Semantic speech decoding from intracortical recordings during natural speech production

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Executive Summary

Brain-machine interfaces (BMIs) allow for direct communication between the brain and external devices, offering a powerful solution for restoring communication and thereby significantly improving the quality of life in individuals with severe communication impairments. Speech decoding, specifically, can help individuals that lost the physical ability to speak but maintain intact underlying cognitive abilities, to regain the ability to communicate over speech.

Advances in the field of machine learning provide us with opportunities to explore even the most intricate facets of speech decoding. However, little focus has been placed on decoding speech from stereoencephalography (sEEG) brain recordings, commonly used in clinical settings. These are intracranial recordings of neural activity captured by thin depth electrodes implanted inside the brain, with placement and quantity tailored to each patient's medical needs.

Speech can be divided into two components: a lower level motor activity and a higher-level cognitive process. Since higher-level cognitive processes are widely distributed across the brain: it is therefore of interest to decode speech from sEEG. Relying on computational word embedding models to transform the recorded speech into a mathematically tangible concept, we can build classification models to decode the semantic categories of the spoken words at accuracies significantly higher than chance.

Our findings show that widespread regions of the brain as well as a large range of frequency bands contain speech-related content in sEEG recordings, providing opportunities for speech BMI improvement. Whereas most research in the field focuses on heavily stereotyped tasks, this work relied on a natural, unrestricted conversation task, where each participant was freely speaking to an experimenter, attempting to approach real-world conditions where BMIs would be applied.

For those interested in learning more about communication BMIs, I encourage exploring the BrainGate trials. BMIs exemplify the profound impact that the synergy between engineering and neuroscience can have on improving patients' lives.