Course syllabus for

Introduction to Brain Imaging in Neuroscience: With a Focus on MRI, PET, EEG and MEG Methods, 7.5 credits

Introduktion till hjärnavbildning inom neurovetenskap: med fokus på metoderna MRI, PET, EEG och MEG, 7.5 hp
This course syllabus is valid from autumn 2021.
Please note that the course syllabus is available in the following versions:
Autumn2021 , Autumn2023 , Autumn2024

Course code	2QA313
Course name	Introduction to Brain Imaging in Neuroscience: With a Focus on MRI, PET, EEG and MEG Methods
Credits	7.5 credits
Form of Education	Higher Education, study regulation 2007
Main field of study	Medicine
Level	Second cycle, has only first-cycle course/s as entry requirements
Grading scale	Fail (U) or pass (G)
Department	Department of Clinical Neuroscience
Decided by	Education committee CNS
Decision date	2020-12-16
Course syllabus valid from	Autumn 2021

Specific entry requirements

At least 120 credits in psychology, psychiatry, neuro science, medicine, or medical technology. Alternatively 60 credits within psychology, psychiatry, neuro science, medicine, or medical technology on/at Secondary level.

And proficiency in English equivalent to English B/English 6.

Objectives

After taking the course, the student should be able to:

- describe the function of the instruments used to perform structural magnetic resonance imaging (sMRI), functional magnetic resonance imaging (fMRI), positron emission tomography (PET), electroencephalography (EEG) and magnetoencephalography (MEG), and to describe what aspect of the brain's structure and function these instrument register

- describe basic principles for analysis of data from measurements using sMRI, fMRI, PET, EEG and MEG
- give an overview of clinical and academic applications for each of the imaging methods
- give an overview of instruments and analysis methods used for multimodal brain imaging.

Content

The course covers the theoretical background to the brain imaging methods sMRI, fMRI, PET, EEG and MEG, such as what aspects of the human brain's structure and function they register, and the operation principles of the imaging instruments. The coursed gives the student a good understanding in how the different methods are used within in academic research as well as within health care. The course also addresses how the imaging methods can be combined in multimodal analyses, and discusses the interplay between development of theory, instrumentation, method, and applications.
The course begins with an introduction to brain imaging methods within neuroscience. In separate course modules, the course then offers the student a deeper understanding of the different methods sMRI, fMRI, PET, EEG and MEG, with multi modal brain imaging as a final and concluding course module.

Structural magnetic resonance imaging (sMRI), 1.5 hp

Grading scale: GU

The goal of the sMRI module is to provide the students with a solid understanding of structural magnetic resonance imaging (sMRI) and the tools available to analyse sMRI data. Firstly, the physiological basis of the sMRI signals and how they are measured will be discussed - the fundamentals of image processing will be introduced together with an overview of basic MRI physics. This module will then focus on main sMRI methods. The module will cover state-of-the-art methods for investigating brain morphology (automated segmentation of volume, cortical thickness, etc), and it will also cover methods for studying brain connectivity, including diffusion imaging. The sMRI module will also cover advanced methods for data analysis (multivariate data analysis, deep learning and graph theory) and other popular sMRI techniques such as quantitative susceptibility mapping, arterial spin labelling, etc, with a focus on future directions. Finally, several applications, including how sMRI is used today in clinical practice, will be discussed.

Functional magnetic resonance imaging (fMRI), 1.5 hp

Grading scale: GU

In the fMRI module, the students will be introduced to the study of brain activity using magnetic resonance imaging (MRI). The neuronal and physiological basis of the functional MRI (fMRI) signals and how they are measured will be discussed. Task fMRI and resting state fMRI will be presented as methods to address research questions about: localization of brain function, brain functional connectivity, decoding within and between subject variables from patterns of activity and studying representations of percepts, actions and thoughts. Experimental design and data analysis techniques adequate to different research questions will be addressed. The students will also be introduced to fMRI applications for clinical studies and practice.

Positron emission tomography (PET), 1.5 hp

Grading scale: GU

In this module the students will be introduced to brain imaging using the nuclear imaging technique Positron Emission Tomography (PET). The basic principles of radioligands and their development will be described, as well as their application in neuroscience research and clinical applications. Experimental design and data analysis techniques adequate to different research questions and clinical applications will be addressed. The areas will range from basic research to understand the central nerve system's physiology and pathophysiology of various diseases to development and evaluation of current

and novel treatment strategies, and also the use of PET in a clinical setting in differential diagnosis of various diseases.

Electroencephalography (EEG) and magnetoencephalography (MEG), 1.5 hp

Grading scale: GU

In the EEG and MEG module, the student is first introduced to the neural basis of the MEG and EEG signal. The module then focuses on how this neural signal is registered by the different sensor technologies used within the MEG and EEG fields, including current developments of next-generation MEG and EEG sensor technologies. The data processing steps are then briefly explained, including an overview of different strategies for analysing MEG and EEG data, including evoked- and induced responses, source analysis, functional connectivity, and multivariate pattern analysis. A strong emphasis is then placed on how MEG and EEG are used in research and in clinical and commercial applications.

Multimodal brain imaging, 1.5 hp

Grading scale: GU

Multimodal imaging has become a powerful way to investigate the human brain, link brain structure to brain function, and understand human behaviour.

In this module, the student is introduced to common strategies to combine sMRI, fMRI, PET, EEG and MEG data. Instrumentation for multimodal studies is then described, together with the most popular methods for multimodal, including examples from multimodal imaging of neurological and psychiatric disorders. The student is finally introduced to emerging multimodal imaging techniques and future directions, including recent techniques for brain stimulation and their combination with sMRI, fMRI, EEG and MEG.

Teaching methods

The teaching methods used in this course are teacher-led lectures, group discussions and an individual advanced study project. Mandatory course elements occur. The course is conducted online with the support of the Karolinska Institute digital learning platform. Via this platform, the student has access to different types of course content, such as recorded lectures and recommended literature, and can also interact with other students within the course and with the course teachers, for example during group discussions.

Examination

Learning objectives are examined partly through knowledge tests in connection with each course topic. The course is also examined through an individual project. During the last week of the course, the student presents and discusses her/his project in small groups together with teachers and other students. Mandatory course elements occur.
All mandatory lectures are recorded and are accessible for rehearsal during the course period.
Each of the five course modules is graded with a Pass or Fail grade. To pass the course, a pass grade is required for all course modules as well as for the individual advanced study project.

Absence from or non-fulfillment of mandatory course elements
The examiner decides whether, and if so how, absence from compulsory course elements can be made up for. Study results cannot be reported until the student has participated in compulsory course elements or compensated for any absence in accordance with instructions from the examiner. Absence from a compulsory course element could mean that the student can not retake the element until the next time the course is offered.

Possibility of exemption from the syllabus' regulations on examination
If there are special grounds, or a need for adaptation for a student with a disability, the examiner may

decide to deviate from the syllabus' regulations on the examination form, the number of examination opportunities, the possibility of supplementation or exemptions from the compulsory section/s of the course etc. Content and learning outcomes as well as the level of expected skills, knowledge and attitudes may not be changed, removed or reduced.

Transitional provisions

Examination will be provided for one year after a possible closure of the course or with a new syllabus.

Other directives

The course is offered in English.
Course evaluation will be carried out in accordance with the guidelines established for education at Karolinska Institutet.

Literature and other teaching aids

Mandatory literature

Mandatory literature for sMRI, fMRI, EEG/MEG, multimodal modules

Op de Beeck
Introduction to Human Neuroimaging

Cambridge University Press, 2019
LIBRIS-ID:v544gm5tsk6w0drb

Mandatory literature for PET module

Hooker, JM
Human Positron Emission Tomography Neuroimaging
Carson, RE

2019
URL: Länk
Ingår i:
Annual review of biomedical engineering

Palo Alto, CA : Annual Reviews Inc., 1999-
ISSN:1545-4274 LIBRIS-ID:11243398
4 (2019) :21, s. 551-581

Recommended literature

Recommended literature for sMRI

Neuroimaging in Dementia
Barkhof, Frederik.; Fox, Nick C.; Bastos-Leite, António J.; Scheltens, Philip.

1. : Berlin, Heidelberg : Springer Berlin Heidelberg, 2011
ISBN:9783642008184 LIBRIS-ID:12214863
URL: Table of Contents / Abstracts
Library search

Brain Mapping: The Systems
Arthur W. Toga

Academic Press, 2000
LIBRIS-ID:12311334

Hornak, Joseph P.
The Basics of MRI

J.P. Hornak., 1996-2020
URL: Länk

Recommended literature for fMRI

Chen, Jingyuan E.
Functional Magnetic Resonance Imaging Methods
Glover, Gary H.

2015
URL: Länk
Ingår i:
Neuropsychology Review

1998-
LIBRIS-ID:8856623
URL: Table of Contents / Abstracts
25 (2015) :3, s. 289313

Rosen, Bruce R
fMRI at 20 : Has it changed the world?
Savoy, Robert L

2012
URL: Länk
Ingår i:
Neuroimaging

InTech, 2010
LIBRIS-ID:14931198
15 (2012) :62, s. 1316-24

Poldrack, R.A.
Progress and Challenges in Probing the Human Brain
Farah, M.J.

2015
URL: Länk
Ingår i:
Nature

London : Nature Publishing Group, 1997-
ISSN:1476-4687 LIBRIS-ID:10307483
526 (2015) :7573, s. 371-379

Recommended literature for PET

Vernaleken, Piel M

Positron emission tomography in CNS drug discovery and drug monitoring

Rösch, F

2014

URL: Länk

Ingår i:

Journal of medicinal chemistry

1963-

ISSN:1520-4804 LIBRIS-ID:4414509

URL: Table of Contents / Abstracts

26 (2014) :57, s. 9232-58

Laruelle, M

Imaging synaptic neurotransmission with in vivo binding competition techniques : A critical review

2000

URL: Länk

Ingår i:

Journal of cerebral blood flow & metabolism

1981-

ISSN:1559-7016 LIBRIS-ID:11241905

URL: Fritt tillgänglig via

20 (2000) :3, s. 423-51

Recommended literature for EEG/MEG

Baillet, Sylvain

Magnetoencephalography for brain electrophysiology and imaging.

2017

URL: Länk

Ingår i:

Nature : Neuroscience

London : Nature Publishing Group, 1998-

LIBRIS-ID:9999938

20 (2017) s. 327339

Supek, Selma.

Magnetoencephalography : From Signals to Dynamic Cortical Networks

Aine, Cheryl J.

Berlin, Heidelberg : Springer Berlin Heidelberg, 2014 - XXI, 1013 p. 266 illus., 215 illus. in color.

ISBN:9783642330452 LIBRIS-ID:16951042

URL: Table of Contents / Abstracts

Library search

Recommended literature for multimodal brain imaging

Kriegeskorte, N

Representational similarity analysis : Connecting the branches of systems neuroscience

Mur, M.; Bandettini, P

2008

URL: Länk

Ingår i:

Frontiers in systems neuroscience

LIBRIS-ID:11607101

URL: Fritt tillgänglig via

2 (2008) :4,

Cichy, R.M.

Resolving human object recognition in space and time

Pantazis, D; Oliva, A

2014

URL: Länk

Ingår i:

Nature : Neuroscience

New York : Nature Publishing Co., 1998-

ISSN:1097-6256 LIBRIS-ID:2388812

17 (2014) :3, s. 455-62

McKeith, IG

Diagnosis and management of dementia with Lewy bodies : Fourth consensus report of the DLB Consortium

2017

URL: Länk

Ingår i:

Neurology : official journal of the American Academy of Neurology

New York : Ovid, 1995-

ISSN:1526-632X LIBRIS-ID:4419207

URL: Fritt tillgänglig via

4 (2017) :89, s. 88-100

Jack, CR

NIA-AA Research Framework : Toward a biological definition of Alzheimer's disease

2018

URL: Länk

Ingår i:

Alzheimer's & dementia : the journal of the Alzheimer's Association.

2005-

ISSN:1552-5279 LIBRIS-ID:11249824

14 (2018) :4, s. 535-562

Thompson, Alan J

Diagnosis of multiple sclerosis : 2017 revisions of the McDonald criteria

2018

URL: Länk
Ingår i:
The Lancet Neurology

New York, NY : Lancet Publishing Group, 2002-
LIBRIS-ID:9033699
URL: Table of Contents / Abstracts
17 (2018) :2, s. 162-173

Wardlaw, Joanna M

Neuroimaging standards for research into small vessel disease and its contribution to ageing and neurodegeneration

2013
URL: Länk
Ingår i:
The Lancet Neurology

New York, NY : Lancet Publishing Group, 2002-
LIBRIS-ID:9033699
URL: Table of Contents / Abstracts
12 (2013) :8, s. 822-838