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# Denoising acoustic-induced vibration artifact in intracranial EEG recordings via a phase-coupling decomposition method

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*Introduction:* Intracranial electroencephalography (iEEG) recordings offer enhanced characterization in the spatial, temporal, and spectral domains of the neuronal populations supporting cognition, language and speech. Most of the brain-computer interfaces (BCIs) for speech prosthesis are based on iEEG signal decoding. Nevertheless, it has been shown that acoustic-induced vibration artifacts may affect up to 50% of the iEEG channels during recordings of overt-speech tasks [1]. Thus, there is a need to remove acoustic-induced artifacts from iEEG signals. In this work, we present a denoising method - phase coupling decomposition (PCD) - for artifact removal of acoustic-induced vibrations. The artifactual iEEG recordings show a high phase-coupling coherence in the $\gamma$-band (70 – 250 Hz) with respect to the produced audio [1]. Thus, PCD seeks statistical components with the highest phase-coupling values with respect to the acoustic signal. Here we validate PCD as a valuable pre-processing tool for speech decoding from neural activity.

*Material, Methods and Results:* PCD is a data-driven spatial filtering denoising method based on low-rank factorization. Spatio-spectral decomposition (SSD) [2] is first used to enhance signal-to-noise ratio around the $\gamma$-band and to reduce dimensionality. Phase-coupling optimization (PCO) [3] is then applied to identify sources phase-locked to the acoustic signal. Data consisted of iEEG recordings from 54 patients performing a syllable triplet repetition task [1]. Data cleaning was assessed based on the percentage of clean electrodes with respect to raw data (% gain). Common average reference (CAR) and independent decomposition analysis (ICA) were applied for comparison. The effect of applying each denoising method (CAR, ICA, PCD) as a pre-processing step in a BCI deep learning model [4] for consonant decoding was also evaluated. Results showed that CAR can increase the number of affected electrodes by spreading the artifact presented in "common noise". Although ICA showed the highest reduction in the number of artifact-affected channels (% gain ICA = 21.4 > % gain PCD = 14.7), consonant decoding performance was reduced due to strong degradation of physiological $\gamma$-band modulations.

*Discussion:* While traditional denoising method can jeopardize signal quality, PCD can significantly reduce the strength and extent of the vibration artifact while preserving the underlying neural activity related to speech.

*Significance:* PCD is the first method specifically designed to denoise acoustic-induced vibration artifacts in brain recordings and can be safely used as a pre-processing step for iEEG-based speech decoding.

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