Motor-Imagery Brain-Computer Interface Using Optically Pumped Magnetometers

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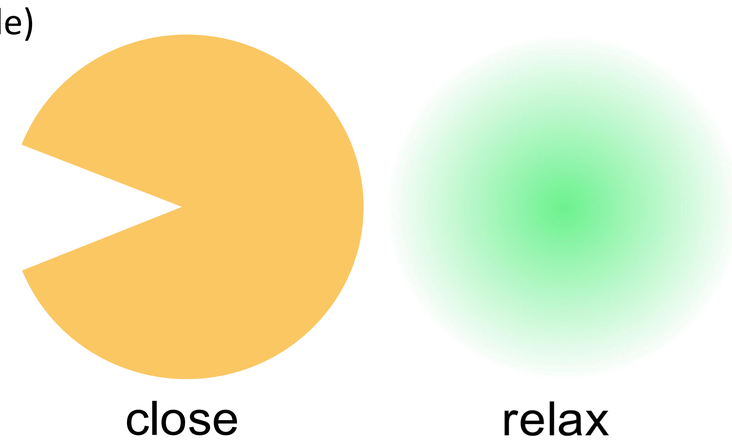
Background

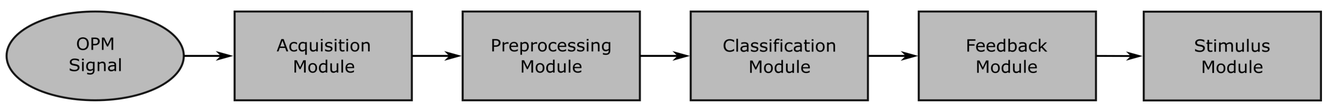
- A simulation study showed that optically pumped magnetometers (OPMs) could reach higher spatial resolution than electroencephalography (EEG) or SQUID-based magnetoencephalography (Boto et al., 2016)
- Motor imagery is associated with modulations of brain oscillations that can be translated into control signals for external devices (brain-computer interface, BCI)
- BCI systems are an important clinical tool for restoration of movement and communication, e.g., after stroke, and can significantly improve quality of life in severe paralysis (Kübler et al., 2016)
- OPM-based BCIs were not established, yet. Here, we investigated OPMs as a new approach for motor imagery-based BCI systems in clinical applications

Methods

- 17 OPMs (FieldLine Inc., Boulder, CO, USA) placed over the motor cortex (C3) of 16 healthy participants (right-handed, 7 female)

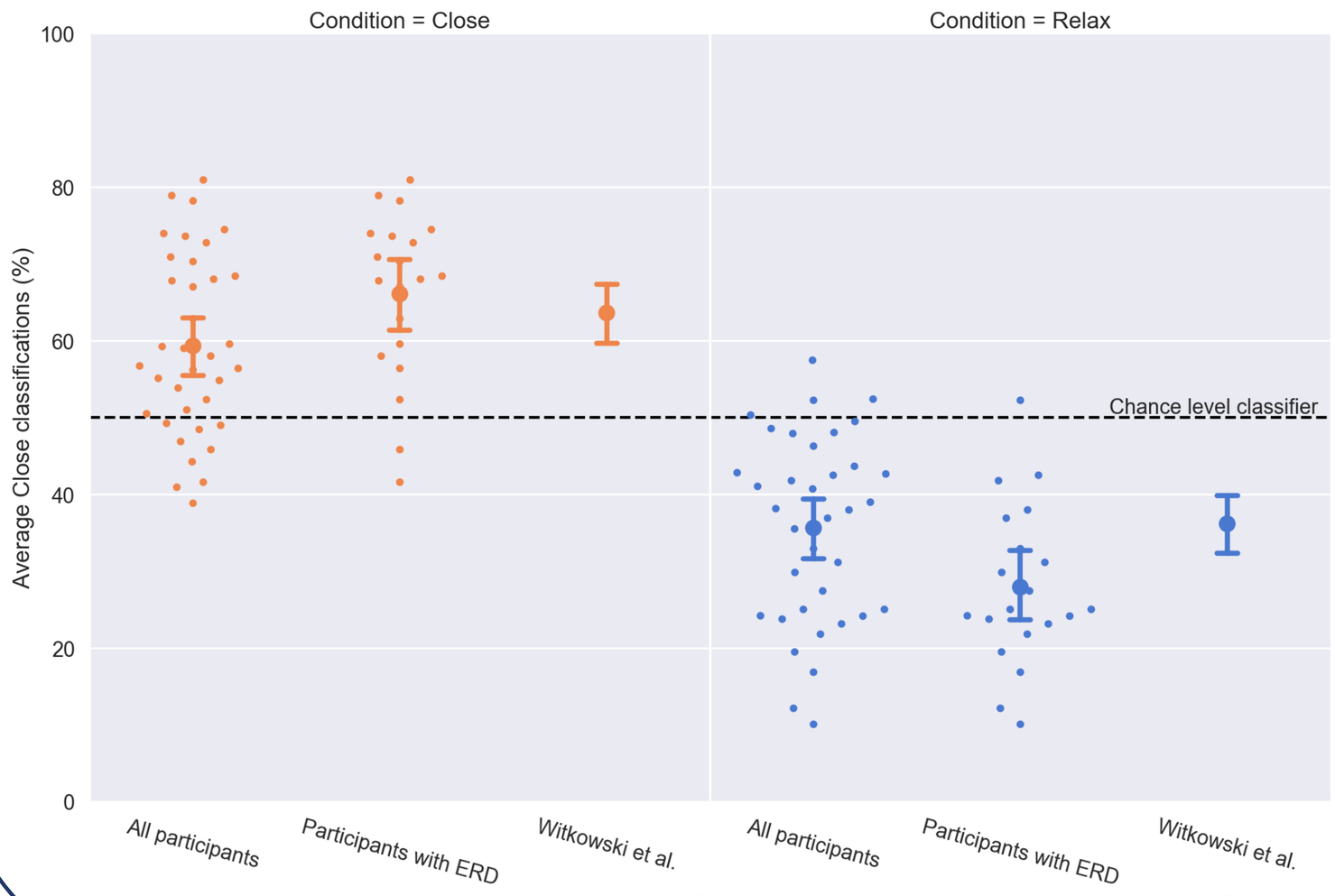


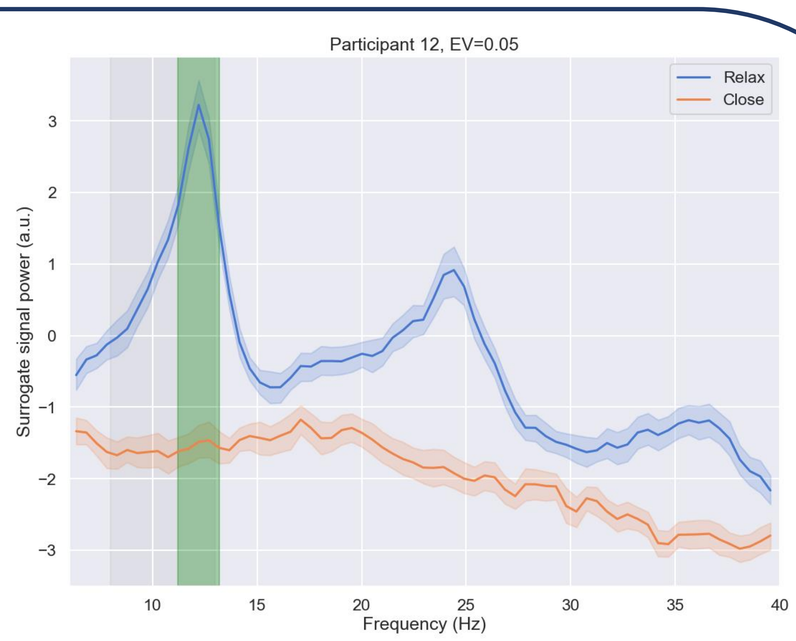
- Motor imagery of grasping movements and relaxation with real-time visual feedback
- Continuous analysis of event-related desynchronization (ERD) for classification

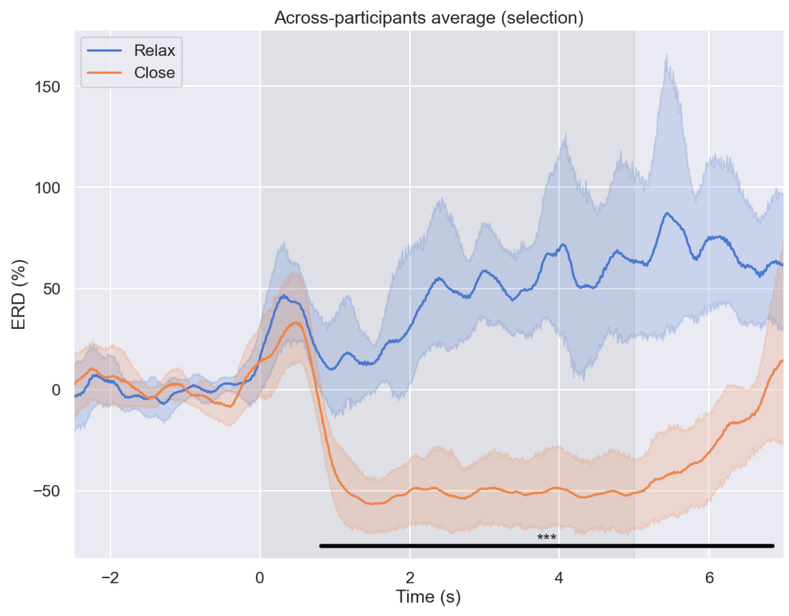


Results

- Distinct motor imagery-related ERD were detected in 10 out of 16 participants
- Motor cortical ERD can be assessed and classified in near real-time using OPMs
- Pipeline performance is comparable with EEG-based BCI systems (Witkowski et al., 2014)







Left panel: Average percentage of Close classifications per trial. Each dot is one participant, the error bars indicate the 95% confidence interval. **Top right panel:** Frequency spectrum over motor cortex after application of CSP for one participant with strong ERD. **Bottom left panel** Trajectory of event-related desynchronization averaged over all participants with significant ERD frequency

Discussion and Conclusions

- **Optically pumped magnetometers allow for real-time classification of motor imagery-related ERD**
- **Classification performance of the presented OPM-based BCI system is comparable with other non-invasive BCI systems (Witkowski et al., 2014)**
- **Improved spatial resolution of OPMs could allow for more degrees of freedom in BCI control, e.g., for assistive devices or motor rehabilitation**
- **More studies are needed to investigate reliability, safety and practicality of OPMs in clinical environments and to explore new methods of data analysis**

References

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