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Music rhythm reconstruction from ECoG

C. Herff[1*], G. Johnson[2], J. Shih[3], T. Schultz[1], D. Krusienski[2]
[1]University of Bremen, Bremen, Germany; [2]Old Dominion University, Norfolk, VA, USA; [3]Mayo Clinic, Jacksonville, FL, USA

*Enrique-Schmidt-Str. 5, 28309 Bremen, Germany. E-mail: christian.herff@uni-bremen.de

Introduction: Imagine being able to record the music you're humming in your head and play it back to others. Prior neuroscientific studies have highlighted auditory processing in the brain in relation to speech [1,2,3] and demonstrated that envelope and spectral properties of perceived speech could be reliably reconstructed. Other studies showed successful reconstruction of acoustic properties from speech production [4] and automatic speech recognition of entire phrases [5]. Perception of melodies and rhythm is generally ubiquitous in humans across age and culture and should also lead to robust representations in neural data. However, only a few studies have investigated neural responses to complex musical stimuli in electrocorticography (ECoG) [6] and have not investigated rhythms and melodies indepentently. Numerous studies exist investigating different aspects of music perception using functional Magnetic Resonance Imaging (fMRI) or the scalp electroencephalogram (EEG), but both of these technologies have limitations in either spatial or spectral resolution, which are necessary for the investigation of the fast processes underlying music perception and production. ECoG, on the other hand, measures high spatial and temporal resolution electrical potentials unfiltered by the skull and scalp, which is more ideal for the investigation of music. Here we investigate cortical responses to perceived drum rhythms and demonstrate reconstruction of the perceived rhythm sound intensities. The investigated drum rhythms lack the rich melodic and harmonic information present in previous studies. Reconstruction of this very simple musical stimuli therefore illustrate basic rhythm perception.

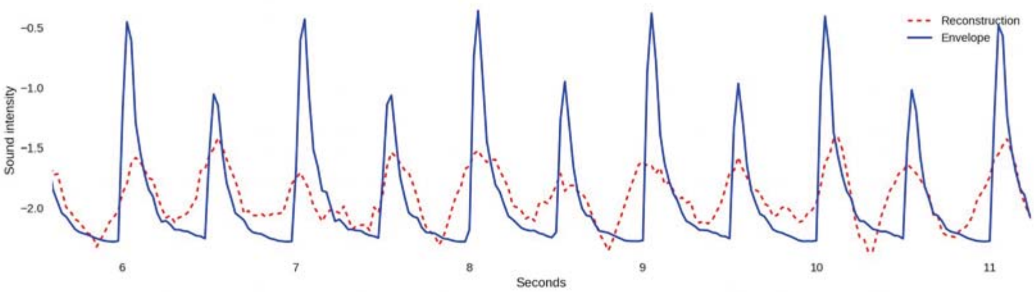

Figure 1. *Drum envelope (blue) and reconstructed (red-dotted) envelope based on high-gamma activity in ECoG electrodes*.

Material and Methods: We presented a simple drum rhythm to seven participants undergoing surgery for intractable epilepsy. Subjects had between 34 and 96 subdural ECoG electrodes implanted (3 left, 4 right hemisphere, frontal; parietal and/or temporal areas covered), based on the clinical need. The sound envelope was extracted using the Hilbert transform in 50 ms windows. We extracted broadband-gamma (70-170 Hz) power in 50 ms windows and time-aligned the ECoG activity to the presented sound stimuli.

Results: We evaluated the possibility to reconstruct perceived sound intensity from the gamma power features across spatial channels using Lasso regression, and evaluated the correlation coefficients (Spearman's r) between actual sound intensity and reconstructed envelope. Statistically significant ($p<0.01$) correlations could be achieved for all subjects with correlations coefficients up to *0.45* (mean *0.15*). Figure 1 illustrates the drum envelope (blue) and the reconstruction (red) from ECoG signals.

Discussion: We show that neural data measured directly from the cortex using ECoG can be used to accurately reconstruct the intensity of a repetitive drum stimulus.

Significance: This is a first step towards synthesizing musical rhythms from mental imagery using intracranial signals by reconstruction very basic musical phenomenon.

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