NATIONAL
ACADEMY OF
NEUROPSYCHOLOGY

Applications of Brain Imaging in Clinical Neuropsychology
Course Syllabus

OVERVIEW

This course outlines the brief history of brain imaging and contemporary developments in the use of functional and structural neuroimaging in the cognitive and clinical neurosciences. The goal is to focus on those imaging methods that permit direct, non-invasive analysis of brain functioning in humans. At the outset, this course will review the basic principles of psychophysiology and functional neuroanatomy to provide context for the discussion of neuroimaging. The course then describes a number of brain imaging techniques and then provides a detailed overview of the most common form of brain imaging modality, MRI, including both structural and functional approaches. The ultimate goal of this course is for the clinical neuropsychologist to understand the basic assumptions of brain imaging approaches and how they are applied (and mis-applied) in the clinical neurosciences, as well as recent clinical applications in diagnostics and treatment planning.

COURSE DIRECTOR

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DURATION, CREDITS, WORKLOAD

This is a 15-week online learning experience that combines journal article readings, online materials, supplemental discussion questions, and student-instructor interactions via an online discussion board. The course is divided into six learning modules with the course schedule outlined below.

Students who successfully complete all course requirements are eligible to receive 30 CE credits for psychologists. The National Academy of Neuropsychology is approved by the American Psychological Association to sponsor continuing education for psychologists. The National Academy of Neuropsychology maintains responsibility for this program and its content.

The DistanCE program expects that a minimum workload of 3-4 hours of work is necessary to keep up with the course.

Target Audience: Clinical psychologists with background in neuroscience or neuropsychology

Instructional Level: Intermediate. The course starts with basic imaging concepts and does not require prerequisite coursework, but does cover advanced principles of imaging methods and applications.

COURSE FEES

NAN Members: $450
Non-members: $750

OBJECTIVES

Upon completion of the course, the learner will be able to:

1. Discuss functional neuroanatomy of the brain, including major landmarks, basic organization of the primary and association cortices, and major connections between cortical and subcortical areas.

2. Explain the basics of conventional clinical imaging, including CT, PET, and MRI.

3. Describe the differences between structural and functional imaging and the distinct classes of functional brain imaging approaches.

4. Apply the terminology used in conjunction with functional brain imaging techniques, including spatial and temporal resolution, electromagnetism, and signal-to-noise ratio.

5. Describe the nature of the signal created across a range of functional neuroimaging methods, including electroencephalography, magnetoencephalography, positron emission tomography, and near-infrared spectroscopy.

6. Discuss the trade-offs between temporal and spatial resolution in brain imaging.

7. Explain the basic physical principles of MRI, the most widely used structural and functional brain imaging approach.

8. Describe how magnetic fields are used to create brain images of differing qualities/susceptibilities, such as T1 versus T2.

9. Explain the nature of the blood oxygen level dependent functional magnetic resonance imaging (BOLD fMRI) signal.

10. Utilize basic BOLD fMRI research designs that isolate blood flow as a surrogate for neural firing, including task-based designs such as block designs and event-related designs.

11. Discuss the limitations and mis-applications of BOLD fMRI.

12. Describe the difference between “activation” studies in brain imaging and “connectivity” studies including resting-state connectivity.

13. Discuss the most reliable clinical applications of fMRI and other technologies.

14. Explain the assumptions and pitfalls associated with each neuroimaging technique.

15. Describe how one might use brain volumetric studies to understand plasticity.

16. Explain the basis for the signal in diffusion tensor imaging (DTI).

17. Discuss how DTI can be used to examine white matter pathology.

18. Provide examples of multi-modal imaging and explain how techniques are integrated.

19. Explain how proton magnetic resonance spectroscopy can be used to examine localized brain metabolism.

20. Discuss how susceptibility weighted imaging can be used clinically.

COURSE REQUIREMENTS

To pass the course requirements and earn continuing education credits or certificates of completion, students must complete all multiple-choice posttest examinations, earning a cumulative percentage of >74% correct. The DistanCE online system automatically records performance on the multiple-choice quizzes, which may be taken multiple times. A discussion board will be available for the course to facilitate communication with the instructor and other students as questions may come up.

SCHEDULE

Week 1-2 Module 1: Functional Neuroanatomy Primer

Anatomy

a. Primary cortical areas
b. Association Cortices
c. Subcortical Structures

Function

d. Sensory, Motor, and Cognition
e. Vision
f. Motor Functioning
g. Memory
h. Language

Week 2-3: Module 2: Traditional structural and Clinical imaging

a. CT Scanning (w and w/o contrast)
b. Angiography
c. Single Photon Emission Tomography

d. Positron Emission Tomography

Week 3-4: Module 3: Functional Brain Imaging Methods (general)

a. Functional brain imaging overview
b. Spatial/Temporal resolution
c. General Categories of imaging and examples

Weeks 5-6: Module 4: Part I: MRI Basics: History and Physics

a. Basic MR Physics
    1. Resonance/Spins/Relaxation
    2. Transverse vs. Longitudinal magnetization
    3. Dephasing and Spin echo
    4. T2 vs. T2*
b. Structural MRI
    T1, T2, T2*

Reading: Khanna et al., 2015 (MRI principles)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4757157/

Weeks 7-8: Module 4 part II: Blood oxygen level dependent fMRI: the signal

a. Nature of the BOLD signal
b. What it is and what it isn't
c. Timing and determinants

Reading: Khanna et al., 2015 (BOLD signal)
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4757157/

Weeks 9-10 Module 4 Part II: Blood oxygen level dependent fMRI: the methods

a. Designs
b. Data Processing: Preprocessing steps
c. Paradigm Development
d. Data Analysis

Weeks 11-12 Module 4 Part III: Promises and pitfalls in Functional Imaging

a. Methodological shortcomings
b. Data interpretation: constraining underdetermined data
c. Considerations in special samples
d. Signal amplitude vs. connectivity
e. Over-stating our data

Reading: NYTimes article and response (available online)

http://www.nytimes.com/2007/11/11/opinion/11freedman.html

Weeks 13-14 Module 5: Connectivity and Network Science

a. Default mode network
b. Resting BOLD signal and methods
c. Connectivity Analysis methods (seed-based, ICA)
d. Graph Theory
e. Clinical applications

Readings: Fox & Raichle (2013)*;* Sporns, O. (2013); Ramot et al., (2017); Bernier et al., (2017)

Week 15: Module 6; Brain volumetrics and Diffusion Tensor imaging

a. Volumetrics and voxel-based morphometry
b. High resolution white matter imaging
c. Other types of white matter imaging: QBAL/ HARDI

Reading: Yamada et al., (2009)

READING LIST

Khanna et al., Functional Neuroimaging: Fundamental Principles and Clinical Applications. *The neuroradiology Journal*
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4757157/ (available online only)

Sporns, O. (2013) Structure and Function of Complex Networks. *Dialogues in Clinical Neuroscience.*
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3811098/pdf/DialoguesClinNeurosci-15-247.pdf

Fox, M.D., Greicius, M. (2013). Clinical applications of resting state functional connectivity. *Frontiers in Systems Neuroscience.*
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2893721/pdf/fnsys-04-00019.pdf

Bernier et al., Dedifferentiation does not account for hyperconnectivity following TBI. Frontiers in Neurology.
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5512341/pdf/fneur-08-00297.pdf

Yamada et al., (2009). MR Tractography: A Review of its clinical applications. Magnetic Resonance in Medical Science.
https://www.jstage.jst.go.jp/article/mrms/8/4/8_4_165/_pdf

Ramot et al.., Direct modulation of aberrant brain network connectivity through real-time NeuroFeedback. *Elife*.
https://elifesciences.org/articles/28974