

COGNITIVE NEUROSCIENCE RESEARCH METHODS

Spring 2017

Mondays & Wednesday, 10:30-11:50am

Baker Hall 332P (CMU Psychology Computer Lab)

Course Code: PSY 85314

Lead Instructor

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Course Description

The broad aim of this course is to teach you how to think like a cognitive neuroscientist. The methods of cognitive neuroscience provide us with the potential to answer some of the most fundamental questions about the nature of brain-behavior relationships. In this course, you will learn how to ask questions from an empirical perspective, build testable hypotheses, and interpret findings from the various methodological techniques used in human cognitive neuroscience research.

The focus of the course will be on human functional neuroimaging, with an emphasis on functional magnetic resonance imaging (fMRI), and electroencephalography (EEG). You will learn the underpinnings of how these techniques work, how they are useful in cognitive neuroscience research, how to design experiments using these methods, and how to process, analyze, and interpret data from these methods.

The course will be roughly split between lectures and hands on laboratory exercises. Classroom lectures will give you a broad overview and conceptual level understanding of issues associated with methods used in cognitive neuroscience research. In the lab portion, you will use the same software and techniques used by cognitive neuroscientists in their research to process and analyze datasets. By the end of the course you should have an understanding of the primary methods of cognitive neuroscience, how these methods are used to answer scientific questions, and hands on experience with analysis software and real data.

Course Website

The full course website can be accessed with your CMU ID via: <http://www.cmu.edu/blackboard>

Recommended Texts

There is no required textbook for the course. Readings will be posted on Blackboard.

Course Objectives

The aim of this course is to provide:

- An overview of the different techniques used in cognitive neuroscience research such as fMRI, EEG, TMS, PET, etc.

- An understanding of the advantages, limitations, and relative utility of different neuroimaging techniques in answering scientific questions.
- An understanding of the ethical issues associated with research.
- A basic understanding of the physical and physiological basis of fMRI, dMRI, and EEG.
- Familiarity with the typical steps of fMRI and EEG pre-processing and basic analysis and the ability to execute these steps in commonly used software packages.
- The fundamentals of experimental designs used in fMRI and EEG and what designs are best suited to different types of hypotheses about the brain.
- An overview of basic statistical analysis of individual and group data.
- The skills to interpret neuroimaging results both in your own experiments and in published research.
- An overview of more advanced data analysis methods such as surface analysis, multivariate pattern analysis (MVPA), and connectivity analysis.
- The understanding to write a methods section for a neuroimaging study, as well how to appropriately present results in writing and figures for a journal publication.
- Sufficient understanding of all of the above to make you a critical consumer of cognitive neuroscience findings.

Evaluation & Grading

Grades will be based on:

- 30% Quizzes
- 40% Data Exercises & Homeworks
- 30% Experiment plan and methods exercise

Quizzes: Short quizzes will be given throughout the semester during class (usually unannounced) to check understanding of concepts and encourage staying on top of the material. Two longer quizzes will also be given around the middle and end of the semester. These longer quizzes will be announced ahead of time. The quizzes will likely be multiple choice or short answer format and conducted online.

Data Exercises & Homeworks: There will be exercises involving data exploration and various stages of data analysis. Most data exercises will be conducted in class, although some time outside of class may be required. Homeworks will be completed entirely outside of class. Due dates for data exercises and homeworks will be announced in class and posted on Blackboard. **Late assignments will be docked 10% for each week they are late. No assignments will be accepted after May 3rd.**

Experiment Plan & Methods Exercise: In the final third of the semester you will apply what you have learned to write an experimental design and analysis plan of a proposed cognitive neuroscience experiment on a topic you are interested in. You will also write up a methods section from your experiment plan as it would be written in a journal manuscript. Details of this exercise will be given later in the semester.

Extra Credit: There will be some opportunities throughout the semester for earning extra credit. Most extra credit assignments will be graded. **Your total extra credit points can increase your grade no more than one grade boundary.** (For example from a A- to an A, or B+ to an A-, *not* from a B to an A.)

Graduate Students: If you are a graduate student and would like to take the course for 12 instead of 9 credits, please see Dr. Pyles. Some additional work targeted at a graduate student level will be required.

Attendance

Attendance is critical. Almost every class there will be a quiz or data exercise. If there are extenuating circumstances that prevent you from attending a class, you must notify Dr. Pyles **before** class by email. In the case of a valid absence, arrangements will be made to make up what you missed.

Software & Computers

Class will be held in a computer lab with Windows PCs. Analysis and exploration of fMRI data in class will primarily be done using BrainVoyager software due to its data visualization capabilities, speed, and relative ease of use. BrainVoyager is commercial software and requires a license. All computers in the lab will have BrainVoyager installed running on a network license. The lab will also be available outside of class (details below). Other software packages such as AFNI, SPM, and FSL will be discussed and demoed, but not used extensively. We will also be using Matlab, MRICron, NeuroElf, and other software. Access to a computer (OSX, Linux, or Win is fine) with Matlab outside of class might be helpful.

***Required:** To save data you are working with during class to resume the following week -- a flash drive with a minimum of 8GB of free space is required (16GB preferred).*

***Computer Lab Access:** The Baker 332P computer lab will be available to you outside of class if you would like to use BrainVoyager or other software. The lab is available 7am-midnight whenever not being used for other classes (a calendar will be distributed). An access code will be provided for access after 5pm.*

Cheating & Plagiarism

Cheating and plagiarism are defined in the CMU Student Handbook, and include (1) submitting work that is not your own for papers, assignments, or exams; (2) copying ideas, words, or graphics from a published or unpublished source without appropriate citation; (3) submitting or using falsified data; and (4) submitting the same work for credit in two courses without prior consent of both instructors. Any student who is found cheating or plagiarizing on any work for this course will receive a failing grade for that work. Further action may be taken, including a report to the dean.

Equal Opportunity Accommodations

All efforts will be made to minimize conflict with students' religious schedules (e.g., holidays, prayer services, etc.) and/or any disabilities. Students should consult with the Equal Opportunity Services (EOS) office at the beginning of the semester in order to setup any necessary accommodations for the class. Please Note: Being firmly rooted in biology, throughout the class we may touch on certain cognitive neuroscience topics that may conflict with certain religious beliefs (i.e., evolutionary biology). Students must be comfortable working with such topics regardless of their religious beliefs on the subject.

Schedule (Tentative!)

The course schedule and topics are subject to change at anytime throughout the course! Changes will be posted to Blackboard and the public schedule website at least 24 hours before class (and usually 3-5 days or even earlier).

Visit to MRI Scanner & EEG Lab: A visit to the CMU SIBR MRI scanner and possibly EEG lab will be arranged outside of normal class time.

Class	Date	Day	Topic
1	1/18/17	W	Cog Neuro Methods History and Overview
2	1/23/17	M	How journal articles are our friends
3	1/25/17	W	Statistics
4	1/30/17	M	MRI Basics and Safety
5	2/1/17	W	IRB/Ethics
6	2/6/17	M	EEG Basics
7	2/8/17	W	Lab: EEG
8	2/13/17	M	Organization of Thought
9	2/15/17	W	Category Selectivity (Paper discussion)
10	2/20/17	M	EEG
11	2/22/17	W	Lab: EEG
12	2/27/17	M	MRI Physics & BOLD
13	3/1/17	W	Lab: Working with MRI Data & Artifacts
14	3/6/17	M	Lab: Pre-processing
15	3/8/17	W	What is fMRI good for? and basic experimental design
	3/13/17	M	SPRING BREAK
	3/15/17	W	SPRING BREAK
16	3/20/17	M	Intro to GLM
17	3/22/17	W	Lab: GLM analysis
18	3/27/17	M	Lab: More analysis and catchup
19	3/29/17	W	Of microtubules and water molecules: Diffusion Weighted Imaging
20	4/3/17	M	Lab: DTI & Tractography 1
21	4/5/17	W	Lab: DTI & Tractography 2
22	4/10/17	M	Advanced fMRI Designs
23	4/12/17	W	Lab: Deconvolution
24	4/17/17	M	Pattern Classification

25	4/19/17	W	Lab: Pattern Classification
26	4/24/17	M	How modeling can help cognitive neuroscience
27	4/26/17	W	Lab: Surface Analysis
28	5/1/17	M	Connectivity Analysis
29	5/3/17	W	Lab: Connectivity Analysis