

## **Temporal dynamics of /æ/ tensing in North American English: An ultrasound study**

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While ultrasound has established itself as a tool for variation research, traditional methods focus on tracing mid-sagittal contours of individual frames of speech sounds, disregarding the temporal aspect of speech. We introduce a method for generating and analyzing time-varying articulatory signals (superficially similar to point tracking data) directly from ultrasound video. The procedure is analogous to generating spectrograms from an acoustic waveform, bringing the study of articulatory variation close to the temporal resolution possible in acoustic studies of formant trajectories.

Articulatory trajectories are extracted as follows: A Principal Component Analysis is performed on the pixels in a region of interest in each of a set of ultrasound images. The first 20 principal components (representing independent axes of variance in the tongue positions) are retained as inputs into Linear Discriminant Analysis with classes based on place of articulation. The result is a time-varying representation of the degree to which the imaged vocal tract matches several articulatory configuration, with a temporal resolution of 60 Hz.

We demonstrate this technique with a study of North American English /æ/, which is tensed before different sets of consonants in different varieties, for reasons that are mysterious, in part because the acoustic correlates of raising can be attributed to nasalization, tongue raising, and other factors. Our study is based on 17 speakers exhibiting distinct regional patterns of /æ/ tensing (including the nasal system of the South and Midlands, pre-velar tensing from the North and Northwest, and the Philadelphia system). Our results show that /æ/ tensing before /m n/ involves a tongue raising gesture that is aligned to the vowel nucleus, while tensing before /g/ involves anticipatory raising toward the velar target. /ŋ/ patterns consistently with the other velar rather than the other nasals.