ARTICLE
Incorporating an ERP Project into Undergraduate Instruction

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Electroencephalogram (EEG) is a relatively non-invasive, simple technique, and recent advances in open source analysis tools make it feasible to implement EEG as a component in undergraduate neuroscience curriculum. We have successfully led students to design novel experiments, record EEG data, and analyze event-related potentials (ERPs) during a one-semester laboratory course for undergraduates in cognitive neuroscience. First, students learned how to set up an EEG recording and completed an analysis tutorial. Students then learned how to set up a novel EEG experiment; briefly, they formed groups of four and designed an EEG experiment on a topic of their choice. Over the course of two weeks students collected behavioral and EEG data. Each group then analyzed their behavioral and ERP data and presented their results both as a presentation and as a final paper. Upon completion of the group project students reported a deeper understanding of cognitive neuroscience methods and a greater appreciation for the strengths and weaknesses of the EEG technique. Although recent advances in open source software made this project possible, it also required access to EEG recording equipment and proprietary software. Future efforts should be directed at making publicly available datasets to learn ERP analysis techniques and making publicly available EEG recording and analysis software to increase the accessibility of hands-on research experience in undergraduate cognitive neuroscience laboratory courses.

Key words: Electroencephalography (EEG); event-related potentials (ERPs); neuroscience education, laboratory course

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The goals of an undergraduate neuroscience curriculum include: 1) introducing students to experimental methodology, design, and data analysis, 2) advanced awareness of a particular field within neuroscience, 3) critical and independent thought, 4) effective communication skills, and 5) ethics (Ramirez et al., 1998; Wiertelak, 2003; Ramirez, 2005; Wiertelak and Ramirez, 2008). However, undergraduate laboratory courses are often constrained by having pre-packaged experiments and little opportunity to have real research experience. In addition, students do not often have the opportunity to learn techniques currently used in neuroscience research. Specifically, in cognitive neuroscience, the prohibitive cost and time investment to use common techniques prevent students from gaining first-hand research experience. Therefore, students do not experience the true nature of research within cognitive neuroscience.

Electroencephalography (EEG) is a relatively cheap, non-invasive method that is commonly used in cognitive neuroscience research. However, direct experience with EEG in undergraduate courses is often limited to analysis of previously collected data (Miller et al., 2008). In order to engage students in a real research experience we have developed a one-semester course, Laboratory in Cognitive Neuroscience at Bowdoin College,

laboratory meetings. During the lecture/journal club portion of the course, students read background materials on cognitive neuroscience methods (e.g., Luck, 2014) and primary research articles (chosen by the instructors) implementing cognitive neuroscience methods (EEG and functional magnetic resonance imaging) to study human cognition (including ERP components related to perception, attention, memory, emotion, language, executive function, and decision-making). Therefore, the lectures/journal club meetings provide practice in reading primary scientific research and essential background knowledge on the methods and topics of research in cognitive neuroscience. During the laboratory portion of the course, students participate in activities designed to teach them research techniques in cognitive neuroscience and then apply what they have learned by designing and implementing their own EEG experiment.

GROUP PROJECT

The laboratory includes multiple weeks of preparation prior to conducting the group project. First, students do online training in the ethical conduct of human research and we discuss writing an APA style research paper. Second, students tour the EEG laboratory and practice setting up and recording EEG data. In this laboratory, students practice applying the electrode cap, inserting conductive gel, checking impedances, and viewing the raw EEG

Figure 2. Raw data plotted in EEGLAB. After each preprocessing step

Figure 3. ERPLAB output of the results of the ERP analysis tutorial dataset. ERPs for each electrode are shown and can be enlarged and used for presentation. Enlarged ERP graph from the two electrodes analyzed showing a greater N170 effect for faces compared to objects. Time is on the X-axis (-200 ms to 200 ms) and amplitude is on the Y-axis (-8 μV to 8 μV), black= face, red = object.

students completed the EPrime tutorial that goes through

behavioral and EEG data, and presented their results orally and written. They gained real research experience, public speaking experience, practice in writing articles for publication, and experience working collaboratively on an experiment. By designing their own experiment they engaged in critical and independent thought and gained expertise in an area of cognitive neuroscience. They

and use it as a basis to describe to other students the EEG technique. Therefore, the group project enhanced student learning compared to assignments that did not include a hands-on research component.

CONCLUSION

Here we have presented a model of a student designed research project using a common technique in cognitive neuroscience (EEG). Through problem-based learning (Albanese and Mitchell, 1993; Savery, 1996; Schuh and Busey, 2001) students were able to learn EEG and test novel ideas which led to a deeper understanding of research in cognitive neuroscience that may be useful in a number of courses at the undergraduate or even graduate level. Additionally, it prepared students to work in an EEG laboratory. We believe that providing real research experience in Laboratory in Cognitive Neuroscience met the goals of an undergraduate neuroscience curriculum by introducing students to experimental methodology, design, and data analysis, plus provided advanced awareness of cognitive neuroscience, an opportunity for critical and independent thought, practice in effective communication, and exposure to ethics in human research. The group project was made possible through the availability of open source software (EEGLAB and ERPLAB), but it also required access to EEG recording equipment and proprietary software (EPrime and MATLAB). In order to increase accessibility of research in cognitive neuroscience in the undergraduate curriculum, efforts should be made to increase publicly available data and freely available recording and analysis software for learning cognitive neuroscience techniques.

REFERENCES

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