

PSYC 4230 – Introduction to Functional MRI Research (Spring 2025)

MW 10:15-11:45AM, Goddard 207

Course Overview

Functional magnetic resonance imaging (fMRI) is a non-invasive neuroimaging technique that allows one to track brain activity more or less in real time as a subject completes a cognitive task. MRI is a recent technology, and fMRI is an even more recent use of that technology. While it has traditionally been used to establish functional localization (i.e., mapping what brain regions are involved in what tasks), fMRI can also be used to answer important questions such as how the brain goes about solving these tasks (i.e., what are the computations the brain performs). fMRI has been used widely in the field of cognitive neuroscience, but it has also been applied in fields such as economics, marketing, sociology, and information systems to name a few.

In this course, we will first cover the basics of MR physics to establish how fMRI works. We will then discuss considerations for fMRI experimental design. If time and resources permit, we will collect some fMRI data as a class. We will spend the bulk of the course working on fMRI data analysis. Note that in order to run your own scans at the Penn MindCORE Neuroimaging Facility, you will need to complete the safety training (which we'll do in this course) as well as hands-on scanner training (which we will not have time to cover in this course). Most people will not need to do this latter step as they will not be running scans on their own.

Learning Goals

- ***Understand the Basics of fMRI:*** Students will be able to describe the fundamental principles of functional Magnetic Resonance Imaging (fMRI), including how fMRI measures brain activity through blood-oxygen-level-dependent (BOLD) signals.
- ***Apply Knowledge of Brain Anatomy and Physiology:*** Students will be able to identify key brain structures and explain how fMRI data are used in functional localization.
- ***Analyze and Interpret fMRI Data:*** Students will gain basic skills in preprocessing and analyzing fMRI data, including understanding common preprocessing steps, statistical approaches, and software tools used in fMRI analysis. Students will also interpret results in a scientifically sound manner.
- ***Evaluate the Strengths and Limitations of fMRI:*** Students will critically assess the advantages, limitations, and ethical considerations associated with using fMRI in cognitive and clinical research settings.
- ***Communicate Scientific Findings in Writing:*** Students will develop proficiency in scientific writing by clearly presenting their fMRI analysis findings, interpreting results, and discussing implications in a format suitable for scientific reports or publications.

Schedule

(Note: subject to change. Updates to the schedule will be posted to Canvas)

Week	Date	Topic	Reading	Due
1	1/15	Intro to fMRI; MRI Safety	Optional: ABB Unix Tutorial	
2	1/20	MLK Day (No Class)	NA	
	1/22	MR Physics	MR Physics Video Radue et al. (2016)	Level-1 Safety Training

	1/24			Assessment 1
3	1/27	Hemodynamic Response & BOLD	Huettel Chapter 6 ABB: Download AFNI ABB: Download the Data	Install AFNI on your computer
	1/29	Neuroanatomy Basics	Neuroanatomy Review Optional: BIDS Specification	
	1/31			Assessment 2
4	2/3	Experimental Design	Ashby Chapter 4	
	2/5		ABB: Flanker Task	
	2/7			Assessment 3
5	2/10	Visualizing Data & SNR	Duyn (2012)	
	2/12		ABB: Looking at the Data	
	2/14			Assessment 4
6	2/17	Preprocessing	Hazeltine et al. (2000) ABB: Preprocessing ch1-7	SNR output
	2/19			
	2/21			Assessment 5
7	2/24	Time Series	Botvinik-Nezer et al. (2020)	
	2/26		Reynolds et al. (2023) ABB: Time Series	
	2/28			Assessment 6
8	3/3	Group Analyses in AFNI	Eklund et al. (2016); Brown, E. N., & Behrmann, M. (2017); Cox et al. (2017)	APQC Output (sub-01)
	3/5		ABB: Group Analysis in AFNI	
	3/7			Assessment 7 *Group analysis: Flanker task t-test
9	3/10	Spring Break (No Class)	NA	NA
	3/12	Spring Break (No Class)	NA	NA
10	3/17	Atlases and Alignment	ABB: Registration and Normalization	
	3/19	Writing an fMRI Paper	Poldrack et al. (2008)	
	3/21			Assessment 8
11	3/24	Data Collection	NA	Flanker task methods and results
	3/26			
	3/28			Assessment 9
12	3/31	Introduction to Checkerboard Analysis	Kastner et al. (2004)	
	4/2			
	4/4			Assessment 10

13	4/7	How to Read/Review an fMRI Paper	Astur 2008	Research Proposal Topic
	4/9			
	4/11			Assessment 11
14	4/14	Reproducibility and Data Sharing	ABB: BIDS overview	NA
	4/16			
	4/18			Assessment 12
15	4/21	Resting State fMRI	ABB: Functional Connectivity	Research Proposal Outline
	4/23			
	4/25			Assessment 13
16	4/28	Advanced Statistical Approaches	[TBD]	Flickering Checkerboard Paper
	4/30	MVPA & RSA	[TBD]	*Assessment 14
	5/13			Research Proposal Final

NB: ABB = Andy's Brain Book, our free textbook: <https://andysbrainbook.readthedocs.io/en/latest/>

Other readings will be provided as PDF documents.

Class Time and Location

The class's scheduled meeting time is Monday and Wednesday at 10:15-11:45AM in Goddard 207.

Instructor

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<https://tinyurl.com/mindcoremri>

Office hours by appointment: drkirwan.youcanbook.me.

Course Canvas

The course Canvas site is: <https://canvas.upenn.edu/courses/1829513>

Course Assignments

Weekly Assessments Each week you will complete an assessment for that week's material. The assessments in the beginning of the class will be heavily focused on theoretical concepts (i.e., readings and lecture materials) but will shift to more practical, hands-on material later in the course. (variable points/wk for a total of 175 pts)

Attendance It is to your advantage to attend every class meeting. We will be working through examples in class. Come prepared (i.e., having done the reading) and participate for these points.

Note that you may miss up to three classes without it affecting your attendance points. If you need to miss more than 3 classes (e.g., for grad school interviews, to attend a conference/wedding/Spring Training Opening Day), please talk to me well in advance. (5 pts/class for max 125 pts).

Data Analysis and Results We will perform two complete data analyses in this class. In the first, we'll download freely available data from openneuro.org and work through the analysis steps as outlined in Andy's Brain Book. In the second, we'll generate our own data and repeat the process. I'll be offering a lot of support along the way for the first analysis while the second will be an opportunity for you to exercise what you have learned. There will be a series of preliminary assignments along the way to make sure the process is going OK. The final product for both analyses will be a write-up of the methods and results in the style of a scientific manuscript. (Series of assignments worth 350 pts total)

Final Research Proposal The final project for the class will be to write a formal research proposal for your first fMRI experiment. This will be something that you should be able to turn around and include in a grant or IRB application. The project will be due the last day of the final exam period. Your proposal will be graded on the introduction/motivation for the project, the details of the proposed method and analysis, and writing style. (Series of assignments worth 350 pts total)

Late Work Policy

Due dates/times for all assignments are listed on Canvas. Late assignments will be graded for reduced points according to the table below. As you can see, assignments turned in a couple of hours late will be graded for nearly full points. After a day or so, though, the max points possible drops off dramatically. Assignments more than 3 days late will be graded for half points. If there are extenuating circumstances, please let us know and we will consider exceptions to this policy.

Hrs Late	Max Score	Hrs Late	Max Score	Hrs Late	Max Score	Hrs Late	Max Score
1	0.99	20	0.92	39	0.71	58	0.55
2	0.98	21	0.91	40	0.7	59	0.55
3	0.98	22	0.9	41	0.69	60	0.54
4	0.98	23	0.89	42	0.68	61	0.54
5	0.98	24	0.88	43	0.67	62	0.53
6	0.98	25	0.88	44	0.66	63	0.53
7	0.97	26	0.87	45	0.64	64	0.53
8	0.97	27	0.86	46	0.63	65	0.53
9	0.97	28	0.85	47	0.62	66	0.52
10	0.97	29	0.83	48	0.62	67	0.52
11	0.96	30	0.82	49	0.61	68	0.52
12	0.96	31	0.81	50	0.6	69	0.52
13	0.95	32	0.8	51	0.59	70	0.52
14	0.95	33	0.79	52	0.58	71	0.51
15	0.95	34	0.77	53	0.58	72	0.51
16	0.94	35	0.76	54	0.57	>72	0.5
17	0.93	36	0.75	55	0.57		
18	0.93	37	0.74	56	0.56		
19	0.92	38	0.73	57	0.55		

Electronics Use Policy

Much of the work in the class will be computer based. If you have a laptop, you'll need to install the free AFNI software package (instructions provided in class). If you don't have a laptop, please let me know as soon as you can.

No cell phones.

Readings

All texts will be made available via links/downloads on the course Canvas site. *There are no required books to purchase for the course.* Our main text will be “[Andy's Brain Book](#)” (ABB), a free online textbook with loads of examples and walk-throughs of how to analyze fMRI data using different common software packages and analytical approaches. This book is very focused on the practical aspects of fMRI analysis, however. If you would like to supplement with more theoretical and technical readings, I recommend “Functional Magnetic Resonance Imaging (3rd Edition)” by Huettel et al. ([Penn bookstore link](#)). In addition to ABB, I will also post occasional research articles or additional readings to the course Canvas site. I recommend you complete the reading assigned for a class before the class session so that you can ask questions about the reading in class.

Lecture Slides

Lecture slides will be posted to Canvas in advance of the corresponding class meeting.

Religious Observances

I am happy to accommodate your needs in observing religious holidays. *Please contact me within the first two weeks of class if you are going to need religious accommodation.*

In accordance with university policy, no major assignments will be due on Christmas, Rosh Hashanah, Yom Kippur, the first two days of Passover, and Good Friday. If you observe another holiday and would like similar accommodations, please contact me. I will be happy to make suitable arrangements with you.

For more information about university policies about religious observances, see: <http://provost.upenn.edu/policies/faculty-handbook/students/iv-h>.

Accessibility Policy

I welcome all Penn students and am happy to do what I can to make your learning experience comfortable and effective. If you have a disability or needs you think I should know about, please do not hesitate to let me know. I will keep all information strictly confidential. Please also contact the Weingarten Center if you have a disability and want to learn more about accommodations:

Student Disabilities Services

Weingarten Learning Resources Center

Stouffer Commons 3702 Spruce Street, Suite 300

215.573.9235

<http://www.vpul.upenn.edu/lrc/sds/>

Plagiarism and Generative AI Policy

You will be awarded points for your own work only. It's fine to use AI for idea generation or to refine/revise your writing, but the ideas and words in your work must be your own. The same applies for the words of others—don't use the words of others and try to claim them as your own. It is fine to work with classmates on analysis projects (e.g., sharing code/tips/tricks), but all papers and other assessments must be completed on your own.

Grading Policy

Your grade will be calculated on the number of points you earn from assessments, papers, and other assignments divided by the total number of points possible. A general rule of thumb for undergraduate college courses is "2-3 hours of study out of class for every hour in class". A 'C' is an acceptable grade and a 'B' a good grade, while an 'A' represents an outstanding level of accomplishment even in comparison with peers who are often excellent students. I will award grades of C-, D, UW, or E only after individual consideration concerning whether the student's performance in the course merits such a grade.

As a general rule: an adequate answer will receive an adequate grade. What this means is that if you merely answer the question on an essay exam, you may not receive full points. Full points are reserved for exceptional answers where you demonstrate that you have a full understanding of the concept being tested.

Writing good assessment questions is one of the hardest parts of my job. Inevitably a bad or poorly worded question slips through. I will entertain written challenges to assessment questions up to one week following the return of the assessment to you. Include the question you're challenging, the answer I marked as correct, the answer you gave, and your reasoning for choosing that question. Include relevant passages from the textbook or lecture notes to support your reasoning.

At the end of the semester, there will inevitably be one or two students who are within a percentage point or two of a grade cutoff. You may be tempted to ask if I can "bump you up" those couple of points to the next grade. The answer will be no. Dropping the cutoff by a couple of points for you will mean that now another person will be within a couple of points of the new cutoff. If I lowered the cutoff for you why not lower it for the next student as well, and so on.

Grade Scale

Grade	Minimum %	Grade	Minimum%
A	93%	C	73%
A-	90%	C-	70%
B+	87%	D+	67%
B	83%	D	63%
B-	80%	E	0%
C+	77%		