What is the exact relationship between beta band activity and hand motor imagery?

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Introduction: The characterization of the event-related desynchronization (ERD) and synchronization (ERS) phenomena in the mu and beta frequency bands [1] almost three decades ago marked the discovery of the first reliable non-invasive markers of brain activity during motor-related tasks. Since then, the Brain-Computer Interface (BCI) community has heavily relied on band-limited power changes as the classification feature of interest, developing algorithms that best capture relative differences across experimental conditions. However, recent findings in neuroscience have challenged the idea that signal power best describes the movement-related modulation of brain activity, especially in the beta frequency band. Beta band activity has been shown to occur in short, transient events rather than sustained oscillations on a single-trial level [2]. This finding implies that the ERD/S patterns only emerge as trial-averaged activity markers and that signal power may, thus, not be able to capture all relevant brain activity modulations during motor-related tasks. The analysis of beta band burst activity has the potential to provide access to activity markers that are at least as sensitive as beta power in terms of classification, and that could describe more subtle changes of condition-specific activity.
Material, Methods, Results: Pursuing this hypothesis, we analyzed the activity of channels C3 and C4 during "left" and "right" hand motor imagery from an open EEG dataset [3]. Using a new burst detection and waveform analysis algorithm [4], we show that classification features that describe the modulation of burst rate for bursts with distinct waveforms can be more informative than beta band power and are more reliable than conventional burst activity representations such as the overall burst rate, burst peak amplitude, and the temporal and frequency spans of bursts (see Fig. 1).
Discussion: These results shed light on the non-linear relationship between beta burst activity and band power, emphasizing that the field of BCI can benefit from incorporating recent neurophysiological findings.
Significance: This work serves as a proof-of-concept for constructing a suitable-for-classification representation of beta burst activity in the context of motor-related BCI paradigms.

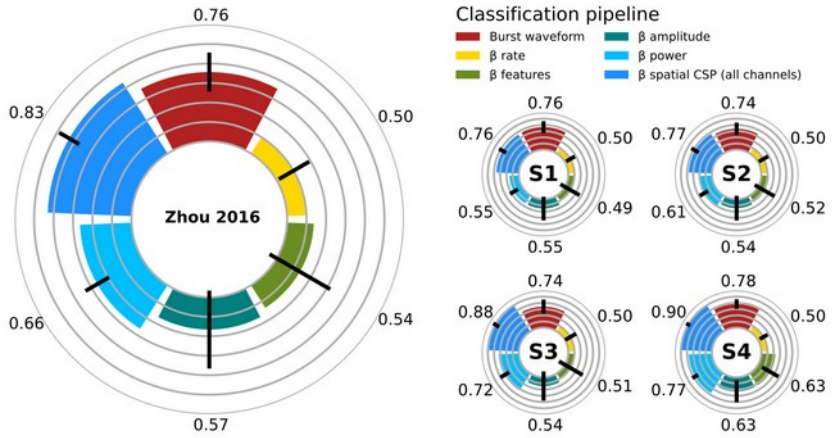

Figure 1. Average and subject-specific classification scores based on different feature extraction algorithms for the Zhou 2016 open motor imagery dataset in "left vs right hand" task.

References
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