PSY 516, *Introduction to Neural Data Analyses*: *Analyzing Neural Time-series Data*
Spring, 2026, Mondays, 1^{00}-3^{45} P.M.
Room 323 Psychology

INSTRUCTOR

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COURSE DESCRIPTION AND OBJECTIVES

The goal of this course is to provide you with a conceptual, mathematical, and pragmatic understanding of time-, time-frequency-, and synchronization-based analyses of neural time series data, especially electroencephalographic (EEG) signals. Stated differently, the course has three main objectives:

a) To provide students with the tools to process and analyze EEG data using standard (e.g., ERP, topography) methods in Matlab.
b) To provide students with the tools to process and analyze EEG data using advanced (e.g., frequency and time-frequency decomposition, directional coupling) methodologies in Matlab.
c) To prepare students to analyze an EEG study independently, including generating plots and computing statistics.

These principles and programming approaches will be relevant not only for surface-recorded EEG signals, but for other neural time-series data such as magnetoencephalographic (MEG) signals and local field potentials (LFP). The focus of the course is on the pragmatic implementation of signal processing approaches, and will be run in a collaborative workshop format. This format will be a flipped class[1] where we will read and watch lectures outside of class; our time in class will be devoted to short presentations and working through programming exercises using Matlab to be sure we all understand how to process neural timeseries data.

Our roadmap for the course will be the wonderfully detailed yet highly accessible and sometimes entertaining book by Mike X Cohen (2014): *Analyzing neural time series data: Theory and practice*, Cambridge, MA: MIT Press. This book is available for purchase from online vendors of your choice, as well as for free from the University of Arizona library as an electronic resource. We will work through chapters of the book, including chapter exercises that include Matlab code provided by Mike Cohen.

EXPECTED LEARNING OUTCOMES

By the end of the course, you should:

a) Have gained an understanding of how and why specific analyses are performed.
b) Be able to interpret results conducted with these approaches.
c) Demonstrate that you understand the methodological and practical issues involved with these analyses.
d) Be able to perform single-subject and group-level statistical analyses of neural time-series data.

COURSE WEBPAGE

Please visit the course webpage (psychophyslab.arizona.edu, courses) for links to:

- Purchase the text or access the electronic version via the library
- Obtain a copy of the syllabus and the current up-to-date schedule of topics and assignments
- Download Matlab code and data that accompany the book
- Access video lectures that accompany some topics in the book
- Access coding assignments and other class resources.

Any changes to the course content or schedule will be reflected on the course webpage.

[1] The flipped classroom is a pedagogical model in which the typical lecture and homework elements of a course are reversed. Short video lectures are viewed by students at home before the class session, while in-class time is devoted to exercises, projects, or discussions.

Course Structure

The course will follow a workshop format. Each class session may involve some lecture/demonstration and will involve active practice with coding in Matlab. For a 3-credit course, we should have 150 minutes of class each week; our class is scheduled for 165 minutes, so this allows for one or two short breaks totaling 15 minutes.

You should read the assigned readings and view any assigned lectures before class. You should bring your laptop with you to each class and be prepared to work on the problem sets that I will provide in class. We will work collaboratively, and have an opportunity to project our screens to the big screen as we discuss strategies for solving the problems.

Readings

All readings will be from the sole book (and roadmap) for the course:

Cohen, MX. (2014): *Analyzing neural time series data: Theory and practice*, Cambridge, MA: MIT Press.

Other Materials You Will Need

You will need to install Matlab on your computer if you have not done this already. Please follow the link to "Download and Install Matlab" on the course webpage. When given an option for what to install, you can omit any of the "Simulink" packages that are part of Matlab/Simulink. Only install Matlab and its toolboxes. Once complete, launch Matlab and be sure it does not give you any license errors. If you are having trouble, let me know.

Evaluation

- ***In-class problem sets and class participation (60%):*** I intend for everyone to be able to achieve all these points by showing up having read the chapters, having viewed the videos, and being ready to code and collaborate. Because attendance is required for participating and coding, it is important that you attend class. Knowing that quotidian exigencies, unanticipated entanglements, and unforeseen clandestine government missions are a part of life, you can miss one class with no penalty whatsoever. You may also attend a class virtually (via Zoom) if you cannot be in town, or if illness would dictate you stay home, and this can still count for attending with prior permission of the instructor. If you need to miss more than one class, then for any absence after that excused absence you will need to produce incontrovertible evidence before the next class period that you have completed the homework for the missed class period. You will submit your Matlab script file by the end of each class day to D2L as proof of the work completed.

- ***Function project (40%)***: By the end of the class, you should be able to write a well-documented function in Matlab that does something useful with EEG data. The function could graph waveforms in a new way. The function could calculate a summary value given an input. The function could transform the data in some way. The function could calculate statistics for a group of input datasets. The function should work and be something you can demonstrate to the class. You will demonstrate your function during a 20-minute demonstration in one of the final two class periods. In that 20-minute presentation, you should explain why your function is needed (what makes it useful), demonstrate its use, and show highlights of your code. You should upload your completed function (m file) and any necessary data (mat file) in D2L by 11 AM of the day you will be presenting your function. Your grade on this function will be determined by: 1) the instructor's evaluation of the code's accuracy and readability (50%); 2) Class ratings of your presentation and function by class members using a grading rubric (50%) that will be distributed at least 4 weeks before the function presentations begin.

Grading Scale

Based on the highest points obtained by any class member (total of all in-class problem sets and the function), obtaining at least 90% of this score will result in an A, 80-89.9% will result in a B, and less than 80% will result in a C.

Incompletes

Short of major medical illness or global catastrophe, there is virtually no reason I will award an incomplete grade for this course. Incompletes merely move a crisis from one time to another. But if you encounter unresolvable challenges, please talk to me as soon as you can so we can review options before running up against immovable deadlines.

D2L

I don't much like D2L I'm not kidding. It aggravates me. But we will used D2L for a few purposes: 1) it will host a copy of the syllabus, and a link to the course webpage; 2) the D2L calendar will remind you when class meets, and when office hours are held; 3) You will submit your daily class work and your functions there. That's all. And that's sufficient to meet the University mandate to use D2L. All class resources will be on the the course webpage.

ABSENCES

See above under "Evaluation."

CHANGES IN COURSE CONTENT, SCHEDULE, REQUIREMENTS

The information contained in this syllabus, other than the grade and absence policies, may be subject to change with reasonable advance notice, as deemed appropriate by the instructor.

MIKE COHEN'S TRINITY OF EEG DATA ANALYSIS EQUATIONS

If Mike were teaching this class, you'd need to learn these three equations by heart and recite them on command when asked to do so at any time. These three equations form the mathematical bases of most advanced EEG data analyses. Although I won't ask you to be able to recite these equations at any time of day, in any mood, and in any state of consciousness (as Mike would), consider it a grand idea if you memorize them. It is a well-known fact that knowing these equations increases your market value, professionally, financially, and socially. It's true.

Sine wave: $A \sin(2\pi ft + \theta)$

"Aey sine two pie eff tee plus theta"

Euler's formula: $Me^{ik} = M(\cos(k) + i\sin(k))$

"Em ee to the eye kay equals em cosine kay plus eye sine kay"

Gaussian: $e^{-t^2/2s^2}$

"ee to the minus tee squared over two ess squared"

University Policies and Other Information

Diversity and Inclusion

Diversity unites and moves us forward. The diverse backgrounds, experiences and perspectives that each student brings to this class will be viewed as a resource, strength, and benefit. In this class, we have a unique and important opportunity to learn from the information and ideas shared by each other, and we also a responsibility to do so with sensitivity and respect. Ideally, science would be objective. However, as you will learn, much of science is subjective and is historically build on a small subset of privileged voices. It is important to make note of this and to think about how significant research findings may be biased by their nature of being carried out on a typically small, non-representative sample of participants. Moreover, powerful bodies such as the American Psychiatric Association and American Psychological Association may utilize frameworks that have not always accounted for the experiences of people from historically disenfranchised groups and, as a result, systemic biases within these organizations may have unintentionally perpetuated inequities in access, representation, and treatment.

I would like to create a learning environment for my students that honors diverse identities (including race, ethnicity, gender, age, class, sexuality, gender identity, nationality, religion, ability, etc.) and supports a diversity of experiences, thoughts, and perspectives. To learn more about the Psychology department's commitment to diversity and inclusion, please visit https://psychology.arizona.edu/psychology-for-all.

Preferred Name and Gender Pronouns

This course affirms people of all gender expressions and gender identities. If you would prefer that a different name from your legal one or the one that appears on the class roster be used, the university has established guidelines that allow students and employees to indicate their chosen or preferred first names. Please see the following link for more information: https://registrar.arizona.edu/sites/default/files/preferred-chosen_name_guidelines_v2_0.pdf. I want to be sure that I refer to you in your preferred way. If you prefer a name other than the one on the class roster, please let me know. I will try my best to remember your preferred names and pronouns, but please also feel free to give me a reminder. Also, students are able to update and edit their pronouns in UAccess. To change your listed pronoun on UAccess, navigate to the Student Self Service page, go to the personal information section"

Accessibility and Accommodations

At the University of Arizona, we strive to make learning experiences as accessible as possible. If you anticipate or experience barriers based on disability or pregnancy, please contact the Disability Resource Center (520-621-3268, https://drc.arizona.edu) to establish reasonable accommodations.

Other University Classroom Policies that Apply to this Class

Please familiarize yourself with additional University Policies available here: https://catalog.arizona.edu/syllabus-policies . These include:

- Non-Discrimination and Anti-Harassment Policy
- Threatening Behavior Policy
- Code of Academic Integrity
- Safety on Campus and in the Classroom

Graduate Student Resources

For resources, please visit the University of Arizona's Basic Needs Resources page: https://basicneeds.arizona.edu

Tentative Schedule of Topics & Readings

Date	Topics	Chapters	Videos
26-Jan	Lecture Overview topics and chapters; Introduction to Matlab		
2-Feb	Matlab Tutorial	1,2,3,4,5	
9-Feb	Practicalities of EEG measurement and experimental design Preprocessing steps necessary and useful for advanced data analysis EEG artifacts: their detection, influence, and removal Overview of time-domain EEG analyses	6 7 8 9	See Website
16-Feb	The dot product and convolution The discrete time Fourier transform, the FFT, and the convolution theorem Morlet wavelets and wavelet convolution	10 11 12	See Website
23-Feb	Complex wavelets and extracting power and phase Band-pass filtering and the Hilbert transform Short-time FFT	13 14 15	See Website
2-Mar	Multi-taper Less commonly used time-frequency decomposition methods Time-frequency power, and baseline corrections	16 17 18	See Website
9-Mar	**Spring Break!!!!!!!!!!**		
16-Mar	Inter-trial phase clustering Total, phase-locked, and non-phase locked power, and phase clustering Interpretations and limitations of time-frequency power and phase analyses Surface Laplacian	19 20 21 22	See Website
23-Mar	Principal components analysis Basics of single dipole and distributed source imaging Introduction to the various connectivity analyses Phase-based connectivity	23 24 25 26	See Website
30-Mar	Power-based connectivity Granger prediction Mutual information	27 28 29	See Website
6-Apr	Cross-frequency coupling Graph theory Advantages and limitations of different statistical procedures	30 31 32	See Website
13-Apr	No formal class: hack-a-thon day to work on your functions		
20-Apr	Non-parametric permutation testing Within-subject statistical analyses Group-level analyses and appropriate data analysis strategies	33 34 35	See Website
27-Apr	Recommendations for reporting results in figures, tables, and text Recurring themes in this book, and some personal advice The future of cognitive electrophysiology Class presentation of personally-written functions (First Group from class)	36 37 38 None	See Website
4-May	Class presentation of personally-written functions (Second Group from class)	None	

Other resources you might find of interest:

Cohen, M.X. (2017). *MATLAB for Brain and Cognitive Scientists*. Cambridge: The MIT Press.
Cohen, M.X. (2021). *Linear Algebra: Theory, Intuition, Code*. Sincxpress.
Steve Smith's online (free): *The Scientist and Engineer's Guide to Digital Signal Processing*
Mike X Cohen's YouTube channel: https://www.youtube.com/@mikexcohen1