MSc Neuroimaging for Clinical & Cognitive Neuroscience

School of Psychological Sciences
Faculty of Medical & Human Sciences

Module Information

*Please note that this is a sample guide to modules. The exact content and combination of modules may change without prior notice.
Section B: Syllabus, Course Units and Route through the Programme

**Semester One**

Compulsory Components

- Neuroimaging Techniques (15 credits)
- Image Analysis (15 credits)
- Experimental design and optimisation (15 credits)
- Functional neuroanatomy (15 credits)

**Semester Two**

Compulsory Components

- Advanced Image Analysis (15 credits)
- Cognitive and Social Neuroscience (15 credits)
- Clinical and Behavioural Neuroscience (15 credits)
- Cognitive Psychology for Clinical Neuroscience
- Research Project preparation

**Summer**

- Research Project
Neuroimaging Techniques

Course Unit Aims

To provide students with a solid grounding in functional and structural neuroimaging methodology. The unit focuses on the technological methods of a number of neuroimaging techniques including MRI, fMRI, PET and EEG/ERP, highlighting their relative strengths and limitations.

Course Unit Learning Outcomes

By the end of this course, students will:

• Have an in-depth knowledge of the technological bases of each neuroimaging technique
• Have a detailed understanding the kinds of information about each technique provides about the brain
• Have a general understanding of the ways in which these different techniques can be used to explore brain function
• Have a good working knowledge of the relative advantages and disadvantages of each technique, based on their strengths and limitations.
• To be able to evaluate the appropriateness of using a particular neuroimaging technique to answer a specific question about brain function.
• To be able to consider the various strengths and weaknesses of different imaging techniques

Course Unit Content

This unit will describe the methodological bases of a number of neuroimaging modalities (MRI, fMRI, PET and EEG/ERP) by exploring the technological features of each modality, the relevant neurophysiology of the brain and the interaction between the two. In doing this, the specific ways in which each modality generates information about the brain will be described with a focus on the differences between the types of information they can produce and what they can tell us about brain structure and function. The unit will also explore the relative strengths and weaknesses of each modality and ways in which they might be used in a convergent fashion to enhance data acquisition, analysis and interpretation.

Functional Neuroanatomy

Course Unit Aims

This module aims to provide students with a solid grounding in general neuroanatomy with a particular focus on factors relating to the localisation of regional brain activity and spatial resolution in fMRI and EEG research.

Course Unit Learning Outcomes

By the end of the course unit, students will:
• Have a strong neuroanatomical knowledge
• Have a clear understanding of the different levels of spatial localisation
• Be able to compare across different levels of spatial localisation with relative ease
• Have a broad knowledge and understanding of the factors that influence spatial localisation in both fMRI and EEG/ERP
• Be able to identify and differentiate brain regions quickly and accurately
• be able to discuss how to optimise spatial localisation
• be able to use software to explore, identify and illustrate spatial localisation

Course Unit Content
This unit will provide students with a neuroanatomical overview complemented by focussed investigations of some key brain areas (including the frontal lobes and the medial temporal lobes). Spatial localisation will be discussed at a gyral level, a cytoarchitechtonic level (Brodmann’s areas) and a voxel level. The advantages and disadvantages of region of interest and voxel-based analyses will be contrasted. The course will explore the factors which influence the level and accuracy of spatial localisation and resolution, including MR related artefact and EEG source issues. In addition, students will be introduced to a selection of software that is used to aid localisation.

Image Analysis

Course Unit Aims
The course aims to provide students with a comprehensive knowledge of functional and structural neuroimaging and electrophysiological methodologies. The unit focuses on the image analyses aspects of a number of techniques including MRI, fMRI, PET and EEG/ERP. In addition to gaining knowledge of image analysis theory, students will learn how to conduct various aspects of image analysis through hands-on experience with analyses packages.

Course Unit Learning Outcomes
By the end of the course, students will be able to:
• have comprehensive understanding of each stage of image analysis
• have a well-developed knowledge of the advantages and disadvantages of each analysis parameter
• draw appropriate inferences based on the image analysis employed
• evaluate the appropriateness of using a particular neuroimage analysis method
• consider the various strengths and weaknesses of different analyses techniques
• gain experience of and expertise with all the stages of preprocessing neuroimaging data
• perform both participant- and group-level statistics on neuroimaging data

• analyse neuroimaging data using varied designs, such as blocked, event-related and mixed designs.

Course Unit Content
This unit will explore the image analyses aspects of a number of neuroimaging techniques covering both theoretical and practical perspectives. Students will gain valuable hands-on experience with a number of analysis packages with the aim of consolidating and building upon their knowledge of image analysis theory. In turn, gaining a comprehensive knowledge and understanding of the various stages of analysing neuroimaging and electrophysiological data will provide a firm foundation upon which any future image analysis package can be learnt, with relative ease. The unit will also explore the relative strengths and weaknesses of selecting various imaging parameters and the resulting inferences that can be drawn.

Experimental Design and Optimisation

Course Unit Aims
This module aims to provide students with a solid working knowledge and detailed understanding of the key factors involved in the design and optimisation of functional imaging experiments (fMRI and EEG/ERP) and how these impact on data analysis and interpretation. The course also aims to provide the skills required to be able to design an effective and valid fMRI and EEG/ERP experiment.

Course Unit Learning Outcomes
By the end of the course unit, students will be able to:

• Have a solid understanding of how to set up a good research hypothesis in cognitive brain imaging

• Have a detailed understanding of the key issues involved in fMRI and PET experimental design

• Have a detailed understanding of the key issues involved in EEG/ERP experimental design

• Have a good working knowledge of the relative advantages and disadvantages of blocked, event and mixed designs.

• Have a good working knowledge of various categorical, factorial and parametric designs and issues relating to their interpretation.

• Design and set up an fMRI and EEG/ERP experiment

• Critically evaluate cognitive brain imaging data in terms of the experimental design

• Use a computerised stimulus presentation procedure

Course Unit Content
This unit will explore the complex interaction between experimental design variables, the characteristics of the hemodynamic response function and cortical neuronal activity and the demands of MR and EEG/ERP data acquisition procedures, and their respective environments. The course will explore both blocked and event-related designs and will
highlight the potential advantages of mixed designs. There will be a strong focus on contrasting different types of experimental design and the relative strengths and weaknesses they bring to an experiment. Confounding factors, control and power issues and the fundamentals of how to set up a good research hypothesis will be explored. The major theoretical component of the course will be complemented by the acquisition of practical experimental paradigm development skills and quantitative statistical analysis skills.

Cognitive Psychology for Clinical Neuroscience

Course Unit Aims

Provide students with a broad grounding in current theories and methods in cognitive science. The course will explore both behavioural and computational research drawing examples from areas such as language, memory, attention, perception and action.

Course Unit Learning Outcomes

Having attended the course, students will:

• Have a broad knowledge of cognitive psychology
• Have a broad understanding of the methods used to explore cognitive models
• Have a broad understanding of the methodology of computational modelling
• Have a working knowledge of examples of computational models
• Have an understanding of how cognitive science feeds into, and interacts with, related areas such as cognitive neuroscience.
• Be able to critically explore cognitive models
• Be able to critically explore computational models
• Be able to explore potential developments to current models

Course Unit Content

This unit will explore theoretical developments in a wide selection of areas of cognition. It will highlight the role played by behavioural experiments in establishing and testing models of cognition. The course will also focus on the contribution made by computational models of cognition and will provide an introduction to this methodology. The interaction between the behaviour-based and computation-based approaches will be emphasised with examples drawn from several areas of cognition.
Advanced Image Analysis

Course Unit Aims
To provide students with an introduction to, and a working knowledge of, a selection of advanced imaging techniques, focusing on both acquisition and analysis methodology. In addition, the course will provide some advanced mathematical, statistical and neurophysiological background to these methods.

Course Unit Learning Outcomes
At the end of this unit students will:

• have a solid grasp of a selection of advanced imaging techniques and how they can be used to contribute to research.

• understand some of the mathematical, statistical and neurophysiological factors underlying these advanced methods.

• understand the neurophysiological issues that need to be addressed by the advanced techniques

• be able to evaluate the use of advanced image analysis techniques to answer specific questions about brain function.

• be able to select the most appropriate technique to address the question in hand.

• be able to discuss some of the mathematical and statistical models and assumptions that underlie the methods

• have some specialised Analysis skills

Course Unit Content
The course will provide theoretical and practical background to a number of key advanced methods in image analysis including connectivity, diffusion tensor imaging and EEG/ERP source localisation. This will be complemented by a series of lectures focusing on theoretical issues underlying the methodology such as Bayesian inference and probabilistic modelling, signal detection, connectivity, coherence analysis, synchronisation and phase analysis and the relationship between the BOLD fMRI signal and variables such as blood flow and blood volume. The practicalities, strengths and limitations of combined concurrent EEG/ERP and fMRI acquisition will also be explored. Lectures will be linked to practical sessions providing introductory hands-on training in a number of advanced image analysis methods. The course builds on the Image Analysis module by exploring advances in techniques and proposed solutions to specific problems and challenges.
Cognitive and Social Neuroscience

Course Unit Aims
Provide students with a broad background to fMRI and EEG/ERP applications in cognitive and social neuroscience. Through examples, the course will illustrate a variety of ways in which these techniques can be used to explore the neural bases of cognition, emotion, social cognition and behaviour.

Course Unit Learning Outcomes
By the end of this course, students will:

• Have a detailed understanding of how fMRI and EEG have been used to explore cognitive and social neuroscience
• Understand how questions asked with functional neuroimaging can address issues raised by lesion studies
• Be able to critique a variety of analytical approaches used to address the neural basis of cognitive and social neuroscience
• Be able to develop a theoretically relevant hypothesis
• Be competent at evaluating research exploring cognitive and social theories using functional imaging

Course Unit Content
The course will describe a series of studies using functional neuroimaging techniques to explore questions in cognitive and social neuroscience. Examples of areas covered include, language, memory, attention, face recognition, cross-modal processing, sleep, emotion and social cognition. The course will explore and evaluate ways in which different acquisition and analysis techniques have been used to investigate contrasting questions, showing how in some cases they have provided convergent data. The course will evaluate the validity of analytic approaches incorporating personality measures. The unit will also draw on human lesion work to illustrate how functional neuroimaging hypotheses have evolved and how data from functional neuroimaging informs human lesion models.
Clinical and Behavioural Neuroscience

Course Unit Aims
Provide students with a broad background into the ways in which fMRI, PET and EEG/ERP have been used to address clinical and behavioural questions in neuroscience through examples concerning disorders such as dementia, depression, epilepsy and pain. The course aims to provide a current and future perspective on the clinical and behavioural applications of neuroimaging techniques.

Course Unit Learning Outcomes
By the end of this course, students will:

• Have a detailed understanding of how fMRI, PET and EEG/ERP have been used to explore clinical and behavioural neuroscience

• Understand how questions asked with functional neuroimaging can address clinically and behaviourally relevant issues

• Understand the limitations and methodological requirements of the functional neuroimaging of clinical populations

• Be able to evaluate published research

• Be able to critically evaluate the potential of different techniques to address specific clinical questions

Course Unit Content
The course will describe a series of studies using functional neuroimaging techniques (fMRI, PET and EEG) to explore questions in clinical and behavioural neuroscience. Current research will be explored with the aim of providing an accurate view of the current ability of these techniques to address clinically significant issues and the future potential of the techniques with respect to clinical research questions. Methodological factors particular to dealing with clinical populations and/or those displaying behavioural deficits will be addressed. The course will provide students with the background needed to be able to develop and design an appropriate experiment that will ask appropriate clinical questions while having a solid understanding of the current limitations of these techniques within the clinical arena.
Research Project

Course Unit Aims:
Provide students with the experience of exploring brain imaging data within the context of an original piece of research. Students will develop abilities to critically evaluate published research, to develop research questions and hypotheses, to explore data in novel ways, to carefully interpret brain activation data within a theoretical and/or methodological context and to develop research-writing and presentation skills.

Course Unit Learning Outcomes
By the end of the course unit students will:
• Have an in-depth understanding of the literature specific to the area of investigation
• Understand how to identify an appropriate research question
• Identify and employ the appropriate research methods and analysis techniques necessary to answer their research question
• Understand how to interpret their data
• Understand the limitations to their data interpretation
• Understand the requirements of scientific writing
• Understand the requirements of data presentation
• Understand the ethical issues and processes involved in research
• Be able to critically evaluation of literature relevant to the topic
• Be able to generate timely and theoretically and/or methodologically grounded research questions
• Show appropriate use of image analysis techniques

Course Unit Content
Under supervision, students will use their newly acquired brain imaging skills to carry out an investigation into a specific research question that can be addressed using brain imaging data. Students will be required to produce a research report which will include a theoretical background, aims, description of methods, data analysis and results and a detailed discussion of the data and their theoretical and/or methodological interpretation. In addition, students will produce a poster presentation of their research and will be required to present this for assessment.