Research Methods and Trends in Educational Neuroscience (BEP-670)

College of Education, The University of Alabama

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Room: Carmichael Hall 109
Meeting Time: Thursdays, 3:00pm – 5:50pm
Office hours: By appointment
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Course Description

Educational Neuroscience is an emerging area of research grounded in multiple disciplines including (but not limited to) education, psychology, neuroscience, and cognitive science. The purpose of this course is to explore major research trends and methodologies in educational neuroscience through readings and discussions, and hands-on data analysis activities.

Course Objectives

- Students will explore mainstream research methodologies in educational neuroscience.
- Students will compare and contrast various cognitive neuroscience research methodologies.
- Students will synthesize, criticize and interpret empirical work and theoretical perspectives in a specific domain of their choice that relate to their research interests and future research agenda.
- Students will discuss heuristics for designing educational neuroscience studies and acquire preliminary experiences in analyzing behavioral and neuroimaging data.
- Students will formulate ideas for future empirical research in their field of study that incorporate perspectives and methodology from brain science.

Prerequisites

BEP 570 - Foundations of Educational Neuroscience is a prerequisite for this course. Students who have a background in cognitive neuroscience or educational neuroscience can take this course without taking BEP 570 with the instructor's approval.

Overview of Weekly Themes

1. Introduction to Functioning of the Brain and the Nervous System
2. Research Methods in Educational Neuroscience
3. Transcranial Magnetic Stimulation & Lesion Studies
4. Skin Conductance & Eye Movements

5. Functional Magnetic Resonance Imaging (fMRI) & Functional Near-Infrared Stereoscopy (fNIR)
6. Electroencephalography (EEG) and Magnetoencephalography (MEG)
7. Physiological Bases of EEG
8. Common ERP Components & Oscillatory Neuronal Dynamics
9. P300, LRP & ERN Components
10. Design of EEG/ERP Experiments
11. Filtering and Artifact Detection
12. Frequency and Time-Frequency Domains Analyses
13. Baseline Correction and Averaging & Independent-Component Analysis
14. Statistical Analysis of EEG/ERP Data and Reporting of Results
15. Connectivity with EEG

Course Activities

Weekly Readings & Reflections

Most of the weekly readings are from the textbooks. In addition we will read review or primary research articles. You can download the articles from the Blackboard site. The text books are available full-text as ebooks from the library. You can also purchase hardcopies from the campus supply store.

Each week you will write a reflection that will synthesize ideas from that week's readings and post these on the forum for that week in Blackboard. You are expected to submit your reflections by 6 pm the day before the class (Wednesday). The title of your reflection should be concise and should summarize the main theme of your reflection (e.g., Language evolution parallels changes in brain structure). At the end of your reflection you will pose two discussion questions to be covered in class. The discussion question should be in a separate paragraph and in bold-text, so that viewers of your post can quickly spot your big question for the week.

Course Sessions

Classes are held in Carmichael 109. Each class will begin with a lecture (~1hr) providing a summary of the content covered in the readings. In the second part (~1hr 50 min) we will have discussions based on the readings and questions posted by the students.

On select weeks we will have the class in the Educational Neuroscience Lab (Barne's building, 1057) to do some hands-on data collection / analysis activities.

Discussion Leader

Every week one student will act as a discussion leader. The discussion leader will organize and refine the discussion questions posted on Blackboard and will lead the discussion. It is imperative that the discussion questions are posted by 6pm the day before the class so that the discussion leader has enough time before the class to prepare the discussion questions.

Data Analysis

There will be two data analysis assignments during the semester using some sample EEG/ERP data sets. The goal is to help you acquire some preliminary hands-on experiences in neuroscience/psychophysiology data analysis. Students will be provided with step-by-step tutorials explaining how to do the analyses. The data analysis workstations in the educational neuroscience lab will be made available to the students to complete these assignments.

Project

The project is an opportunity to focus on a topic that is of interest to you, and to design a research study in this domain. You will write a research proposal for an educational neuroscience study. In the proposal you will (1) synthesize the literature about a specific cognitive phenomenon, learning process, disorder, or any other area of research of your choice, (2) formulate a set of research questions that address a gap in the literature, (3) provide testable claims related to the research questions, (4) propose a set of experiments that address you research questions and claims, and (5) reflect on the implications of the proposed study for educational design and practice.

Deliverables

In addition to the weekly reflections, there are four deliverables:

(a) Data analysis results: You will submit the results of your analysis of sample data with a brief interpretation of the results (max 300 words) for the two data analysis exercises.

(b) Prospectus: By the fourth 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-to-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) Proposal presentation: You will give a 10-min presentation to introduce your project and to get feedback from the class.

(d) Final paper: You will submit your research proposal at the end of the semester (max 4000 words).

Grading

Readings and reflections (3 or 4 pts each week (2 pts for the reflection, 1 pt for the discussion questions, 2 pt for leading the discussion). You can miss up to two reflections without losing points.)	3 x 13 + 4 = 43 pts
Data analysis assignments	6 x 2 = 12 pts
Prospectus	10 pts
Proposal presentation	5 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	

Textbooks

The textbooks are available full-text as ebooks from the library.

ANTSD:

Cohen, M. X. (2014). *Analyzing neural time series data: theory and practice*. MIT Press.

ITERP:

Luck, S. J. (2014). *An introduction to the event-related potential technique*. MIT Press.

MIM:

Senior, C. E., Russell, T. E., & Gazzaniga, M. S. (2006). *Methods in mind.* MIT Press.

Weekly Readings

1. **Introduction to Functioning of the Brain and the Nervous System**

   Nicholls, J. G., Martin, A. R., & Fuchs, A. (2001). Principles of signaling and organization. *From Neuron to Brain*, 1, 3-22.

   Society for Neuroscience. (2002). Brain Facts: A Primer on the brain and nervous system. *Society for Neuroscience*.

2. **Research Methods in Educational Neuroscience**

   Tolmie, A. (2014). Research methods in educational psychology. Mareschal, D., Butterworth, B., & Tolmie, A. (Eds.). *Educational neuroscience*. John Wiley & Sons.

   Varma, S., & Schwartz, D. L. (2008). How should educational neuroscience conceptualise the relation between cognition and brain function? Mathematical reasoning as a network process. Educational Research, 50(2), 149–161.

   Dick, F., Lloyd-Fox, S., Blasi, A., Elwell, C., Mills, Debbie. (2014). Neuroimaging methods. Mareschal, D., Butterworth, B., & Tolmie, A. (Eds.). *Educational neuroscience*. John Wiley & Sons.

3. **Transcranial Magnetic Stimulation & Lesion Studies**

   MIM Chapter 1: Transcranial Magnetic Stimulation in Human Cognition

   MIM Chapter 3: Cognitive neuroscience and nonhuman primates: Lesion studies

4. **Skin Conductance & Eye Movements**

   MIM Chapter 5: Skin Conductance: A psychophysiological approach to the study of decision making

   MIM Chapter 8: Eye movements

5. **Functional Magnetic Resonance Imaging (fMRI) & Functional Near-Infrared Stereoscopy (fNIR)**

   MIM Chapter 9: Functional Magnetic Resonance Imaging

   Lloyd-Fox, S., Blasi, A., & Elwell, C. E. (2010). Illuminating the developing brain: the past, present and future of functional near infrared spectroscopy. *Neuroscience & Biobehavioral Reviews*, 34(3), 269-284.

6. **Electroencephalography (EEG) and Magnetoencephalography (MEG)**

   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

   MIM Chapter 10: Electroencephalography

   MIM Chapter 12: Magnetoencephalography

7. **Physiological Bases of EEG**

ITERP Chapter 2: A Close Look at ERPs and ERP Components

ANTSD Chapter 5: Introduction to the physiological bases of EEG

Kappenman, E. S., & Luck, S. J. (2012). ERP components: The ups and downs of brainwave recordings. The Oxford Handbook of Eventrelated Potential Components, 3-30.

8. Common ERP Components & Oscillatory Neuronal Dynamics

ITERP Chapter 3: Overview of Common ERP Components

Bastiaansen, M., Mazaheri, A., & Jensen, O. (2011). Beyond ERPs: Oscillatory Neuronal Dynamics. The Oxford handbook of event-related potential components, 31.

9. P300, LRP & ERN Components

Polich, J. (2012). Neuropsychology of P300. Luck, S. J., & Kappenman, E. S. (Eds.). *Oxford handbook of event-related potential components*, 159-188.

Smulders, F., Miller J.O. (2012). The lateralized readiness potential. Luck, S. J., & Kappenman, E. S. (Eds.). *Oxford handbook of event-related potential components*, 159-188.

Gehring, W.J., Liu, Y., Orr, J.M., Carp, J. (2012). The error-related negativity (ERN/Ne). Luck, S. J., & Kappenman, E. S. (Eds.). *Oxford handbook of event-related potential components*, 159-188.

10. Design of EEG/ERP Experiments

ITERP Chapter 4: The Design of ERP Experiments

ANTSD Chapter 4: Introduction to Matlab programming

ANTSD Chapter 6: Practicalities of EEG measurement and experimental design

--[LAB] Stimulus Presentation & Data Acquisition Software Overview--

Neurobs Presentation Tutorial & Demo

11. Filtering and Artifact Detection

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

--[LAB] Data Analysis Software Overview --

EEGLAB/ERPLAB & MATLAB Demo

12. Frequency and Time-Frequency Domains Analysis

ITERP Chapter 7: Basics of Fourier analysis and filtering

ANTSD Chapter 10: The dot product and convolution

ANTSD Chapter 11: The discrete time Fourier transform, the FFT, and the convolution theorem

13. Baseline Correction and Averaging & Independent-Component Analysis

ITERP Chapter 8: Baseline correction, averaging, and time-frequency Analysis

Makeig, S. & Onton, J. (2011). ERP Features and EEG Dynamics. The Oxford handbook of event-related potential components, 31.

14. Statistical Analysis of EEG/ERP Data and Reporting Results

ITERP Chapter 10: Statistical Analysis

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), 1-21.

15. Connectivity with EEG

ANTSD Chapter 25: Introduction to the various connectivity analyses

Sakkalis, V. (2011). Review of advanced techniques for the estimation of brain connectivity measured with EEG/MEG. *Computers in Biology and Medicine*, *41*(12), 1110–1117.

Disability Statement

If you are registered with the Office of Disability Services, please make an appointment with me as soon as possible to discuss any course accommodations that may be necessary.

If you have a disability, but have not contacted the Office of Disability Services, please call (205) 348-4285 (Voice) or (205) 348-3081 (TTY) or visit 133-B Martha Parham Hall East to register for services. Students who may need course adaptations because of a disability are welcome to make an appointment to see me during office hours. Students with disabilities must be registered with the Office of Disability Services, 133-B Martha Parham Hall East, before receiving academic adjustments.

The Code of Academic Conduct

All students in attendance at the University of Alabama are expected to be honorable and to observe standards of conduct appropriate to a community of scholars. The University expects from its students a higher standard of conduct than the minimum required to avoid discipline. Academic misconduct 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. The Academic Misconduct Disciplinary Policy will be followed in the event of academic misconduct.