

Long-lag oro-laryngeal timing in onsets is a perceptual cue to voicing in codas

Chandan R. Narayan

Speech Acoustics and Perception Lab, York University, Toronto

Vowels are consistently shorter before voiceless consonants than before voiced consonants, a correlation that has been observed across genetically diverse languages (e.g., Chen, 1970). Vowel duration is also positively correlated with the aspiration duration of a preceding consonant such that longer vowels follow longer aspiration. This pattern is found in both aspiration languages like English and languages as well as languages like Tamil with only short-lag oro-laryngeal timing (Narayan, 2023). The present study asks 1) whether coda voicing has a *long-distance* effect on onset oro-laryngeal timing (Weismer, 1979; Choi et al., 2016; Mielke and Nielsen, 2018), and 2) whether listeners can use the structured variation in long-lag onsets to predict the voicing feature of the coda in CVC syllables.

Exp.1 examined the relationship between coda voicing and onset aspiration duration in English production. Speakers ($n=20$) read target monosyllabic words in stressed position in a sentence frame. Targets were real English C_1VC_2 words where $C_1=/p, t, k/$, $V=/æ, ɔ, ε, ɪ, ʌ/$, $C_2=/p, t, k, b, d, g/$ (e.g., pick/pig, pot/pod, tack/tag, tuck/tug, cot/cod, etc.). Measurements for target words included aspiration duration (VOT) and vowel duration. A mixed-effects model of aspiration duration was fit as a function of onset place of articulation and coda voicing, with random intercepts for subjects and words. The model revealed a fixed effect of coda voicing, such that mean VOT increased by ~ 12 ms when codas were voiced ($t = 3.94$). The significant interaction terms suggested that the difference between onset VOT when codas were voiced or voiceless was less pronounced when onsets were alveolar or velar than bilabial (Fig.1).

Exp.2 investigated listeners' knowledge of the long-distant effect of coda voicing on onset long-lag aspiration timing. English speakers ($n=26$) listened to sentences where the target (final) C_1VC_2 non-word was gated such that *only* the transient burst, long-lag aspiration noise, and one glottal cycle was present (e.g., "Pat has a toad that said $[k^h]/[k^{hh}]$ "). The target C_1 was either $/p/$ or $/k/$, and aspiration lengths were either short (25ms for $[p^h]$, 50ms for $[k^h]$) or long (125ms for $[p^{hh}]$, 150ms for $[k^{hh}]$); $V=/æ, ε, ɪ/$. The 100ms difference between short and long aspiration levels was required to mitigate the Weber's law-like discrimination of long-lag VOTs (Rosner, 1984). Listeners were asked to guess (2AFC) the final word in the sentence with two choices differing only in C_2 voicing (e.g., <kep>/<keb>, <pap>/<pab>, etc.). A mixed-effects model of listeners' responses, as a function of aspiration length, onset place of articulation, and vowel quality showed that shorter onset aspiration reduced the probability that listeners guessed that a coda was voiced ($\beta = -1.16$, $z = -2.13$) (Fig.2).

Although the aspiration length difference in the perception task was an order of magnitude larger than the production effect, the results of Exp. 2 suggest that listeners *know* that increased oro-laryngeal asynchrony is indicative of the aerodynamic effort required for implementing increased vowel duration before phonologically voiced codas. In this way, phonetic knowledge includes the structured variation of long-lag oro-laryngeal timing in syllable onsets as a long-distance cue to coda voicing.

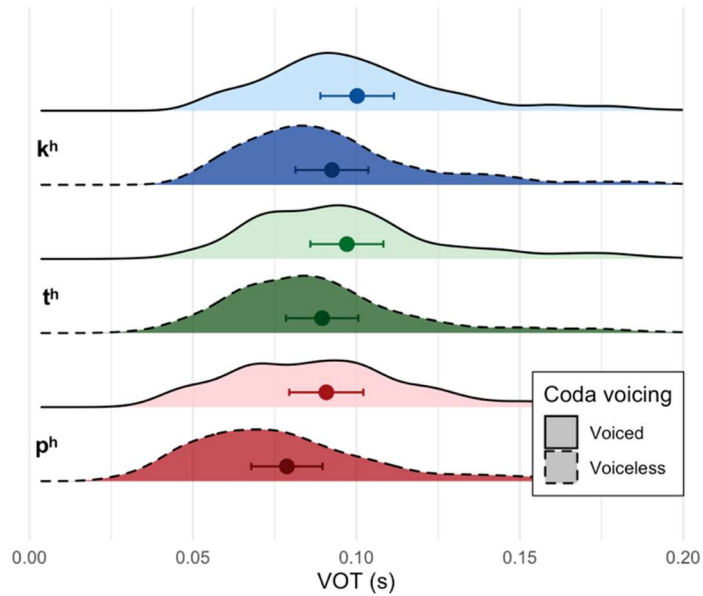


Fig. 1. Predicted mean VOT estimates and confidence intervals with overlain density plots of observed values.

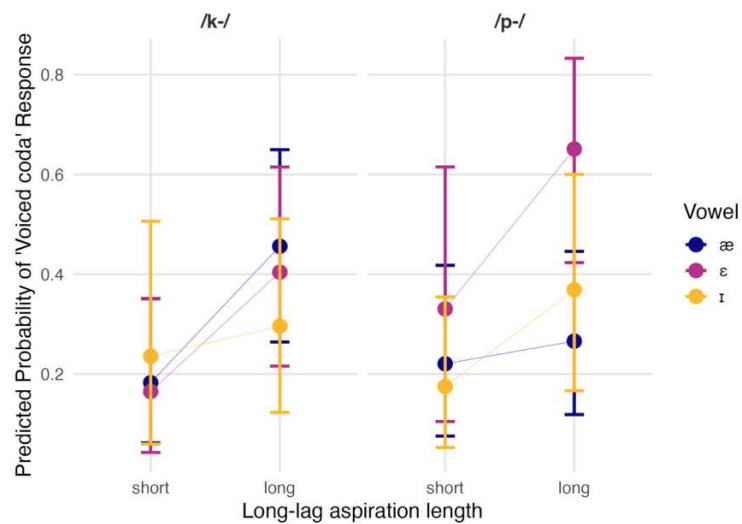


Fig. 2. Predicted probability of listeners identifying aspiration-only stimuli as having a voiced coda.

References

- Chen, M. (1970). Vowel length variation as a function of the voicing of the consonant environment. *Phonetica*, 22(3), 129-159.
- Choi, J., Kim, S., & Cho, T. (2016). Phonetic encoding of coda voicing contrast under different focus conditions in L1 vs. L2 English. *Frontiers in Psychology*, 7, 624.
- Mielke, J., & Nielsen, K. (2018). Voice Onset Time in English voiceless stops is affected by following postvocalic liquids and voiceless onsets. *The Journal of the Acoustical Society of America*, 144(4), 2166-2177.
- Narayan, C. R. (2023). Speaking rate, oro-laryngeal timing, and place of articulation effects on burst amplitude: Evidence From English and Tamil. *Language and Speech*, 66(4), 851-869.
- Rosner, B. S. (1984). Perception of voice-onset-time continua: A signal detection analysis. *The Journal of the Acoustical Society of America*, 75(4), 1231-1242.
- Weismer, G. (1979). Sensitivity of voice-onset time (VOT) measures to certain segmental features in speech production. *Journal of Phonetics*, 7(2), 197-204.