BEP-490/675 Cognitive Electrophysiology

ESPRMC Department, College of Education, The University of Alabama

Instructor: Firat Soylu (fsoylu@ua.edu)
Room: Barnes 1038
Meeting Time: Monday 12 pm-3 pm
Office hours: Email to make an appointment
Office: Barnes 1038

Course Description

The purpose of this course is to introduce cognitive electrophysiology methods used in cognitive and educational neuroscience. The course specifically focuses on EEG (electroencephalogram) and ERP (event-related potentials) methods, and covers central topics and issues, including design of EEG/ERP experiments, filtering, artifact detection and rejection, frequency and time-frequency analyses, ERP analysis, and functional connectivity.

Course Objectives

In this course students will:

- learn about signal processing methods used in cognitive electrophysiology research
- acquire preliminary experiences in experimental research design, data collection, and analysis of EEG and ERP data
- synthesize, criticize and interpret empirical work and theoretical perspectives on cognitive electrophysiology research
- learn about open source research software and open science research practices
- formulate ideas for future empirical research in their field of study

Prerequisites

BEP 570 - Foundations of Educational Neuroscience course is a prerequisite. However students with previous introductory-level neuroscience coursework can take this course with instructor approval.

Textbook

Both textbooks are **available full-text as ebooks** (pdf) from the UA library.

- **ITERP**: Luck, S. J. (2014). An introduction to the event-related potential technique. MIT Press.
- **ANTSD:** Cohen, M. X. (2014). Analyzing neural time series data: theory and practice. MIT Press.

Software

- **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 have free access to MATLAB and all its toolboxes.

- **EEGLAB:** EEGLAB is an open-source and free data analysis toolbox that works on MATLAB. Download EEGLAB
- **ERPLAB:** ERPLAB is an open-source and free data analysis toolbox that works as a plugin to EEGLAB on MATLAB. Download ERPLAB

All additional reading materials are included under the Outline of Topics section.

Summary of Course Activities

Weekly Readings & Discussion Questions

Most of the readings will be from the two textbooks. The e-copies (pdfs) of the textbook chapters are available from the UA library as well as the course website. You can purchase hardcopy versions online.

Each week you will complete the assigned readings before class. The readings will provide you with a preliminary understanding of the content, but it is likely that aspects of the content will be hard to understand initially. You will post at least two questions on the discussion board for the week (we will use Padlet to post the discussion questions, the links are in the weekly schedule). We will discuss these questions in class and will make sense of the content together. The questions posed should be directly relevant to the content covered in that week and should help shape the discussion that takes place in class. When posting your questions please consider referring to specific sections in the readings (with page numbers). You are expected to submit your discussion questions by 8 am on the day of the class.

Course Sessions

Each class will begin with a lecture (~40 min) providing a summary of the content covered in the readings. In the second part we will have discussions based on the readings and questions posted by the students. The third part will involve hands-on data collection or analysis activities. We will move the class to the ELDEN Lab (Barnes, 1051) to do the hands-on data collection activities.

Mid-term

There will be a mid-term exam measuring your understanding of the concepts, theories, and methods covered in class. This will be an open book exam and will take place during the class.

Project

The goal of the project is to give you the opportunity to go through all stages of doing research from data collection to data analysis and eventually authoring a research manuscript. During the class we will collect data to replicate previously established EEG/ERP results. You can also collect data for an experiment of your choice. You will the data collected in class to conduct an analysis and write a research report. Details on the project will be provided in class.

Deliverables

In addition to the weekly discussion questions, there are four deliverables:

(a) Prospectus: By the seventh week of the class you will submit a two page prospectus for your project that lays out the focus of your project, the research questions and your preliminary ideas for the research design. We will have a one-on-one meeting to discuss your project ideas. The proposal will also have a tentative bibliography showing the body of work you ground your work in.

(c) Final paper: You will submit your final paper at the end of the semester (~5000 words).

(d) Poster: You will prepare a digital poster and present it in our last class.

Weekly Schedule & Content

1. Introduction (Aug 23)

- Introduction to EEG research
- Setting up the software environment: MATLAB, EEGLAB, & ERPLAB

2. What are EEG and ERP, and what are they good for? (Aug 30)

- ITERP Chapter 1: A Broad Overview of the Event-Related Potential Technique
- ANTSD Chapter 2: Advantages and Limitations of Time and Time Frequency Domain Analyses
- ANTSD Chapter 3. Interpreting and Asking Questions about Time-Frequency Results

3. Key Background Issues for EEG & ERP (Sept 13)

- ITERP Chapter 2: A Close Look at ERPs and ERP Components
- ITERP Chapter 3: Overview of Common ERP Components
- ANTSD Chapter 5: Introduction to the Physiological Bases of EEG

4. The Design and Interpretation of EEG/ERP Experiments (Sept 20)

- ITERP Chapter 4: The Design of ERP Experiments
- ANTSD Chapter 6. Practicalities of EEG Measurement and Experiment Design

5. Artifact Detection & Rejection (Sept 27)

- ITERP Chapter 6: Artifact Rejection and Correction
- ANTSD Chapter 7: Preprocessing Steps Necessary and Useful for Advanced Data Analysis
- ANTSD Chapter 8: EEG Artifacts: Their Detection, Influence, and Removal

6. Time-Frequency Domain Analysis & Filtering (Oct 4)

- ITERP Chapter 7: Basics of Fourier analysis and filtering
- ANTSD Chapter 9: Overview of Time-Domain EEG Analyses

7. Baseline Correction and Averaging & Independent-Component Analysis (Oct 11)

- Prospectus due!
- ITERP Chapter 8: Baseline Correction, Averaging, and Time-Frequency Analysis

8. Measurement (Oct 18)

- Mid-term!
- ITERP Chapter 9: Quantifying ERP Amplitudes and Latencies

9. Statistical Analysis of EEG/ERP Data and Reporting Results (Oct 25)

- ITERP Chapter 10: Statistical Analysis
- ANTSD Chapter 32: Advantages and Limitations of Different Statistical Procedures

10. Scripting in MATLAB for EEG/ERP Analysis (Nov 1)

- ANTSD Chapter 4: Introduction to MATLAB Programming

11. Project Data Analysis (Nov 8)

- Kappenman, E. S., Farrens, J. L., Zhang, W., Stewart, A. X., & Luck, S. J. (2021). ERP CORE: An open resource for human event-related potential research. NeuroImage, 225, 117465. https://doi.org/10.1016/j.neuroima

12. Project Data Analysis (Nov 15)

- Keil, A., Debener, S., Gratton, G., Junghöfer, M., Kappenman, E. S., Luck, S. J., ... Yee, C. M. (2014). Committee report: Publication guidelines and recommendations for studies using electroencephalography and magnetoencephalography. Psychophysiology, 51, 1–21. http://doi.org/10.1111/psyp.12147

13. Project Data Analysis & Writing and publishing a research report (Nov 22)

- Friston, K. (2012). Ten ironic rules for non-statistical reviewers. NeuroImage, 61, 1300–1310. http://doi.org/10.1016/j.n
- Noble, W. S. (2017). Ten simple rules for writing a response to reviewers. PLoS Computational Biology, 13(10), e1005730. http://doi.org/10.1371/journal.pcbi.1005730

14. Project Presentations (Nov 29)

Final paper due (Dec 8th)

Grading

Weekly discussion questions & Participation	3x13 = 39 pts
Tutorials (3 pts each x2)	2 x 3 = 6 pts
Mid-term	10 pts
Prospectus	5 pts
Poster	10 pts
Final Paper	30 pts
Total	100 pts

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

Resources

Neuroimaging Software

- EEGLAB, ERPLAB, SPM12, FSL, AFNI

Statistics Software

- JASP, JAMOVI, R, Rstudio

Image & Media Editing

- Adobe Suite (free to UA members), GIMP

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 three 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 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 not get any participation points for unexcused absences. In addition, two and more unexcused absences will lead to a letter grade reduction in the final grade.

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).

"All students in attendance at The University of Alabama are expected to be honorable and observe standards of conduct appropriate to a community of scholars. Academic misconduct by students includes all acts of dishonesty in any academically related matter and any knowing or intentional help or attempt to help, or conspiracy to help, another student commit an act of academic dishonesty. Academic dishonesty includes, but is not limited to, the following acts, when performed in any type of academic or academically related matter, exercise or activity: ◦ Cheating: Using or attempting to use unauthorized materials, information, study aids or computer-related information. ◦ Plagiarism: Representing the words, data, works, ideas, computer programs or output, or anything not generated in an authorized fashion, as one's own. ◦ Fabrication: Presenting as genuine, any invented or falsified citation or material. ◦ Misrepresentation: Falsifying, altering or misstating the contents of documents or other materials related to academic matters, including schedules, prerequisites and transcripts."

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.

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 important 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/