The role of the tongue root in phonation of American English stops

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Background. In American English, phonologically voiced consonants are often phonetically voiceless in utterance-initial position (Lisker & Abramson, 1964). Utterance-initial position is the context in which it is possible to test whether or not a language has stops with pre-voicing because 'active voicing' gestures by speakers are needed in this position (Beckman et al., 2013). Other than Westbury (1983), there is little articulatory evidence regarding utterance-initial voicing in American English. Westbury (1983) found that the tongue root is advanced in voiced consonants in utterance-initial positions, but he did not distinguish between phonated and unphonated voiced stops. The current study explores the question of what the phonetic target of voiced stops in English is and how the tongue root is employed to reach that phonetic target, comparing phonated voiced stops, unphonated voiced stops, and voiceless stops in utterance-initial position.

Hypothesis. One adjustment for initiating or maintaining phonation during the closure is enlarging the supraglottal cavity volume primarily via tongue root advancement (Westbury, 1983; Narayanan et al., 1995; Proctor et al., 2010). The same mechanism that is responsible for phonation during closure also facilitates short positive voice onset time (VOT) (Cho & Ladefoged, 1999). This study focuses on whether phonated voiced stops and unphonated voiced stops show the same tongue root position or not. If they are the same, it would suggest that speakers have the same phonetic target, i.e. short positive VOT, for both phonated and unphonated stops, but phonation can occur as a by-product of achieving that goal. If tongue positions are not the same, then it would suggest that speakers have phonation during closure as the phonetic target for phonated voiced stops.

Method. This study uses ultrasound imaging and acoustic measures to examine how tongue position corresponds to phonation in American English. Eight speakers of American English recorded voiced and voiceless stops in utterance-initial position at three places of articulation (labial, alveolar, and velar). For voiced stops, two different following vowels (high/low) were recorded. There were a total of 90 stimuli. Smoothing Spline (SS) ANOVA was used to compare the average contours between unphonated/phonated voiced and voiceless stops (Gu, 2002; Davidson, 2006).

Results. Acoustic results showed that there were 35 phonated stops out of 477 utterance-initial stops (7.3%). Ultrasound images showed that in utterance-initial position, there was a clear distinction between voiced stops and voiceless stops in the tongue root position for the alveolar and velar places of articulation. Labial stops do not participate in the pattern because they do not involve the tongue at all for the stop itself. Figures below demonstrate that both phonated (green curves) and unphonated (blue curves) voiced stops show more advanced tongue root than voiceless stops (orange curves) when the place of articulation is alveolar (Figure 1) or velar (Figure 2). Even without acoustic phonation during closure, the tongue root is advanced for voiced stops in comparison to voiceless stops for supraglottal cavity enlargement.

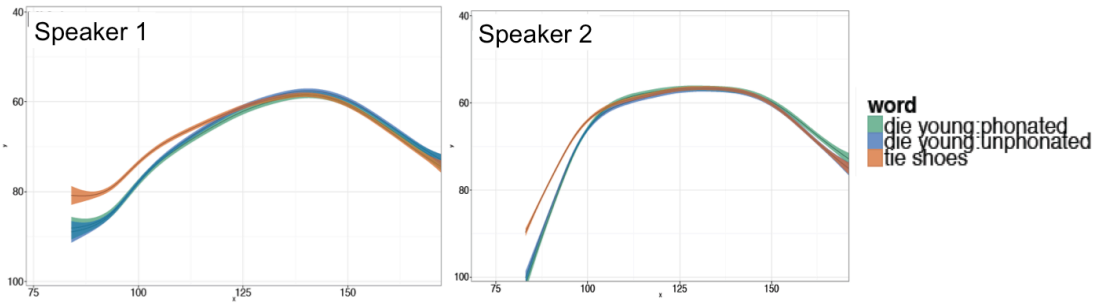

Figure 1. Phonated /d/ vs. unphonated /d/ vs. voiceless /t/ (SS ANOVA plots of two speakers)

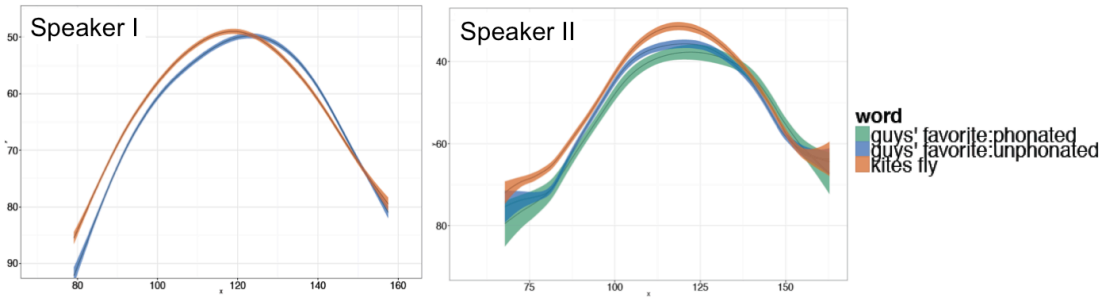

Figure 2. Phonated /g/ vs. unphonated /g/ vs. voiceless /k/ (SS ANOVA plots of two speakers, these are two different speakers from the speakers of *Figure 1*)

Discussion. These results are consistent with speakers having a short positive VOT as the target for both phonated and unphonated stops in utterance-initial position, but other articulatory adjustments are responsible for the presence or absence of phonation. One possible source of phonation may be hyper-articulation (Baese-Berk & Goldrick, 2009). (cf: hypercorrection in German: Jessen & Ringen, 2002)

Future Research (Pilot Study). The results found in English can be compared to other languages with different laryngeal feature systems, such as Spanish (a language with pre-voicing), German (a language similar to English), Thai or Hindi (a language with voiced/voiceless unaspirated/voiceless aspirated distinction), and Korean (a language without phonological voicing). A pilot study on Spanish showed that the tongue root is advanced in phonated voiced stops compared to (unaspirated) voiceless stops. English unphonated voiced stops are phonetically similar to Spanish unaspirated voiceless stops, but the tongue position is different in these two languages when they're both compared to the phonated voiced stop in their respective language. The difference is that in English, phonated and unphonated voiced stops are the same phoneme, whereas in Spanish, phonated voiced stops and unaspiraetd voiceless stops are different phoneme. This result indicates that the difference in tongue root position reflects the phonological laryngeal contrasts of English and Spanish, and phonation during closure in English is just accidental or entirely due to some other articulatory adjustment. A pilot study on Korean showed that the tongue root is advanced in tense stops, which have a shortest positive VOT, compared to lenis or aspirated stops, which have a longer VOT. These results confirm that tongue root advancement facilitates short positive VOT as well as phonation during closure. In this regard, German is expected to show the similar pattern to English, and Thai or Hindi are expected to show more tongue root advancement in voiced stops, followed by voiceless unaspirated stops, and then voiceless aspirated stops.

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