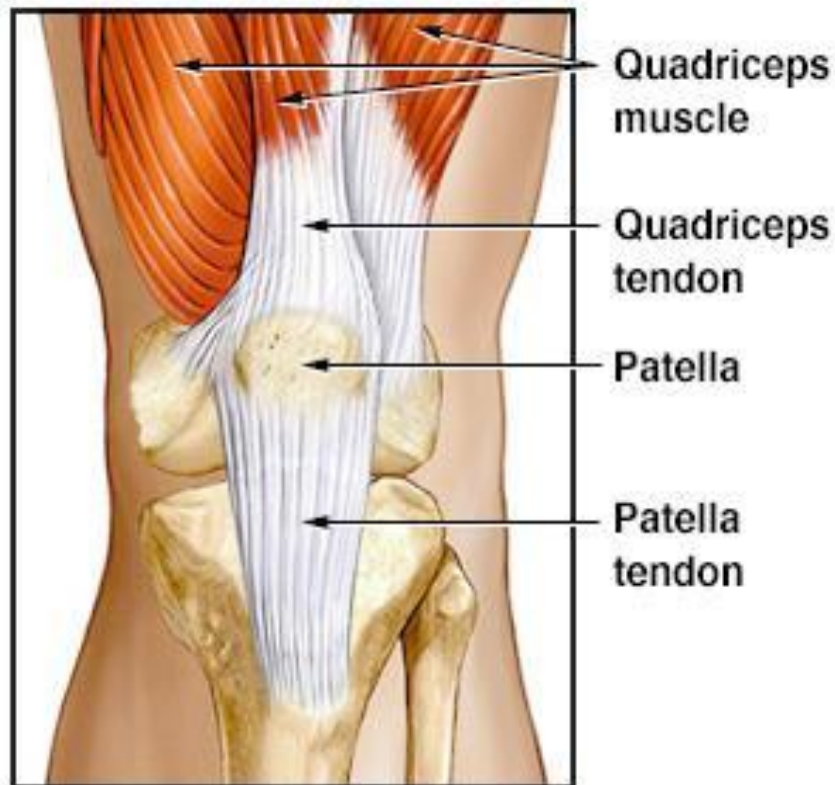
Botbreuken

- Botten en breuken niet te zien
- Zwelling wel



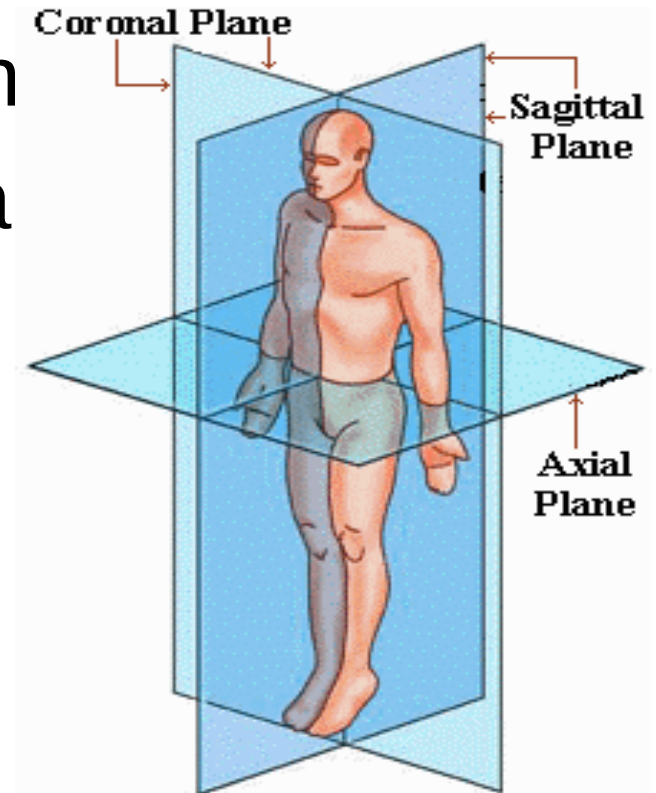
Pezen

- Quadriceps & patella



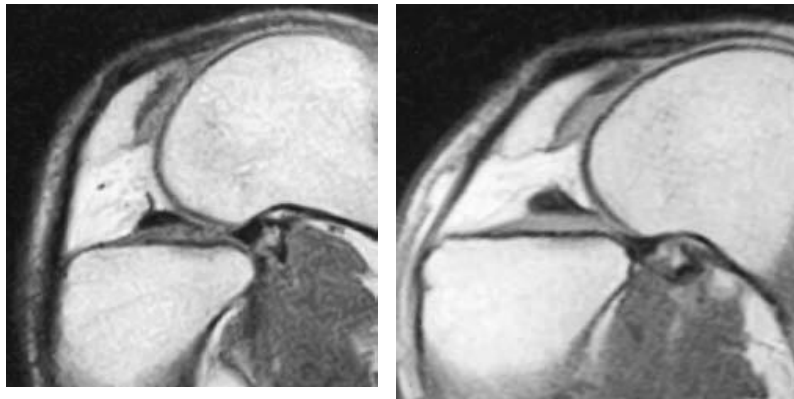
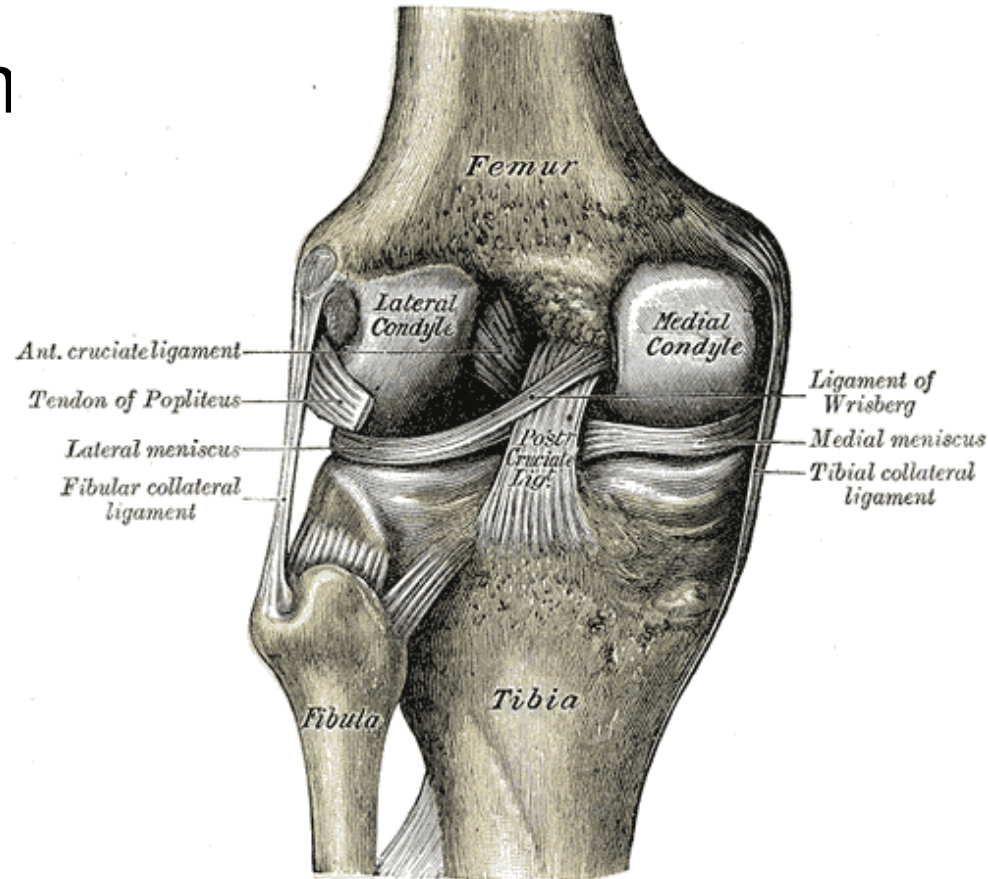
Techniek

- Goede diagnose van belan
- Coronaal, sagittaal en axia
- 3 hoeken
- T1- of T2-gewogen scan



Onderzoek

- Buiging kniegewricht
- Japanners
- Veel belasting
- Condyles



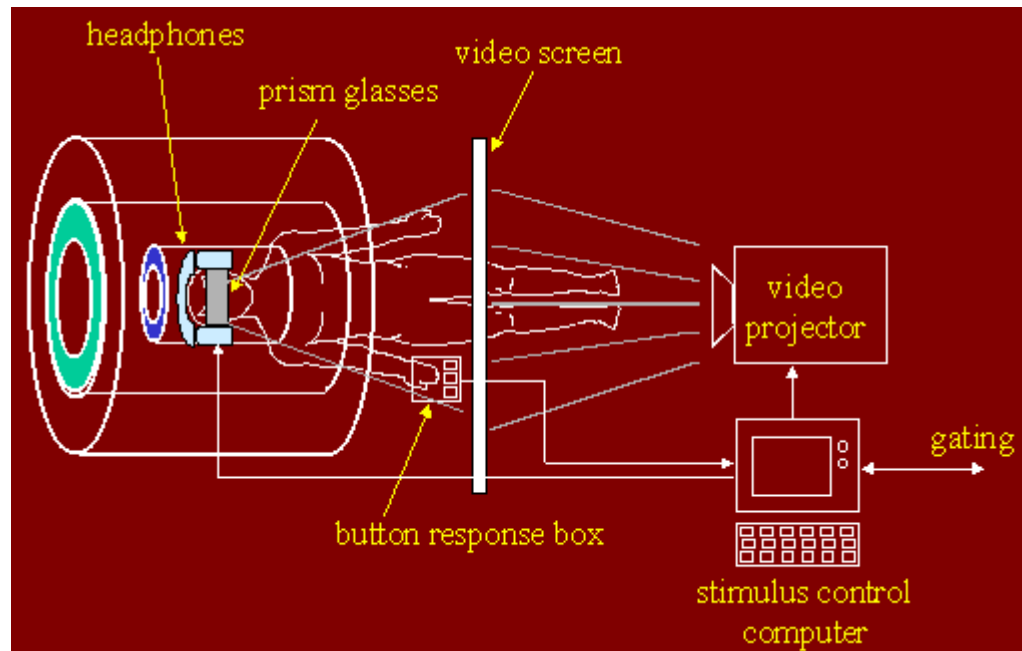
Project III:

MRI en de hersenen

Functional magnetic resonance imaging
(fMRI)

Magnetic resonance spectroscopy (MRS)

fMRI



http://users.fmrib.ox.ac.uk/~peterj/lectures/hbm_1/sld003.htm

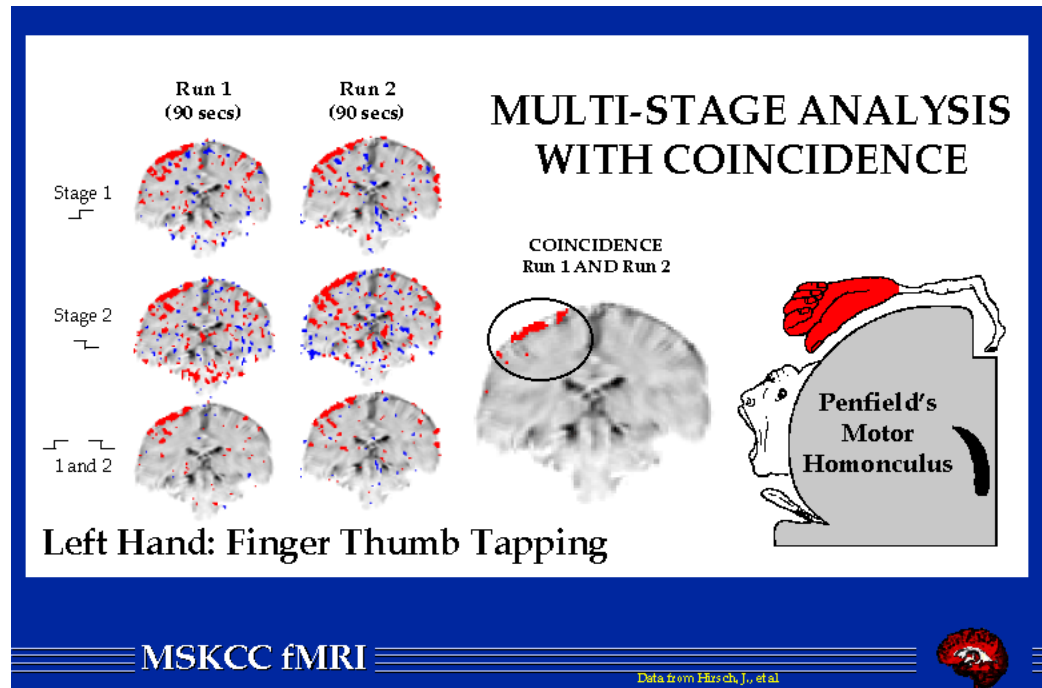
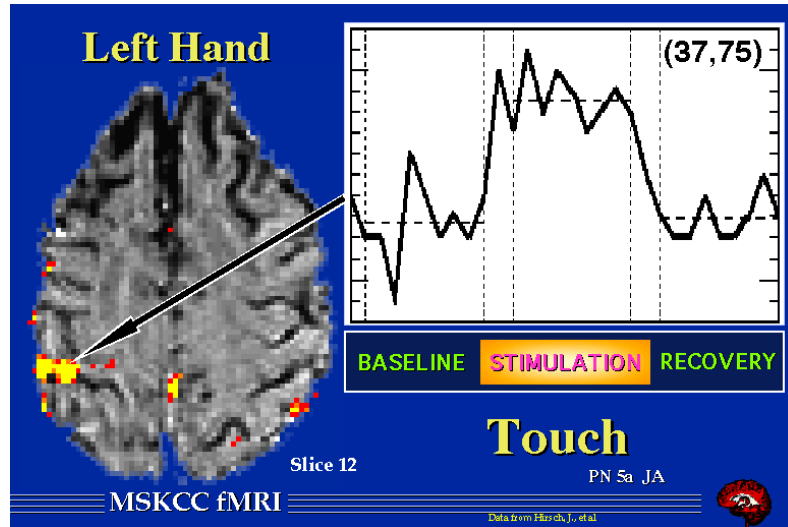
BOLD

- BOLD: Blood-oxygen-level-dependence
- Aerobe glycolyse
- Piek bij 4-5 seconden
- Verandering verhouding oxihemoglobine (diamagnetic) en deoxihemoglobine (paramagnetic)
- Verhoogd MRI signaal

Voordelen van fMRI

- Geen injecties van radioactieve isotopen nodig
- Korte scantijd (1,5 – 2 minuten per run)
- De in-plane resolutie is ongeveer 1,5x1,5 mm

Voorbeeld van fMRI

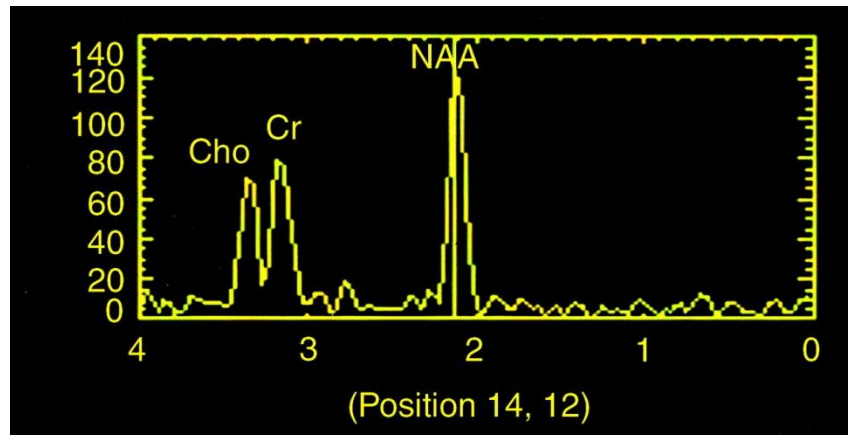


Toepassing

- Hersentumoren
- Onderzoek naar de fysiologie van cognitieve en waarnemende hersenfuncties
- Onderzoek naar de fysiologie van neurologische afwijkingen

MRS

- Onderdrukking signaal van water
- Chemical shift
- Metabolieten
- Hersentumoren



<http://theoncologist.alphamedpress.org/cgi/content/full/9/3/312/F1>

Vragen

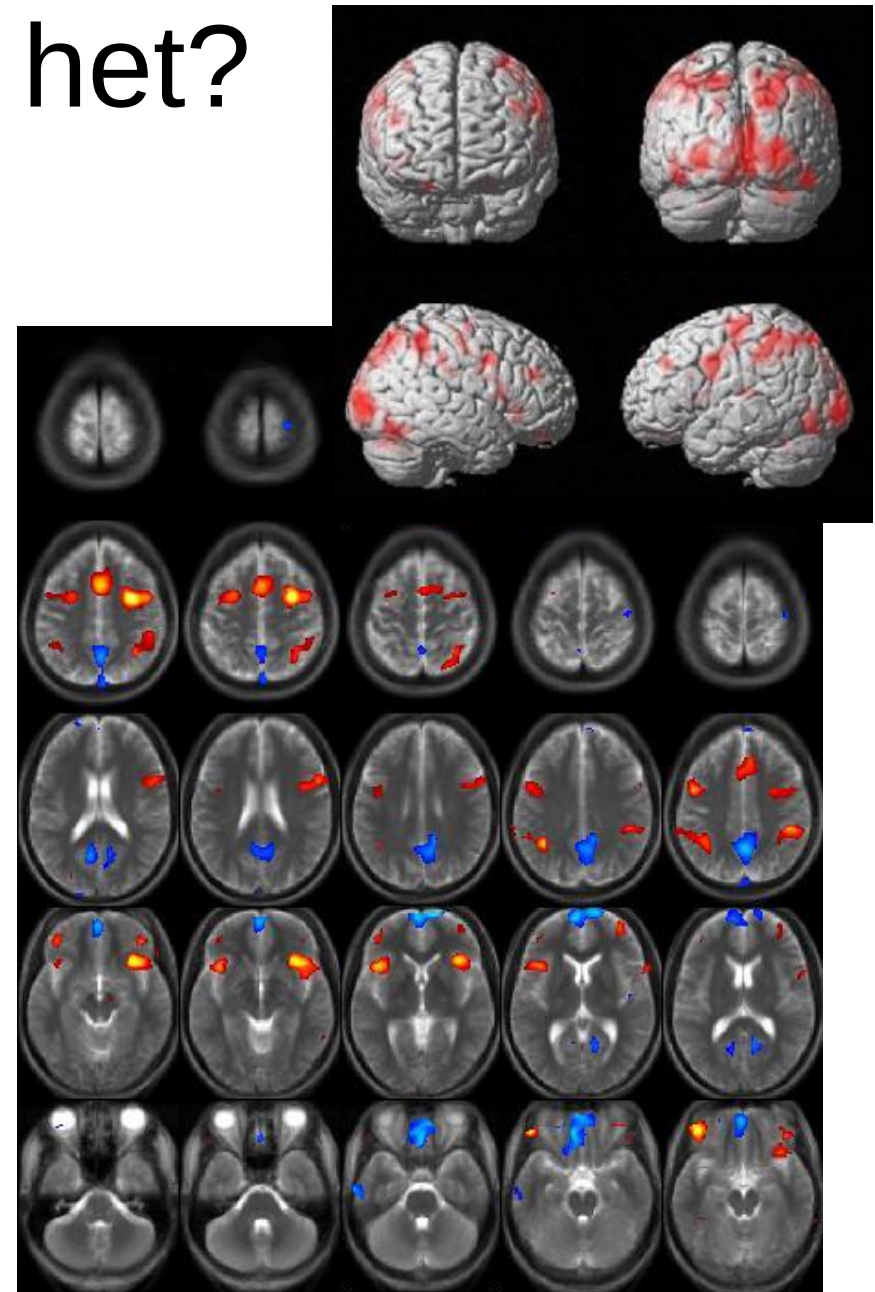
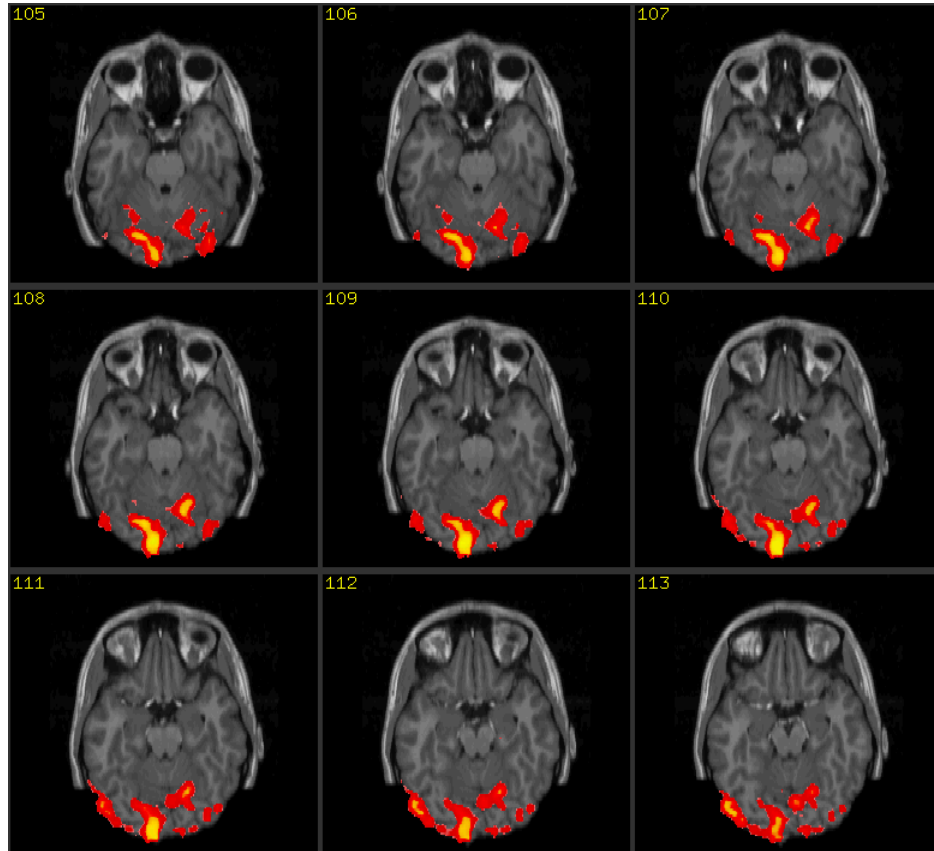
Project IV:

fMRI

Functional MRI

Functional Magnetic Resonance Imaging

Wat is het?

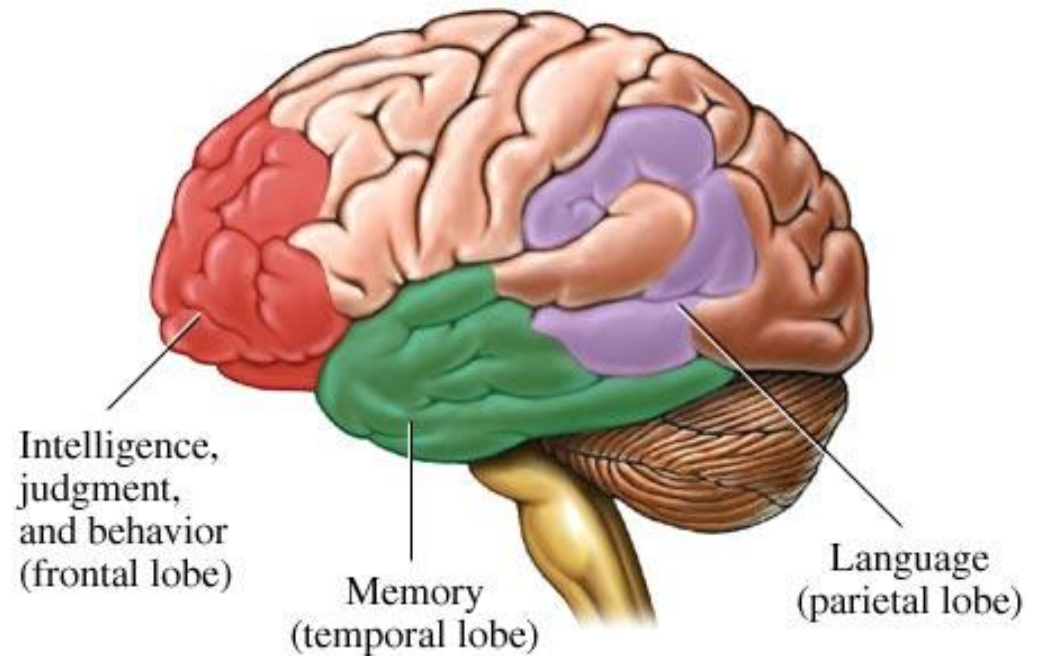


Wat is het?

- Scan van de hersenen
- Kleuren geven intensiteit van doorbloeding (met zuurstofrijk bloed) aan
- Dus: vormen indicatie van de mate van activiteit van de betreffende hersendelen.

Brain Mapping

- Via fMRI kijken welk deel van de hersenen betrokken is bij welke processen.
- Laten mensen bepaalde taken uitvoeren en kijken welke delen van de hersenen oplichten in de



Voor- en nadelen

- Hoge 'spatial resolution': 1mm
- Hele brein scannen
- Indirect -> gevoelig voor niet-neurale dingen
- Slechte 'temporal resolution'
- Ziet gezond en ziek brein

BOLD

- Neuronen geen reserves glucose + zuurstof
- Verhouding (de)oxyhemoglobine verandert
- Oxyhemoglobine diamagnetisch
- Deoxyhemoglobine paramagnetisch
- $\mathbf{M} = \chi \cdot \mathbf{H}$
- Statistische analyse na veel metingen

Interpretatie

- Stijging bloedtoevoer duurt 1-5 seconden
- BOLD-signaal zeer zwak (niet meetbaar)
- Correlatie BOLD en hersenactiviteit?
- Verschil 'in rust' en 'in activiteit' is hersenactiviteit

Voor- en nadelen

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