Classifier-based latency estimation for covert attention ERP decoding

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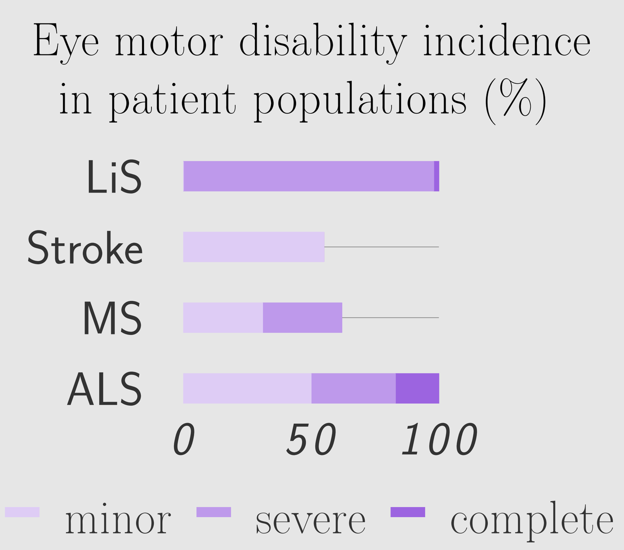
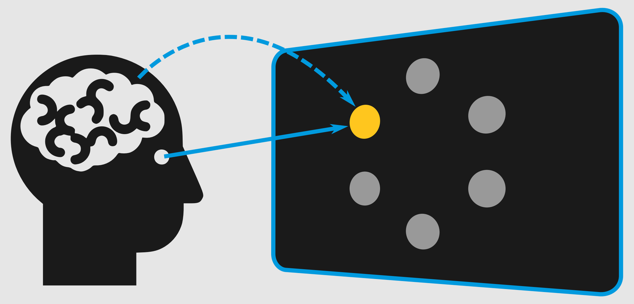
1 Gaze-independent visual oddball interface

Eye motor disability

The BCI target population suffers from eye motor disabilities, warranting the development of gaze-independent communication paradigms. While other active BCI modalities (auditory, somatosensory, ...) can work, visual paradigms exploiting spatial attention often yield the highest ITR [3]. We aim to design a visual oddball interface that can be operated efficiently by gaze-impaired patients through accurate covert attention classification.

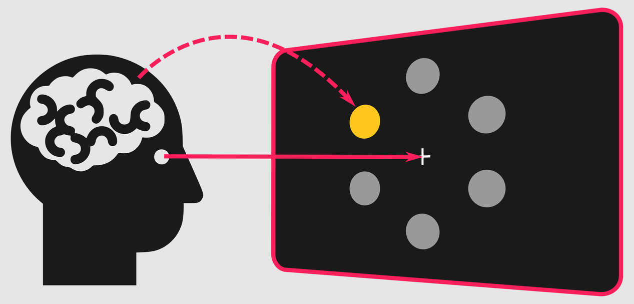


Conventional visual attention settings



Overt attention

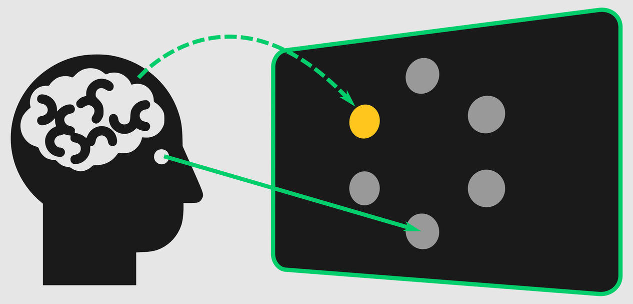
Persons with full eye motor control can gaze at intended targets.



Covert attention

Fixating the gaze at the center is a common solution, but this also requires a degree of eye motor control.

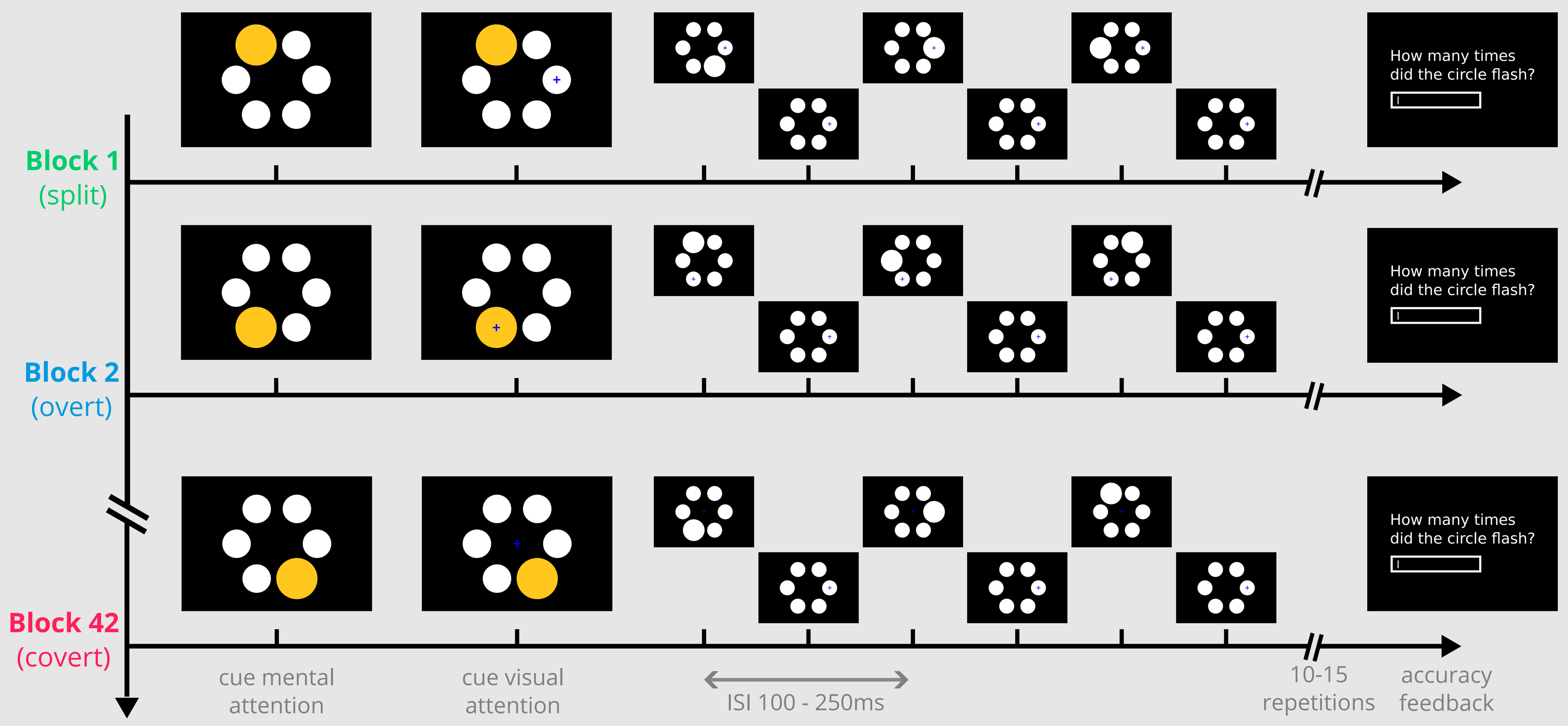
Proposed visual attention setting



Split attention

We design an interface that allows for the split attention conditions that can occur in patients with involuntary eye movements.

Experimental protocol

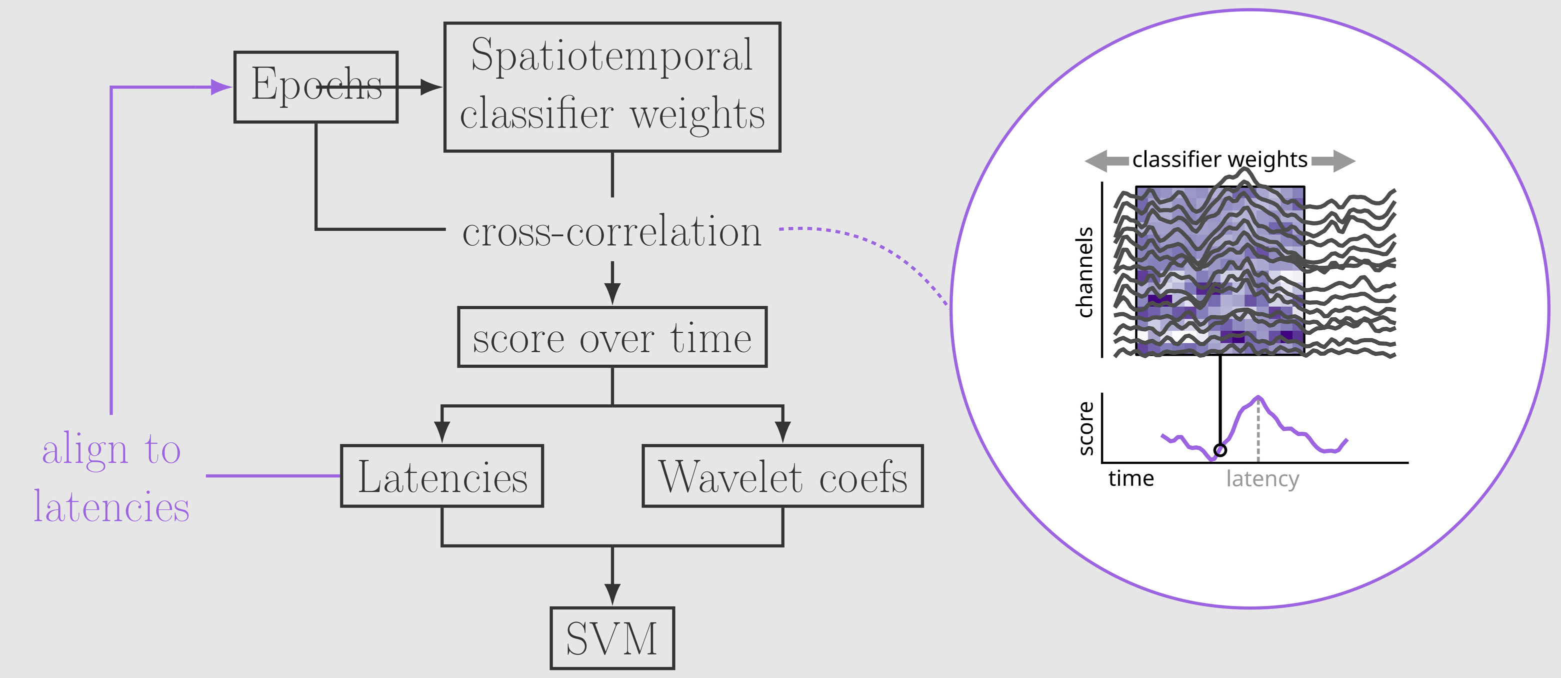


2 Novel ERP latency estimation procedure

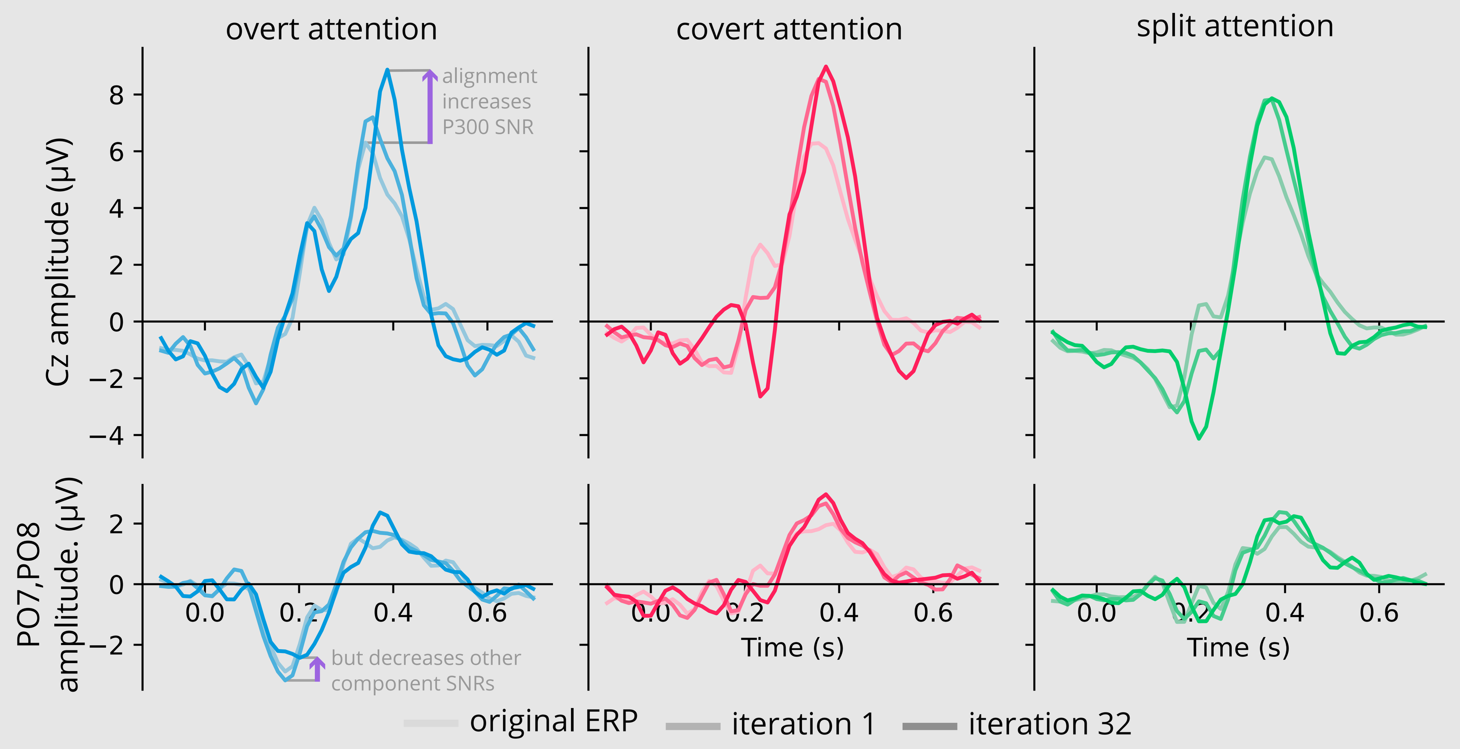
The jitter problem

Latency jitter correction improves covert attention decoding performance [1]. High jitter decreases SNR when averaging over multiple trials. In order to correct for jitter, an algorithm must accurately estimate single-trial ERP latencies. Classifier-based latency estimation [2], paired with a time-regularized linear classifier [4] is a technique that can be used classify jittered signals and extract latencies. We propose a more accurate latency estimation and classification algorithm that iteratively applies classifier-based latency estimation.

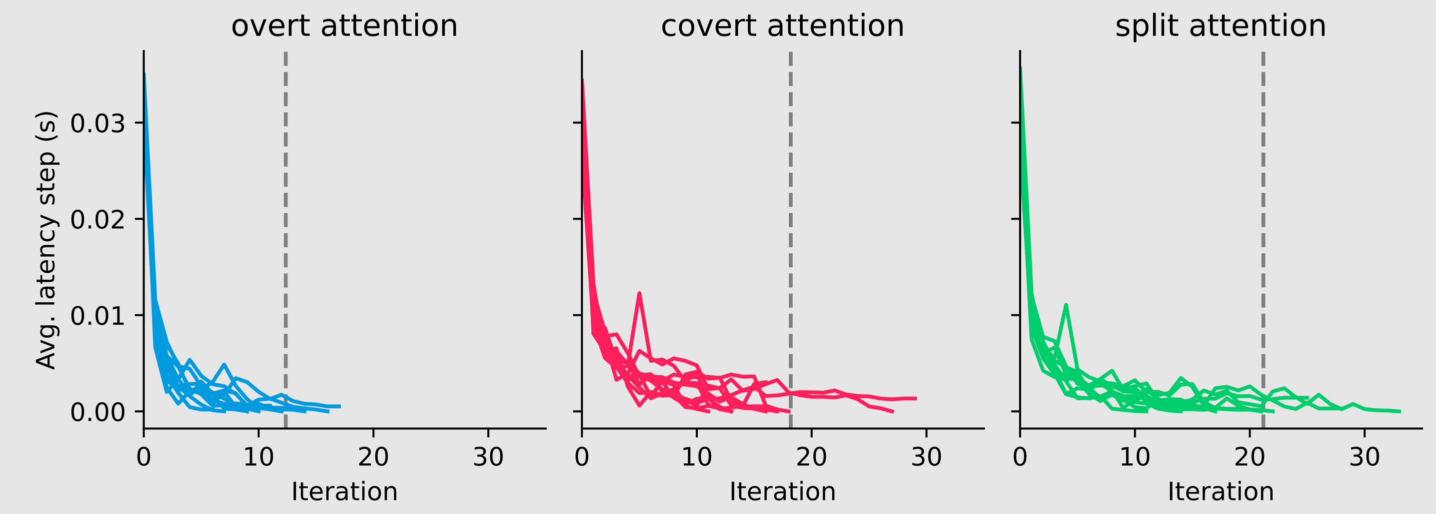
Woody Classifier-Based Latency Estimation (wCBLE)



Alignment improves SNR



Convergence

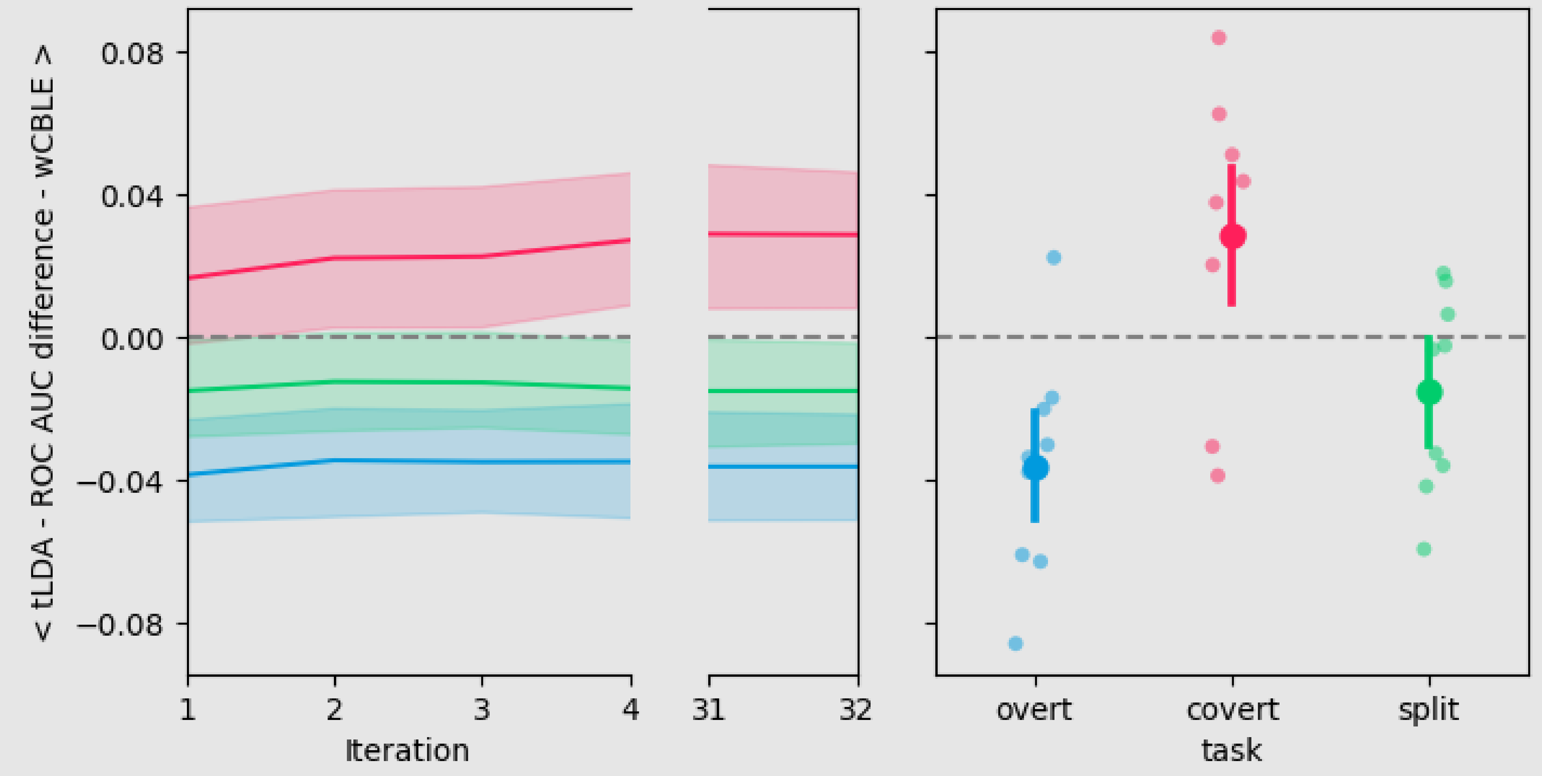


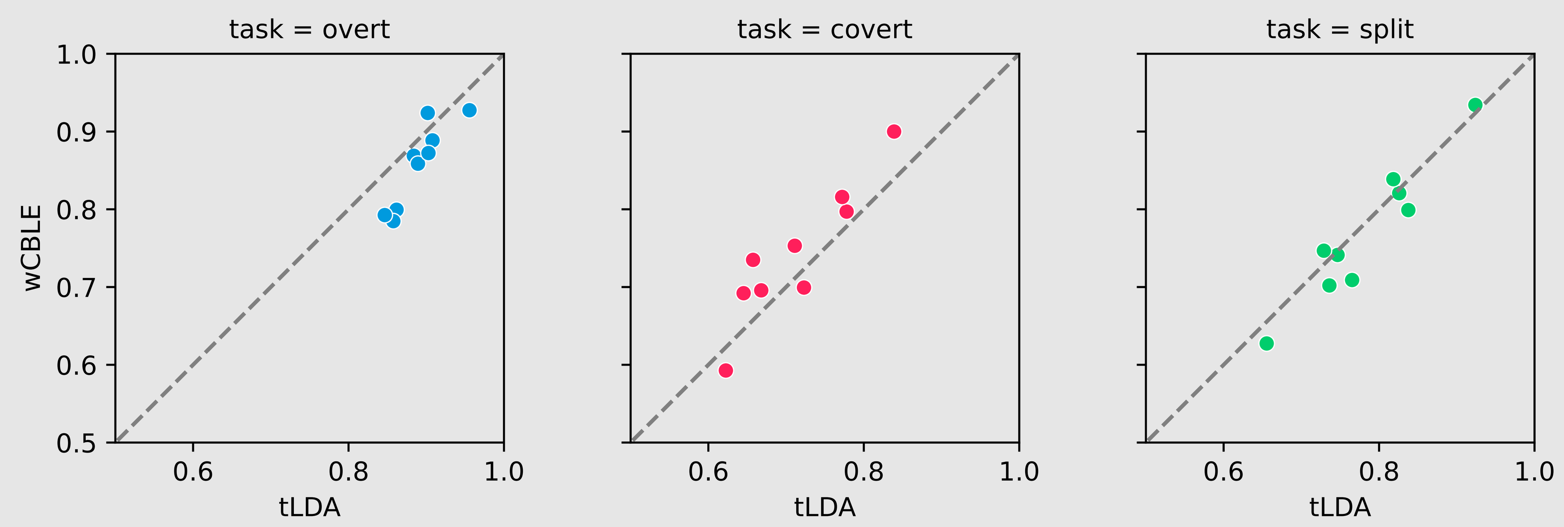
3 Improvement in covert attention decoding

Preprocessing

1. Band-pass filter between 0.5 and 32Hz
2. Resample to 64Hz
3. ICA eye artifact rejection
4. Remove bad trials according to eye-tracker
5. Subtract non-target average

Single trial classification performance





While covert attention decoding performance is significantly improved, there is a significant decrease in overt attention performance. This is probably due to the high contribution of early visual ERP components in overt attention, which are destroyed by the alignment procedure. No significant effect is observed for split attention decoding. Future work will investigate a multi-component approach.

References

[1] P. Aricò et al. “Influence of P300 latency jitter on event related potential-based braincomputer interface performance”. en. In: Journal of Neural Engineering 11.3 (May 2014), p. 035008.

[2] Md Rakibul Mowla, Jane E. Huggins, and David E. Thompson. “Enhancing P300-BCI performance using latency estimation”. In: Brain-Computer Interfaces 4.3 (July 2017), pp. 137–145.

[3] A. Riccio et al. “Eye-gaze independent EEG-based braincomputer interfaces for communication”. en. In: Journal of Neural Engineering 9.4 (July 2012), p. 045001.

[4] Jan Sosulski and Michael Tangermann. “Introducing block-Toeplitz covariance matrices to remaster linear discriminant analysis for event-related potential braincomputer interfaces”. en. In: Journal of Neural Engineering 19.6 (Nov. 2022), p. 066001.