Tracking Student Attention During Different Instructional Activities using Mobile EEG

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INTRODUCTION

- Understanding fluctuations in attention has important implications for understanding classroom learning for students.
- Online measures of student attention have long been of interest to educators (LLyod, 1968; McLeish, 1966), however assessing student attention in real time is challenging.
- Behavioral measures of attention in the classroom – including self-report (Bunce et al., 2010; Risko et al., 2012), direct observation (Johnstone & Percival, 1976; Raca & Dillenbourg, 2013), and assessment of learning-related activities and outcomes (Scerbo et al., 1992) – are indirect and prone to methodological issues including bias and measurement error.
- Researchers have started to examine the electro-encephalography (EEG) correlates of attention. **Alpha-range (8-12Hz) oscillations** recorded over visual cortex was identified as a neural indicator of attention (Haegens et al., 2011).
- Lacking, however, is the neural assessment of attentional abilities in real-life contexts, a key piece to understanding:
  - 1) how these skills influence learning opportunities in the moment (such as in the classroom) and,
  - 2) how these skills are influenced by contextual factors in academic setting.

Utilizing portable EEG in a mock classroom setting, the current study aims to examine student's attentional engagement as measured by behavioral coding and alpha power during different types of instructional activities.

RESEARCH QUESTIONS

I. Does student attention, **measured by behavioral coding,** vary as a function of the type of instructional activity they are engaged in?

II. Does student attention, **measured by the EEG indicator (alpha oscillation)**, vary as a function of the type of instructional activity they are engaged in?

III. Do behavioral and EEG measures of student attention illustrate different patterns of attentional changes across four types of instructional activities?

METHODS

Participants:

- 23 undergraduates from a large public university;
- M_{age} = 20.61 years, N_{men} = 5;
- 35% (N = 8) self-identified as White, 17% (N =4) as Latino/Latinx, 39% (N =9) as Asian and 8% (N =2) as Mixed or Others.

Procedure:

- As a group, 4-9 undergraduate students participated in a lesson on educational neuroscience in a mock classroom. Lessons consisted of four activities, performed in order: 1) listening to a lecture, 2) watching a video, 3) discussing a set of questions with a partner, and 4) taking a written test individually. Each type of activity was approximately 15 minutes long.
- In each group, 2 or 3 students were randomly selected to be assessed with the portable EEG equipment throughout the lesson.
- EEG data was recorded using SMARTING 24-channel mobile EEG amplifiers (mBrainTrain, Belgrade, Serbia) and all lessons were video-taped.

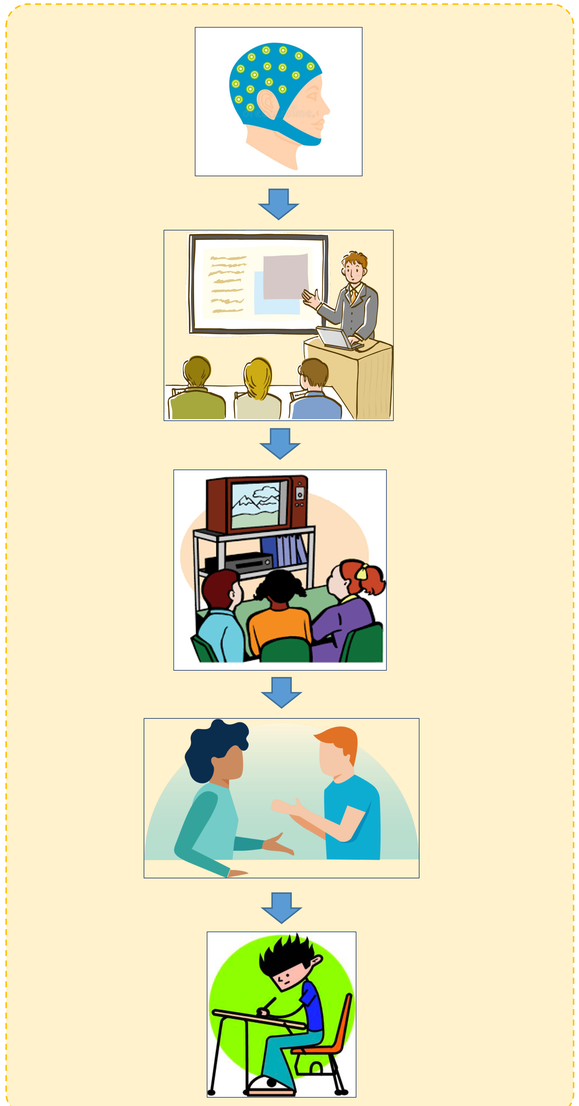
METHODS

Behavioral Coding:

- Student attention during each type of activity was behaviorally coded on 1-min epochs with 3 categories: Attentive, In attentive, or Missing data;
- Inter-rater reliability (> 85%) was achieved between the master coder and all trained coders;
- **Percentage of Attentive epochs** was calculated as the behavioral indicator of attention for each participant in each activity.

Alpha Power:

- Normalized using power values between 30-50 Hz band.
- Calculated as **normalized mean power values in the 7.5–12.5Hz frequency band** alpha range oscillation at 2.56ms epochs.
- Four occipital scalp sites were used, Pz, POz, O1 and O2.



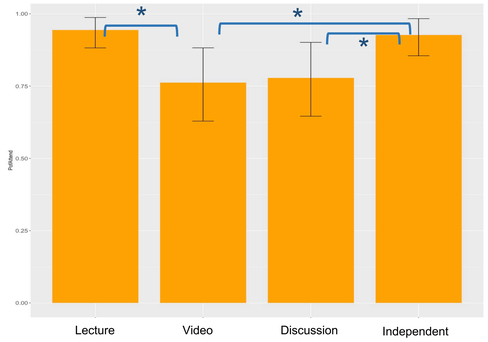
RESULTS

Behavioral Results:

Type of instructional activity had a significant effect on students' attentiveness, $\chi^2(3) = 10.44$, $p < .05$.

- Specifically, no behavioral difference were observed in student attentiveness during teacher-initiated activities (lecture and video watching) relative to in student-initiated activities (paired discussion and independent work), b = -0.01, t (41) = -.23, p > .5.
- Students' attention was coded as **higher during the independent work than in paired discussion**. b = -0.07, t (41) = -2.21, p = .03
- Students also showed significant **higher level of attentiveness in lecture compared to video watching**, b = 0.09, t (41) = 2.39, p < .05.

Figure 1. Mean Percentage of Attentiveness in Four Activities

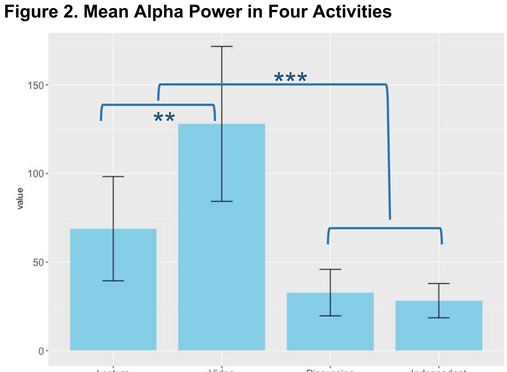


EEG Results:

The type of instructional activity had a significant effect on alpha power, $\chi^2(3) = 19.43$, $p < .001$, as did the sites of EEG electrodes on the scalp, $\chi^2(3) = 28.68$, $p < .001$. However, the interaction effect between activity types and site was not significant, $\chi^2(9) = 6.62$, $p > .5$.

- In contrast to coded behavioral observations, significantly higher alpha showed in teacher-initiated activities (lecture and video watching) than in student-initiated activities (discussion and independent work), b = -28.48, t (58) = -3.95, p < .001. This suggests that students **had higher attentional engagement in student-initiated activities** (partner discussion and independent work).
- No difference was found between paired discussion and independent work time, b = 3.70, t (58) = .26, p > .5.
- The alpha power was **higher in video watching than in lecture**, b = -35.31, t (58) = -2.69, p < .01.

Figure 2. Mean Alpha Power in Four Activities



RESULTS

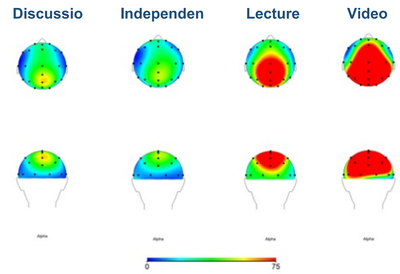


Figure 3. Occipital Alpha Power Change in Four Activities

- Planned contrasts showed a significant higher alpha power at central electrodes (Pz and POz) than at lateral ones (O1 and O2), b = 24.94, t(219) = 5.24, p < .001.

Correlational Results:

- No significant correlations were found between participants' scores during independent written test and the percent of attentiveness from behavior coding, nor with alpha power values.
- Participants' attentiveness (behavior and alpha power) was not associated with individual factors, such as gender or bilingual status.

DISCUSSION

Results from **behavioral coding** suggested that **students were overall the least attentive during video watching, followed by paired discussion**, and were comparatively engaged during lecture and independent work.

On the other hand, changes in **alpha power** indicated that **students' attention was lower during video watching and the lecture than during discussion and independent work.**

This discrepancy between behavioral and EEG results could partially attribute to the insufficiency of the behavioral coding scheme, which heavily relied on participants' gaze. For instance, a student might be looking at the instructor and appearing attentive but mind wandering about the film he/she watched the night before.

The different patterns of attentional changes observed in the current study illustrate the importance and unique value of using the EEG method for examining students' attention-related behaviors in real-world classrooms.

No association was found between measured attention and students' performance on the test. One possibility is that the lesson was simple, and the test focused heavily on facts. Additionally, only a few participants expressed strong interests in the topic covered by the mock lesson.

FURTURE DIRECTIONS

- EEG measures using alpha-range oscillation might be particularly useful in examining attention-related behaviors in class with participants whose behavioral data are difficult to collect, for example, young children.
- Future study should explore the relationship between attention changes in the classroom and students' learning outcomes.
- Nuanced examinations of attention fluctuation related to the length and frequency of different activities could offer more insights on pedagogical practices that aim to optimize students' engagement in class.

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