

Articulatory constraints on prosodic enhancement of English voiceless sibilants

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Prosodic organization influences segmental realization, but the magnitude and direction of these effects are mediated by articulatory demands and the need to preserve phonological contrast [1–3]. Because such factors can shape or obscure prosodic influences, understanding the phonetics–prosody interface requires examining how prosodic effects interact with these constraints. The English voiceless sibilants /s/ and /ʃ/ offer an ideal test case: their frication noise requires precise control of tongue posture, lip rounding, and constriction geometry [4,5], making them stringent indicators of how prosodic structure shape phonetic realization while maintaining phonological contrast. Because prominence-related and boundary-related prosodic effects have been argued to target different aspects of contrast—paradigmatic versus syntagmatic—often yielding different strengthening patterns [6–8], their influence on the /s/–/ʃ/ contrast may not be symmetrical. Vowel coarticulation adds another conditioning factor—e.g. differences between /i/ and /u/ in constriction location and lip rounding may facilitate or restrict the extent to which prosodic effects surface. The present study asks whether the phonetic continuum reflects these differentiating influences or instead shows uniform prosodic strengthening across segments and coarticulatory contexts. We examine these possibilities in American English by analyzing frication duration and spectral center of gravity to assess how prosodic structure shapes the realization of voiceless sibilants under articulatory and phonological constraints.

Acoustic data from 20 speakers of American English (10F) were analyzed. Six monosyllabic words containing /s/ or /ʃ/ (e.g. sack–shack, seen–sheen, suit–shoot), embedded in frame sentences designed to manipulate focus and boundary conditions (Table 1). Focus was either phonological (/s/–/ʃ/ contrast), lexical (contrast with a semantically related word), or absent, while boundary position was either Intonational Phrase-initial (IP) or phrase-medial Word-initial (Wd). Frication duration and spectral center of gravity (CoG) [9] were extracted and analyzed using linear mixed-effects models with Consonant, Focus, Boundary, and Vowel as fixed factors.

The results (Figs. 1–2) show that both /s/ and /ʃ/ remain sensitive to prosodic structure despite their articulatory rigidity. Focus increased frication duration and CoG under focus (Phon, Lex) for both segments, indicating temporal and spectral strengthening (Figs. 1a, 2a). Boundary effects surfaced only in the absence of focus, with IP-initial tokens showing marginally longer frication but significantly lower CoG (Figs. 1e, 2e). Crucially, only focus produced contrast-specific modulation in the spectral domain. Under focus, /s/ showed a substantially greater CoG increase than /ʃ/, augmenting the /s/–/ʃ/ distinction (Focus × Consonant; Fig. 2d). No comparable enhancement emerged in the temporal domain (Fig. 1d). An additional analysis of the Consonant × Focus × Vowel interaction for /i/ and /u/ showed that the focus-driven /s/–/ʃ/ separation was further conditioned by vowel context, with a larger separation before /i/ than before /u/.

Findings demonstrate that prosodic structure fine-tunes the realization of English voiceless sibilants, yet this fine-tuning is constrained by articulatory and phonological demands. Focus exerted the most robust influence, enhancing the phonological contrast primarily by raising /s/’s CoG rather than by lowering /ʃ/. This pattern is consistent with a low-cost articulatory strategy: further lowering the CoG of /ʃ/ would conflict with the acoustic consequences of palatoalveolar frication, whereas increasing /s/’s CoG aligns with its articulatory-acoustic properties. Boundary effects, by contrast, were weak and prominence-dependent—consistent with domain-initial strengthening [1,10] serving a syntagmatic role but insufficient to enhance phonological contrast. Coarticulatory vowel context further shaped prosodic effects, with /i/ amplifying and /u/ attenuating the focus-driven spectral enhancement. Overall, these patterns show that prosodic strengthening operates within—and is restricted by—the articulatory configuration of the segment, its coarticulatory context, and the phonological contrast it encodes, illustrating how prosody, phonological contrast, and articulatory constraints jointly shape fine-grained phonetic realization.

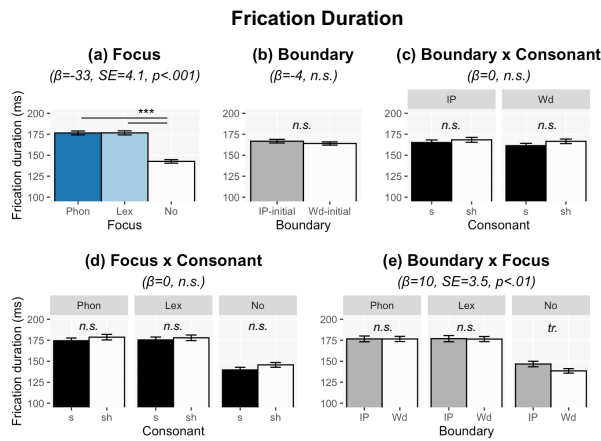


Figure 1. Results on frication duration by (a) Focus, (b) Boundary, (c) Boundary $\times$ Consonant, (d) Focus $\times$ Consonant, and (e) Boundary $\times$ Focus context. (** $p < .001$; tr . $.05 < p < .07$; $n.s.$ $p > .09$)

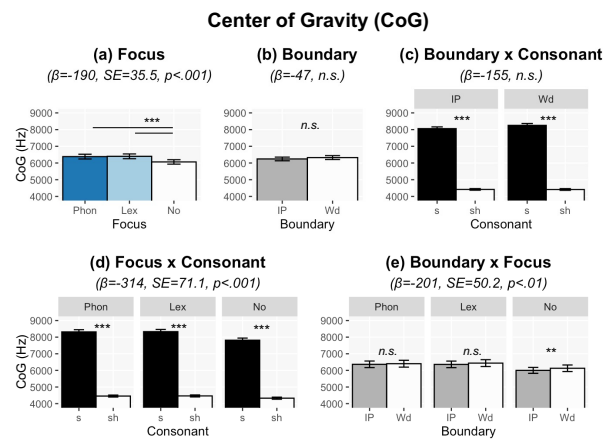


Figure 2. Results on center of gravity by (a) Focus, (b) Boundary, (c) Boundary $\times$ Consonant, (d) Focus $\times$ Consonant, (e) Boundary $\times$ Focus context. (** $p < .001$; $p < .01$; $n.s.$ $p > .09$)

Table 1. Example sentences by focus and boundary context. (Underlined: **target words**; bold: **focused words**)

Boundary Focus	IP-initial	Wd-initial
PhonFoc	A: Did you write ‘ SHACK well again’? B: Not really. ‘ <u>SACK</u> well again’ was what I wrote.	A: Did you write ‘say SHACK well again’? B: No. I wrote ‘say <u>SACK</u> well again’.
LexFoc	A: Did you write ‘ BAG well again’? B: Not really. ‘ <u>SACK</u> well again’ was what I wrote.	A: Did you write ‘say BAG well again’? B: No. I wrote ‘say <u>SACK</u> well again’.
NoFoc	A: Did you write ‘sack WELL again’? B: Not really. ‘ <u>Sack</u> WEIRD again’ was what I wrote.	A: Did you write ‘say sack WELL again’? B: No. I wrote ‘say <u>sack</u> WEIRD again’.

References

- [1] Cho, T. (2016). Prosodic boundary strengthening in the phonetics-prosody interface. *Language and Linguistics Compass*, 10(3), 120-141.
- [2] Fletcher, J. (2010). The prosody of speech: Timing and rhythm. In W. J. Hardcastle, J. Laver, & F. E. Gibbon (Eds.), *The Handbook of Phonetic Sciences* (2nd ed., pp. 523–602). Wiley-Blackwell.
- [3] Cho, T. (2025). Advancements of phonetics in the 21st century: Phonetic universals, language variation, and phonetic grammar. *Journal of Phonetics*, 111, 101426.
- [4] Jongman, A., Wayland, R., & Wong, S. (2000). Acoustic characteristics of English fricatives. *The Journal of the Acoustical Society of America*, 108(3), 1252-1263.
- [5] Tabain, M. (2001). Variability in fricative production and spectra: Implications for the hyper-and hypo-and quantal theories of speech production. *Language and Speech*, 44(1), 57-93.
- [6] Cho, T. (2005). Prosodic strengthening and featural enhancement: Evidence from acoustic and articulatory realizations of /a, i/ in English. *The Journal of the Acoustical Society of America*, 117(6), 3867-3878.
- [7] de Jong K. (1995). The supraglottal articulation of prominence in English: linguistic stress as localized hyperarticulation. *Journal of the Acoustical Society of America*, 97, 491–504.
- [8] Cho, T., Kim, D., & Kim, S. (2017). Prosodically-conditioned fine-tuning of coarticulatory vowel nasalization in English. *Journal of Phonetics*, 64, 71-89.
- [9] DiCanio, C. (2013). *Spectral moments of fricative spectra script in Praat* [Computer script]. Haskins Laboratories & SUNY Buffalo. <https://www.acsu.buffalo.edu/~cdicanio/scripts/>
- [10] Barnes, J. A. (2002). *Positional neutralization: A phonologization approach to typological patterns* (PhD dissertation), University of California, Berkeley.