Introduction to Neuroimaging Methods

MRC Cognition and Brain Sciences Unit

University of Cambridge

http://imaging.mrc-cbu.cam.ac.uk/methods/IntroductionNeuroimagingLectures

Workshops will take place at the CBU in the West Wing Seminar Room.
External attendees please report to reception.

Details will be announced before individual events via our skillstraining mailing list. To subscribe, please send an e-mail to skillstraining-subscribe@mrc-cbu.cam.ac.uk.
Our workshops are targeted at master's/PhD students and post-doctoral researchers from the Cambridge cognitive neuroscience community.
The workshops are free and open to everyone.
However, we have a limited number of spaces. If we reach our limit, priority will be given to students and junior post-doctoral researchers in cognitive neuroscience programmes.

We expect attendees to have basic skills in scientific computing and programming, e.g. at the level taught in our previous workshops. It might help to refresh your memories a little bit.

Please contact olaf.hauk@mrc-cbu.cam.ac.uk with questions and comments.

The following pages contain an overview of our schedule, and more detailed descriptions of individual workshops with some suggestions for introductory reading.

MRC Cognition and Brain Sciences Unit
75th ANNIVERSARY 1944 - 2019

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EEG/MEG and Brain Stimulation					
	Mon	Tue	Wed	Thu	Fri
	April 1st	April 2nd	April 3rd	April 4th	April 5th
10.00-12.00	**Some physics you might find useful** Olaf Hauk	**EEG/MEG I – Pre-processing** Olaf Hauk	**EEG/MEG III – Time-frequency and functional connectivity** Olaf Hauk	**Brain Stimulation** Benedikt Zoefel	**Brain connectivity** Rik Henson
13.30-15.30	**EEG/MEG lab tour and demo** Olaf Hauk, Clare Cook	**EEG/MEG II – Source Estimation** Olaf Hauk	**Multimodal Imaging** Rik Henson	**Voxel-based lesion-symptom mapping** James Stefaniak, Grace Rice	
(f)MRI					
	Mon	Tue	Wed	Thu	Fri
	April 8th	April 9th	April 10th	April 11th	April 12th
10.00-12.00	**MRI Physics I** Marta Correia	**MRI Physics II** Marta Correia	**fMRI II – GLM and experimental design** Johan Carlin	**Introduction to diffusion MRI** Marta Correia	**Multivariate neuroimaging analysis: Theory** Ian Charest, Tim Kietzmann
13.30-15.30	**MRI lab tour and demo** Marta Correia, Marius Mada	**fMRI I – Preprocessing** Johan Carlin	**fMRI III – Group analysis and statistical inference** Johan Carlin	**Graph Theory** Sarah Morgan	**Multivariate neuroimaging analysis: Workshop** Ian Charest, Tim Kietzmann, Johan Carlin

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Multimodal Neuroimaging in SPM12

Further Details TBA

Jason Taylor[1], Rik Henson[2], Will Penny[3], Vladimir Litvak[4]

[1]University of Manchester; [2]University of Cambridge, [3]University of East Anglia, [4]University College London

	Mon	Tue
	May 13th	May 14th
AM	**fMRI single-subject analysis**	**fMRI and EEG/MEG multi-subject statistical analysis**
PM	**EEG/MEG single-subject analysis**	**EEG/MEG source estimation and Dynamic Causal Modelling (DCM)**

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Brief descriptions of above workshops and some suggestions for introductory reading

Some Physics You Might Find Useful
Olaf Hauk
I will illustrate some physical concepts needed for the interpretation of EEG/MEG and fMRI data, such as electric and magnetic fields, electromagnetic waves etc. This will include some experimental demos.

EEG/MEG lab tour
Clare Cook, Olaf Hauk
We will introduce the CBU EEG/MEG lab, and show how a standard MEG study is run. This includes placing and digitising HPI coils, positioning the volunteer, and acquiring real data for about 10 minutes. This data set will be used in the next three EEG/MEG workshops.

Our EEG/MEG Wiki: http://imaging.mrc-cbu.cam.ac.uk/meg/CbuMeg

EEG/MEG I – Pre-processing
Olaf Hauk
We will take data acquired during the preceding lab tour, and analyse them to the level of evoked fields and potentials. In the process, we will talk about signal generation, data reviewing, artefact correction (Maxfilter, ICA), filtering and averaging.

Literature relevant to all EEG/MEG workshops:

Gross J et al. 'Good practice for conducting and reporting MEG research.' Neuroimage 2013, 65:349-63.

Cohen, Mike X; 'Analyzing Neural Time Series Data'; MIT Press.

Picton et al. 'Guidelines for using human event-related potentials to study cognition: recording standards and publication criteria.' Psychophysiology 2000, 37(2): 127-52.

Hari R, Puce A. 'MEG-EEG Primer'. Oxford University Press 2017.

Luck SJ. 'An Introduction to the Event-Related Potential Technique'. MIT Press.

Hansen PC, Kringelbach ML, Salmelin R. 'MEG – An Introduction To Methods'. Oxford University Press 2010.

Basic intro to EEG/MEG: http://imaging.mrc-cbu.cam.ac.uk/meg/IntroEEGMEG

EEG/MEG II – Source Estimation

Olaf Hauk

We will talk about the basics of EEG/MEG source estimation, including forward and inverse solutions. We will apply some linear source estimation methods to the evoked data from the previous workshop. In the process, we will co-register MRI and MEG coordinate systems, and look at structural MRI data for source space and head model generation. We will then compare different methods as well as EEG and MEG with respect to spatial resolution using the concepts of point-spread and cross-talk.

Dale M, Sereno MI. 'Improved Localization of Cortical Activity by Combining EEG and MEG with MRI Cortical Surface Reconstruction: A Linear Approach'. Journal of Cognitive Neuroscience 5:2, 162-176.

Michel et al. 'EEG Source Imaging'. Clin Neurophysiol 2004, 115:2195-2222.

Fuchs M et al. 'Linear and Nonlinear Current Density Reconstructions'. J Clin Neurophysiol 1999, 16(3):267-295.

Hauk O, Wakeman D, Henson R. 'Comparison of noise-normalized minimum norm estimates for MEG analysis using multiple resolution metrics'. Neuroimage 2011, 54(3):1966-74.

EEG/MEG III – Time-frequency and functional connectivity

Olaf Hauk

We will talk about the basics of time-frequency analysis (Fourier analysis, wavelets) and how it can be used to estimate functional connectivity (e.g. coherence, phase-locking), and illustrate this in some hands-on work on sample data sets. This will include issues about source estimation at the single-trial level. We will briefly talk about the basics of effective connectivity.

Cohen, Mike X; 'Analyzing Neural Time Series Data'; MIT Press (covers various aspects of EEG/MEG analysis).

Bastos A.M., Schoffelen J-M; 'A Tutorial Review of Functional Connectivity Analysis Methods and Their Interpretational Pitfalls', Front Syst Neurosci 2016.

Lachaux JP et al. 'Meauring phase synchrony in brain signals'. Hum Brain Map 1999, 8(4):194-208.

Multimodal Imaging

Rik Henson

This lecture will describe possible generative models that can be used to integrate data from EEG, MEG and fMRI.

Brain Stimulation

Benedikt Zoefel

This talk will provide an introduction to brain stimulation methods, with a focus on transcranial magnetic stimulation (TMS) and transcranial electrical stimulation (tES). I will cover the principles of these techniques, the physiological basis of the effects, the different protocols used, and examples of how brain stimulation can be used as an experimental and therapeutic tool.

Bolignini N, Ro, T. (2011) Transcranial magnetic stimulation: disrupting neural activity to alter and assess brain function. J Neuroscience, 30(29): 9647-50

Jackson et al. (2016) Animal models of transcranial direct current stimulation: Methods and mechanisms. Clinical Neurophysiology 127, 3425-3454

Herrmann CS, Rach S, Neuling T, Struber D (2013) Transcranial alternating current stimulation: a review of the underlying mechanisms and modulation of cognitive processes. Front Hum Neurosci 7: 279.

Voxel based morphometry and lesion-symptom mapping

James Stefaniak, Grace Rice

This talk will provide an introduction to the related techniques of VBM and VLSM that attempt to relate brain structure with behavioural performance in healthy and lesioned individuals. We will discuss the logic, advantages and disadvantages behind these techniques and the basic analysis pipeline.

Rorden C, et al. (2007). Improving lesion-symptom mapping. J Cogn Neurosci;19(7):1081-1088.

Seghier ML, et al. (2008). Lesion identification using unified segmentation-normalisation models and fuzzy clustering. Neuroimage;41(4):1253-1266.

Geva S, et al. (2012). A comparison of VLSM and VBM in a cohort of patients with post-stroke aphasia. Neuroimage Clin;1(1):37-47.

Brain connectivity

Rik Henson

This lecture will introduce concepts of functional and effective connectivity, briefly describe effective connectivity in fMRI (eg dynamic causal modelling) and then expand on the larger range of methods available for measuring connectivity with EEG/MEG.

MRI Physics I

Marta Correia

This talk will cover the basic principles of MRI physics for beginners, including nuclear spins and net magnetization, excitation and relaxation mechanisms, slice selective gradients, frequency and phase encoding, image formation and k-space.

MRI Physics II

Marta Correia

This talk is aimed at fMRI beginners and will be divided into two parts. Firstly, I will talk about the biophysics of fMRI and the basic mechanism behind BOLD contrast. In the second half, I will discuss common image artefacts and ways to work around them.

fMRI I – Preprocessing

Johan Carlin

We will cover basic preprocessing of fMRI data, and some useful diagnostic visualisations to help spot problems.

Ashburner, Friston, Penny: Human Brain Function, section 1 - draft chapters available here: https://www.fil.ion.ucl.ac.uk/spm/doc/books/hbf2/

Cusack et al: Automatic analysis (aa): efficient neuroimaging workflows and parallel processing using Matlab and XML. https://doi.org/10.3389/fninf.2014.00090

fMRI II – GLM and experimental design
Johan Carlin
This workshop covers the basic principles of single-subject design focusing on how it is implemented in SPM. We will also discuss how to design efficient fMRI experiments.

Ashburner, Friston, Penny: Human Brain Function, section 2 - draft chapters available here: https://www.fil.ion.ucl.ac.uk/spm/doc/books/hbf2/

Rik Henson's wiki entry on design efficiency (adapted from his technical chapter in the above edited book): http://imaging.mrc-cbu.cam.ac.uk/imaging/DesignEfficiency

fMRI III – Group analysis and statistical inference
Johan Carlin
After a short recap of the GLM, which also is the basis of group analysis, we will review some example designs. We will focus especially on statistical inference and multiple comparisons correction.

Ashburner, Friston, Penny: Human Brain Function, section 3 - draft chapters available here: https://www.fil.ion.ucl.ac.uk/spm/doc/books/hbf2/

Eklund et al: Cluster failure: Why fMRI inferences for spatial extent have inflated false-positive rates. https://doi.org/10.1073/pnas.1602413113

Introduction to diffusion MRI
Marta Correia
This workshop will cover the basic principles of diffusion MRI acquisition and data analysis.

Graph Theory
Sarah Morgan
An introduction to graph theoretical analysis of brain networks, aimed at beginners. We will discuss the motivation for graph theoretical approaches, learn how to calculate some simple graph theory metrics, compare the results to null models and signpost some novel, more complex graph theoretical techniques.

'Network Neuroscience', Bassett and Sporns, Nature Neuroscience, volume 20, pages 353–364 (2017)

'The economy of brain network organization', Bullmore and Sporns, Nature Reviews Neuroscience, volume 13, pages 336–349 (2012)

'Fundamentals of Brain Network analysis', Fornito, Zalesky and Bullmore, Academic Press, 2016 (book)

Multivariate neuroimaging analysis: Theory and Practice
Ian Charest, Tim Kietzmann, Johan Carlin
This workshop will cover the basic principles of multivariate pattern analyses for fMRI, and provide hands on experience with decoding analyses and representational similarity analyses.

Kriegeskorte N, Mur M, Bandettini P. 'Representational similarity analysis – connecting the branches'. Front Syst Neurosci 2008.

Laakso A, Cottrell G. 'Content and cluster analysis: assessing representational similarity in neural systems'. Phil Psych 2000, 13(1).