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A Protocol for Measuring Learner Attention and Engagement

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HAL Authorization

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NeuroRhythms

Motivations

Context: For effective learning when controlling a Brain-Computer Interface (BCI), the learner must be involved. It is therefore necessary to consider their levels of attention and engagement during the task [1].

- Sustained Attention is the ability to maintain attention on a specific task for an extended period of time [2];
- Engagement is a cognitive process by which a person memorizes information and makes connections between them [1].

Problem: To detect attention and engagement using EEG, it is necessary to define specific relevant markers to detect variations in each of these components. Currently, in the literature, several different EEG indexes are proposed [3].

We therefore design a protocol to compare them in a learning context.

Approach: university students follow a half-hour video lecture while measuring their levels of attention and engagement using EEG. These levels are then compared with responses i) to questionnaires about the lecture and ii) to tests of attention and encoding.

Material

Protocol

- Ideally, 20-30 healthy participants at university
- Questionnaires for participant pre-screening and biographical data collection
- Attention and encoding tests (with EEG : D2-R, possibly RL/RI-16)
- Video courses (with EEG)
- Questions on Attention and Engagement elements related to the lecture. Answers to questions are marked 0, 0.5 or 1.

Equipment

- a laptop and a 36" screen
- an EEG cap with 64 active electrodes
- Biosemi ActiveTwo EEG amplifier
- OpenViBE to manage triggers, run video and record EEG signals and triggers.

Methods

1. Participants complete a pre-screening and biographical data questionnaire and an attention test with EEG.
2. Then, participants watch a 30-minute lecture from the Collège de France by Yasmine Belkaid on immune defenses and sexual dimorphism [3] while wearing an EEG cap.
3. They must then complete a 20-question questionnaire about the lecture content. The elements needed to answer the questions are marked by triggers via OpenVibe.

- EEG signal pre-processing is currently performed offline using MNE. A high-pass filter is applied at 1Hz along with a notch filter at 50 Hz. An Artifact Subspace Reconstruction (ASR) is then applied, followed by an Independent Component Analysis (ICA). The components are then classified using ICLabel, and all those not identified as 'brain' are excluded.

- For measuring attention and engagement, to date, only one index per component has been used.

- For **attention**, we used this power ratio : $\frac{\beta}{\alpha + \theta} : (F3 + F4)/2$

The calculation was performed by averaging the power from the frontal electrodes F3 and F4 [4].

- For **engagement**, we used this ratio : $\frac{\theta}{\alpha} : (F3 + F4 + FC5 + FC6)/4$

Theta power was averaged over the frontal electrodes F3, F4, FC5, FC6, and Alpha power over the parietal electrodes P7, P8 [5].

Preliminary results

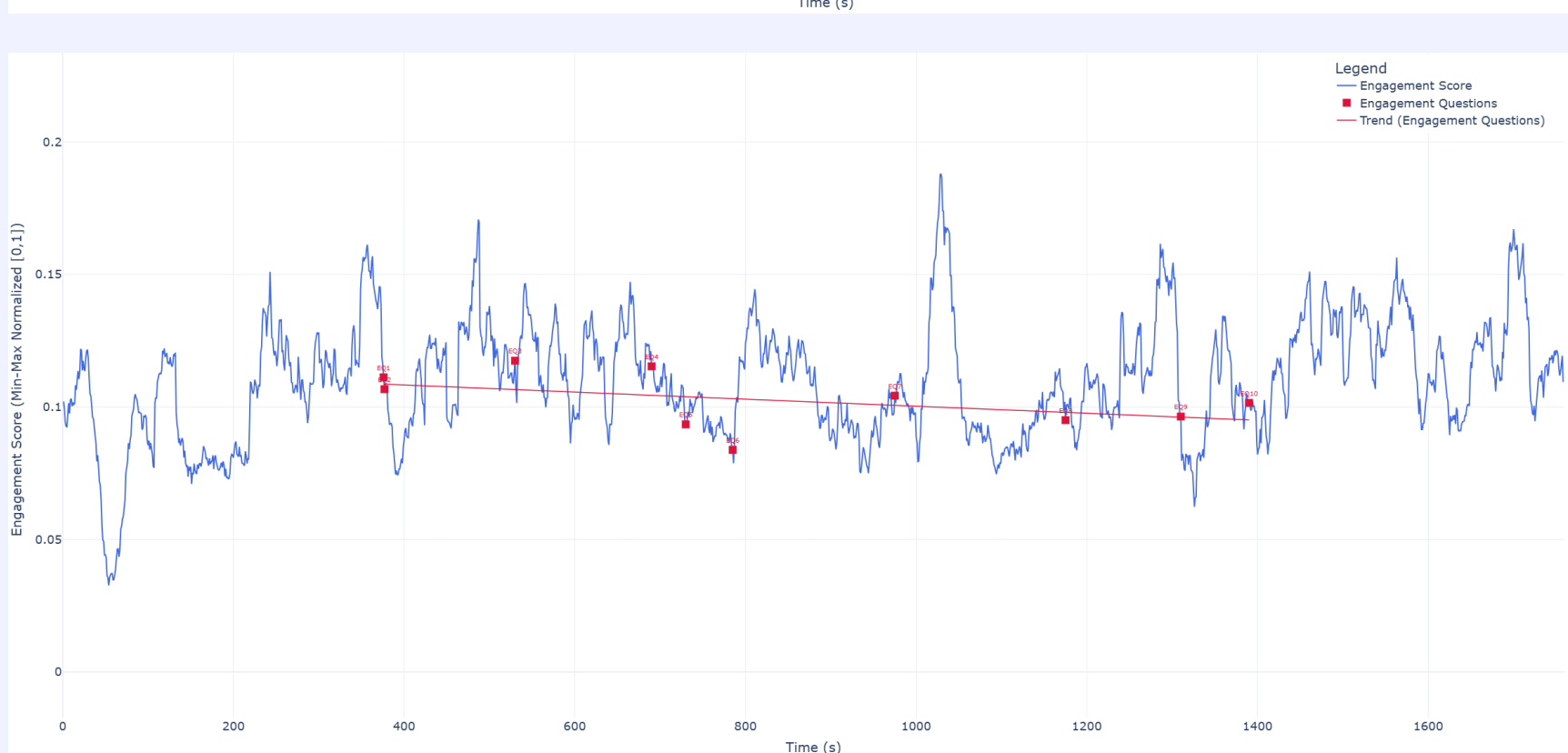
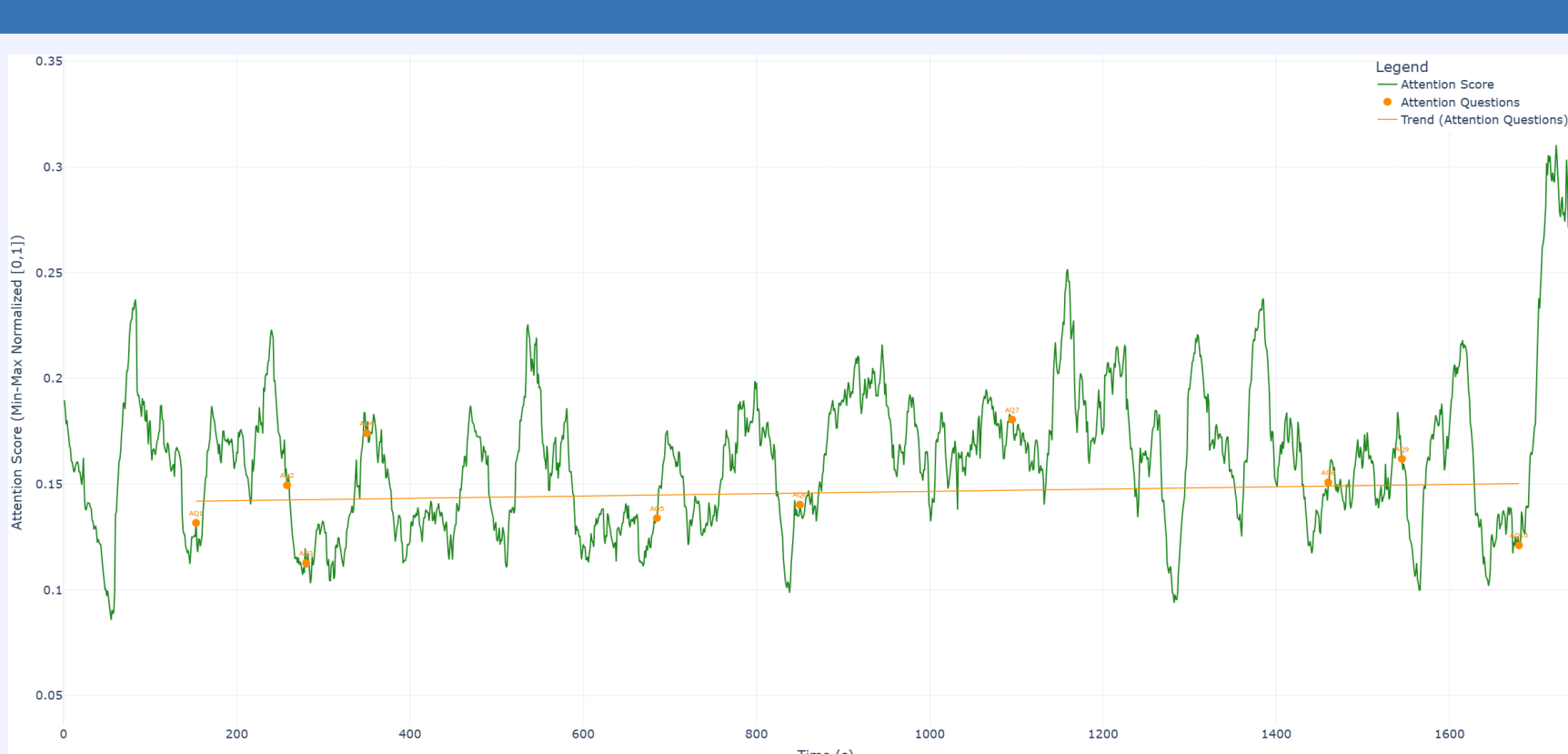


Fig. 1: attention (top) and engagement (bottom) indexes during the lecture. Marks correspond to times at which the post-questions were asked.

Spearman's correlation between attention and engagement indexes: -0.23 (p=0.33, one subject only)

Expected results

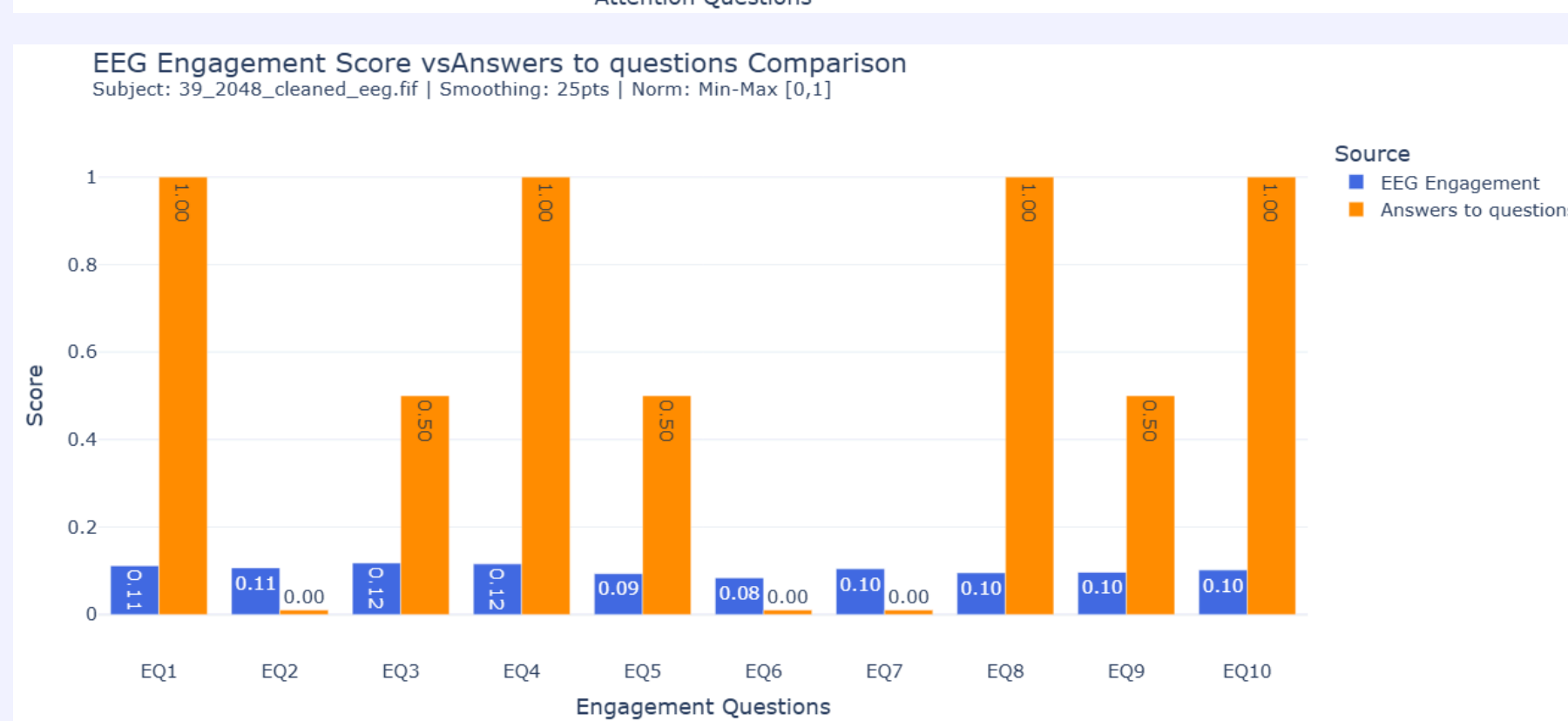
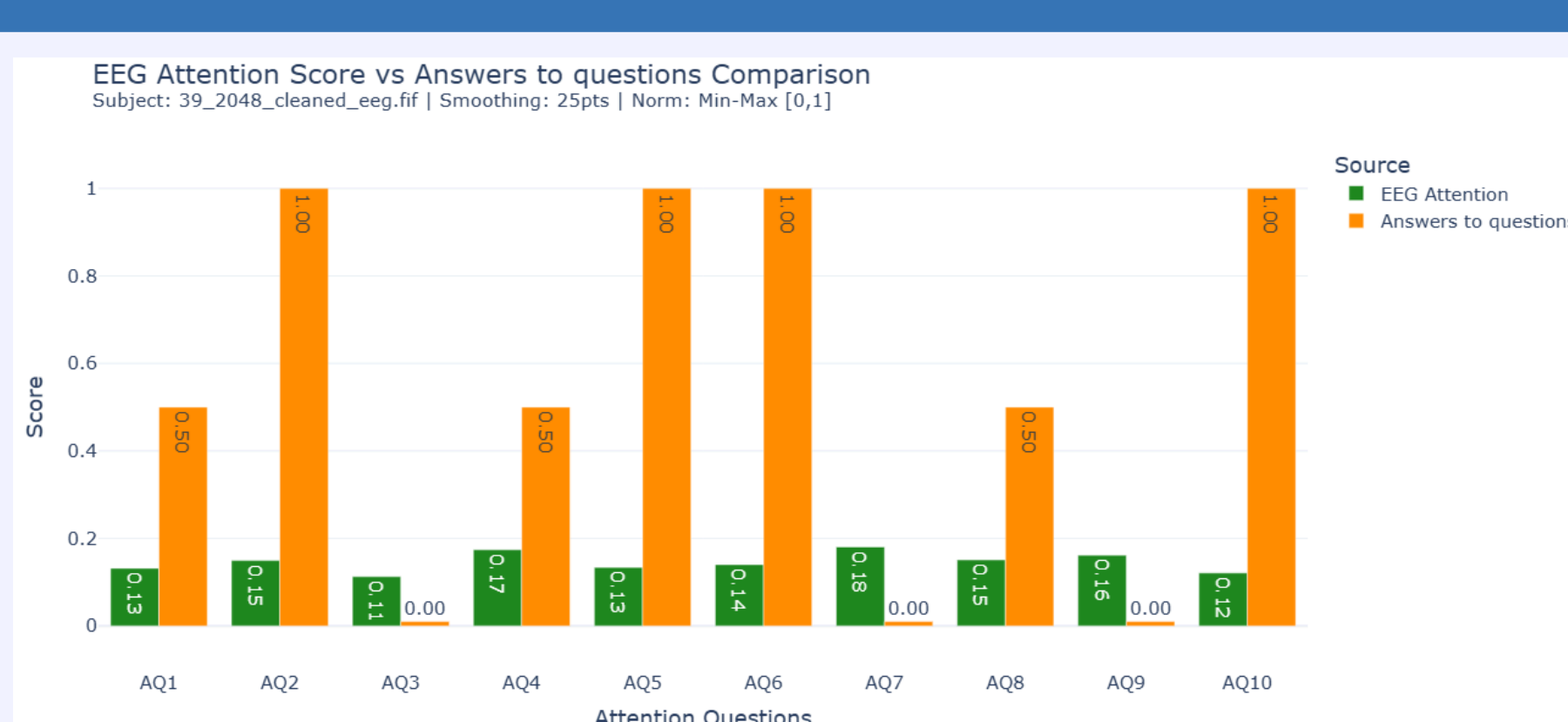


Fig. 2: attention (top) and engagement (bottom) indexes during the lecture compared to (simulated) marked answers to post-lecture questions.

Future work

Seeking for other biomarkers:

- Connectivity Analysis:
 - Fronto-posterior alpha tracks attention.
 - Fronto-parietal theta reflects engagement.
- Attention :
 - Posterior alpha: Decrease signals active visual attention. Increase indicates inhibition/disengagement & quantifies attentional lapses.
 - Alpha/beta hemispheric asymmetry indicates alerting network state.
 - Gamma band fluctuations may also signal attention.
- Engagement :
 - Median frontal theta power suggests engagement levels.
 - Signal entropy could also measure engagement.

And then?

- Enable online detection.
- Fusion of markers for each component.
- Ethic approval is on going.
- Recordings will start in June 2025.
- Results are expected in August 2025.

Conclusion

This new protocol aims to reflect the variations in attention and engagement levels using EEG indexes. In our first results, both selected indexes are not correlated which confirms that both formulas measure different components. The literature suggests various avenues for refining the analyses and improving the distinction between attention and engagement. For each component, distinguishing aperiodic activity from oscillatory activity is a major lead.

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 [5] Bierciewicz, K., Borawski, M., and Duda, J. (2020). Method for selecting an engagement index for a specific type of game using cognitive neuroscience. International Journal of Computer Games Technology, 2020 :1–19.