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Structured covariation of acoustic cues to coda voicing throughout the syllable

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In English, multiple acoustic cues signal the voiced-voiceless distinction in stop codas. The strongest cue to this contrast is preceding vowel duration: voiced codas tend to be associated with longer vowels and voiceless codas with shorter vowels. Recent research has found that speakers may use multiple cues to stop voicing, and they do so in a manner that is highly structured. Building on our prior work with female speakers (Jacewicz et al., 2021), we investigated the covariation of temporal cues to coda voicing in males (n = 45, N = 2,506 productions). We found that, in running speech, the coda voicing contrast was cued not only by the preceding vowel but as early as the onset of a monosyllabic word. The specific long-distance temporal relationships between onset stop (affecting closure duration, voicing during the closure and VOT) and coda consonants (stops and fricatives) indicate a syllable-wide distribution of cues to coda voicing. The temporal patterns in males were generally consistent with females. There were also systematic prosodic and regional dialect effects on the nature of stop closure voicing, with higher prevalence of prevoicing (i.e., negative VOT) in Southern males than Southern females.

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1. INTRODUCTION

Stop coda voicing is implemented through several temporal and spectral cues. In English, it has been established that the primary acoustic cue to voicing contrast in coda stops is the duration of the preceding vowel—greater duration is associated with voiced rather than voiceless stops (Peterson & Lehiste, 1960; Raphael, 1972; Luce & Charles-Luce, 1985; Song et al., 2012; Penny et al., 2018; Millasseau et al., 2021). Additionally, irregular pitch periods (i.e., glottalization) at a vowel's offset have been correlated with voiceless stop codas (Shattuck-Hufnagel et al., 2011; Song et al., 2012; Penny et al., 2018; Millasseau et al., 2021). Regarding the acoustic characteristics of the stop itself, studies have found that the duration of the closure was unreliably linked with the voicing distinction, with a tendency for longer closures to be associated with voiceless coda stops (Luce & Charles-Luce, 1985; Penny et al., 2018; Millasseau et al., 2021). Another cue is the presence of voicing in the closure (i.e., sustained, low-frequency periodicity following the amplitude drop of the oral closure), which is indicative of a voiced coda stop (Raphael, 1972; Shattuck-Hufnagel et al., 2011; Song et al., 2012; Penny et al., 2018; Millasseau et al., 2021). Finally, longer burst durations and the presence of post-release noise have been associated with voiceless coda stops (Shattuck-Hufnagel et al., 2011; Song et al., 2012; Millasseau et al., 2021). A summary of these cues is provided in Table 1. It is important to note that the analyses of voicing cues in the studies listed in Table 1 were restricted to immediately adjacent segments, i.e., the syllable-final stop itself and the preceding vowel.

Table 1. Local spectral and temporal cues to coda voicing for voiced (V) and voiceless (VL) codas.

	Longer preceding vowel duration	Glottal-ization in vowel	Longer closure duration	Voice bar in closure	Longer burst duration	Post-release noise
Peterson & Lehiste (1960)	V					
Raphael (1972)	V			V		
Luce & Charles-Luce (1985)	V		~VL			
Shattuck-Hufnagel et al. (2011)		VL		V		VL
Song et al. (2012)	V	VL		V	VL	VL
Penny et al. (2018)	V	VL	~VL	V		
Millasseau et al. (2021)	V	VL	VL	V	VL	

~inconclusive finding

Unlike the coda stops, syllable onset stops—which have been more frequently examined than those in the coda position—utilize the primary cue of voice onset time (VOT) to implement the voicing distinction (Lisker & Abramson, 1964). Importantly, recent work examining the use of voicing cues at the syllable onset addressed the role of speakers as an additional source of variability in voicing implementation. It was found that individual speakers' usage of voicing cues—VOT just one of several—can be systematic so that specific multiple cues covary across speakers to produce the voicing contrast (Clayards, 2018). This systematic covariation of multiple cues to voicing has been studied as a local coarticulatory effect (as discussed thus far, within the immediate phonetic environment).

However, evidence exists that multiple cues to stop voicing can be distributed over larger domains, covarying at a long distance within a syllable (Hawkins & Nguyen, 2004). Specifically, in monosyllabic words, acoustic characteristics of the syllable onset /l/ were found to covary predictably with a voiced or voiceless coda, suggesting that "voicing in the coda defines the nature of the whole syllable" (Hawkins & Nguyen, 2004, pp. 220). Additional support for the syllable-wide distribution of voicing cues comes from our recent study (Jacewicz et al., 2021) that examined long-distance effects of coda voicing on temporal cues to voicing in the word-initial stop /b/ in running speech (closure duration, voicing during the closure, and VOT). There was a systematic relationship between the voicing cues in /b/ and a voiceless or voiced coda, indicating that information about coda voicing is already available in the syllable onset stop. The specific long-distance relationship is illustrated in Figure 1: stop closure in /b/ was shorter when the coda was voiced than voiceless (left panel), and the extent of voicing during the closure was greater when the coda was voiced than voiceless (right panel). This covariation was influenced by regional dialect used in that study as an additional source of variability in stop voicing implementation (Herd, 2020): the closures of Southern speakers from western North Carolina (NC) were shorter and more voiced than those in the Midland (central Ohio (OH)) and the North (southeastern Wisconsin (WI)).

The current study builds on these findings and has two goals. First, it seeks to verify these long-distance relationships in male speakers because the above patterns were found in females. Gender-based differences in production may be expected because women are leaders of sound change (Labov, 2001) and tend to speak slower than men (Jacewicz et al., 2010). Thus, the covariation of temporal voicing cues in the syllable onset may be manifested with different strengths in males than females. Second, the study extends the previous findings by examining the relationship between the individual cues to voicing in the coda (and not just the status of coda voicing—voiced, voiceless) and the cues to voicing in the word-initial /b/.

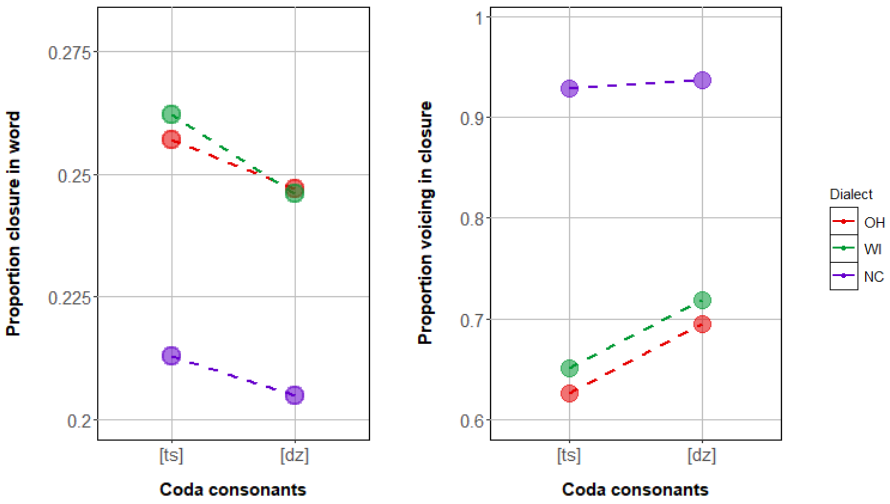


Figure 1. Syllable onset /b/ closure and closure voicing in adult females.

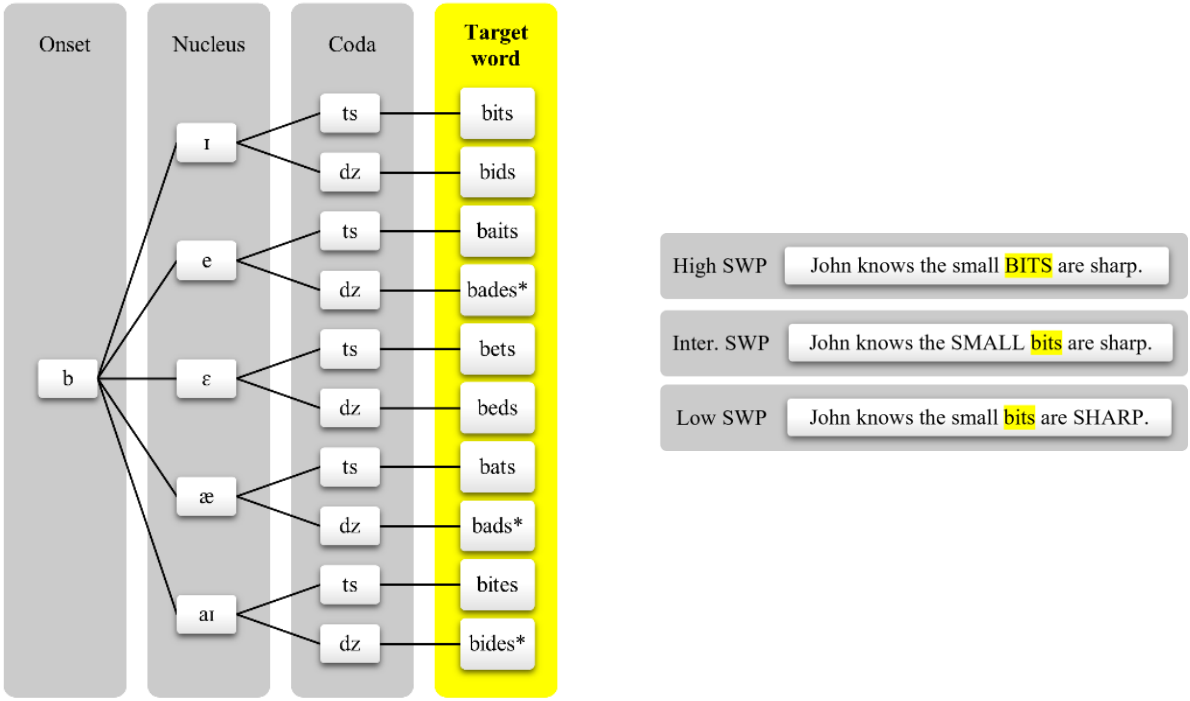
2. METHODS

A. DATASET & PARTICIPANTS

Audio files used in the present study come from a larger database that contains speech samples from more than 500 speakers of AE. There were 45 adult males included in this analysis, each representing one of three AE dialect regions: Midland (OH, n = 13), North (WI, n = 16), or South (NC, n = 16). These male speakers came from the same speech communities as females in our previous study (Jacewicz et al., 2021). A speaker was considered representative of his region if he were born, raised, and had spent the majority of his life in that dialect community. None of the participants reported a history of speech, language, or hearing disorders.

B. STIMULI & RECORDING PROCEDURE

Stimuli selection was as in our previous study (Jacewicz et al., 2021). Ten monosyllabic target words of the type CVCC were constructed as shown in Figure 2. A voiced stop /b/ was in syllable onset and the voicing contrast was in the coda position consisting of voiced or voiceless stop+fricative sequence.



*The following definitions were provided for nonsense nouns: bade, a brand-name knife; bad, a blunder; and bide, a small animal.

Figure 2. Left: Structure of the ten target words. Right: Systematic variation of prosodic prominence. The target word is highlighted here for illustrative purposes but was not indicated to participants in any way.

Target words were embedded in sentences, and the onset /b/ always occurred in the intersonorant position between preceding liquid /l/ and a vowel (e.g., "small bats"). The main sentence stress was varied by instructing participants to emphasize a specified word in each sentence, as indicated to the speaker by all capital letters. This was done to create three gradient levels of stress for the target word to control for prosodic variation. The levels were: high (when the target word was emphasized); intermediate (when the preceding word was emphasized); low (when the sentence-final word was emphasized). Examples of varying stress word position (SWP) are shown in Figure 2.

Stimuli were recorded following the same procedure as in the study with female speakers. The sample in the current study consisted of a total of 2,610 tokens. After excluding tokens unsuitable for acoustic analysis (e.g., audio with artifact or respiratory irregularities in the voice, as confirmed by visual and auditory reinspection between two researchers, 4% of all recordings) the final set for analysis included 2,506 tokens.

C. ACOUSTIC ANALYSIS

Recordings were downsampled from 44.050 kHz to 11.025 kHz and pre-emphasized (98%) prior to analysis. Stop closure voicing was characterized by four acoustic landmarks (Figure 3): stop closure onset (A), voicing offset during stop closure (B), closure release (C), and voicing onset for the vowel (D). Each landmark was individually identified from waveform displays in Adobe Audition 1.0 and cross-checked with spectrograms. In instances where a stop closure was voiced throughout, B=C. All measurements determined by the researcher were verified by running a custom MATLAB program. This script superimposed the manually identified values onto the waveform. Rechecks and adjustments were made as

needed. From the acoustic landmarks shown in Figure 4 and defined in Table 2, the following measures were derived: closure duration (C–A), voicing during closure (B–A), and VOT (D–C). To account for speech rate and speaker variability, closure duration was measured as a proportion within the target word. Similarly, voicing during closure was measured as a proportion within the /b/-closure. VOT was analyzed as a raw duration (in ms).

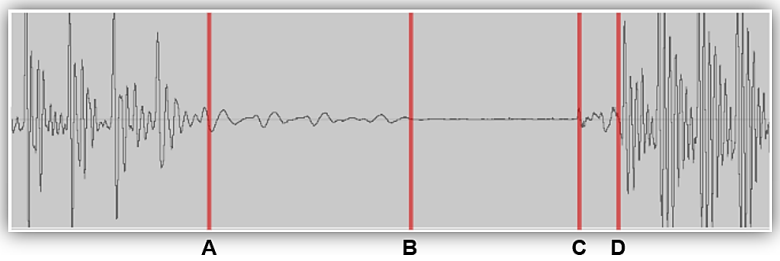


Figure 3. Waveform display of stop closure /b/ in the intersonorant position. A: Stop closure onset. B: Voicing offset during stop closure. C: Closure release. D: Voicing onset for vowel.

Table 2. Acoustic landmarks and their definitions.

Fig. 4	Acoustic landmark	Defining waveform characteristics
A	Stop closure onset	Drop in overall amplitude Drop in formant intensity (spectrogram) Shift toward sinusoidal period
B	Voicing offset during stop closure	Diminishing periodicity
C	Closure release	Onset of first transient
D	Voicing onset for vowel	Onset of resumed periodicity Significant amplitude increase Prominent higher formants (spectrogram)

3. RESULTS

A. TEMPORAL PATTERNS AT SYLLABLE ONSET

The temporal relationships between closure duration (CD) and voicing during the closure (VDC) of the syllable-initial /b/ as a function of coda voicing are shown in Figure 4, separately for each dialect. The patterns for males are displayed with reference to those for females (redrawn from Figure 1). We observe that, overall, the temporal relationships for males are consistent with females, however there are also notable dialect-related differences. We present the results separately for each measure (CD, VDC, and VOT). As in our previous study (Jacewicz et al., 2021), mixed effects linear regression was run on male data with R packages glmmTMB (Brooks et al., 2017) and lmer (Kuznetsova et al., 2017).

I. CLOSURE DURATION

Syllable onset /b/ closures were significantly longer when the coda was voiceless rather than voiced, $t(2494) = 6.5$, $p < .001$ (e.g., /b/ closure duration was greater in “bits” /bɪts/ than “bids” /bɪdz/—see Figure 5, left panel). This varied with prosodic prominence (SWP) for voiceless codas, with the longest closures occurring in the high SWP, followed by intermediate and low, respectively. The gradient effect was not observed between the intermediate and low SWPs for voiced codas. The model for CD did not include dialect (see Eq. (1) for R syntax), indicating that, unlike in females, CDs in males were not affected by dialect variation and CDs in NC males did not differ from any other dialect.

$$glmmTMB([prop_CD_word] \sim coda\ voicing + SWP + coda\ voicing{:}SWP + (1|speaker)) \quad (1)$$

II. VOICING DURING THE CLOSURE

Unlike CD, the extent of VDC was affected by dialect variation: OH and WI closures exhibited more voicing when the coda was voiced rather than voiceless (see Figure 5, right panel). This pattern was not observed in NC, as those closures were almost always fully voiced (96.7% of NC tokens) and therefore already at or near ceiling for the extend of voicing There was also the effect of SWP on VDC in OH and WI (but not in NC) with the low position associated with the greatest proportion of VDC, followed by intermediate and high, respectively. This effect is illustrated in Figure 5; see Eq. (2) for R syntax. Overall, the VDC results for males are generally consistent with females.

glmmTMB([prop_VDC] ~ coda voicing + SWP + dialect + coda voicing:dialect + SWP:dialect + (1|speaker)) (2)

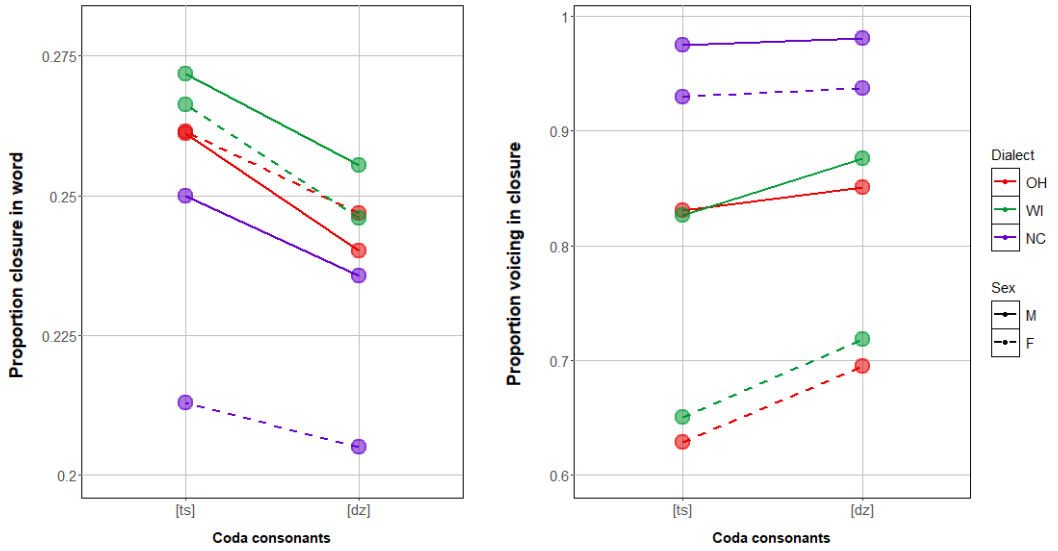


Figure 4. Closure and closure voicing in males (solid lines) as compared to females (dashed lines).

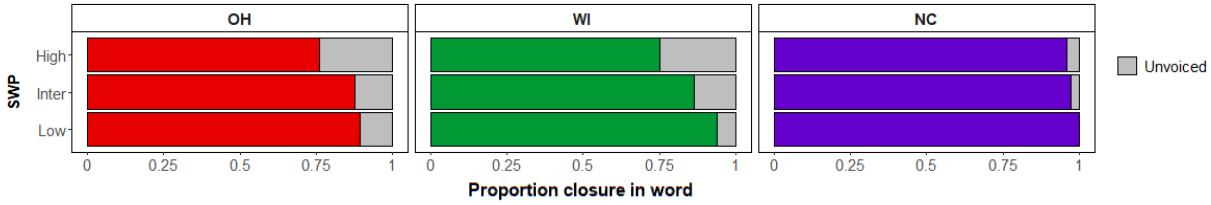


Figure 5. Closure voicing as a function of prosodic prominence.

III. VOICE ONSET TIME

Dialect was the only significant effect on VOT (see Eq. (3)). VOTs in NC were shorter (M = 5.7 ms) than in either OH (M = 9.4 ms) or WI (M = 10.8 ms), $F(2,2503) = 322$, $p < .001$. All pairwise comparisons were significant. It needs to be clarified that in our study, we defined VOT as the post-release lag duration (i.e., positive VOT) and tokens with prevoicing (i.e., negative VOT) were excluded from analyses. Of the three dialects, NC had the most tokens excluded due to prevoicing (71 tokens) and only 8 tokens were excluded from OH and 12 from WI. The current results for VOT in males are generally consistent with females; however, the mean durations in OH and WI (but not in NC) were comparatively greater in males.

lmer([VOT] ~ dialect + (1|speaker)) (3)

B. TEMPORAL PATTERNS SYLLABLE-WIDE

Addressing the second goal of the study, we now consider the temporal relationships between the individual cues to voicing in the coda and the cues to stop voicing at the onset (i.e., CD, VDC, and VOT). Given that syllable codas consisted of two segments, the stop and the fricative, we measured the durations of both as well as the duration of the preceding vowel as the strongest cue to coda voicing. In this paper, we are concerned with the following voicing cues in the coda: the overall coda duration, proportions of a stop and a fricative in the coda, and vowel duration. The analysis of VDC in coda stops is still ongoing and will not be reported here. Because stops were followed by fricatives, release bursts were not observed and stop durations only included closures.

Based on the acoustic measurements in a subset of the data (the analyses are still ongoing), the following systematic temporal relationships emerged syllable wide. The cues to a voiceless coda (as in [bVts]) were manifested in longer onset (longer CD, longer VOT, and shorter VDC), shorter vowel, and longer coda (with a shorter stop and longer fricative). Conversely, the cues to a voiced coda ([bVdz]) were in comparatively shorter onset (shorter CD, shorter VOT, and longer VDC), longer vowel, and shorter coda (with a longer stop and shorter fricative). The schematic for these relationships can be seen in Figure 6.

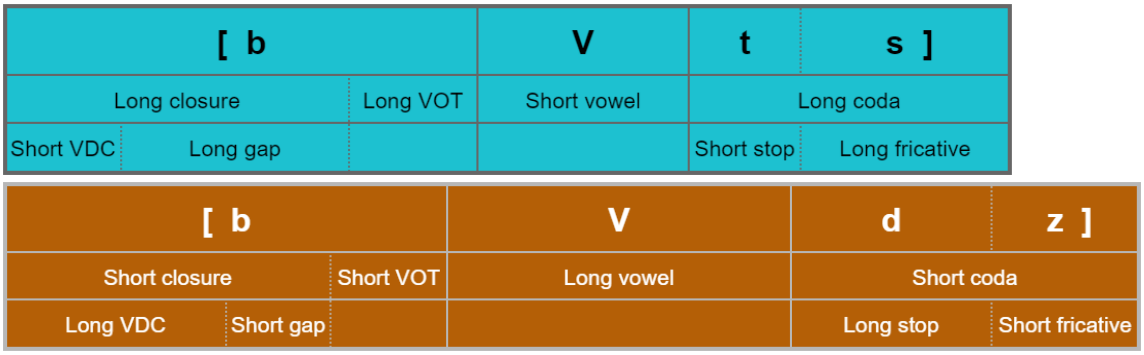


Figure 6. Syllable-wide relationships cueing voiceless vs. voiced codas.

Figure 7 illustrates these temporal relationships in two productions by a male OH speaker. The top panel shows a waveform of "bats" (from the truncated phrase "…small bats are…"). Note the longer closure in /b/ (with shorter VDC), shorter vowel, and longer voiceless fricative (relative to the coda stop). The bottom panel shows a waveform of "bads" (from "…small bads are…"). Note the shorter closure in /b/ (with longer VDC), longer vowel, and shorter voiced fricative (relative to the coda stop). In addition, note the presence of VDC in the voiced coda stop and a lack of it in the voiceless stop.

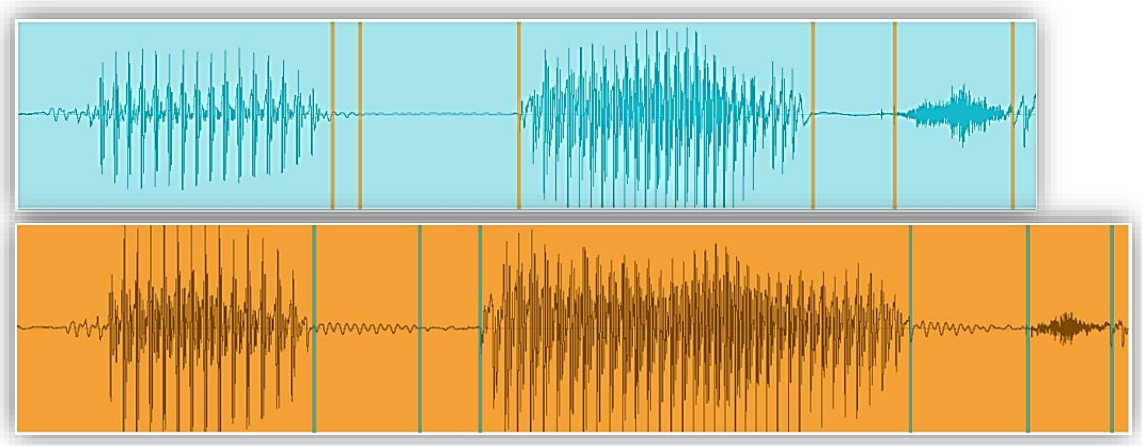


Figure 7. OH male production of "bats" (top) and "bads" (bottom).

Based on our acoustic analyses to date, we expect considerable variability in the nature of stop coda voicing, which may also be related to dialect variation. For example, Figure 8 shows the voiced coda in "… bids are…." produced in the same sentence by a man from OH (top) and NC (bottom). Both stop closures are fully voiced but the amplitude of voicing in NC is visibly greater than in OH and the voiced fricative is produced differently in the two dialects. The nature and sources of the variability in coda voicing will be determined in our ongoing work.

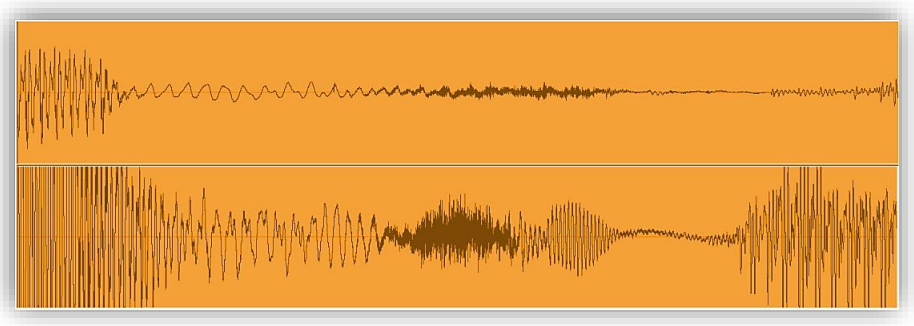


Figure 8. OH (top) and NC (bottom) male productions of the coda in "bids."

4. DISCUSSION

The temporal patterns at syllable onset for male speakers found in this study correspond to those in females (Jacewicz et al., 2011), confirming that information about coda voicing is available in the syllable earlier than in the preceding vowel. This implies that the primary cue to coda voicing contrast—the duration of the preceding vowel—covaries with the temporal relationships in the syllable-initial segment (here the stop /b/), suggesting that the contrast is executed by a long-distance motor planning involved in the production of the entire syllable. The specific patterns confirmed here with male speakers were that a longer closure of the initial /b/ was associated with a voiceless coda and a shorter closure with a voiced coda. The only difference between the two datasets was that closure durations in males were not affected by dialect variation, whereas the closures in NC females were significantly shorter than in either WI or OH. To explain these discrepancies, additional analyses of absolute closure duration (and not only as a proportion in a word) in males are necessary, which will be addressed as our work progresses.

The patterns of covariation of voicing cues at the onset in the male speakers—closure duration and the extent of voicing during the closure—matched those of the female speakers: less voicing in the closure was associated with a voiceless coda and more voicing with a voiced coda. We note that, overall, male speakers produced more closure voicing than females, particularly in OH and WI (Figure 4). Although this difference still needs to be assessed statistically, it is possible that this is a systematic gender-specific effect, reflecting characteristics of male versus female speech.

Consistent with females, predictable patterns of variability in the nature of closure voicing as a function of prosodic variation were also evident in males. Figure 9 illustrates this variability, showing a longer closure with a dissipating voicing before a stressed vowel (left panel) and a shorter closure with continuous voicing before an unstressed vowel (right panel). The two waveforms represent productions by the same WI male speaker and both samples are of equal overall duration (267 ms). This differential pattern can be explained by aerodynamics of the vocal apparatus in that the increased respiratory force for a stressed vowel affected the timing necessary for the equalization of the transglottal pressure during the stop closure, whereas no such increase for an unstressed vowel gave rise to the continuous vibration of the vocal folds (Keating, 1984; Docherty, 1992).

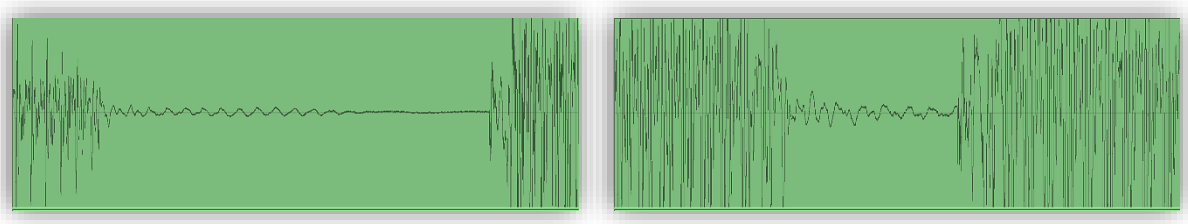


Figure 9. Closure voicing dissipates in a stressed vowel (left) and remains "unbroken" in an unstressed vowel (right). Both 267-ms samples are from a WI male production of "…small bats…"

However, variability in the nature of closure voicing can also come from dialect variation. Figure 10 provides such an example, showing two waveforms of equal duration (367ms) corresponding to productions of a WI speaker (left) and a NC speaker (right). Both speakers produced the same sentence and stop closures come from the stressed target word in "…dull bades…" . As can be seen, voicing does not dissipate before a stressed vowel, and both closures are voiced throughout in ether production. This may indicate the use of active strategies to prolong voicing (Westbury & Keating, 1986), however the amplitude of voicing is visibly greater in NC than in WI. Greater voicing amplitude in Southern stop closures was also reported in Podesva et al. (2015), suggesting that the degree of voicing may be mediated by social influences on production (Labov, 2001).

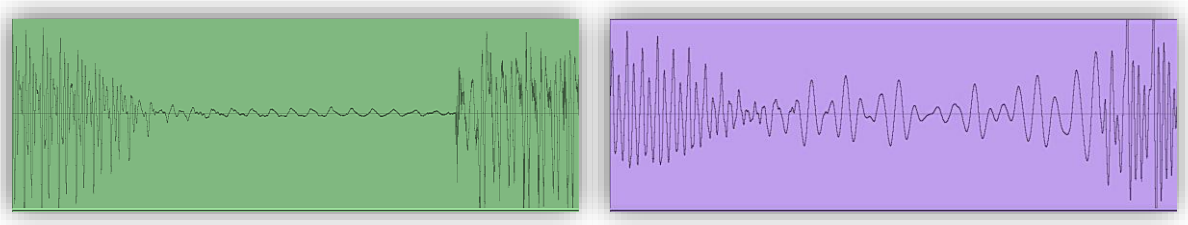


Figure 10. Fully voiced closures in a stressed vowel in WI (left) and NC (right). Both 367-ms samples are from a male production of, "…dull bades…"

The current findings for VOT in males are also consistent with females in that dialect was the only significant predictor of VOT patterns. As in NC females, VOTs in NC males were shorter than in any other dialect, and NC males also prevoiced more often than males in either OH or WI. Although prevoicing (i.e., the negative VOT) was also more frequent in NC females, NC males prevoiced comparatively more tokens (2.83% versus 1.41% of the entire sample). This result also supports previous sociophonetic reports of a higher prevalence of prevoicing in Southern males than females (Herd, 2020). In our sample, the nature and extent of prevoicing was affected by prosodic variation and it was most frequent in the intermediate SWP when /b/ immediately followed the main sentence stress (e.g., "…TALL beds…"). Figure 11 illustrates this prevoicing pattern, which seems to be related to a specific way of producing emphasis in this Southern dialect, i.e., by prolonging /l/.

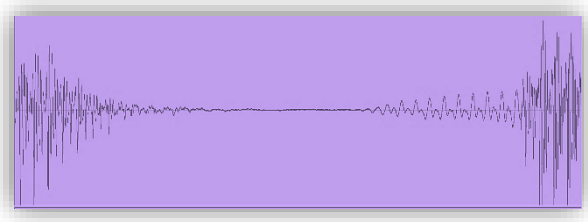


Figure 11. Prevoiced closure of /b/ in a NC speaker following a prolonged /l/.

5. CONCLUSION

Taken altogether, the current results support the existence of a syllable-wide distribution of acoustic cues to coda voicing in monosyllabic words. This finding implies that temporal relationships observed here in production may have perceptual relevance in that they may enhance perceptual dimensions of perceived syllable-wide voicing contrasts. Future work is needed to explore this possibility.

REFERENCES

Brooks, M. E., Kristensen, K., van Benthem, K. J., Magnusson, A., Berg, C. W., Nielsen, A., Skaug, H. J., Mächler, M., and Bolker, B. M. (2017). "glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling," R J. 9(2), 378–400. https://doi.org/10.32614/RJ-2017-066

Clayards, M. (2018). "Individual talker and token covariation in the production of multiple cues to stop voicing," Phonetica 75(1), 1–23. https://doi.org/10.1159/000448809

Docherty, G. J. (1992). The Timing of Voicing in British English Obstruents (De Gruyter Mouton, Berlin). https://doi.org/10.1515/9783110872637

Hawkins, S., and Nguyen, N. (2004). "Influence of syllable-coda voicing on the acoustic properties of syllable-onset /l/ in English," J. Phon. 32(2), 199–231. https://doi.org/10.1016/S0095-4470(03)00031-7

Herd, W. (2020). "Sociophonetic voice onset time variation in Mississippi English," J. Acoust. Soc. Am. 147(1), 596–605. https://doi.org/10.1121/10.0000545

Jacewicz, E., Arzbecker, L. J., Fox, R. A., and Liu, S. (2021). "Variability in within-category implementation of stop consonant voicing in American English-speaking children," J. Acoust. Soc. Am. 150(5), 3711–3729. https://doi.org/10.1121/10.0007229

Jacewicz, J., Fox, R. A., and Wei, L. (2010). "Between-speaker and within-speaker variation in speech tempo of American English," J. Acoust. Soc. Am. 128(2), 839–850. https://doi.org/10.1121/1.3459842

Keating, P. A. (1984). "Physiological effects on stop consonant voicing," Work. Pap. Phon. 59, 29–34. https://linguistics.ucla.edu/people/keating/Keating_1984b_WPPvoicing.pdf (Last accessed October 27, 2022).

Kuznetsova, A., Brockhoff, P. B., and Christensen, R. H. B. (2017). "lmerTest package: Tests in linear mixed effects models," J. Stat. Softw. 82(13), 1–26. https://doi.org/10.18637/jss.v082.i13

Labov, W. (2001). Principles of Linguistic Change: Social Factors, Vol. 2 (Language in Society) (Blackwell, Oxford).

Lisker, L., and Abramson, A. S. (1964). "A cross-language study of voicing in initial stops: Acoustical measurements," Word 20(3), 384–422. https://doi.org/10.1080/00437956.1964.11659830

Luce, P. A., and Charles-Luce, J. (1985). "Contextual effects on vowel duration, closure duration, and the consonant/vowel ratio in speech production," J. Acoust. Soc. Am. 78(6), 1949–1975. https://doi.org/10.1121/1.392651

Millasseau, J., Yuen, I., Bruggeman, L., and Demuth, K. (2021). "Acoustic cues to coda stop voicing contrasts in Australian English-speaking children," J. Child Lang. 48(6), 1262–1280. https://doi.org/10.1017/S0305000920000781

Penny, J., Cox, F., Miles, K., and Palethorpe, S. (2018). "Glottalisation as a cue to coda consonant voicing in Australian English," J. Phon. 66, 161–184. https://doi.org/10.1016/j.wocn.2017.10.001

Peterson, G. E., and Lehiste, L. (1960). "Duration of syllable nuclei in English," J. Acoust. Soc. Am. 32(6), 693–703. https://doi.org/10.1121/1.1908183

Podesva, R. J., Eckert, P., Fine, J., Hilton, K., Jeong, S., King, S., & Praat, T. (2015). Social influences on the degree of stop voicing in inland California. University of Pennsylvania Working Papers in Linguistics, 21(2), 166–176. https://repository.upenn.edu/pwpl/vol21/iss2/19 (Last viewed October 31, 2022).

Raphael, L. J. (1972). "Preceding vowel duration as a cue to the perception of the voicing characteristic of word-final consonants in American English," J. Acoust. Soc. Am. 51(4B), 1296–1303. https://doi.org/10.1121/1.1912974

Shattuck-Hufnagel, S., Demuth, K., Hanson, H. M., and Stevens, K. N. (2011). "Acoustic cues to stop-coda voicing contrasts in the speech of 2-3-year-olds learning American English," in Where Do Phonological Features Come From? Cognitive, physical and developmental bases of distinctive speech categories edited by G. N. Clements and R. Ridouane (John Benjamins, Amsterdam) pp. 327–342. https://doi.org/10.1075/lfab.6.12sha

Song, J. Y., Demuth, K., and Shattuck-Hufnagel, S. (2012). "The development of acoustic cues to coda contrasts in young children learning American English," Acoust. Soc. Am 131(4), 3036–3050. https://doi.org/10.1121/1.3687467

Westbury, J. R., and Keating, P. A. (1986). "On the naturalness of sop consonant voicing," J. Ling. 22(1), 145–166. https://www.jstor.org/stable/4175821 (Last viewed October 27, 2022).