

Effects of coda laryngeal features and stimulus language on perceived vowel duration

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Vowels are longer before voiced consonants than before voiceless consonants in many languages, including English (Chen 1970) and Hindi (Durvasula & Luo 2014), but not Telugu (Reddy 1988). Hindi and Telugu also differ in effects of breathy voiced stops; vowels are longer before them than before plain voiced stops in Hindi, but not in Telugu. Various explanations for the voicing effect have been proposed (e.g. Chen 1970, Kluender et al. 1988), but no explanation has been substantiated. Less work examines the breathiness effect.

I present two studies on how coda features affect perceived duration of preceding vowels when the codas themselves are removed. For both Hindi and Telugu stimuli, native English listeners perceive vowels produced before voiced stops as longer than vowels from before voiceless stops, suggesting a possible perceptual origin of voice-induced duration differences. Vowels from before Hindi breathy voiced stops are perceived as even longer, but have the opposite pattern for Telugu stimuli, likely reflecting differences in breathiness assimilation.

Study 1: 24 American English speakers heard isolated vowels extracted from VC forms produced by a Hindi speaker, with the consonant and the transition into it removed, and categorized each vowel as ‘long’ or ‘short’, with instructions that they were deciding about duration. They were not trained in the contrast. The original codas were voiced, voiceless, and breathy voiced stops. Items were blocked by vowel quality (/a/, /i/, /u/). Vowel duration was manipulated to create stimuli covering a 10-step duration continuum (129 ms to 252 ms).

Study 2: 24 American English speakers heard isolated vowels extracted from VC forms produced by a Telugu speaker and categorized each vowel as ‘long’ or ‘short’ in duration. All parameters other than the language used for the stimuli were the same as for Study 1.

Regression models for effects in Study 1 and 2 are given in Tables 1 and 2, respectively; the effects of duration and original coda voicing are illustrated in Figures 1 and 2.

English speakers can perceive and categorize vowel duration; in both studies, the actual duration of the vowel was a major predictor of whether it was identified as ‘long’ or ‘short’.

Coda voicing was a significant predictor of responses. For both Hindi and Telugu stimuli, listeners gave more responses of ‘long’ when the original coda had been voiced than when it had been voiceless. Vowels exhibit several acoustic influences of following stops, which may be contributing to the differences in perceived duration; within the stimuli for both studies, vowels before voiced stops had lower F1 and less jitter than vowels before voiceless stops.

Coda breathiness was a significant predictor of responses for the Hindi stimuli; listeners gave more ‘long’ responses when the original coda had been a breathy voiced stop than when it had been plain voiced. In contrast, for the Telugu stimuli, vowels from the breathy voiced environment elicited fewer ‘long’ responses. The different effects are likely due to differences in realization; vowels before breathy voiced stops are breathy in Hindi, reflected in spectral tilt and harmonics-to-noise ratio (HNR), but not in Telugu.

Vowel quality also matters; high vowels, which are shorter in production than low vowels, elicited more ‘long’ responses, suggesting listeners’ compensation for expected durations.

Vowels produced before voiced codas are perceived as longer than vowels produced before voiceless codas, which suggests a possible perceptual pathway for the development of voicing-conditioned vowel duration, particularly because the perceptual difference is present even in stimuli from a language which lacks the voicing effect. Coda breathiness has different effects based on stimulus language, paralleled by differences in realization; vowels assimilate to breathiness of coda stops only in Hindi. Greater perceived duration of these Hindi vowels suggests that vowel breathiness increases perceived length, providing a possible explanation for why they are often longer than modal vowels (cf. Gordon & Ladefoged 2001).

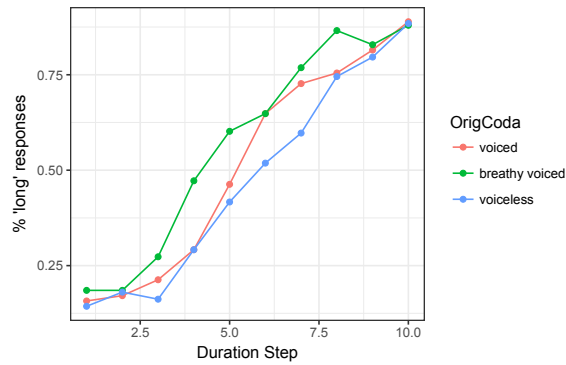


Figure 1. Study 1 : 'long' responses, by coda features (Hindi stimuli)

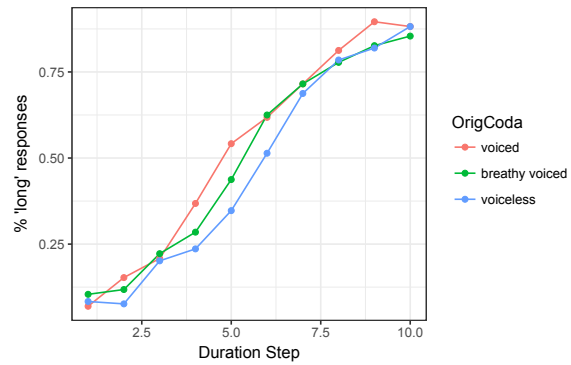


Figure 2. Study 2 : 'long' responses, by coda features (Telugu stimuli)

	Estimate	Std. Error	Z value	P value
(Intercept)	-2.58	0.16	-15.9	< 0.0001***
DurationStep	0.48	0.013	38.0	< 0.0001***
OrigCoda-Voiceless	-0.23	0.074	-3.12	0.0018***
OrigCoda-BreathyVoiced	0.35	0.074	4.65	< 0.0001***
Vowel-i	0.22	0.074	2.97	0.003**
Vowel-u	-0.052	0.074	-0.71	0.48
ResponseTime	-0.023	0.057	-0.41	0.68

Figure 1. Generalized linear mixed model for 'long' responses in Study 1 (Hindi stimuli). 270 trials per participant. Intercept: OrigCoda = Voiced; Vowel = /a/

	Estimate	Std. Error	Z value	P value
(Intercept)	-3.08	0.18	-117.2	< 0.0001***
DurationStep	0.55	0.017	33.0	< 0.0001***
OrigCoda-Voiceless	-0.40	0.094	-4.2	< 0.0001***
OrigCoda-BreathyVoiced	-0.19	0.094	-2.0	0.044*
Vowel-i	0.27	0.94	2.8	0.0045**
Vowel-u	0.24	0.94	2.6	0.0096**
ResponseTime	0.039	0.041	0.94	0.35

Figure 2. Generalized linear mixed model for 'long' responses in Study 2 (Telugu stimuli). 180 trials per participant. Intercept: OrigCoda = Voiced; Vowel = /a/

[1] Chen, M. 1970. Vowel length variation as a function of the voicing of the consonant environment. *Phonetica* 22, 129-159.

[2] Durvasula, K. & Luo, Q. 2014. Voicing, aspiration, and vowel duration in Hindi. In S. Ohlsson & R. Catrambone (eds.), *Proceedings of meetings on acoustics*, 060009. Acoustical Society of America.

[3] Gordon, M. & Ladefoged, P. 2001. Phonation types : A cross-linguistic overview. *Journal of Phonetics* 29, 383-406.

[4] Kluender, K.R., Diehl, R.L., & Wright, B.A. 1988. Vowel-length differences before voiced and voiceless consonants: An auditory explanation. *Journal of Phonetics* 16, 153-169.

[5] Reddy, K.N. 1988. The duration of Telugu speech sounds: An acoustic study. *IETE Journal of Research* 34.1, 57-63.