PSY 596L, *Analyzing Neural Time-series Data*
Spring, 2022, Mondays, 2ᵒᵒ-4⁴⁵ 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 on the Amazon.com website, as well as 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 (jallen.faculty.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.

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[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 homework I'll provide the day of class. We will work collaboratively, and take turns projecting 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. You should go to softwarelicense.arizona.edu and under types of licenses click on your designation (student for almost all of you) and find Matlab. If 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. This takes quite a while. 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 homework 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 COVID protocols 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 live script file at the end of each class section 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 15-minute demonstration in one of the final two class periods. In that 15-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 noon 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 homework 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 challenges related to

COVID or similar issues, 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 functions: 1) it will host a copy of the syllabus, and a link to the class webpage; 2) the D2L calendar will remind you when class meets, and provide a link to office hours via Zoom; 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 class 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. I

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

UNIVERSITY OF ARIZONA LAND ACKNOWLEDGEMENT

The University of Arizona resides on ancestral lands of the Tohono O'odham and Pascua Yaqui nations, where many today continuously reside in their ancestral land. I acknowledge the privilege it is to teach and learn in this region and I express my gratitude to these nations. For more information about native lands on which UA sits, see https://nasa.arizona.edu.

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.

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

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: http://lgbtq.arizona.edu/use-chosen-or-preferred-names. 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 our 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, and click on "Names."

STUDENTS WITH SPECIAL NEEDS

If you anticipate barriers related to the format or requirements of this course, please meet with me so that we can discuss ways to ensure your full participation in the course. If you determine that disability-related accommodations are necessary, please register with Disability Resources (621-3268; drc.arizona.edu) and notify me of your eligibility for reasonable accommodations. We can then plan how best to coordinate your accommodations.

ACADEMIC INTEGRITY

Students are expected to adhere to the UA Code of Academic Integrity as described in the UA the Academic Integrity policy: https://deanofstudents.arizona.edu/policies-and-codes/code-academic-integrity . Cheating or plagiarism on the exam or the paper will result in a failing grade for the course, a notice will be sent to the Dean's office, and expulsion from the University of Arizona can result. Plagiarism is defined as any case where one person tries to take credit for the ideas or work of another, including fellow students, or published authors.

OTHER UNIVERSITY CLASSROOM POLICIES THAT APPLY TO THIS CLASS

Please familiarize yourself with these additional University Policies:

- Non-Discrimination and Anti-Harassment Policy. The University of Arizona is committed to creating and maintaining an environment free of discrimination: http://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy
- Threatening Behavior by Students. The University seeks to promote a safe environment where students and employees may participate in the educational process without compromising their health, safety, or welfare: http://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students

CLASSROOM BEHAVIOR POLICY AND THE USE OF ELECTRONIC GIZMOS SPECIFICALLY

It is my intent, and I ask you to join me, in creating a positive learning environment that is free from distractions. Computers will be used as a central tool in this class, but as we all know, they can be a potent distraction. Please do not use them for purposes other than class-related coding and seeking code assistance; i.e., don't use them during class for social media, e-chatting/texting, shopping, catching up on email, organizing a flash mob, plotting mass insurrection (as a nonexhaustive list) or you will be asked to leave the classroom. Please turn your phones to silent mode and do not use them during class or you will be asked to leave the classroom.

COVID-19-RELATED INFORMATION

Where posted, face coverings that cover the nose, mouth, and chin are required to be worn at the University of Arizona (e.g., in classrooms, laboratories and studios with posted signage). Any student who violates such a directive will be asked to immediately leave the learning space and will be allowed to return only when they are wearing a face covering. Subsequent episodes of noncompliance will result in a Student Code of Conduct complaint being filed with the Dean of Students Office, which may result in sanctions being applied. The student will not be able to return to the learning space until the matter is resolved.

Please also consider the following University guidelines:

o   If you feel sick, or may have been in contact with someone who is infectious, stay home. Except for seeking medical care, avoid contact with others and do not travel.

o   Notify your instructor(s) if you will be missing a course meeting or an assignment deadline.

o   Non-attendance for any reason does **not** guarantee an automatic extension of due date or rescheduling of examinations/assessments.

> o   Please communicate and coordinate any request directly with your instructor.

o   If you must miss the equivalent of more than one week of class, you should contact the Dean of Students Office DOS-deanofstudents@email.arizona.edu to share documentation about the challenges you are facing.

o   Voluntary, free, and convenient COVID-19 testing is available for students on Main Campus. .

o   COVID-19 vaccine is available for all students at Campus Health.

o   Visit the UArizona COVID-19 page for regular updates.

Tentative Schedule of Topics & Readings

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

Other recommended sources for the seriously inclined:

Lyons, R. G. (2012). *Understanding Digital Signal Processing* (3rd Ed.). Boston, MA: Prentice Hall.

Rosenbaum, D.A., Vaughan, J., & Wyble, B. (2014). *Matlab for Behavioral Scientists* (2nd Ed.). New York: Routledge.

Ingle, V.K., & Proakis, J.G. (2017). *Digital Signal Processing Using MATLAB* (3rd Ed.). Stamford, CT: Cengage Learning

Steve Smith's online (free) Digital Signal Processing Book: http://www.dspguide.com/

Mike X Cohen's complete set of Lecturelets: http://mikexcohen.com/lectures.html