Lecture:
- Einführung in die Magnetresonanztomografie des ZNS -

- Introduction to Magnetic Resonance Imaging of the Central Nervous System -

Summary:
This lecture series is a comprehensive introduction to Magnetic Resonance Imaging (MRI). After the presentation of the technical basics in the first four parts, special brain imaging techniques (such as fMRI, DTI, anatomical MRI) are presented in dedicated consecutive lectures.

Target audience and prerequisites:
The lecture series is open to everybody who wants to learn about MRI. Importantly, there are no prerequisites. All mathematical and technical basics that are required for understanding the concepts of MRI will be explained in the single lectures. The explanations are in general based on plots and graphical figures, mostly avoiding mathematical equations.

Language:
English or German, as requested by the audience.

Place and Time:
In presence: Seminar area of the Cooperative Brain Imaging Center (CoBIC), Heinrich-Hoffmann-Str. 9, Building 88, Campus Niederrad; Thursdays 15.00-16.30.
Online (if requested or if lectures in presence are not possible): Links will be sent to registered participants.

Script:
Scripts and recordings of all relevant parts can be made available to registered participants.

Registration:
Via E-Mail to Prof. Dr. Ralf Deichmann <Deichmann@med.uni-frankfurt.de>

(see next pages for an overview of the lecture series)

Overview of the different parts:

Bascis 1 (The Absolute Basics)
- Why do we need the strong magnetic field
- What is the purpose of the "RF coils"
- Why are scans acoustically so noisy
- How do we get images
- What is "T1- and T2-weighting" and how is it used in clinics

Basics 2 (Spin Echo Techniques)
- The parameters T1, T2, PD: clinical applications of weighted images
- Holes in the brain: the effect of field distortions
- Spin Echo sequences - the workhorse in clinical MRI
- Setting up your protocol: How to choose "TE" and "TR" for optimum contrasts
- The FLAIR sequence

Basics 3 (Gradient Echo Techniques)
- The difference between T2 and T2* weighting
- Spin echo vs. gradient echo techniques
- Applications of gradient echo sequences:
  - -- T1 weighting: anatomical imaging
  - -- T2* weighting (1): venography
  - -- T2* weighting (2): mapping iron-rich brain regions
  - -- T2* weighting (3): fMRI - functional imaging
- A non-mathematical introduction to k-space
  - -- What k-space can do to your data: spikes!
  - -- Processing photos in k-space

Basics 4 (Fast MRI Techniques)
- The three most indispensable fast imaging techniques:
  - -- Turbo Spin Echo in clinics
  - -- FLASH for anatomical imaging
  - -- EPI for fMRI and DTI
- Volume Saturation and Fat Saturation
  - --How to render certain regions or fatty tissue "MRI invisible"
- MR Angiography without contrast agents
- The wrap-around artefact
  - -- Why the nose may end up in the neck

Functional MRI (fMRI)

- The BOLD (Blood Oxygenation Level Dependent) effect
- BOLD: the technical basis (TE and T2*)
- BOLD: the physiological basis (CBF, CBV and CMRO2)
- The haemodynamic response
- Data flow in fMRI experiments
- How to avoid image distortions:
  -- Field mapping
  -- The TOPUP method
- How to avoid signal dropouts:
  -- Optimizing TE
  -- Optimizing the slice thickness
  -- Z-Shimming
  -- Slice Tilting

Diffusion Weighted MRI and DTI

- A primer on diffusion effects:
  -- The random walk: getting home from the pub
  -- A droplet of milk in a cup of coffee
  -- Diffusion in the kitchen: a scientific study on vanishing teaspoons
- How to do Diffusion Weighted Imaging (DWI)
- How to do Diffusion Tensor Imaging (DTI)
- The parameters of interest:
  -- Eigenvalues
  -- Mean Diffusivity and Trace
  -- Fractional Anisotropy (FA)
- Clinical Application of DWI: diagnosis of stroke
- Applications of DTI:
  -- What does FA tell us about the structural organization of the brain?
  -- How does fibre tracking work?
- Things that can go wrong in a DTI study

Anatomical MRI

- How to get T1-weighted anatomical data:
  FLASH - MPRAGE - MDEFT
- What to do with anatomical data:
  -- Normalization (Talairach and MNI coordinates)
  -- Segmentation
  -- Voxel based morphometry (VBM)
  -- Voxel based cortical thickness (VBCT) mapping
- Some famous VBM studies:
  -- Do taxi drivers have bigger brains?
  -- The effect of juggling on the brain

- Clinical VBM applications
- Advice: how to avoid artifacts in your anatomical data
- Comparison of FLASH, MPRAGE and MDEFT

Clinical Applications of MRI
- Magnevist, Omniscan et al.: Gadolinium-based contrast agents
- NSF (Nephrogenic Systemic Fibrosis): a warning about Gadolinium
- Multiple Sclerosis: lesion detection with MRI
- Angiography and Venography
- Brain perfusion: measurement and diagnostic value
- Tumour detection with MRI
- MRI in Stroke
- FLAIR: better visibility of lesions using fluid suppression

Quantitative MRI: Relaxometry
- What is quantitative MRI and relaxometry
- What are the advantages versus conventional MRI
- The most frequently mapped parameters: T1, T2 and T2*
- Clinical applications:
  - Multiple Sclerosis
  - Parkinson's Disease
  - Epilepsy
  - Brain Tumor Imaging
  - Stroke
  - Hepatic Iron Overload
  - Imaging the Lung Function
  - Alzheimer's Disease
- Construction of synthetic anatomies with improved contrasts

Quantitative MRI: Proton Density (PD) Mapping
- What is the "proton density" / the "water content"
- Normal values in brain tissue
- What does it tell us about macromolecular compounds
- How do we measure it
- Clinical applications:
  - Multiple Sclerosis
  - Brain Tumor Imaging
  - Anatomical imaging with improved contrasts
  - Mapping the Macromolecular Tissue Volume

MR Neuroimaging at High Magnetic Fields

- Human MRI at 7 Tesla and beyond
- High fields: advantages and technical problems
- Neuroimaging techniques that profit from high fields:
    + High resolution anatomical imaging
    + fMRI: Retinotopic Mapping
    + DTI
    + Susceptibility weighted imaging
    + Clinical applications

MR Spectroscopy
(Special part given by a colleague from the Dept. of Neuroradiology)
- Adding another dimension to MR imaging
- Detecting metabolites from their spectral "fingerprints"
- Combining spectral and spatial resolution
- Example: spectroscopy results for a tumour patient

Further parts will be given by colleagues from the Dept. of Neuroradiology, such as lectures about **Functional Anatomy** and **MR imaging in daily clinical practice**.