CHARACTERISTIC TIME COURSES OF ELECTROCORTICOGRAPHIC SIGNALS DURING SPEECH

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ABSTRACT

Electrophysiology has produced a wealth of information concerning characteristic patterns of neural activity underlying movement control in non-human primates. Such patterns differentiate functional classes of neurons and illuminate neural computations underlying different stages of motor planning and execution. The scarcity of high-resolution electrophysiological recordings in humans has hindered such descriptions of brain activity during uniquely human acts such as speech production.

The goal of this dissertation was to identify and quantitatively characterize canonical temporal profiles of neural activity measured using surface and depth electrocorticography electrodes while pre-surgical epilepsy patients read aloud monosyllabic utterances. An unsupervised iterative clustering procedure was combined with a novel Kalman filter-based trend analysis to identify characteristic activity time courses that occurred across multiple subjects. A nonlinear distance measure was used to emphasize similarity at key portions of the activity profiles, including signal peaks. Eight canonical activity patterns were identified. These activity profiles fell broadly into two

classes: symmetric profiles in which activity rises and falls at approximately the same rate, and ramp profiles in which activity rises relatively quickly and falls off gradually. Distinct characteristic time courses were found during four different task stages: early processing of the orthographic stimulus, phonological-to-motor processing, motor execution, and auditory processing of self-produced speech, with activity offset ramps in earlier stages approximately matching activity onset rates in later stages. The addition of an anatomical constraint to the distance measure to encourage clusters to form within local brain regions did not significantly change results. The anatomically constrained results showed a further subdivision of the eight canonical activity patterns, with the subdivisions primarily stemming from sub-clusters that are anatomically distinct across different brain regions, but maintained the base activity pattern of their parent cluster from the analysis without the anatomically constrained distance measure. The analysis tools developed herein provide a powerful means for identifying and quantitatively characterizing the neural computations underlying human speech production and may apply to other cognitive and behavioral domains.