BEP-330/674 Computational Methods in Cognitive/Educational Neuroscience

College of Education, The University of Alabama

Instructor: Firat Soylu (fsoylu@ua.edu)
Room: Graves Hall 313
Meeting Time: Thursdays, 12:00 PM – 2:50 PM
Office hours: Email to make an appointment
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Course Description

Cognitive and educational neuroscience research methods (e.g., EEG/ERP, fMRI) heavily rely on use of computational tools. Students who are interested in conducting neuroimaging research often have difficulty with deciding which tools to use, manage the technical difficulties involved with creating an analysis pipeline, and debug & document the analysis process. The purpose of this course is to introduce signal processing methods and computational tools, skills, and heuristics that are essential for conducting cognitive and educational neuroscience research.

Course Objectives

The students will learn about:
- foundational concepts and skills in coding & scripting
- signal processing methods used in neuroscience research
- different open source and free tools and software for neuroimaging research
- preparing and formatting data for analysis
- developing batch files and writing scripts to automatize analysis steps
- running analysis both in personal computers and in high-performance computing (HPC) environments

Prerequisites

Some previous experience with and/or coursework on neuroimaging (e.g., fMRI) or electrophysiological (e.g., EEG) research is required for this course.

Software & Textbook

- **MATLAB**: You will need to have MATLAB on your laptop to be able to do the in-class activities and assignments. UA has a MATLAB site license, meaning that all students and faculty members have free access to MATLAB and all its toolboxes. Visit https://oit.ua.edu/software/matlab/ for more info & to download MATLAB.
- **MBCS**: We will read chapters and do exercises from "Cohen, M. X. (2017). **MATLAB for Brain and Cognitive Scientists**. MIT Press." This book is available as a hardcopy from the UA Library.
- All additional reading materials are linked on this syllabus (under the schedule section).

Summary of Course Activities

This course will have two main components:

1) **Scripting in MATLAB & foundational knowledge of signal processing methods used in neuroscience research.** We will cover select chapters from the textbook the first nine weeks. The chapters include coding exercises as well. Students are expected to read the assigned chapters and complete the coding exercises before the class. After this, they will post at least two questions on the Padlet site, before the class. We will discuss answers for the questions posted ine ach class.

2) **Learning about heuristics, best practices, and free and open software for data management and analysis.** Students will learn about available sources for conducting research, will acquire practical skills in analyzing data, documentation, & building a pipeline, and discuss current approaches to neuroscience research (e.g., open science, replicability, data sharing).

Class Structure

Each class starts with on overview of the content presented in the readings by the instructor, followed by a discussion of the questions posted by the students prior to the class. In the second half of the class we will conduct hands-on exercises and activities that target understanding practical applications of computational tools used in research.

Weekly Tasks

- **Readings.** Students are expected to cover all assigned weekly readings and complete all scripting exercises attached to the readings.
- **Discussion questions.** Students are expected to post at least two discussion questions on the Jamboard discussion board site for the week. We will discuss these questions during the class. Each week's discussion board is linked in the schedule below.
- Both the reflections and the discussion questions are due 8:00 AM on the day of the class (Monday).

Weekly Class Activities

Over the semester we will conduct practical, hands-on activities with:
- Matlab scripting for data analysis and visuzalization
- Linux/Mac OS X Terminal Commands & Bash scripts
- Data exploration (PivotTables & Graphs)
- EEG & ERP data analysis (EEGLAB/ERPLAB)
- Structural & functional MRI analysis (SPM 12)

Quizzes

- There will be three quizzes to evaluate students' understanding of the content presented in class. The quizzes will target both theoretical concepts as well as scripting skills.

Course Project

The project is an opportunity to focus on an area that is of interest to you. For the project you will develop instructional materials or documentation (e.g., job aid, instructional video, manual) on a specific topic related to the course contents. Students will meet with the course instructor to discuss their project ideas.

Schedule & Weekly Themes

1. Introduction (Jan 24)
- MBCS Chapters 1-3 (pgs. 1-30)

2. **MATLAB Environment & Variables (Jan 31)**

   - MBCS Chapters 4-5 (pgs. 31-62)

3. **Functions & Control Statements (Feb 7)**

   - MBCS Chapters 6-7 (pgs. 67-99)

4. **Input-Output & Plotting (Feb 14)**

   - MBCS Chapters 8-9 (pgs. 103-141)
   - Quiz I

5. **Matrix Algebra (Feb 21)**

   - MBCS Chapter 10 (pgs. 147-164)

6. **Fourier Transform (Feb 28)**

   - MBCS Chapter 11 (pgs. 167-188)

7. **Convolution & Review (Mar 6)**

   - MBCS Chapter 12 (pgs. 193-201)
   - We will review content from MBCS Chapters 4-15

   ————March 11 - 18 Spring Break————

8. **Nonparametric Statistics (Mar 21)**

   - MBCS Chapter 15 (pgs. 233-246)
   - Quiz II

9. **Covariance and Correlation (Mar 28ee)**

   - MBCS Chapter 16 (pgs. 249-263)

10. **Frequency Analyses (April 4)**
    - MBCS Chapter 18 (pgs. 287-306)

11. **Time-Frequency Analysis (April 11)**

    - MBCS Chapter 19 (pgs. 311-331)

12. **Magnetic Resonance Images (April 18)**

    - MBCS Chapter 25 (pgs. 407-415)

13. **Review of Content (Apr 25)**

    - We will review the entire course content
    - Quiz III

Grading

Weekly readings, questions & class participation (3 pt)	13x3 = 39 pts
Quizes (x3)	10x3 = 30 pts
Final Project proposal	6 pts
Final project	25 pts
Total	100 pts

Grading scale: A: 90 - 100, B: 80 - 89, C: $70 - 79$, D: $60 - 69$, F: 0 - 59

Resources

Websites

Octave Online

Neuroimaging Software

- EEGLAB, ERPLAB, SPM12, FSL, AFNI

Statistics Software

- JASP, JAMOVI, R, Rstudio

Image & Media Editing

- Adobe Suite (free to UA members), GIMP

Books

Linear Algebra   Interactive Linear Algebra by Dan Margalit, Joseph Rabinoff (online interactive book)

Neuroscience Methods
- Luck, S. J. (2014). An introduction to the event-related potential technique. MIT press.
- Poldrack, R. A., Mumford, J. A., & Nichols, T. E. (2011). Handbook of functional MRI data analysis. Cambridge University Press
- Cohen, M. X. (2014). Analyzing neural time series data: theory and practice. MIT press.

Data Analysis & Coding
- Cohen, M. X. (2017). MATLAB for brain and cognitive scientists. MIT Press.

Open Data

- NIMH Data Archive (https://nda.nih.gov/)
- Open fMRI (deprecated; https://openfmri.org/)
- OpenNeuro (https://openneuro.org/)
- Harvard Dataverse (https://dataverse.harvard.edu/
- OSF (https://osf.io/)
- Human Connectome Project (https://humanconnectome.org/)
- ABCD Study (abcdstudy.org/; https://nda.nih.gov/abcd)
- Brain Imaging Data Structure (https://bids.neuroimaging.io/)
- ABIDE (Autism Brain Imaging Data Exchange; https://fcon_1000.projects.nitrc.org/indi/abide/)
- Max Planxk Institut Leipzig Mind-Brain-Body LEMON dataset (Link)

Policy Statements

Policy on Missed Exams and Coursework

It is important that students turn in all assignments on time. Except in the case of documented severe illness, funeral of a family member, or a personal, catastrophic or religious event (as defined by the University policies), assignments submitted late, within two days of the deadline, will receive a 50 % grade reduction. Late assignments, after three days of the deadline, will not be accepted.

Attendance Policy

Class attendance is necessary and required. It is expected that you undertake appropriate prior preparation for each class period and actively participate during class. Attendance will be taken. You will lose 3 pts from your final score for each unexcused absence. In the case of an excused absence (documented severe illness, funeral of a family member, or a personal, catastrophic or religious event, as defined by the University policies), please contact me by email in advance of the absence.

Notification of Changes

The instructor will make every effort to follow the guidelines of this syllabus as listed; however, the instructor reserves the right to amend this document as the need arises. In such instances, the instructor will notify students in class and/or via email and will endeavor to provide reasonable time for students to adjust to any changes.

COVID19 Safety & UA Return Plan

All University faculty, staff, and students are expected to maintain a commitment to the health and safety of our campus community. Due to the current COVID-19 pandemic, specific health and safety standards are in place to minimize exposure and community spread on campus. In the interest of your health and safety and that of all UA students, faculty and staff, the University reserves the right to change the mode of instruction or schedule of instruction at any time, based upon prevailing public health and other guidance. While the method of delivery may change, educational instruction and opportunities will continue. As such, the University will not provide a refund of tuition, in whole or in-part, based on any such changes. Detailed information on changes in format or schedule can be found at https://studentaccounts.ua.edu/ and https://financialaid.ua.edu/.

All students must be familiar with and abide by the requirements outlined in the UA Return Plan | UA System Comprehensive Health and Safety Plan. Students must (1) wear a mask or face covering at all times while participating in face-to-face class; (2) adhere to social distancing standards; and (3) comply with all other health and safety restrictions. If a student refuses to comply with the requirements, the student will be asked to leave the class and reported for a conduct violation. Unless a student has an exemption from the requirement to wear a face covering, (more information can be found at http://ods.ua.edu/covid-19-disability/), the student will be reported to Student Life for further disciplinary action. More information on these requirements and UA Healthcheck system and screening can be found at http://healthinfo.ua.edu/returnplan. You are expected to visit the site and comply with all noted requirements related to in-person class attendance.

Mission of the College of Education

Our mission in the College of Education is to be a leader in Alabama and across the nation in teaching, scholarship, advocacy, and service by developing professionals with pedagogic and disciplinary expertise who advance the intellectual and social conditions of all learners in a globalized society.

Conceptual Framework Summary

The vision of the College of Education (COE) at The University of Alabama is to develop effective, ethical, and reflective professionals who advance the theme of the COE: Unite, Act, and Lead (UA Leads). By engaging in theoretically informed and intellectually advanced effective practice our graduates will

UNITE with the larger community to collaboratively nurture cultural competence, empathy, and a vision of equity and justice for all learners;

ACT to develop the full potential of all learners to be excellent professionals in their fields; and

LEAD through continuous research-based critical inquiry of policy and reflective practice to enable transformative change in our diverse local and global communities.

Dispositions

We strive to create programs that emphasize Fairness and Equity, Reflective Stance for Professional Practice, a Commitment to Diversity, and a Culture of Collaboration.

Statement on Academic Misconduct

Students are expected to be familiar with and adhere to the official Code of Academic Conduct provided in the Online Catalog (https://catalog.ua.edu).

Statement on Disability Accommodations

- Contact the Office of Disability Services (ODS) as detailed in the Online Catalog.
- The Office of Disability Services (ODS) is the central contact point for UA students with disabilities. The goal of ODS is to ensure that University programs and services are accessible to qualified students with disabilities. For student who may require their services more information is available at http://ods.ua.edu. ODS is located at 1000 Houser Hall and their phone number is 348-4285 (voice) or 348-3081 (TTY).

Severe Weather Protocol

Please see the latest Severe Weather Guidelines in the Online Catalog. The link for the Severe Weather Guidelines is https://ready.ua.edu/severe-weather-guidelines/

Statement on Pregnant and Parenting Students

Title IX is a federal law that prohibits discrimination on the basis of sex in an education program. Among the types of gender discrimination covered by this statute, Title IX protects against discrimination related to pregnancy or parental status. Protection extends to students who are pregnant or who have either had a false pregnancy, termination of pregnancy, have gone through childbirth, or are recovering from any of those conditions. Title IX regulations also prohibit a school from applying any rule related to a student's parental, family or marital status that treats students differently based on their sex. For more information, please visit http://provost.ua.edu/uploads/3/9/7/6/39760652/student_pregnancy_faq_final_8_11_17.pdf

Statement on Religious Observances

The University of Alabama respects the religious diversity of our academic community and recognizes the import of religious holy days and observances in the lives of our community members. For more information, please go to http://provost.ua.edu/religious-observances.html

Statement on Academic Work Duplication

Any submission of academic work designed to meet the requirements of a particular credit-bearing course is assumed to be work completed for that course and only that course; the same material submission, or material that is substantially similar, may not be used to meet the requirements of another course. Any violation of this rule may result in a referral to the Associate Dean for Student Services and Certification for disciplinary action.

UAct Statement

The UAct website provides an overview of The University's expectations regarding respect and civility. The website link is https://www.ua.edu/campuslife/uact/