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Single unit recordings reveal high level role of precentral gyrus in speech production

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Introduction: Recently, we showed that intracortical recordings from ventral precentral gyrus (vPCG) can be used to decode speech in real-time at high accuracy [1]. However, the representation of speech at a neural ensemble level has not yet been well described. Here, we show that neural population activity contains a simultaneous representation of up to four syllables of the upcoming word, and that preparatory activity is highly correlated with execution-period activity. These results suggest a higher-level role for vPCG in speech production than previously hypothesized.

Material, Methods, and Results: A Braingate participant with anarthria due to bulbar ALS received two Utah arrays in vPCG. We instructed her to attempt to speak four syllable nonsense words with balanced combinations of phonemes while recording multi-unit threshold crossings from 128 electrodes. We observed phoneme-specific tuning to all four syllables during motor preparation (Fig 1A, blue bars). However, when the syllables were separated into two words, we did not observe phoneme-specific activity for the second word (Fig 1A, orange bars). Additionally, using linear discriminant analysis, we applied phoneme decoders to preparatory and execution related activity and found that they generalized well across contexts (Fig 1B).

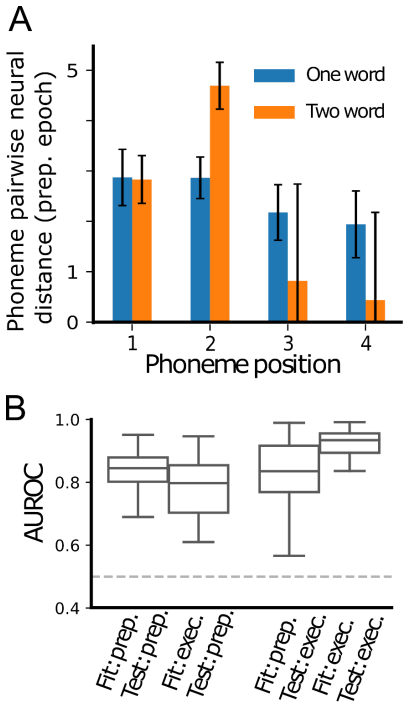

*Figure 1: **A)** Attempted speech of 4 syllable nonsense words has encoding for all syllable postions. When broken into two 2 syllable words, only the first word was encoded. **B)** Decoders fit to preparatory (execution) activity had median crossvalidated AUROC of 0.83 (0.80) for prediction of phonemes during execution (preparation)*

Discussion: We observed that vPCG encodes long sequences of phonemes, but not for more than one word into the future. A low level representation of articulators would predict orthogonal subspaces for preparation and execution as observed in non-human primate dorsal premotor cortex [2]. Instead, vPCG represents phonemes similarly during motor preparation and execution. This suggests that vPCG plays a higher role in the hierarchy of speech production than simply generating the immediately upcoming articulatory motor commands (as predicted by fMRI [3]).

Significance: Further elucidating the role of this region in the speech production hierarchy could facilitate the development of more reliable and faster speech prostheses.

References:

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