Long-lag voice-onset time in English onsets is longer when codas are voiced, and listeners know it

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Introduction

- Vowel duration is famously correlated with the voicing status of the following consonant, an effect found in unrelated languages (Chen, 1970) → longer vowel duration when following C is phonologically voiced than voiceless
- Stressed vowel duration is also positively correlated with preceding oro-laryngeal timing → long vowels correspond to long voice-onset time (VOT) in onset Cs (Narayan, 2022)
- Combining the coda voicing and oro-laryngeal timing facts we make the prediction that onset VOT is longer when the coda consonant is voiced
    - Previous research has indeed found this result with oral stops (3 speakers) (Weismer, 1979) and liquid codas (Mielke and Nielsen, 2018)

Research goals:

Can the coda-voicing effect on onset oro-laryngeal timing be replicated with a larger sample size in Canadian English?

- What is the nature of this effect and how can we explain it in terms of biomechanical constraints?

What is the perceptual import of the effect of coda voicing on onset long-lag VOT?

- Can listeners predict coda voicing from *only* variation in onset aspiration? → *phonetic knowledge* and speaker effort

EXPERIMENT 1: Production

Methods

- Speakers of Canadian English (*n*=20) participated in the speech production task
- Speakers recorded individually in sound-attenuated booth using high-quality microphone directly at 44.1kHz

Materials

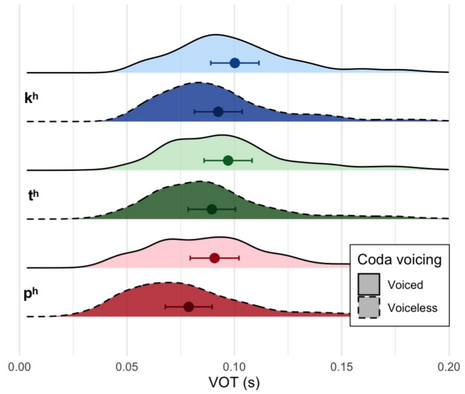
- Real English monosyllabic words (C_1VC_2) embedded in the sentence, "Say the word__quickly."
- C_1={p,t,k}, V={æ,ʌ,ɔ,ɪ,ɛ}, C_2={p,t,k,b,d,g}; All real-word combinations of C_1VC_2 were included → "pack, tug, cod," etc.
- Target words were randomized in a list with non-target monosyllables and recorded twice by each speaker

Analysis

- Measurements on target words extracted (*n*=2376) taken by phonetically trained researchers:

VOT: duration between onset of transient burst noise of plosive release and periodic oscillation of following vowel
Vowel duration: duration of periodic oscillation before coda closure

For a copy of the poster and references please write to chandann@yorku.ca or scan this QR code.
Thanks to the York Phonophony Group



Coda-voice effects on onset oro-laryngeal timing?

VOT ~ Onset_POA * Coda_voice + (1|subject) + (1|word)

- VOT increases with coda voicing (*t*=3.94)
- Difference between Ons VOT (coda[+vc]) vs. Ons VOT (coda[-vc]) ~ 12ms
- Effect is likely result of automatic aerodynamic adjustment necessary for increased vowel duration for coda voicing

Proportional expansion of CV gesture?

Is the VOT ratio (VOT/Vdur) the same in both coda voice contexts?
VOT ratio: Coda[+vc] = 0.65; Coda[-vc] = 0.88 (est. marginal means)

- Increase in CV duration before voiced codas in primarily due to vowel expansion; suggesting that VOT increase is automatic and not controlled

EXPERIMENT 2: Perception

Are listeners aware of the long-distance relationship between aspiration duration and coda voicing? → Can listeners predict coda voice from onset aspiration?

VOT duration difference of ~12ms in the 75-100ms aspiration band falls below the threshold of perceptibility → Weber's law for VOT? (Rosner, 1984) → Test with endpoints of the long-lag continuum

Methods

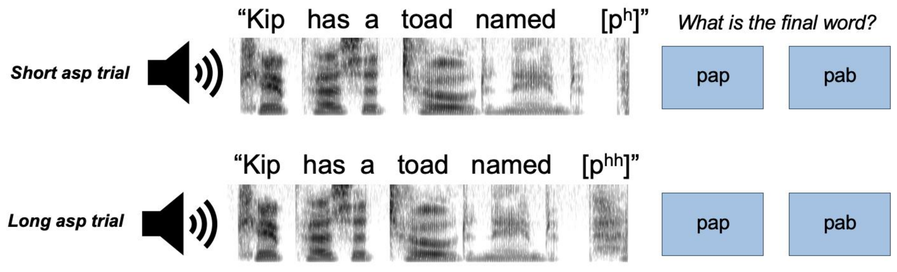
- Canadian English listeners (*n*=26) (in lab) guess the final consonant of a non-word after hearing *only* **short** or **long** aspiration

Stimuli

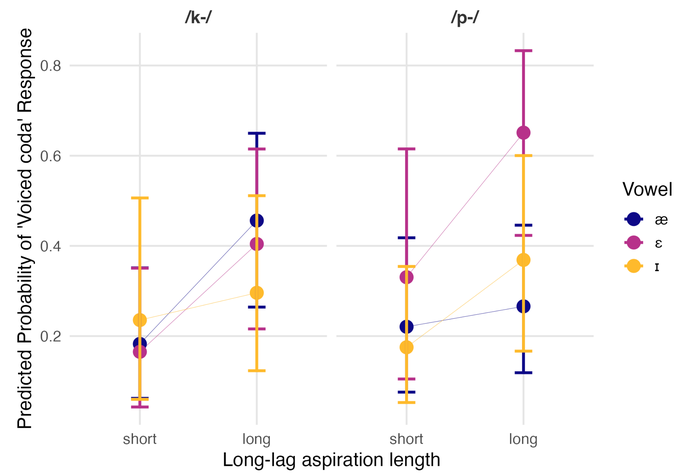
- Targets were burst transient + aspiration + 3 glottal cycles
- *p* targets: **[pʰ]** (25ms), **[pʰʰ]** (125ms); *k* targets: **[kʰ]** (50ms), **[kʰʰ]** (150ms)
- Aspiration from real words with V={æ, ɪ,ɛ} (e.g., pat/pad, cap/cab)
- Targets were embedded in a sentence in final position

2AFC Task

- Listeners hear a sentence with a final target and given two non-word choices (e.g., <pap> or <pab>)



Do listeners use onset aspiration to guess coda voicing?



- Short aspiration reduces probability that listeners guess that coda is voiced (*z*= -2.13)
- Effect is greater in [ɛ] context relative to the reference [æ] (*z*=2.82)

Discussion

Long-lag VOT variability and coda voicing

- Clear and consistent effect of coda voicing on onset oro-laryngeal timing, replicating previous report of the effect
- Aerodynamic source for longer aspiration duration before voiced stops? → oral volume is greater before voiced stops due to passive larynx lowering in order to support transglottal pressure differential (Stevens, 1999) → longer time for positive pressure air in larger oral cavity to be equalized with ambient pressure relative to smaller oral cavity
- Weismer (1979) suggests that the effect is related to greater *articulatory force* accompanying the implementation of the long vowel preceding the voiced coda consonant
- The effect is small and below the threshold of discriminability in the long-lag and suggests that the process is *automatic* and uncontrolled, unlike the short/long aspiration characterizing word/syllable-initial plosive voicing

Listener knowledge of aspiration duration and coda voicing

- 100ms difference between aspiration durations significantly affected listeners prediction of coda voicing → long aspiration leads to greater "voiced" coda responses
- While the effect is not comparable to aspiration as a primary perceptual cue to onset plosive voicing, the results suggest that listeners *know* that increased aspiration in onsets is a characteristic of the articulatory effort required to implement a long vowel
- Perception results suggest that listeners' phonetic knowledge includes long-distance (by proxy) effect of coda voicing emerging as a sub-phonemic cue in word-onset plosives

References for *“Long-lag voice-onset time in English onsets is longer when codas are voiced, and listeners know it”* [ASA-2026, Philadelphia]

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