PURSUE

Preparing Undergraduates for Research in STEM-related fields Using Electrophysiology

https://pursueerp.com/

Cindy M. Bukach, Jane W. Couperus, & Catherine L. Reed

Preparing **U**ndergraduates for **R**esearch in **S**TEM-related fields **U**sing **E**lectrophysiology

Supported by grants from NSF DUE 1625521 & 1914858, DUE 1625610 & 1914834, DUE 1626554 & 1914855, the Association for Psychological Science Fund for Teaching and Public Understanding of Psychology Science, and the James S. McDonnell Foundation Scholar Award for Understanding Human Cognition

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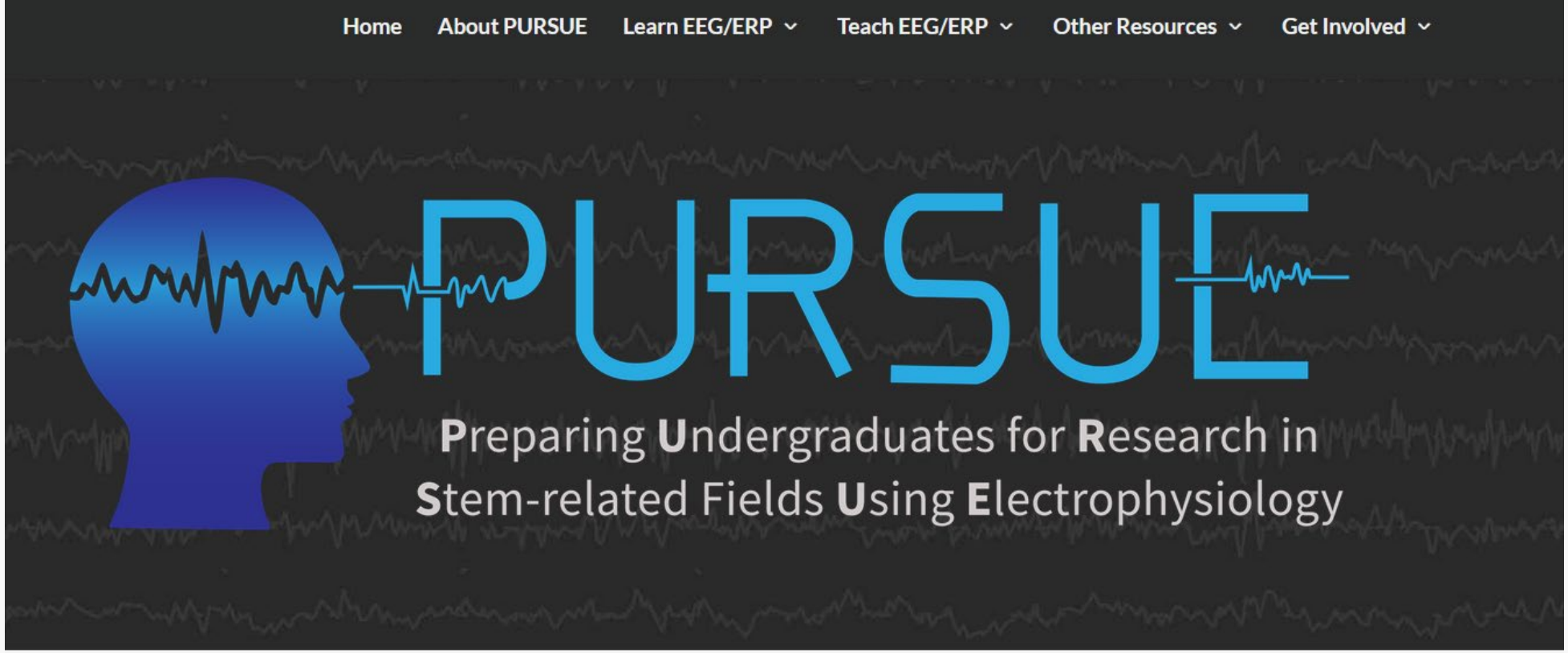

PURSUE is a collaborative initiative to facilitate the training of undergraduates in **cognitive electrophysiology**. Our site contains instructional tools and teaching materials to guide educators in developing curricula for **EEG/ERP** classrooms and lab environments.

More About the Project

https://pursueerp.com/

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- **Our goal is to provide instructional tools and teaching materials to guide educators in developing curricula for EEG/ERP classrooms and lab environments**

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The PURSUE Team

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Hampshire College

Dr. Cathy Reed
Claremont McKenna College

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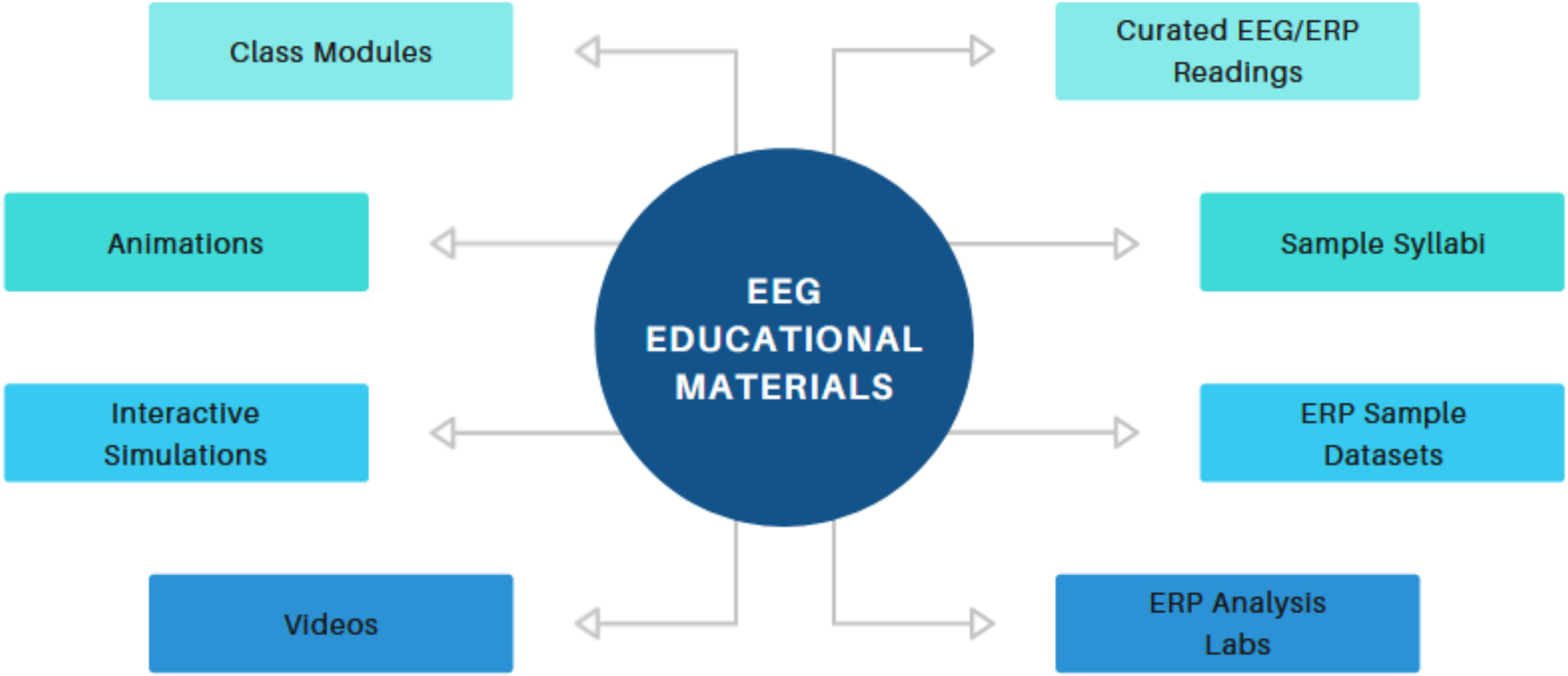

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Overview of Materials

- Previously Available
  - Animations
  - Interactive Simulations
  - Videos (Capping Procedures)
- Available as of August, 2020
  - ERP Sample Data Sets
  - ERP Data Processing Labs
  - Introduction to EEG/ERP
    - Short PPT lecture insert
    - 2 day PPT class module
  - Sample Syllabi
  - Curated EEG/ERP Readings
- Future Materials
  - Full Course Modules
    - PPT Lectures
    - Class Activities
    - Additional Animations/Simulations
    - Additional Instructional Videos

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PURSUE data at a glance

- Roughly 300 participants across three institutions (U of Richmond, Claremont McKenna, Hampshire College)
- 6 Event Related Potential Tasks (ERP CORE)
  - N170 (Face Perception Paradigm)
  - MMN (Passive Auditory Oddball Paradigm)
  - N2pc (Simple Visual Search Paradigm)
  - N400 (Word Pair Judgement Paradigm)
  - P3b (Active Visual Oddball Paradigm)
  - LRP and ERN (Flankers Paradigm)
- 15+ Individual/Group Differences Measures
  - Demographics (e.g. gender, SES)
  - Clinical Inventories (e.g. Beck Depression/Anxiety inventories)
  - Cognitive Tasks (e.g. working memory, executive function)

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Sample ERP Data Sets

- 20 participants for each of three components
  - P300/P3b
  - N400
  - N2pc
- 5 Individual/Group Differences Measures for each component

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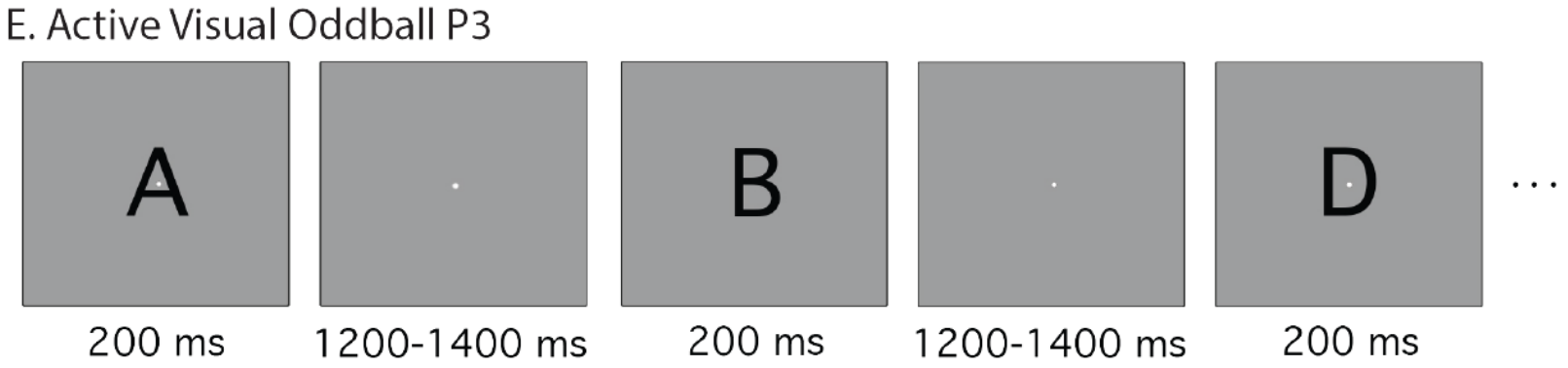
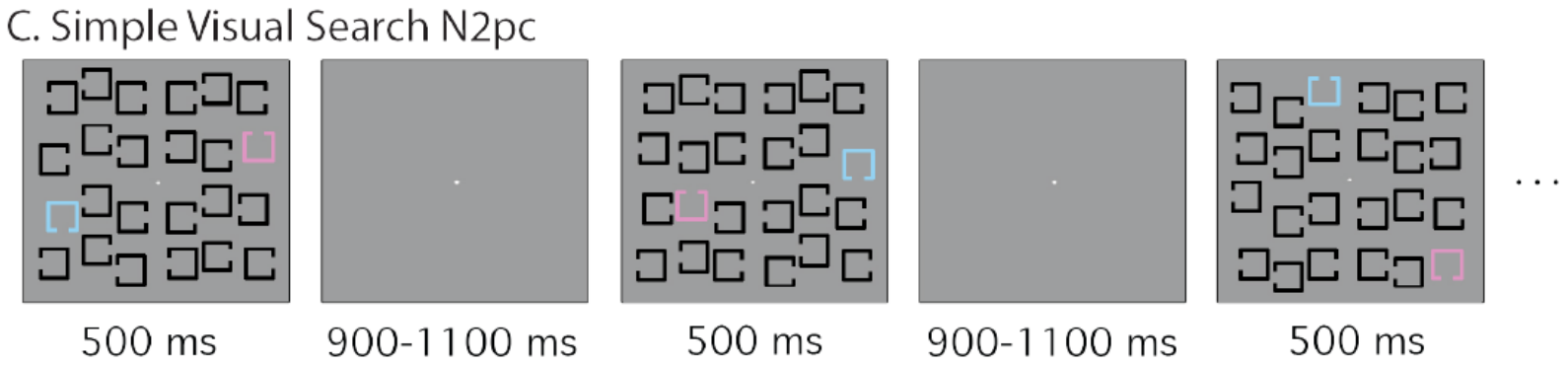
ERP Tasks





Kappenman et al., 2020

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Available Individual/Group Differences

- P300
  - Hours of Sleep
  - Perceived Stress
  - Beck Depression Inventory
  - Beck Anxiety Inventory
  - Autism Quotient Scale
- N400
  - Number of Languages Spoken
  - Visual Working Memory Accuracy
  - Spatial Working Memory Accuracy
  - Beck Depression Inventory
  - Beck Anxiety Inventory
- N2pc
  - Visual Search Task Accuracy
  - Visual Search Task Reaction Time
  - Visual Working Memory Accuracy
  - Spatial Working Memory Accuracy
  - Autism Quotient Scale

- Gender and Age are provided in all datasets

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What Files Are Provided?

- Raw Data Files for Each Participant (BrainVision)
- Average File for Each Participant (ERPlab)
- BDF Files, Re-referencing File
  - Excel Sheet that provides a legend of bins in BDF files
- Excel Sheet with Individual Differences and Amplitude Data for Electrodes of Interest (latency in some cases)
- Overview of the methods for ERPs and Behavioral Tasks/Surveys
- Overview of how the data is coded in the Excel Sheet along with what students might find in the data

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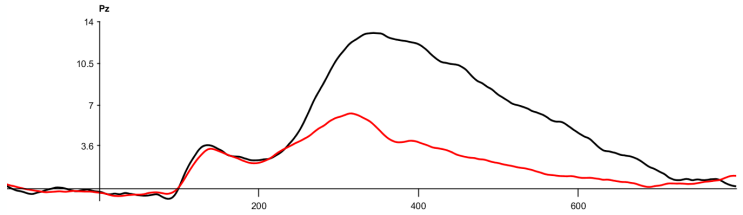
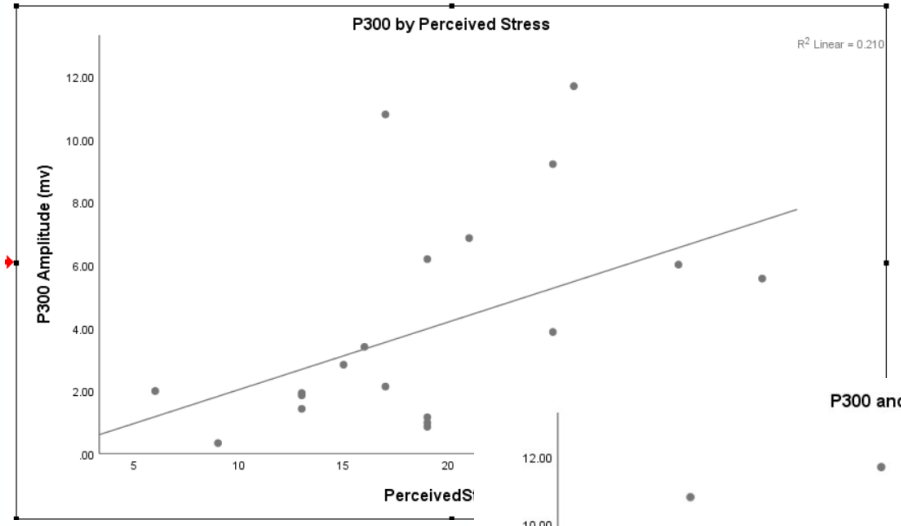
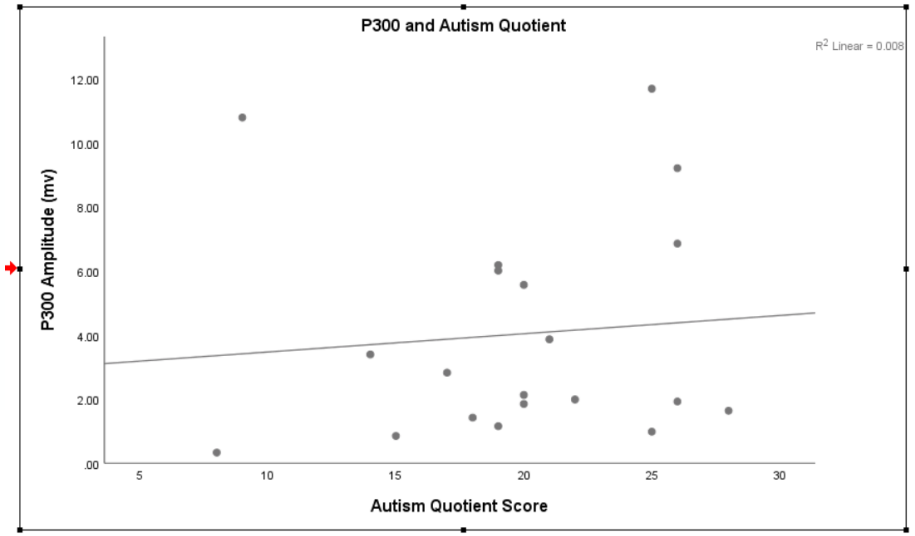
What is in the data???

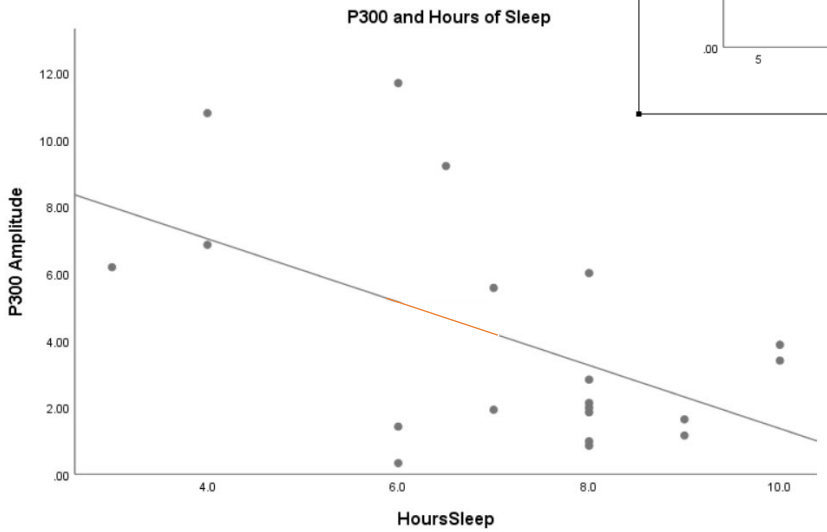




Positive



None



Negative

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Intermission

Please visit our concession stand.

Sign up for the listserv (link in the Chat window) to continue the dialogue!

Teaching Psychophysiology in the Pandemic:

Online Resources

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ERP Data Processing Labs

- 6 labs
  - Filtering
  - Bad Channels and Epoching
  - Artifact Rejection
  - Average and Grand Averages
  - Waveform Quantification
  - Statistical Analysis

  - Additional protocol document containing full steps of analysis for students

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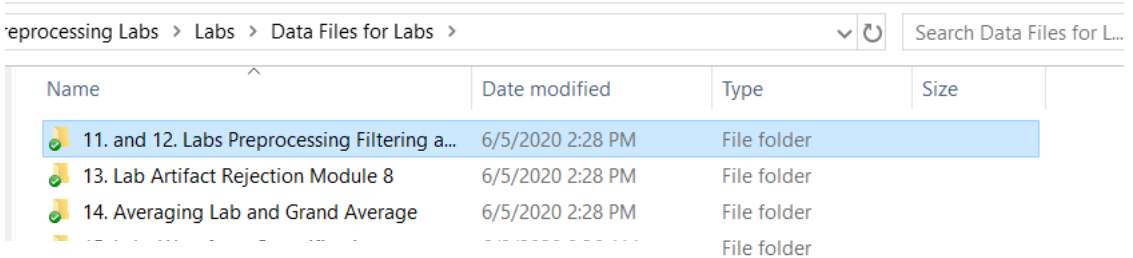
Lab Materials

- Data Sets
- Worksheets
- Tutorial Videos



Lab Activity Module 7 Filtering

For this lab please follow along and answer for yourself all the questi
to #9 and #10 please answer them on this document.

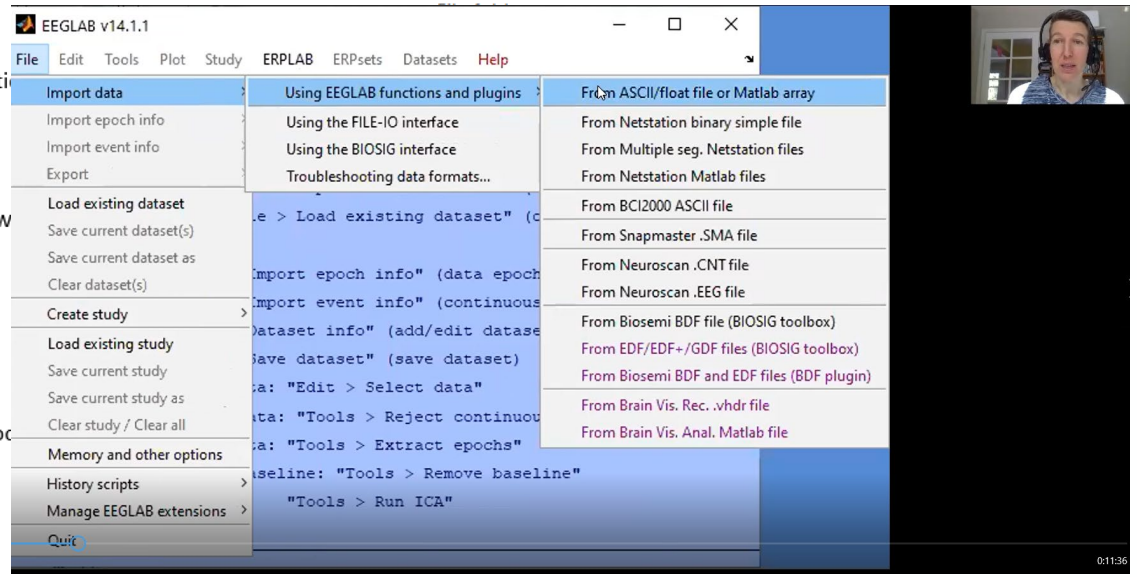
Filtering

In this lab you will learn to open a file and filter the data. You w

WordPr (N400) 1070 and 1096

Setting up the files:

1. Open Matlab & EEGlab & ERPlab
    a. You will work between EEGlab and ERPlab to preproc
    b. Click on Matlab icon
    c. In main window type "eeglab: to start EEGLAB
        i. >> eeglab
        ii. GUI comes up in small blue box
    d. ERPlab should be a pull down menu at the top of the EEGLAB GUI



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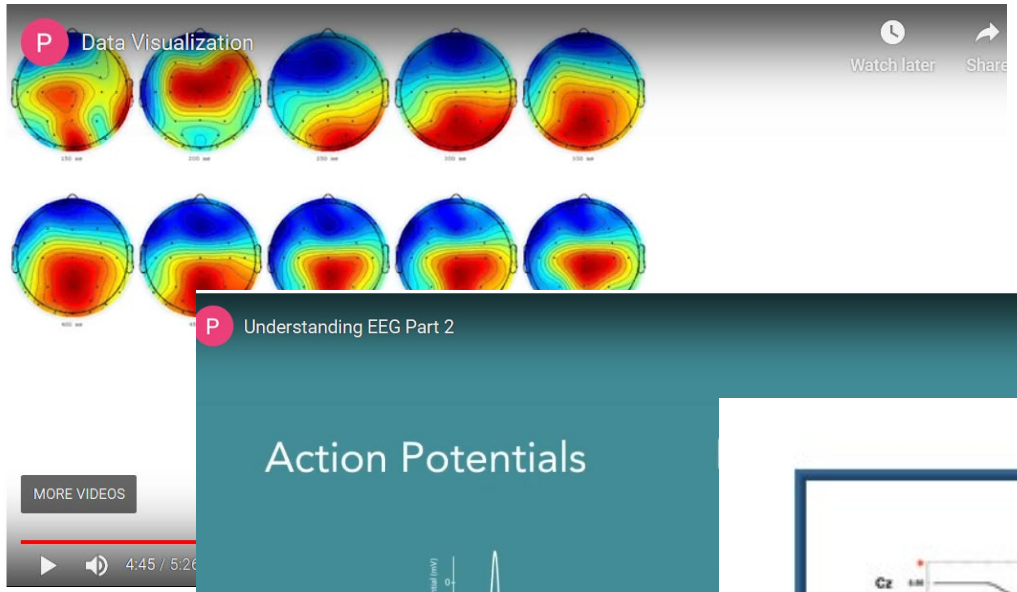
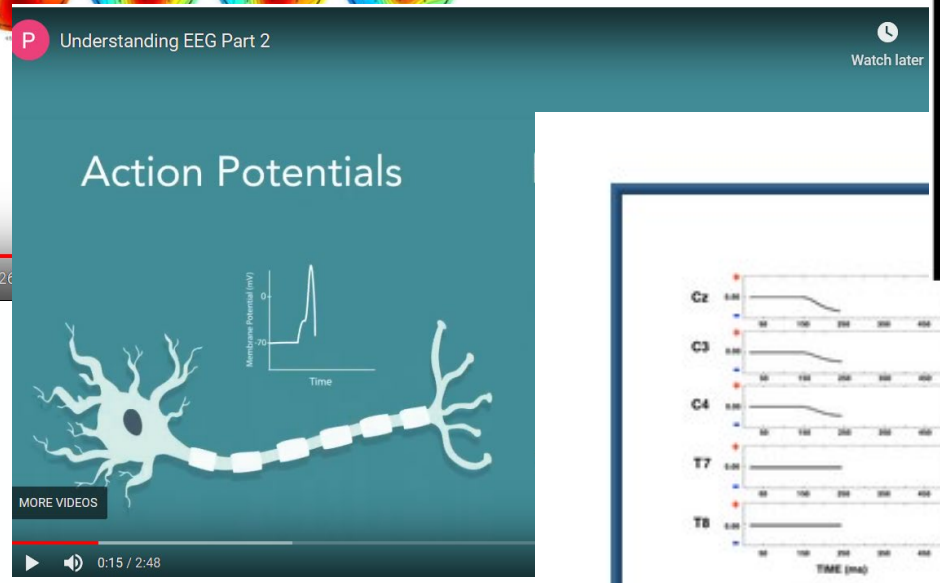
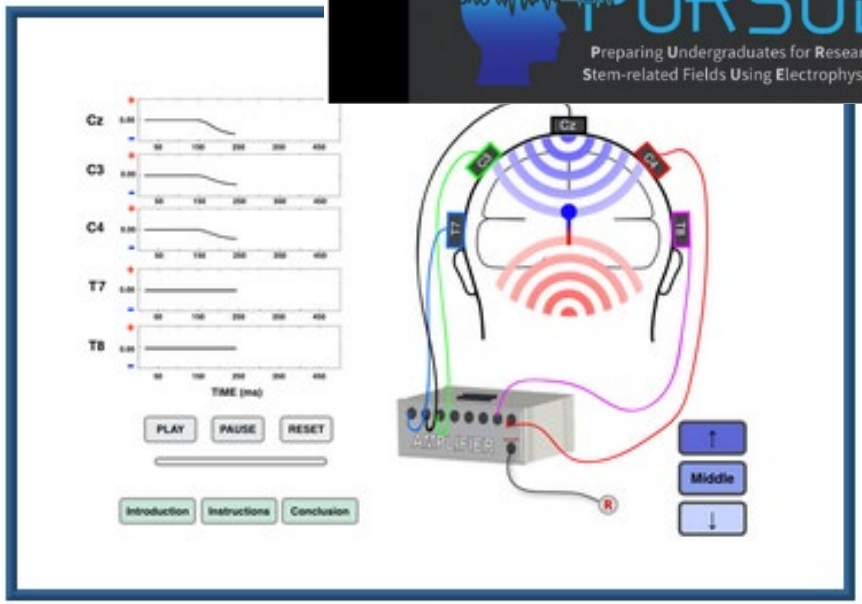
Animations, Interactive Simulations and Videos







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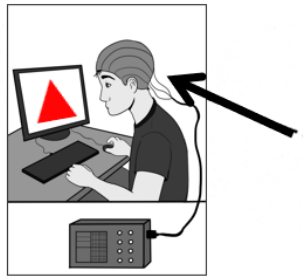
Introduction to EEG/ERP

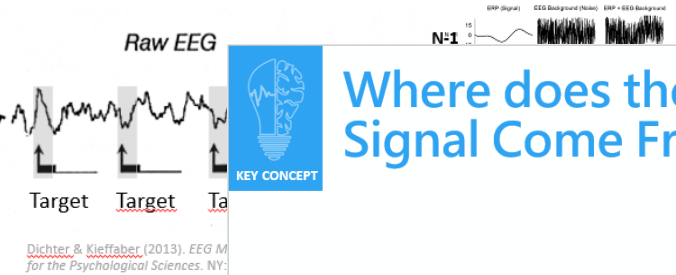
- Short Introductory Slides
  - Can use part or whole as an insert in a class
- Introduction to ERPs (2 Day Class Series)

Event-related Potentials (ERPs)

- ERPs are averaged over trials of the same condition to reduce noise and reveal the underlying pattern associated with the event



CC 4.0 by Emilia Hagen 2016



Dichter & Kieffaber (2013). *EEG M*
for the Psychological Sciences. NY:

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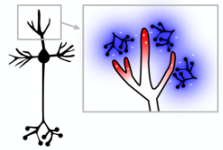
KEY CONCEPT

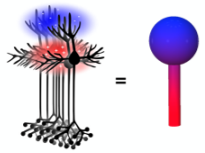
Where does the EEG Signal Come From?

Postsynaptic Potentials
- Affect local ion concentrations surrounding the cell

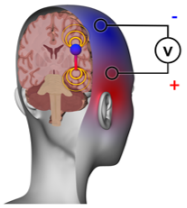


Dipoles
- A difference of charge between two parts of the neuron

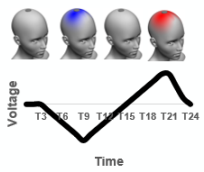
Summation
- Synchronous dipoles from aligned neurons summate



Scalp Distribution
- Dipole potentials spread to scalp



EEG Waveforms
- Electrodes measure changes in scalp voltage over time



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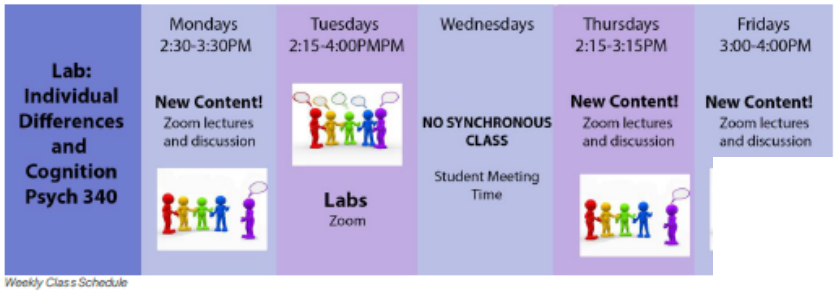
Sample Syllabi and Curated Readings

Psych 340 Lab: Individual Differences and Cognition



Weekly Class Schedule

Course Description

The primary goals of this course are to learn abou
methodology, and to conduct a study from develop
analysis on the topic chosen by the class – we will
area groups early in the semester. The course will
theory behind event related potentials as well as o
research methodologies and ERP techniques as y
develop and implement an ERP study.

Instructor:

Dr. Jane W. Couperus

Student Check-In Ho

9:00-10:00AM EST Mon, Wed.
12:45-1:45PM EST Thurs. or by a
Please feel free to email me to set
appointment at anytime.

Course Learning Goals

- Develop an understanding the neurological underpinnings of Event Related Pote
Research and common ERP components.
- Develop the ability to design and program a research study
- Develop the ability to processes ERP data for statistical analysis

CHAPTER 27

EVENT-RELATED POTENTIALS

Steven J. Luck

Event-related potentials (ERPs) are electrical *potentials* generated by the brain that are *related* to specific internal or external *events* (e.g., stimuli, responses, decisions). They can be recorded noninvasively from almost any group of research participants, and they can provide information about a broad range of cognitive and affective processes. Consequently, the ERP technique has become a common tool in almost all areas of psychological research, and students and researchers must be able to understand and evaluate ERP studies in the literature. These studies often involve a set of terms and concepts that are unfamiliar to many psychologists, however; several technical issues must be understood before a student or researcher can read and evaluate ERP studies. This chapter provides students and researchers with this background information so that they can be informed consumers of ERP studies in their area of interest. More detailed works are available for those who would like to learn more or who would like to conduct their own ERP experiments (Handy, 2005; Luck, 2005).

This chapter begins with an example of a particu-

ERPs. The next sections describe how ERP
erated in the brain and how the neural gen
of a given ERP can be localized. This infor
followed by a discussion of the basic techn
involved in recording and analyzing ERPs,
study of impaired cognition in schizophren
patients as a concrete example. The chapte
with a set of questions that should be aske
reading and evaluating an ERP study.

EXAMPLE 1: THE N170 COMPONEN AND FACE PROCESSING

Figure 27.1 shows the results of an experim
ing on the N170 component, a negative-goi
over visual cortex that typically peaks aroun
after stimulus onset. In a typical N170 parad
tographs of faces and various types of nonfa
are briefly flashed on a computer monitor and the
participants passively view the stimuli. In the ERP
waveforms shown in Figure 27.1a, the *x*-axis repre-
sents time relative to stimulus onset (measured in
milliseconds) and the *y*-axis represents the magnitude

Luck: Chapter 27 -- Event-Related Potentials (2012)

Luck, S. J. (2012). *Event-related potentials*. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbooks in psychology®. APA handbook of research methods in psychology, Vol. 1. Foundations, planning, measures, and psychometrics* (p. 523–546). American Psychological Association. https://doi.org/10.1037/13619-028

This chapter introduces common ERP components as well as specific examples of components encountered in various ERP experiments. The example of a study on the N170 component shows how ERPs are beneficial in cognitive neuroscience research. The discussion of the particular benefits of analyzing ERPs over other methods is informative. ERP components are defined and explained in-depth (e.g., how it relates to cognitive function, the origin of its name, its general range or latency, and other common characteristics). Luck uses an example experiment about impaired cognition in schizophrenia to demonstrate various facets of analyzing ERPs (e.g., difference waves, artifact correction, extracting averaged ERPs, and quantifying latency and amplitude). Luck then examines the electrical activity of postsynaptic potentials, several limitations of ERPs (including difficulties with localization), and statistical analyses in ERP analyses. He concludes by providing a list of twelve questions to consider when evaluating ERP studies.

Ratings:

Content Rating	2.3	• Very relevant to an introductory course, but some specific information about common ERP components may be too detailed for a general methods course • More relevant for a module or later in a ERP course • Useful resource to come back to when analyzing ERP waveforms.
Content Complexity Level Rating	2.0	• Several terms and concepts were unclear to the novice reader • Information about specific components would be easier to understand with previous exposure • Overall, it was easy to follow with helpful examples
Interest Level Rating	1.9	• Very engaging because the specific examples made the material more approachable and interesting • Consider only including the examples and pairing with Luck 2014 (above)
Length Rating	3.1	• 24 pages -- took a while to finish, but it was engaging
Overall Combination Rating	2.1	• This reading would be helpful to read before a lecture and can be read independently • Concepts are relevant and do not feel overwhelming

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Future Materials, Trainings and Workshops

- Modular Full Semester Course

Module 1: Introduction
1. Conceptual Overview

Module 2: From Neuron to Waveform
1. Physiology
2. Measurement

Module 3. ERP Components
1. ERP Components and Neural Sources
2. ERP Components and Associations with Cognitive Processes
3. Reading ERP Papers: Research Question and Hypothesis

Module 4. Basics of Research Design
1. Introduction to Research Design
2. Design Details
3. Reading ERP Papers: Research Design Elements

Module 5. Programming the Experiment
1. Parameters of the Experimental Design
2. Programming the Study
3. Ethical Considerations

Module 6 Data Collection
1. ERP Recording
2. Capping

Module 7 Data Preprocessing
1. Early Preprocessing Steps
2. Artifact Rejection and Correction

Module 8 Averaging
1. Averaging Subject Data
2. Creating an ERP waveform
3. Grand Averages
4. Plotting and Interpreting ERP Components

Module 9 Waveform Quantification and Statistics
1. Quantifying Waveforms
2. Extracting Measurements in ERPLab
3. Statistical Analysis

Module 10 Data Visualization and Interpretation
1. Evaluating and Creating Waveforms
2. Reading ERP Papers: Interpreting Results
3. Writing an ERP Paper

PURSUE

Thank you to our collaborators, students and staff! !

Participating Faculty

Dr. Mara Breen

Dr. David Leland

Dr. Anjali Thapar

Dr. Erika Nyhus

Dr. Jeffrey Sable

Dr. Rebecca Compton

Staff

Olivia Stibolt

Zachary Cole

Nadia Bukach

Students

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Thank You!!

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