Identifying consonantal tasks via measures of tongue shaping: a real-time MRI investigation of the production of vocalized syllabic /l/ in American English

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LATERALS ACROSS SYLLABLE POSITIONS

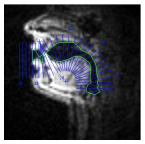
- Laterals: complex tongue shaping through coordination of multiple lingual gestures for side channel airflow
- Consonantal gesture: central constriction between tongue tip and alveolar ridge
- Vocalic gesture: retraction of tongue body
- English /l/ may occur in all syllable positions, including nucleus of unstressed syllables
- /l/-vocalization: tongue tip constriction significantly reduced or completely lost (attested in coda position)
- How does position in syllable nucleus affect production of consonantal element of /l/?
- Does /l/-vocalization completely delete/suppress the consonantal tongue tip gesture of /l/?

DATA

- Images from MRI-TIMIT database at USC: phonetically balanced corpus of 460 sentences
- Two female speakers of American English
- Tokens of /l/ across several syllable positions: onset, intervocalic/ambisyllabic, nucleus, coda

IMAGE ACQUISITION & ANALYSIS

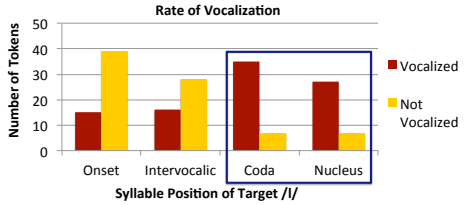
- Real-time MRI with view of entire vocal tract
- Temporal resolution: 23.18 frames per second
- Field of view: 68 x 68 pixels (200 x 200 mm)
- Lay grid of ≈30 lines orthogonal to vocal tract



- Air/tissue boundaries for upper and lower surfaces of vocal tract found for each gridline

RATE OF VOCALIZATION

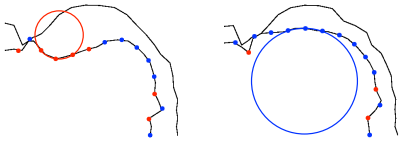
- Vocalization: no contact between tongue tip and palate
- Non-coronal-adjacent tokens of /l/ (adjacent coronals may influence tongue tip gesture of /l/)



- Substantially greater rate of vocalization in coda and nucleus positions than in onset and intervocalic/ambisyllabic positions

MEASURING TONGUE SHAPING

- Downsample tongue contour to fifteen evenly spaced points
- Calculate radius of circle passing through each set of three contiguous points along tongue



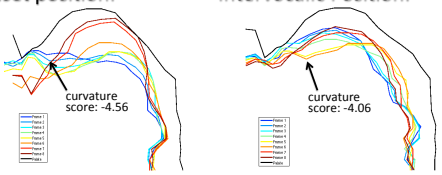
(a) (b)
Comparison of tongue shaping of /l/ in 'lack' (a) and first /d/ in 'deadline' (b)

- Curvature score = $\frac{100}{\text{radius}}$
- Negative curvature score if circle lies outside of tongue contour (as in /l/)
- Positive curvature score if circle lies within tongue contour (as in /d/)
- High-magnitude negative curvature captures maximal curling of tongue during production of /l/

TONGUE SHAPING OF NON-VOCALIZED /l/

- Majority of /l/ tokens in onset and intervocalic/ambisyllabic positions produced with tongue body retraction and tongue tip closure
- All tokens produced with some curling (measured by negative curvature) along tongue blade

Onset position: Intervocalic Position:

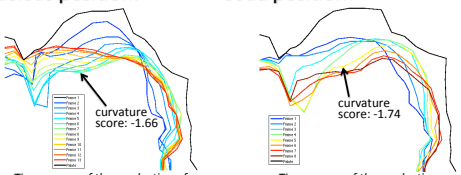


Time course of the production of 'lack' [læk] *Time course of the production of 'silly' from [ɪ] to [i]*

TONGUE SHAPING OF VOCALIZED /l/

- Majority of /l/ tokens in coda and nucleus positions produced without tongue tip closure or even raising of tongue tip toward palate
- All tokens produced with some curling along tongue blade as well as tongue body retraction

Nucleus position: Coda position:



Time course of the production of the final syllable of 'unbeatable' *Time course of the production of 'the wall,' from [ð] to [l]*

CONSONANTAL MANIFESTATION OF /l/

- May not be apparent from formation of constriction alone—tongue curling through blade lowering instead
- Lack of tongue tip constriction: blade lowering/tongue curling does not achieve opening of side channels for lateral airflow—what is being achieved?