PhD-Course in functional neuroimaging

Contact person: Karsten Specht, University of Bergen, Norway

1. Course content

The course is intended to PhD students holding a Master degree in neuroscience, psychology, natural sciences or equivalent, as well as medical students, taking part in a research-training programme in medicine. The course will give an introduction to the field of neuroimaging. The course is divided into three parts.

The first part is a short theoretical introduction into neuroscience and neuroimaging, covering all relevant aspects on physiology, neuroanatomy, some of the most relevant functional networks, as well as the technical aspects behind structural and functional magnetic resonance imaging and related methods, such as DTI and perfusion measurements.

In the second part, the course will introduce the most relevant experimental techniques, used in functional neuroimaging, as well as the methods, used for analysing functional as well as structural MRI data.

The third part is the practical part, where an experiment will be developed, performed on the scanner, analysed, and the results will be discussed.

2. Learning Objectives

After finishing the course, the students will have basic knowledge of neuroanatomy, and functional neuroimaging approaches. This includes that they have learned the technical and physical principles behind magnetic resonance imaging and its different applications. They know what the BOLD effect is and how it could be used for displaying neuronal activations. The students are familiar with the typical experimental fMRI designs, and know the limitations of the different method.

The students got an understanding of the parameters, which are most relevant for designing an fMRI experiment, as well as acquiring and analysing the fMRI data. They will be able to perform the processing of the data and to specify a general linear model, based on the experimental design. Students will be able to analyse the data with standard fMRI analysis software, and they are able to describe the results in an appropriate way.

Knowledge

- Basic knowledge on functional neuroanatomy
    - Landmarks of the brain
    - Import anatomical structures
    - Functional-structural relationship of important sensory and cognitive functions
    - Important brain networks, such as *default mode network* or the *fronto-parietal network*
- Methods of Neuroimaging
    - Physics of MRI imaging and the meaning of important parameter

- Physiological mechanisms behind fMRI and BOLD effect
- Planning and conducting an fMRI study
- Analysis of fMRI data, using the general linear model
- Basic knowledge on alternative analysis approaches, such as *independent component analysis* (ICA)
- Basic knowledge on network and connectivity analyses, such as *dynamic causal modelling* (DCM)

Skills

- Planning an fMRI study from the research idea to the implementation at the scanner
- Selecting the right parameter at the MR scanner
- Analysing fMRI data, using the standard software package *Statistical parametric mapping* (SPM)
- Reporting, describing and presenting results from an fMRI study

Attitudes

- Pitfalls and Limitations of functional MRI and neuroimaging in general
- Feasibility of the methods for clinical research
- Careful interpretation of fMRI results in research articles
- Neuroethical consideration and the possible consequences of incidental findings

3. Course description

Part 1: Introduction to neuroscience

This first part of the course introduces to fundamental knowledge in physiology and neuroanatomy. The course is mostly aimed to repeat these issues rather than introducing them as new knowledge. The content of this part is restricted to those aspects, which are relevant for neuroimaging. These are in particular aspects of configuration of neurons, neuronal signal transmission, physiological basis of the BOLD effect, configuration of the cortex, the different lobes, Brodmann areas, functional division of different brain areas, which are relevant for visual, auditory and sensomotoric processing, as well as some important cognitive networks. The first part continues by introducing the technical aspects of various measurement techniques, commonly used in the field of neuroscience. The main focus is thereby on MR based techniques, such as ordinary structural imaging, functional imaging, diffusion tensor imaging, perfusion imaging (ASL) and spectroscopy.

Part 2: Planning, performing, and analysing na fMRI study (Theory)

This part of the course introduces to the various experimental techniques, used for functional imaging. These are not only block- and event-related designs, but also parametric designs, resting state studies, longitudinal studies, and clinical applications of fMRI. The selection of the experimental design has also consequences on how the study could be performed on the scanner. The various aspects, which have to be considered, will be explained.

Further, different analysis strategies are introduced. These are mainly based on the general linear model (GLM) or on independent component analyses (ICA). The mathematical backgrounds and how they are implemented will be explained. The

reference software for this course will be the MATLAB-based software 'statistical parametric mapping' (SPM) and the 'group ICA fMRI toolbox' (GIFT).
Other software packages, such as FSL and BrainVoyager will be mentioned, as well, but all practical tasks will be demonstrated in SPM.
This part of the course concludes with a discussion of the advantages and disadvantages of the methods explained, especially with respect to possible clinical applications. It will also cover the most relevant aspects for connectivity analyses, using dynamic causal modelling (DCM).

Part 3: Planning, performing, and analysing an fMRI study (Praxis)

In the practical part of the course, students are encouraged to develop a simple fMRI study. This study will be performed on the scanner, located at the Haukeland university hospital and the data will be analysed with the methods, introduced in the second part. The practical session is also aimed to be used for discussing actual projects. Students may have the possibility to present their own studies and to discuss issues such as experimental design and analysis strategies.
This part of the course concludes with some guidelines on how results should be reported, which tools are available for identifying brain areas, etc.

4. Evaluation

The course is concluded by a written home exam (essay).

5. Course credits

3 ECTS

6. Pre-requirements

The course is intended to PhD students that completed a Master degree in neuroscience, psychology, natural science or equivalent, as well as medical students that take part in a research training programme in medicine (forskerlinjen) or equivalent.
Each student should have access to MATLAB®, preferably on their own laptop.

7. Prior knowledge:

There is no prior knowledge necessary, but a basic introduction into Neuroscience is recommended.
Those students, more interested in technical aspects of MR imaging are encouraged to visit first a course in MR physics, like course MEDT8011, hold at NTNU.

8. Teaching methods

Lectures, group discussions, group work, and practical session

9. Teaching language

The lectures will be held in English and the practical session will be held in Norwegian and English

10. Duration of the course
4 days

11. Dates and Deadline
Course date: Summer 2015 (26.05.-30.05.2015)
Application deadline: 30.04.2015

12. Course arrangement & Participants
The course will be part of the course program of the International Graduate School in Integrated Neuroscience (IGSIN; http://www.uib.no/rs/igsin). The course is limited to 15 students.
Course announcement, course details, and registration information will be announced on the IGSIN web-side and on http://folk.uib.no/ksp041/.

13. Contact information
Prof. Dr. Karsten Specht: Karsten.specht@psybp.uib.no

14. Application
Students, interested in participating in the course, should send a request together with a short description of their actual project and their expectations to the course to the contact address, mentioned above. Students will be contacted shortly after the deadline (see above) whether they can participate, since the course is limited to 15 students. If more than 15 students are applying, selection will be based on their application.
External participants are welcome, and PhD students coming from outside Bergen can apply for founding for travel and accommodation from MedIm – Norwegian Research School in Medical Imaging (MedIm) (www.medicalimaging.no).