Combining frequency and time-domain EEG features for classification of self-paced reach-and-grasp actions

Andreas Schwarz[1], Joana Pereira[1], Lydia Lindner[1] and Gernot R. Müller-Putz[1]
andreas.schwarz@tugraz.at, gernot.mueller@tugraz.at
[1]*Institute of Neural Engineering, Graz University of Technology, Austria*

European Research Council

Introduction

Recent studies have shown that complex hand movements, such as reach-and-grasp tasks, can be decoded from low frequency activity of the electroencephalogram (EEG)[1]. In this work we investigated whether additional features extracted from the frequency domain of alpha and beta bands could improve classification performance of rest vs. palmar vs. lateral grasp.

Methods

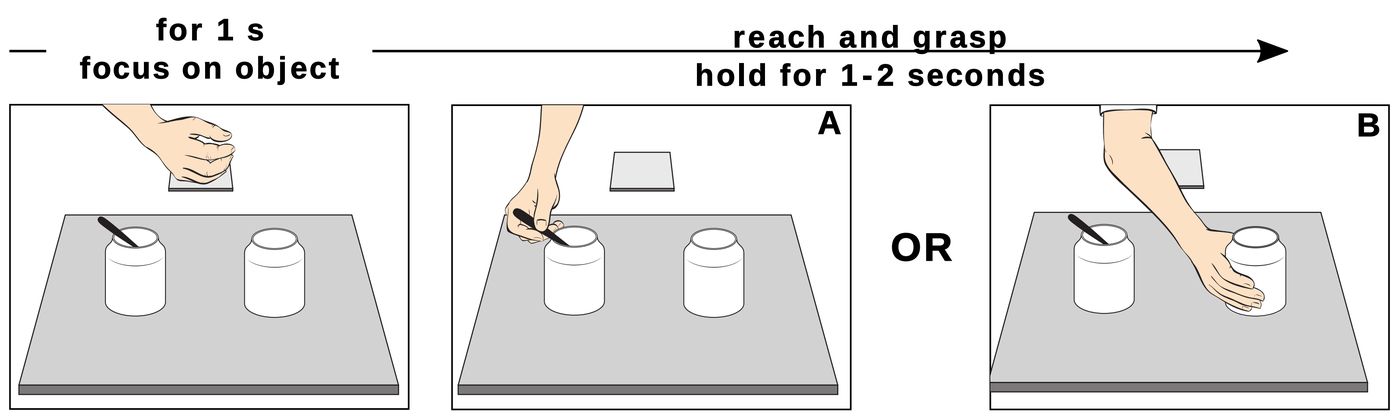

Figure 1: Paradigm: Participants were asked to focus on the object for at least one second before initiating the reach-and-grasp action. They performed a steady reach and grasp towards either a spoon with a lateral grasp (A), or the glass with a palmar grasp(B), followed by a holding period of 1-2 seconds.

In the self-paced experimental setup, 10 healthy participants were asked to perform reach-and-grasps using daily life objects. We recorded 80 trials for each reach-and-grasp conditions and from a no-movement condition. In an offline multiclass classification scenario (10 x 5 crossvalidation), we performed two independent classficiation approaches using different feature sets:

1. Low Frequency Time Domain (LFTD) classification (0.3 - 3 Hz, amplitude values as features, 1 second feature window)
2. Combination of LFTD and bandpower based features from alpha (8-14 Hz) and beta band (17-31 Hz)

Results

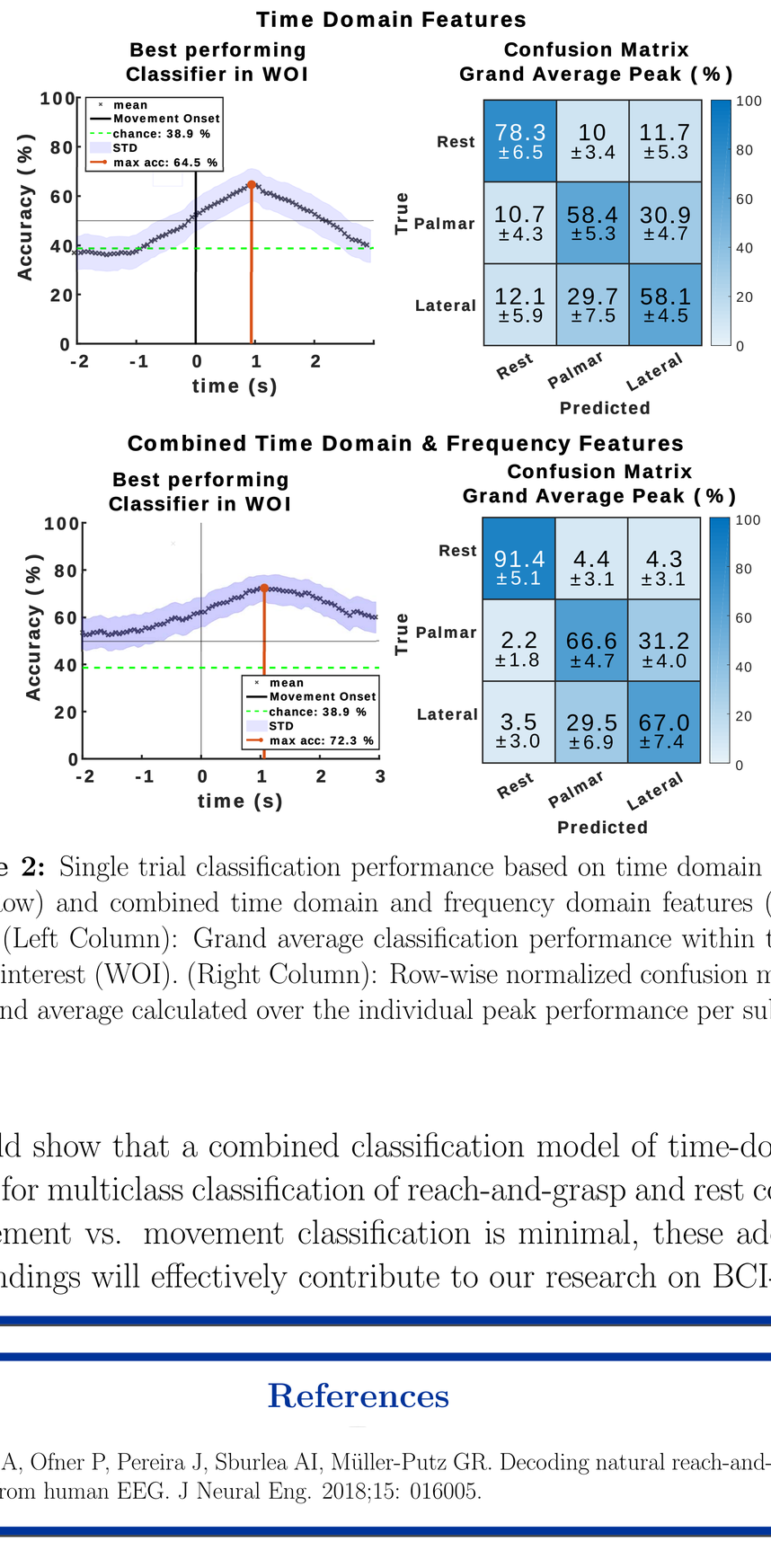

Figure 2: Single trial classification performance based on time domain features (Top Row) and combined time domain and frequency domain features (Bottom Row). (Left Column): Grand average classification performance within the window of interest (WOI). (Right Column): Row-wise normalized confusion matrix of the grand average calculated over the individual peak performance per subject.

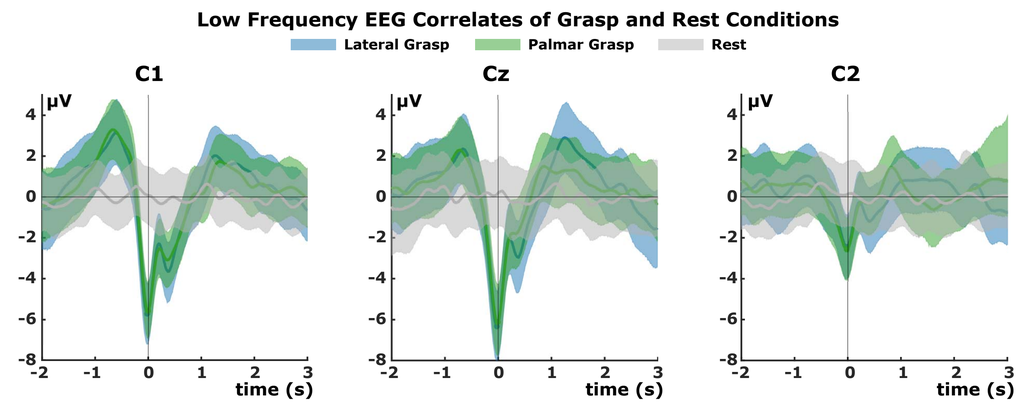

Figure 3: Low frequency EEG correlates of grasp and rest conditions of channels C1, Cz and C2. Colored shaded areas show the confidence interval, bold lines the grand average of the designated reach-and-grasp action. The thin perpendicular line at second zero represents the movement onset.

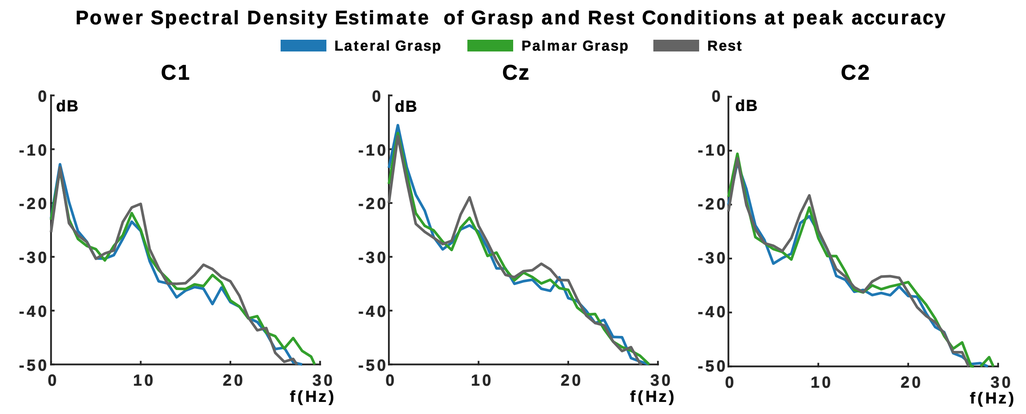

Figure 4: Grand average PSD of the peak accuracy feature window for channels C1, Cz and C2. Bold lines show the condition specific PSDs.

Conclusion

We could show that a combined classification model of time-domain and frequency-domain features leads to significantly higher classification performances for multiclass classification of reach-and-grasp and rest conditions. While the contribution of the frequency-domain features for the classification of movement vs. movement classification is minimal, these additional features considerably boost movement vs. rest classification.We believe that these findings will effectively contribute to our research on BCI-controlled neuroprosthesis for persons with high spinal cord injury.

References

1. Schwarz A, Ofner P, Pereira J, Sburlea AI, Müller-Putz GR. Decoding natural reach-and-grasp actions from human EEG. J Neural Eng. 2018;15: 016005.

Acknowledgments

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