PSY 1309: Essentials of fMRI for Cognitive Neuroscientists

Fall 2021

I. Course Overview

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Wednesdays 3-5:30pm
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Course Summary

With functional magnetic resonance imaging (fMRI), we can now see into the human brain and map activity across different regions. If you are using fMRI in your research, or think you may want to in the future, this course will cover the critical aspects of neuroimaging with the goal of making you an informed practitioner. In the first part of the course, we will cover content including signal acquisition, experimental protocol design and power, and the general linear modeling framework for data analysis. In the second part of the course, we will survey the recent advances in fMRI data analysis, e.g. multivariate analyses, voxel-wise encoding models, functional connectivity analyses. Depending on your level of experience, you will complete a project that employs one of these techniques, either on your own dataset, or from datasets available online.

This course is intended for both advanced undergraduates and graduate students. Post-docs are also welcome to audit.

Prerequisites

The Psychology Department requires completion of Science of Living Systems 20 or the equivalent of introductory psychology (e.g. Psych AP=5 or IB =7 or Psych S-1) and at least one foundational course from PSY 14, MCB 80, or MCB 81 before enrolling in this course; or permission of instructor."

Schedule

Week 1 Course Overview (note: all asynchronous on this date)
Week 2 Measurement: The Scanner and Brain Data
Week 3 Measurement: MR Physics and Signal
Week 4 Preprocessing and the GLM
Week 5 Experimental Design: Statistical Considerations
Week 6 Experimental Design: Cognitive and Neural Hypotheses
Week 7 Analysis: Overview
Week 8 Analysis: Contrasts, Maps, ROIs
Week 9 Analysis: Multi-voxel pattern analysis
Week 10 Analysis: Representational similarity analysis
Week 11 Analysis: Resting state
Week 12 Analysis: Topic TBD
Week 13 *Thanksgiving*
Week 14 Open Science and Course Review

II. Components of the Class

Pre-Class work

To prep for each class, you'll have two main tasks: the first is to watch a few short videos, and the second is to complete the weekly paper exercise, which basically involves dissecting the methods sections of your paper of choice, one paragraph at a time.

Online Videos.
Instead of assigning chapters from assorted textbooks, I will be assigning short videos available on youtube from this course on Principles of fMRI. You'll be able to find the videos for the week linked in the weekly module pages. These should be watched before the following lecture. Note: Watch these videos only for exposure to the ideas. You do not need to understand them all or take extensive notes (or any notes?) on them! The in-class session will highlight the key ideas, with the videos as a backdrop, with the space and structure to ask questions about the video content. Additional videos will be assigned for graduate students taking the course for credit, which are optional for undergraduates.

Paper exercises.
In the first weeks of class, you'll pick 1 paper that uses fMRI that you find interesting. Each week, we will go through the sections of the methods paragraphs. Before class, you'll do a small exercises to be completed before class that will be used for subsequent in-class activities. For example, one week you'll have to paste into a slide the 1-2 paragraphs from the paper relating to the fMRI acquisition, and highlight all the terms you don't know. In that class, we'll go through fMRI acquisition, and by the end you'll know a lot more about each of those terms.

In-Class Sessions

These consist of an interactive lecture/discussion combination. I will be white-boarding the key content, and we'll use the week's paper-related homework to guide our in-class discussion and activities.

If you have to miss an in-class session…I understand, it happens. You can miss up to 2 in-class sessions without impacting your grade (because I'll drop two of the weekly quizzes). Though, (perhaps goes without saying), I strongly recommend watching the recorded video, and completing the quiz anyway if you have to miss the in-class session.

Post-Class Work

Weekly Quiz
After each class, there will be a very short quiz, covering the content we discussed in the in-class session, and a new brain anatomical structure (To be a card-carrying cognitive neuroscientist, you gotta know your gross neuroanatomy!). These quizzes will have questions like the ones that will be on the final exam. You will receive 100% on this quiz if you attended the class session and turn something in (regardless of whether your answers were right or wrong). However, we will also grade the quizzes as if it were a test, so you can track your "virtual" scores. This way you can check how we'll you're doing absorbing the content, but without it actually affecting your grade. And this will help you study the content along the way, and get used to the way I ask questions on tests.

Projects

There are two main projects that complement the in-class content stream. These are the oral presentation on a topic of your choice, and the brain data analysis presentation describing your experiences in trying out brain-data processing and analysis.

Oral Presentation

The goal of these presentations is for you to do a deeper-dive into a topic that you're interested in, and then to present what you learned to the class in a sort of mini-lecture. The topics can rely more on a literature review or can be more code/implementation heavy (or both). I'll work with each of you individually to find a topic that has the right scope and complexity for your level of experience. Some previous examples include: survey of fMRI experimental designs in moral decision making (or any specific research area); comparison of single-subject-to-group alignment methods; on the the relationship between electrophysiology and the BOLD signal; partial least squares analysis as an alternative to the GLM framework; survey of multiple-correction methods; survey of ROI defining methods; consequences of different normalizing on MVPA results; intra-subject correlation methods; etc. Most specific analysis methods are available to be covered in detail, since we can't possible cover all of them in the lecture component of the course.

Your presentation will be a recorded 10-12 minute slide show. The point of making these presentation videos is to both to learn something you want to learn, AND, to teach your classmates. After presentations are in, they will be watched asynchronously by at least 3 of your peers, and me, to let you know what we learned, how the information was communicated in terms of clarity, and organization, and just generally how easy it was to learn from it.

Hands-on Data Analysis Project

Over the course of the semester, you'll complete a series of tutorials that step you through data analysis (from the earliest stages of just getting brain data on to your computer, to preprocessing, to fitting statistical models, etc). The goal of this project is to have you feel the pains and the joys of analyzing real fMRI data. Datasets are available online, can be provided, or can be your own.

For the final product, you'll present to people what you learned in the process. This will be a very short presentation 1-3 slides, max, about 3 minutes. The point is to spend your time doing the data analysis, not making an extensive presentation! This project is also actually worth a relatively small percent of your grade, to relieve some pressure and make it easier to actually dive in and learn. Though, projects in which clear extensive effort was put in will be noted and can also help mitigate a low final exam score.

Graduate students taking the course for credit will have a more extensive final project scope. I will meet with you individually to figure out what the best option is. Ideally, it supports your research (e.g. trying that analysis out on your data you always wanted to but never made a priority; trying out some of the new automated work flows programs, etc).

Exam

There will be a final test that is cumulative, with 2-4 short answer questions covering the key points from each week. All information from the videos, lectures, in-class activities, and student presentations, is fair game. However, the emphasis is primarily on content that you are most likely to actually need to know and use as a scientist who uses fMRI in their research.

III. Grading and Evaluation

weekly quiz (drop 2)	25%
paper exercises & class participation	25%
oral presentation	15%
oral presentation feedback	5%
hands-on data analysis project	10%
final exam	20%

Here's the current plan. Your **weekly quiz** is like an attendance quiz. If you go to class, you can then take the quiz and get 100% on it (regardless of whether you got the questions right or not). If you do not make it to class, you can still take the quiz but you don't get the attendance points. (Sorry if the quiz part is confusing. We used to do quizzes in class, so if you missed class you missed the quiz, and this policy was a little more self-evident! I'll explain it better in person). This part gets you 25% of your grade.

Class participation really requires you having done your paper exercises, so I'll jointly assess class participation and those paper exercise grades (30%). It's possible this component of the grade will increase in percentage (to your benefit! ;) A significant chunk comes from your **oral presentation** (15%) and giving feedback to others (5%). Then there's the hands-on data analysis project (10%), and the final exam (15%). I'll tell you more about my teaching philosophy and stance on grades in class!