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An event-related potential brain-computer interface speller using a wearable, single-channel EEG headset

1. Single-channel, wearable EEG spellers

Event-related potential (ERP) brain-computer interfaces (BCIs), such as the P300 matrix speller, enable communication for individuals with motor impairment based on visually evoked neural responses. Traditionally, such systems require multiple scalp electrodes and laboratory-grade EEG setups. We assess whether frontal, single-channel EEG recordings from a wearable headset can feasibly support ERP-based BCI communication.

Benefits:

- Practical and easy to set up
- Economically viable
- Comfortable and aesthetically unobtrusive

Challenges:

- Suboptimal electrode placement
- Lateral bipolar reference reduces signal
- Lack of spatial filtering
- Inconsistent sampling rates and high noise

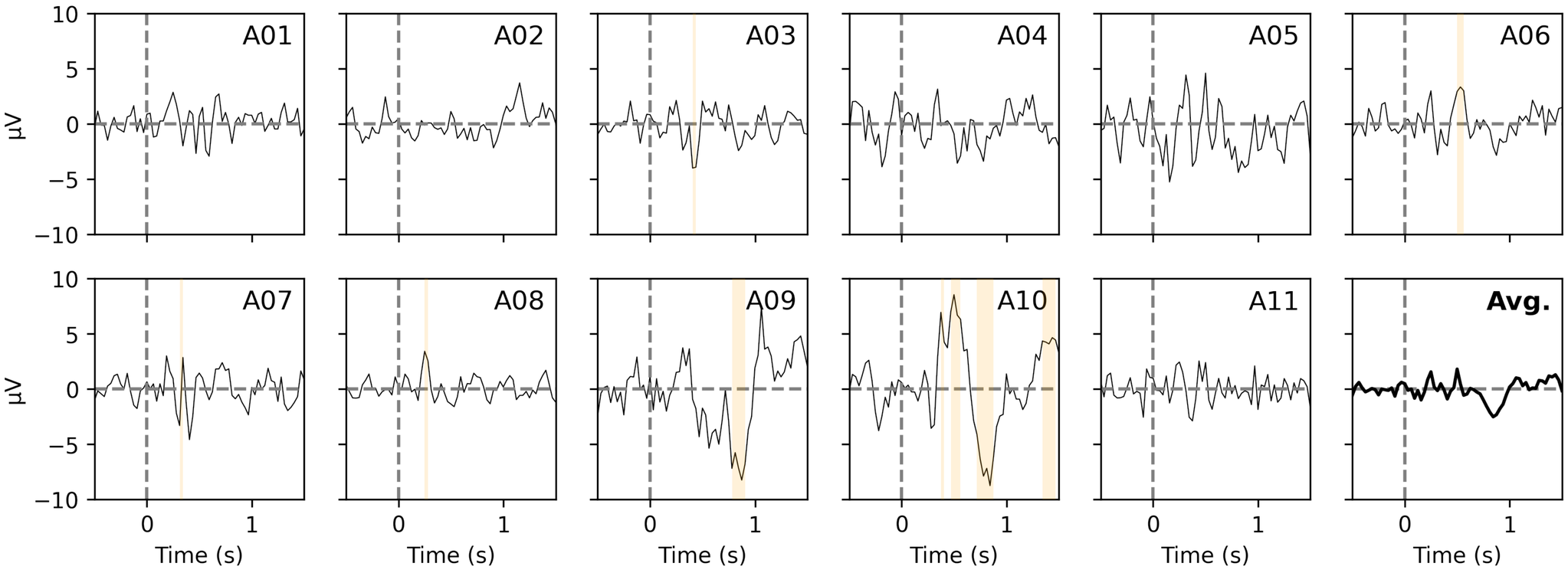
2. Data collection and processing

We used OpenVibe and the MacroTelect BrainLink Pro bluetooth headset with bipolar electrodes at Fp1 and Fp2 and ground on the left earlobe to collect ERPs from 11 right-handed participants.

Preprocessing included:

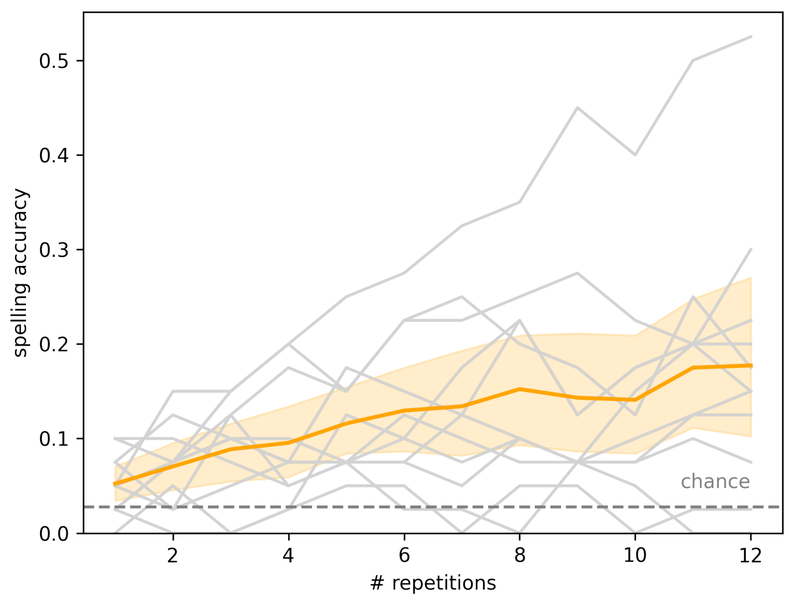
1. Band-pass filtering (1-16 Hz)
2. Clipping for outlier artifact correction
3. Epoching and baseline correction
4. Downsampling to 32 Hz

3. Contrasts between attended and non-attended ERPs per subject



4. Cross-validated decoding performance

Using Linear Discriminant Analysis with Toeplitz-shrinkage covariance matrix regularization.



5. Conclusions

There is **no consistent ERP** present over all subjects. While performance is currently in all cases **below practical usability**, 6 out of 11 participants showed significant evoked responses and **above-chance decoding**. Even though pure character selection accuracy is generally low, this method might yield sufficient information for current large language models to make sensible text predictions.

Performance could be improved through:

- More advanced artifact removal
- Alternative feature representations (e.g. time-frequency embeddings)
- Improved stimulation paradigms and interface design

Future work should validate these approaches in on-line decoding and across larger cohorts and properly control for facial muscle movements synchronized to target stimulation.

Custom middleware: github.com/arnevdk/brainlink-lsl
Analysis code: github.com/arnevdk/brainlink-p300