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Neuroimaging Research for Graduate Scientists - NEME11040 (20CC)

Semester 1 / Autumn **20 Credits**

This Course is composed of various Modules & Activities.

Modules:

Module	Lectures covered within the module
Imaging in Context	Imaging basics History: past & present Terminology & orientation Anatomy basics
CT techniques	Computed Tomography Basics SMPTE exercise Grey scale perception: technical Grey scale perception: applications CT advanced techniques 1 & 2
MR techniques and practicalities	Physics T1 & T2 Localisation k-space MR health & safety Safe running of a MR unit Screening for contraindications & safety Having an MR scan
Imaging stroke	MR diffusion imaging Imaging in cerebrovascular disease: background Imaging in cerebrovascular disease: advanced techniques & concepts 1 & 2 Lacunar stroke 1 & 2
Imaging dementia	SPECT & PET Physics SPECT & PET Scanning Introduction and Alzheimer's disease Vascular and other dementias SPECT and PET imaging in the dementias
Imaging ageing	MR Spectroscopy introduction MR Spectroscopy techniques Ageing, brain volumes & spectroscopy

	Ageing, white matter & cognition
Imaging function	Neurophysiology techniques Neurovascular techniques Applications: Linking Sensation to Spiking
MND	The neuropsychology of motor neurone disease
Systematic Review Methodology	How to do a systematic review

Each Module is composed of Lectures, Reading Lists, MCQ self-assessments, & Discussion Boards.

This course is taught as part of the on-campus Integrative Neurosciences MSc (by research)
This course is not available for CPD or PPD
Further details of modules that may be within your course

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Imaging Basics

Lecture 1
Title: History: past to present
Description: Historical perspective through to modern imaging departments
Author(s): Dr. Andrew Farrall
Learning Objectives
- Outline the historical development of imaging
- List the techniques used in modern imaging departments
- Identify which techniques do or do not use ionizing radiation
- Distinguish between techniques which use ionizing radiation

Lecture 2
Title: Terminology and orientation
Description: Becoming familiar with how radiology looks at the body
Author(s): Dr. Andrew Farrall
Learning Objectives
- Use and interpret radiological orientations, directions and convention

Lecture 3
Title: Anatomy basics
Description: A look at common anatomical landmarks and features
Author(s): Dr. Andrew Farrall
Learning Objectives
- Identify common anatomical landmarks and features including:
- Anatomical landmarks of the head surface anatomy
- Skull features
- Lobes, fissures and sulci
- Grey and white matter
- Arterial supplies to the brain

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Computed Tomography Basics

Lecture 1
Title: Computed Tomography Basics
Description: History, principles and practice
Author(s): Dr. Andrew Farrall
Learning Objectives
- Outline the historical development of scanners
- State the difference between generations of scanners
- Define “pitch” and collimation
- Describe attenuation in CT
- Outline back projection reconstruction
- Outline beam hardening artefact
- Discuss applications of modern CT techniques

Lecture 2
Title: Grey scale perception - Technical
Description: Physics and other relevant concepts behind the grey scale in radiology
Author(s): Dr. Andrew Farrall
Learning Objectives
- Describe the pathway of perception
- Explain radiological imaging and how it uses the grey scale to represent images

Lecture 3
Title: Grey Scale Perception - Applications
Description: How perceiving the grey scale has important clinical ramifications
Author(s): Dr. Andrew Farrall
Learning Objectives
- Describe how the human eye perceives contrast and brightness off grey scale images
- Explain factors which alter human perception of grey scale images
- Discuss the limitations of grey scale imaging

Lecture 4
Title: CT advanced techniques 1
Description: Maximum and minimum intensity projections
Author(s): Dr. Michael Jackson, Dr. Andrew J. Farrall
Learning Objectives
- Describe production of maximum (and minimum) intensity projection images
- Describe the effect of varying slice thickness on MIPs and MinIPs
- Explain the difference between intensity projection and windowing
- Demonstrate clinical uses for intensity projection images
- Describe the limitations of intensity projection images

Lecture 5
Title: CT advanced techniques 2
Description: Multi-planar and 3D reconstructions
Author(s): Dr. Michael Jackson, Dr. Andrew J. Farrall
Learning Objectives
- Understand the role of multi-planar reformatting

- Discuss the advantages and limitations of 3D CT reconstructions
- Be aware of 3D editing techniques
- Name endoluminal visualisation techniques
- Understand differences between orthographic rendering and immersive perspective rendering
- Explain when 3D techniques are complementary to conventional imaging

MR techniques and practicalities

Lecture 1
Title: Physics
Description: Basic principles behind MR
Author(s): Dr. Paul Armitage, Dr. Andrew Farrall
Learning Objectives
- Describe "spin" and its relevance to Magnetic Resonance
- Explain the relevance of protons in MR
- Know the Larmor frequency equation
- Describe “relaxation”
- Define the “Free Induction Decay”
- Distinguish between T1 & T2

Lecture 2
Title: T1 & T2
Description: Using relaxation parameters in imaging
Author(s): Dr. Paul Armitage, Dr. Andrew Farrall
Learning Objectives
- Recognise different tissues have different T1 & T2 values
- Understand how the differences are exploited to generate image contrast
- Differentiate between T1 weighted & Proton Density weighted imaging
- Understand what T1 imaging is useful for clinically
- Understand T2 weighted imaging
- Understand what T2 imaging is useful for clinically
- Discuss how FLAIR & STIR imaging relate to each other
- Know why FLAIR & STIR imaging are used

Lecture 3
Title: Localisation
Description: Overview of how MR signal is associated with the point from which it originates
Author(s): Dr. Paul Armitage, Dr. Andrew Farrall
Learning Objectives
- Explain MR slice selection
- Describe how localization is performed in the MR image plane
- Recognise the difference between frequency and phase encoding
- State the difference between pixel and voxel

Lecture 4
Title: k-Space

Description: Relating raw MR data to the image we see
Author(s): Dr. Andrew Farrall, imaging provided by Dr. Trevor Carpenter
Learning Objectives
- Explain what information lies in k-space
- Describe how k-space relates to MR images
- State the role of the Fourier Transform
- List some common artefacts in MR images which result from errors and problems in k-space

Lecture 5
Title: MR Health and Safety
Description: Health and safety aspects of working within high magnetic fields and other aspects of MR safety
Author(s): Mrs. Iona Hamilton, Mrs. Elaine Sandeman
Learning Objectives
- Explain how to work in a high magnetic field safely
- Describe differences in safety aspects of different types of MR scanner
- List items which may cause hazard in a magnetic field
- Discuss subject-specific factors that may affect safety

Lecture 6
Title: Safe running of an MR unit
Description: Key factors in running a safe and effective human MR scanning facility
Author(s): Prof. Joanna Wardlaw
Learning Objectives
- Outline the key factors involved in setting up and running an MR scanning facility for research in people
- Describe how to ensure safety of staff and subjects or patients being scanned
- Discuss current areas of debate concerning safety of magnetic fields and contrast agents

Lecture 7
Title: Screening for contraindications and safety
Description: To outline the relative and absolute contraindications to MR imaging and ensure safety while having an MR scan
Author(s): Mrs. Iona Hamilton, Mrs. Elaine Sandeman
Learning Objectives
- Describe the individual steps in preparing for an MR examination
- Summarise the major contraindications to MR
- Summarise the key things to watch out for to ensure safety

Lecture 8
Title: Having an MR scan
Description: A description of the steps involved in having an MR scan
Author(s): Mrs. Iona Hamilton, Mrs. Elaine Sandeman
Learning Objectives
- Explain what it is like to have an MR scan, from start to finish

Imaging stroke:

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Lecture 1
Title: MR Diffusion Imaging
Description: Principles, techniques & applications
Author(s): Dr. Mark Bastin
Learning Objectives
- Define diffusion
- Describe how MR is sensitised to diffusion
- Describe what affects diffusion in vivo
- Explain why fast imaging is needed
- Describe diffusion anisotropy
- List some clinical applications of diffusion MR imaging

Lecture 2
Title: Imaging in cerebrovascular disease: background
Description: This lecture illustrates ways in which imaging has improved our understanding of how blood vessel diseases affect the brain, and how imaging is used in research.
Author(s): Prof. Joanna Wardlaw
Learning Objectives
Explain what a stroke is and why stroke is a big health care problem
- Explain how imaging techniques have improved understanding of causes and pathophysiology of stroke
- Illustrate new avenues of stroke research that will lead to future improvements in stroke care

Lecture 3
Title: Imaging in cerebrovascular disease: basic techniques & concepts
Description: Imaging's role in research and how it improves understanding of brain blood vessel disease: CT & DWI
Author(s): Prof. Joanna Wardlaw & Dr Grant Mair (update)
Learning Objectives
Explain what a stroke is and why stroke is a big health care problem
- List various imaging techniques which can be applied to stroke;
- Describe CT & MR imaging findings in stroke;
- Relate imaging findings to cerebral blood flow & clinical outcomes;
- Discuss issues quantifying imaging findings, using DWI as an
- Example
- Discuss issues with imaging animal models, using DWI as an example

Lecture 4
Title: Imaging in cerebrovascular disease advanced techniques & concepts 1 & 2
Description: Imaging's role in research and how it improves understanding of brain blood vessel disease: Perfusion & spectroscopy
Author(s): Prof. Joanna Wardlaw & Dr Grant Mair (update)
- **Learning Objectives**
  Describe basic principles of PWI & perfusion-diffusion mismatch;
- Discuss limitations of PWI & perfusion-diffusion mismatch investigations;
- Describe types of information which MR Spectroscopy can deliver;
- Speculate on how the broader lessons from stroke imaging might affect other research which uses imaging.

Lecture 5
Title: Lacunar stroke, part 1
Description: Introduction to and imaging of lacunar stroke
Author(s): Prof. Joanna Wardlaw
Learning Objectives
- Compare lacunar stroke with large artery stroke in terms of their importance and epidemiology
- Describe small vessel pathology associated with lacunar stroke
- Identify lacunar stroke and associated pathologies on imaging
- Discuss any considerations in imaging lacunar stroke and associated pathologies

Lecture 6
Title: Lacunar stroke – part 2
Description: Current theories regarding causes of lacunar stroke
Author(s): Prof. Joanna Wardlaw
Learning Objectives
- Elaborate on current theories of its causes, focussing on evidence from imaging studies

Imaging Dementia

Lecture 1
Title: Physics
Description: Basic principles behind SPECT
Author(s): Prof. Jonathan Best
Learning Objectives
- Define what a radionuclide is
- Compare and contrast SPECT and PET
- Identify the differences between radionuclide effective halflife, physical half-life and biological half-life
- Name three radionuclides commonly used in SPECT
- Describe the basic components of a gamma camera
- Discuss why collimation is important in SPECT
- Name at least three methods of image reconstruction
- Discuss how SPECT compares to other imaging modalities in terms of spatial resolution, sensitivity and observational time

Lecture 2
Title: Scanning
Description: Applications of SPECT imaging
Author(s): Prof. Jonathan Best
Learning Objectives
- Outline why Cerebral Blood Flow is used as a proxy marker for brain metabolism
- Describe what is meant by biodistribution and understand how it affects to radiation dose
- Describe how Statistical Parametric Mapping is used in SPECT
- Identify what the major differences are between dementias

Lecture 3

Title: Introduction and Alzheimer's disease
Description: Public health burden, diagnosis, use of imaging, Alzheimer's disease
Author(s): Dr. Nadine Dougall, Prof. Joanna Wardlaw
Learning Objectives

- Outline the public health burden of dementia
- Describe the diagnosis of dementia in general
- Explain the variation in diagnosis introduced by use of different criteria
- Outline the diagnosis of Alzheimer's disease specifically
- Outline the pathology of Alzheimer's disease
- Describe the use of imaging in routine practice
- Describe the use of structural imaging in research
- Identify key features associated with dementia on imaging
- Discuss the current limitations of dementia research

Lecture 4
Title: Vascular and other dementias
Description: Neuroimaging in Vascular and other dementias
Author(s): Dr. Nadine Dougall, Prof. Joanna Wardlaw
Learning Objectives

- Define
    - Vascular dementia
    - Lewy body dementia
    - Fronto-temporal (semantic) dementia
- Outline the diagnosis of vascular dementia in general
- Explain the variation in diagnosis introduced by use of different criteria
- Describe the use of structural imaging in research
- Discuss the current limitations of dementia research

Lecture 5
Title: SPECT and PET imaging in the dementias
Description: To outline the role of SPECT and PET imaging in dementia and compare with structural imaging techniques
Author(s): Dr. Nadine Dougall, Prof. Joanna Wardlaw
Learning Objectives

- Describe the role of SPECT in the diagnosis of dementia
- Describe the role of PET in the diagnosis of dementia
- Explain opportunities for improved understanding of dementia through radioisotope imaging
- Discuss limitations and practical difficulties of functional imaging in dementias

Imaging ageing

Lecture 1
Title: Introduction
Description: MR review, & comparison of MR Spectroscopy with MR Imaging
Author(s): Dr. Katherine Lymer
Learning Objectives

- Review MR slice selection and understand its relevance to MR spectroscopy (MRS)
- Explain why good signal-to-noise (SNR) in MRS is critical
- Outline how SNR is optimised in MRS
- Define shimming
- Describe water suppression
- Explain why water suppression is important

Lecture 2
Title: Techniques
Description: Generating spectra; identifying metabolites; clinical applications
Author(s): Dr. Katherine Lymer
Learning Objectives
- Know available nuclei for MRS
- Name common localisation sequences
- Describe Chemical Shift Imaging (CSI)
- Name major metabolites of interest in MRS
- Identify major components of an MR spectrum
- Know applications of MRS in stroke

Lecture 3
Title: Ageing, brain volumes & spectroscopy
Description: This tutorial describes the use of imaging techniques to determine some of the changes that occur in the brain with ageing
Author(s): Dr. Karen Ferguson
Learning Objectives
- Discuss some of the imaging and image analysis techniques that can be used to investigate brain ageing
- Describe some of the changes that occur with ageing in terms of regional brain volumes, cerebrovascular disease, brain metabolites and cortisol endocrinology
- Explain how these changes relate to cognition in healthy ageing
- Outline what factors the changes in cognition in healthy ageing may be due to

Lecture 4
Title: Ageing, white matter & cognition
Description: The appearance and associated features of age-related white matter lesions as determined through imaging research.
Author(s): Dr. Susan Shenkin
Learning Objectives
- Outline the changes in the brain and cognition with age
- Explain what we know of the appearances in MR imaging, risk factors, associated features, and prognostic implications of age-related white matter lesions.
- Discuss new areas for future research

Imaging functions

Lecture 1
Title: Neurophysiology techniques
Description: Magnetoencephalography (MEG) & Electroencephalography (EEG)

Author(s): Dr. David McGonigle
Learning Objectives
- Discuss the relative strengths and weaknesses of MEG and EEG

Lecture 2
Title: Neurovascular techniques
Description: Principles of Positron Emission Tomography and functional Magnetic Resonance Imaging in assessing function
Author(s): Dr. David McGonigle
Learning Objectives
- Discuss the relative strengths and weaknesses of neurovascular techniques as tools for functional neuroimaging

Lecture 3
Title: Applications: Linking Sensation to Spiking
Description: Applying functional imaging techniques to detection of sensory processing
Author(s): Dr. David McGonigle
Learning Objectives
- Describe how physical stimuli are coded by the brain
- Outline the use of functional imaging to detection of sensory processing

MND

Lecture 1
Title: The neuropsychology of motor neurone disease
Description: Imaging and the cognitive consequences of motor neurone disease
Author(s): Dr. Sharon Abrahams
Learning Objectives
- Define:
    - Motor Neuron Disease (MND)
    - MND-Dementia
- Outline the role that imaging has played in improving the knowledge of how MND affects regions of the brain other than the motor system
- Using the example of Classical MND studies, discuss how imaging can be used in conjunction with other approaches, in particular neuropsychology, in research and clinical practice

Systematic review methodology

Lecture 1
Title: How to do a systematic review
Description: The practicalities of conducting a systematic review
Author(s): Dr. Francesca Chappell
Learning Objectives
- Describe the stages of a systematic review
- Explain how to carry out & document each stage

Highlight publication requirements of PRISMA & other relevant guidelines

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