The Role of Tongue Root in Laryngeal Contrasts:
An Ultrasound Study of English, Spanish, Hindi, and Korean
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Background. Many languages have a phonological voicing contrast in stops, but phonetic implementation of voicing varies cross-linguistically. For example, Spanish exhibit phonetic voicing (vocal fold vibration during closure) for stops with the feature [voice]. In English, however, phonemically voiced stops are often phonetically voiceless, especially in utterance-initial position (Lisker & Abramson, 1964). Utterance-initial position is the ideal context to test whether or not a language has pre-voiced stops because ‘active voicing’ gestures by speakers are needed in this position (Beckman et al., 2013). One adjustment speakers can make to initiate or maintain phonation during closure is enlarging the supraglottal cavity volume primarily via tongue root advancement (Westbury, 1983). This mechanism also facilitates short-lag voice onset time (VOT) because it takes less time for pressure to fall sufficiently to initiate vocal fold vibration when the supraglottal cavity is larger and air pressure there is lower (Cho & Ladefoged, 1999). The current study explores the phonetic target of voiced stops in languages with different laryngeal contrasts and how the tongue root is employed to reach a phonetic target, comparing alveolar stops in utterance-initial position.

Hypothesis. This study focuses on whether voiced stops show tongue root advancement compared to voiceless stops (Spanish, English, Hindi) and whether voiceless unaspirated stops have an advanced tongue root compared to voiceless aspirated stops (Hindi, Korean). If both Spanish and English speakers show tongue root advancement for [voice], it would suggest that the phonetic target of [voice] is implemented in the same way, at least in terms of tongue root position, even though English unphonated voiced stops are often phonetically similar to Spanish unaspirated voiceless stops. On the other hand, if tongue root advancement is only shown for Spanish, it would suggest that tongue root advancement is only implemented for actual phonetic voicing. If a Hindi speaker shows more advanced tongue root in voiced stops (voiced stops > voiceless unaspirated stops > voiceless aspirated stops), it might suggest that the tongue root advancement gesture is gradient and can facilitate a three-way contrast as well. On the other hand, if Hindi shows tongue root advancement only for voiced stops, it would suggest that tongue root advancement is one of a variety of maneuvers speakers may use to implement phonological laryngeal contrasts.

Method. Ultrasound imaging and acoustic measures are used to examine how tongue position corresponds to phonation. Eight speakers of American English recorded voiced and voiceless alveolar stops in utterance-initial position. Three Spanish speakers, 1 Korean speaker, and 1 Hindi speaker also recorded stops in their language. Smoothing Spline ANOVA was used to compare the average contours between stops (Gu, 2002; Davidson, 2006).

Results. Ultrasound images showed that in English, a distinction in tongue root position exists between voiced stops and voiceless stops. Figure 1 demonstrates that phonated (green curves) and unphonated (blue curves) voiced stops show more advanced tongue root than voiceless stops (orange curves). Acoustic results showed that 7.3% of stops were phonated. Even without acoustic phonation during closure, the tongue root is advanced for voiced stops in comparison to voiceless stops. These results indicate that a short-lag VOT may be the target for phonated and unphonated stops, and phonation during closure in English is accidental or due to a separate articulatory adjustment.

Figure 1. Phonated /d/ vs. unphonated /d/ vs. voiceless /t/ (SS ANOVA plots of two speakers)
Pilot data on Spanish (Figure 2) show that the tongue root is advanced in phonated voiced stops (blue curve) compared to (unaspirated) voiceless stops (orange curve). Spanish unaspirated voiceless stops are phonetically similar to English unphonated voiced stops, but the tongue position is different in these two languages when they are compared to the phonated voiced stop in their respective language. The difference is that phonated and unphonated voiced stops are variant realizations of the same phoneme in English (thus have same tongue root position), whereas phonated voiced stops and unaspirated voiceless stops are different phonemes in Spanish (thus have different tongue root position). This indicates that the difference in tongue root position reflects the phonological laryngeal contrasts of English and Spanish.

Figure 2. Spanish voiced /d/ vs. voiceless /t/ (SS ANOVA plots of two speakers)

Pilot data on Hindi (Figure 3) show tongue root advancement in phonated voiced stops (blue curve) and voiced aspirated stops (orange curve) regardless of aspiration. Also, tongue root position among voiceless stops does not exhibit differences based on aspiration (pink curve vs. gray curve). This suggests that tongue root advancement aids phonation during closure but not short-lag VOT in Hindi.

Figure 3. Hindi Voiced /d/ vs. voiced aspirated /dh/ vs. voiceless /t/ vs. voiceless unaspirated /th/

Pilot data on Korean show that the tongue root is advanced in tense stops, which have the shortest positive VOT compared to lenis or aspirated stops, which have a longer VOT. These results confirm that tongue root advancement facilitates short-lag VOT as well as phonation during closure.

Discussion. Results show that tongue root advancement can facilitate phonation as well as short-lag VOT, the latter of which has not received much attention in previous literature. Articulatory differences align with a more abstract two-way laryngeal distinction that is the same for Spanish and English even though acoustics are different. However, in a given language, tongue root advancement can be used for one or the other, but not for both. It is then language-specific as to whether advancement corresponds to phonation or short-lag VOT, but it may be more natural to employ it for the former. Further, tongue root position is likely a gesture controlled by speakers and used differently in languages with various laryngeal contrasts (Kingston & Diehl, 1994).

Reference: