Technische Universität München

Optically Pumped Magnetometers: A New Type of Brain Sensors & How They Help Us Analyze Complex Motor Tasks

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Background

- EEG has been the leading technology in motor-based brain-computer interfaces
- EEG's **low spatial resolution limits** the classification of neural signals stemming from **closely located sources**
- **Optically pumped magnetometers (OPMs)** can potentially overcome this issue with their **higher signal quality** [1]

Data Acquisition

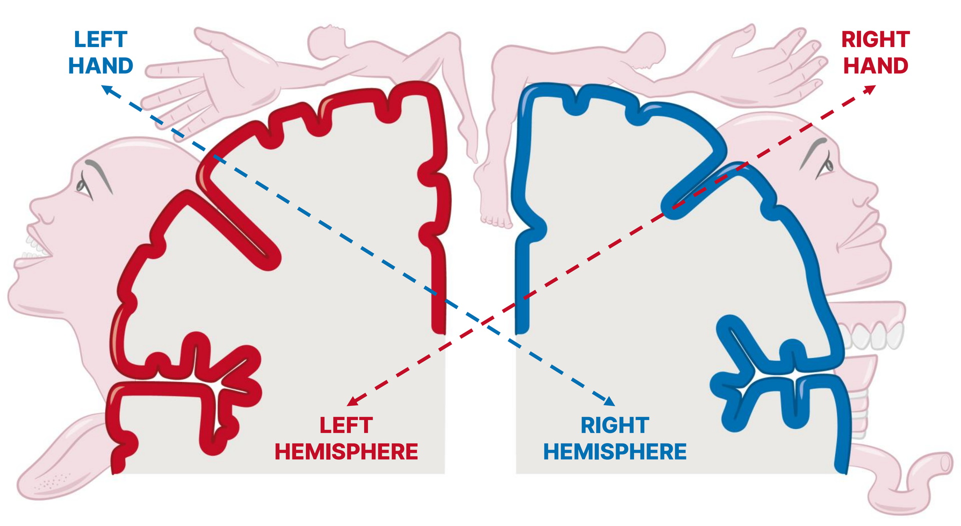
- 720 trials in 4 runs of 10 minutes each
- 1200 Hz sampling rate
- 65 channels each recording along **x, y and z axes**
- 3 classes: **rock, paper, scissors**
- Gestures performed on cue with the **right hand**

Research Questions

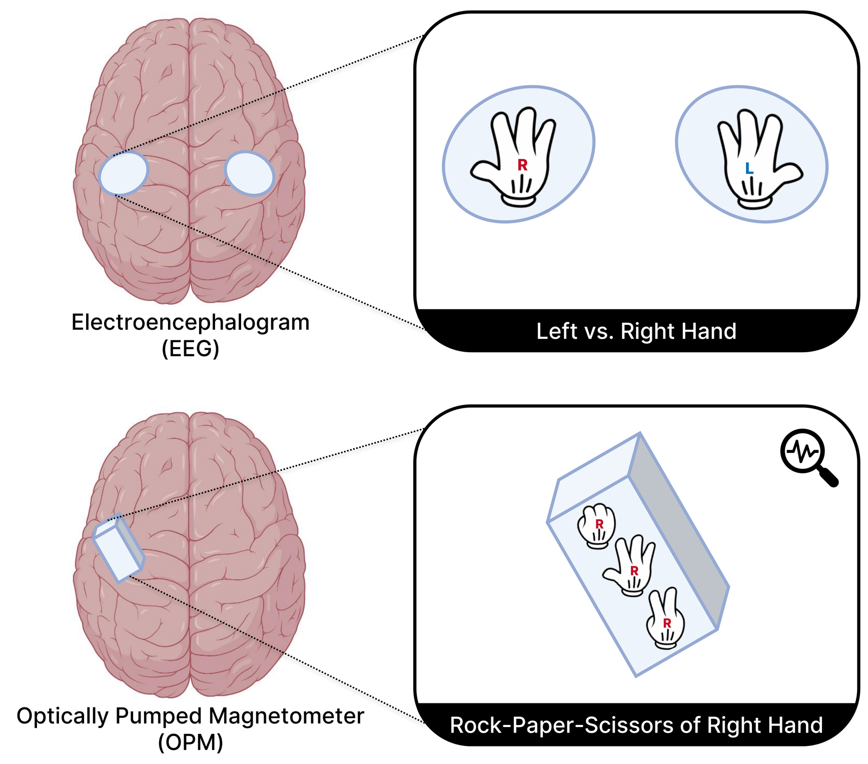
Can OPMs be used for classification tasks that are conventionally not possible with EEG?

Specifically, can OPMs classify rock-paper-scissors gestures from one hand, involving primarily one hemisphere?

In a Nutshell

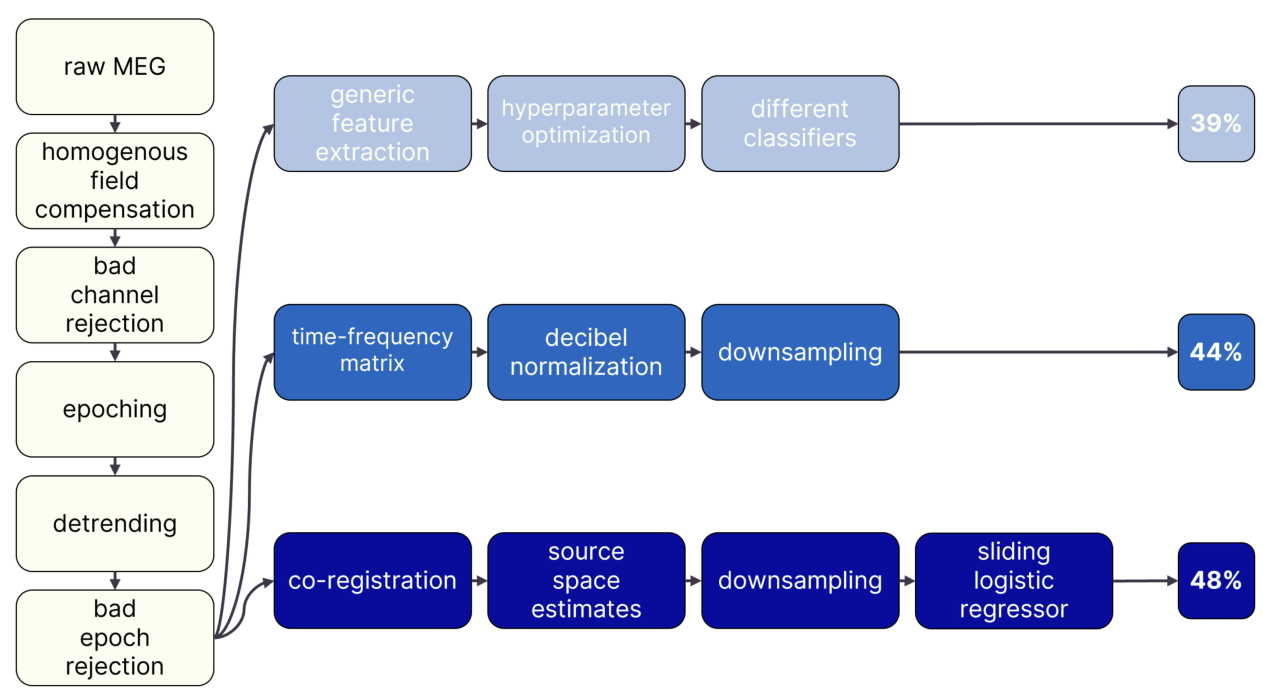


The hands are controlled by **contralateral hemispheres**. [2]



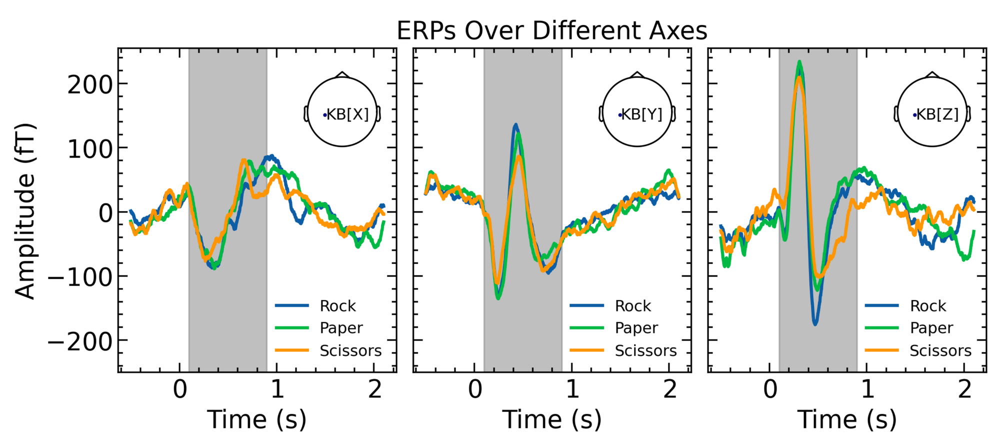
Left- and right-hand signals originate in **separate hemispheres**. EEG's limited spatial resolution suffices to classify these signals.

Signals from **one hemisphere**, like **rock-paper-scissors gestures**, are hard to detect with EEG. OPMs offer a solution.

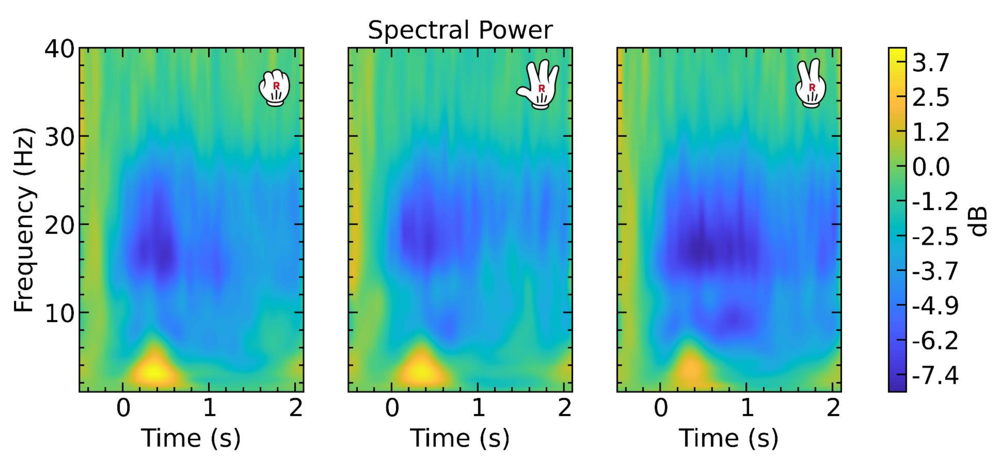


The higher signal quality of OPMs was used to classify rock-paper-scissors gesture executions of the right hand using **three pipelines**.

Sensor Space Analysis



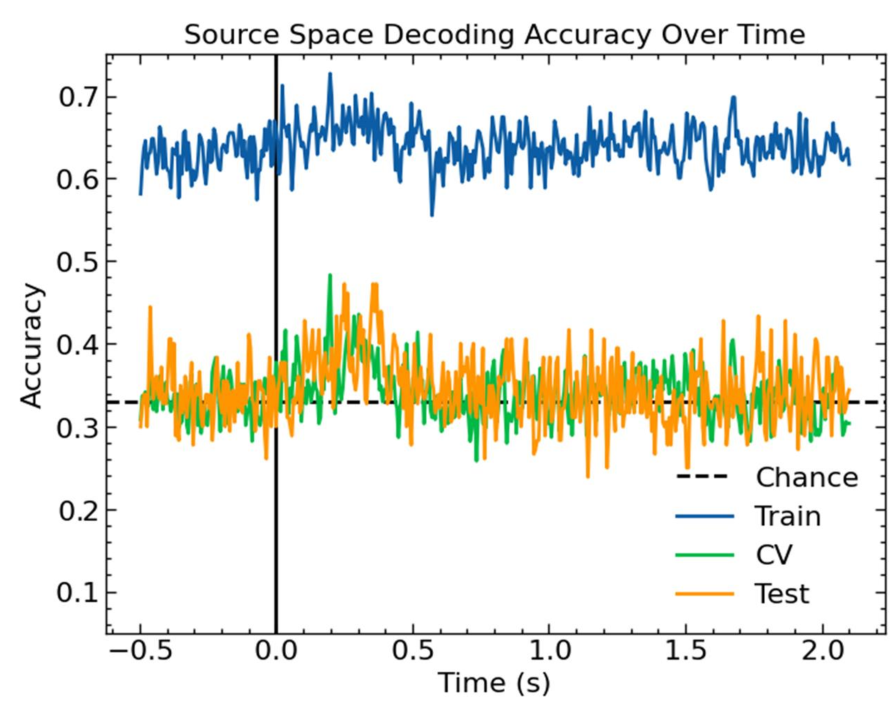
- Task-related **signal modulation within the first second**

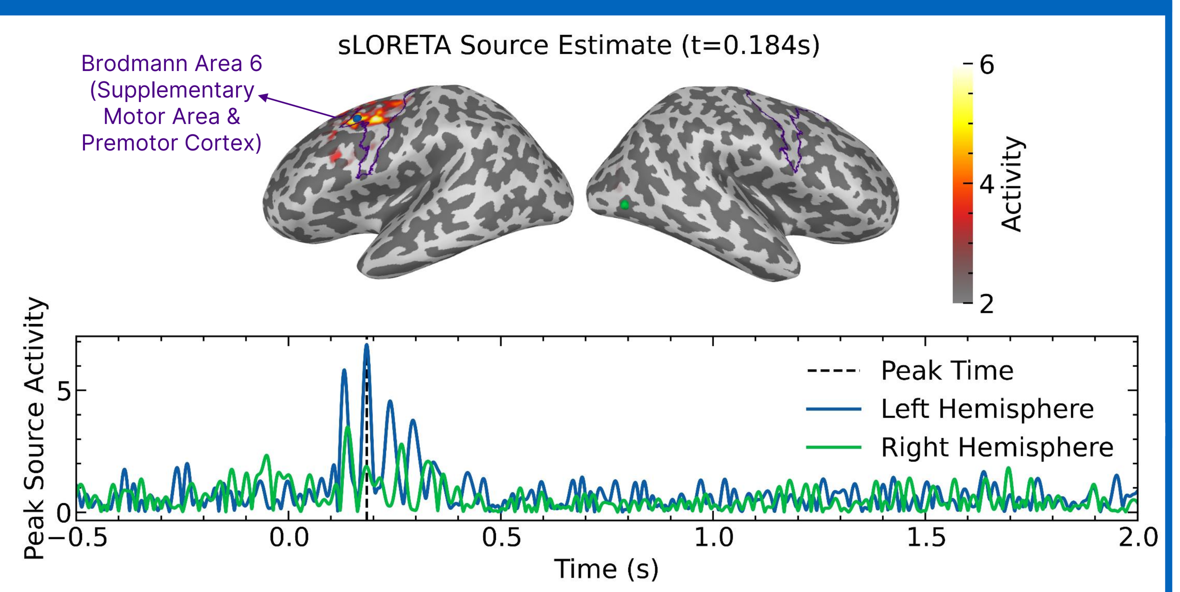


- **Similar ERD patterns** [3] for all classes, strongest power drop for scissors

Source Space Analysis

- High spatial resolution and MRI fitted helmet used for **source localization**
- **Activity within the first second**, consistent with sensor space analysis
- Source space **decoding was highest in the first second**





Conclusion

The classification of **three hand gestures** with spatially close neural origins resulted in a **maximum accuracy of 48%.**

This study highlights **OPM's high signal quality** and thus its **potential use in BCIs.**

Elitenetzwerk Bayern

[1] H. B. Dang, A. C. Maloof, and M. V. Romalis, "Ultrahigh sensitivity magnetic field and magnetization measurements with an atomic magnetometer," Applied Physics Letters, vol. 97, no. 15, p. 151110, Oct. 2010, doi: 10.1063/1.3491215.
[2] J. Nicholas, A. Johannessen, and T. van Nunen, Tactile Working Memory Scale: A Professional Manual. 2019.
[3] G. Pfurtscheller and A. Aranibar, "Event-related cortical desynchronization detected by power measurements of scalp EEG," Electroencephalography and Clinical Neurophysiology, vol. 42, no. 6, pp. 817–826, Jun. 1977, doi: 10.1016/0013-4694(77)90235-8.