Human Laryngeal Cortex in Vocal Pitch Production

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Speakers use vocal pitch to communicate various aspects of meaning, including mood, emphasis, and syntactic structure. Furthermore, precise control of pitch is thought to have been one of the first evolutionary changes in vocal control that ultimately led to human-specific speech abilities. Despite the importance of pitch control in speech production, its neural mechanisms remain poorly understood. To address this, we use electrocorticography (ECoG) to understand the cortical representation of vocal pitch in humans.

Ten subjects were implanted unilaterally with ECoG arrays as part of their treatment for epilepsy (5 left hemisphere). We recorded ECoG while subjects produced spoken utterances. In one task, subjects produced the sentence ?I never said she stole my money?, and were cued to emphasize specific words on a trial-by-trial basis. In a second task, the subjects sang a pitch pattern alternating between ?do mi so mi do? and ?so mi do mi so? (singing task). To understand how electrodes in the ventral sensorimotor cortex control vocal pitch during speaking, we used multivariate regression to predict the high-gamma (HG; 70-150Hz) neural signal from the pitch pattern 200ms into the future.

We found that the produced pitch contour significantly predicted activity in two focal cortical areas that straddled the primary motor homunculus. The first group of electrodes was on the dorsal precentral gyrus, a region that has been implicated in other types of laryngeal control, including voicing and glottal stops (Brown et al., 2008). Pitch control in this upper laryngeal region was particularly prominent in the right hemisphere. We investigated the encoding of pitch patterns using the Fujisaki model of pitch production, and found that the dorsal area encodes both phrase and accent pitch gestures, while the ventral laryngeal area encodes primarily phrase. The activation of the dorsal laryngeal cortex was also correlated with produced pitch during singing, which suggests that this neural mechanism for pitch control extends to non-speech contexts.