1-2015

Some Phonetic Structures of Koasati

Matthew Gordon

Jack B. Martin

Linda Langley

Follow this and additional works at: <https://scholarworks.wm.edu/aspubs>

Part of the [Linguistics Commons](#)

SOME PHONETIC STRUCTURES OF KOASATI¹

MATTHEW GORDON

JACK B. MARTIN

UNIVERSITY OF CALIFORNIA, SANTA BARBARA

COLLEGE OF WILLIAM AND MARY

LINDA LANGLEY

MCNEESE STATE UNIVERSITY

This paper presents results of the first quantitative phonetic study of Koasati, a Muskogean language spoken in Louisiana and Texas. We examine vowel quality, length contrasts in vowels and consonants, the limited system of lexical tone contrasts in nouns, and the grammatical system of tone in verbs. We also study the realization of several word-final consonant clusters (*fn*, *tl*, *lw*, etc.) that are absent in related languages and that are typologically unusual due to their sonority reversals. Finally, we examine the cognates in related languages of the tones we document in Koasati nouns and verbs.

[Keywords: Koasati, Muskogean, phonetics, phonology]

1. Introduction. Koasati (ISO code: *cku*) is a Muskogean language distantly related to Alabama (ISO code: *akz*), Choctaw (ISO code: *cho*), Chickasaw (ISO code: *cic*), Mikasuki (ISO code: *mik*), and Creek (ISO code: *mus*). Koasati is closest to Alabama within the family, though the degree of intelligibility between the two is fairly low. The language is spoken in two locations: by approximately 25% of the 900 enrolled members within the Coushatta Tribe of Louisiana and by another small group of members of the Alabama-Coushatta Tribe of Texas. The language is endangered in both communities. A few individuals in their twenties understand the language and can converse, but regular use of the language is common only among those over the age of 50. This project focuses on the larger group within the Coushatta Tribe of Louisiana.

Most previous work on Koasati has focused on vocabulary, texts, and grammar. Albert Pike, Albert S. Gatschet, and John R. Swanton collected vocabulary and texts (see Kimball 1991:14–15 for discussion of this early work). Mary R. Haas conducted fieldwork in the 1930s, collecting vocabulary,

¹ We are grateful to an Associate Editor of *IJAL* and three reviewers for their many helpful comments on an earlier version of this paper. Special thanks to members of the Coushatta Tribal Council, the Koasati Language Committee, and the Coushatta Heritage Department staff. This research was funded by the National Science Foundation, award #BCS-1065334. Any opinions, findings and conclusions, or recommendations expressed in this content are those of the authors and do not necessarily reflect the views of the National Science Foundation.

texts, and verb paradigms (Haas 1938–39) and publishing a paper on men's and women's speech (Haas 1944). In 1992, David Rising published a thesis on switch-reference in Koasati (Rising 1992). The most extensive documentation of Koasati has been carried out by Geoffrey D. Kimball, who has published a reference grammar (Kimball 1991), dictionary (Kimball 1994), and texts (Kimball 2010).

There has been relatively little attention paid to Koasati phonology, and there are no instrumental phonetic studies of any kind. This paper aims to partially remedy this lacuna by providing phonetic documentation of several properties of Koasati, including formant structure of vowels and temporal characteristics of the pervasive length contrast in vowels and consonants. In addition, we provide a phonetic description of accent in nouns and verbs, comparing the Koasati accentual system with that found in other Muskogean languages. Finally, we explore the phonetic characteristics of a number of typologically unusual (and unique among Muskogean languages) word-final clusters displaying sonority reversals. Sound files containing representative examples of the words analyzed in the study appear in an online-only appendix.

2. Present study. In the remainder of the paper, we present results of several phonetic studies designed to fulfill three goals: first, providing instrumental verification of a number of segmental and prosodic features of the Koasati phonological system; second, contributing to the comparative phonetic documentation of the Muskogean language family; and third, describing the phonetic realization of certain typologically unusual properties.

2.1. Methodology. Our study is based on two lists of words which our experience suggested were representative of the phonological and phonetic properties targeted for examination. The first list comprised 70 items and was recorded from 14 speakers (eight women and six men) in the Coushatta tribal community in Elton, Louisiana. Throughout the paper, data from the eight women are labeled FS1 (female speaker 1) through FS8 (female speaker 8) and data from the six men are labeled MS1 (male speaker 1) through MS6 (male speaker 6). The second list contained 82 words and focused on word-final consonant length and clusters and on the accent system. Recordings of this second list were analyzed for six speakers (four women and two men), of whom four (three women [FS1, FS2, and FS6] and one man [MS1]) constituted a subset of the 14 speakers recording the first list. The remaining two speakers who recorded only the second list are labeled FS9 and MS7 in the paper. All speakers were members of the Koasati Language Committee who use the language every day and who were thought to represent different geographic locations in the community, different ages, and different families. Recordings were made at a sampling rate of 44.1k Hz and a 16 bit depth using a handheld unidirectional Sennheiser MD46 microphone (at a

distance of approximately one foot from the speaker's mouth) connected to a solid-state recorder (Marantz PMD 660/661). Some speakers were recorded individually, while others were recorded in groups ranging from two to four speakers. In the case of the first corpus, speakers read twice a list of words that was randomized and counterbalanced over the two repetitions. Speakers recording the second randomized list repeated each word three times. Data were transferred to computer in preparation for acoustic analysis using Praat (Boersma and Weenink 2010).

2.2. Organization. The paper is divided into three sections: one focused on vowels, another on consonants, and a third on accent in nouns and verbs. Each section begins with a brief phonological overview of the relevant property followed by the results of the phonetic study.

Section 3 targets the vowels. First, we present results of a study of vowel formants designed to determine the extent to which phonemic short and long vowels qualitatively differ, as described in previous research on Koasati and noted for other Muskogean languages. We then investigate the durational profile of phonemic length contrasts in vowels, comparing results with those of similar studies of Koasati's Muskogean relatives Chickasaw and Creek.

Section 4 focuses on the consonants. First, we examine the realization of length distinctions in intervocalic consonants, situating the Koasati results within the typology of phonemic contrasts in duration. We then look at two interesting features of word-final consonants resulting from a productive process of apocope occurring in statements and commands. One of these features is the phonetic realization of a number of typologically unusual final rising sonority consonant clusters, which potentially violate the Sonority Sequencing Principle (Hooper 1976, Selkirk 1984, Clements 1990, and Blevins 1995). The other is the potential existence of phonemic length distinctions in final position arising through apocope following a long consonant.

Section 5 examines the realization of lexical accent contrasts in nouns and grammatical accent in verbs. This phase of the study contains a phonetic study of lengthening processes associated with verb accents to determine whether lengthening neutralizes underlying length contrasts.

3. Vowels. We agree with Haas (1944:n. 2) in recognizing three phonemic vowel qualities.² These may be short or long (1).

² Kimball (1991:23) also recognizes six vowel phonemes but argues for a more abstract analysis with just three vowels. He proposes to reduce the vowel inventory by treating vowel length (:) as a consonant. This would simplify the placement of infixes, which in certain verbs appear to be placed before final CCV or :CV. For this reason, he lists only three vowels—*i*, *a*, and *o*—in his vowel chart and includes : as a glottal glide in his consonant chart (1991:18).

(1) Vowel phonemes

i *i:* *o* *o:*
a *a:*

The examples in (2) are near minimal pairs for short and long vowels in initial position. The length contrast is found initially and medially but not at the ends of words.

(2) Contrasts between short and long vowels in initial position

<i>aha</i>	'sweet potato'	<i>a:ti</i>	'person'
<i>ifa</i>	'dog'	<i>i:sa</i>	'house'
<i>oki</i>	'water'	<i>o:la</i>	'town'

Impressionistically, vowels tend to be increasingly centralized as they get shorter: the short vowels *i*, *a*, and *o* thus approach [ɪ], [ɐ], and [ʊ], especially in closed syllables.³

In addition to the vowel phonemes in (1), Koasati makes a distinction between oral and nasalized vowels. Haas (1944:n. 2) says simply, "All vowels occur also nasalized" and transcribes both long and short nasal vowels. Kimball (1991) takes the position that vowel nasalization is a "marginal" phoneme. He describes the distribution of nasal vowels this way: "Although nasalized vowels frequently occur, all word-medial nasal vowels are the result of either a nasal-fricative sequence, or the operation of the n[asalizing]-grade, which causes morphemic nasalization. Word-finally, nasalization is the result of a nasalizing phrase-terminal marker. Therefore, although nasalized vowels will be written in this work, it must be realized that nasal vowels are not autonomous phonemes in Koasati" (Kimball 1991:25).

We agree with Kimball's basic point: nasalized vowels generally derive predictably from nasal consonants, signal grammatical meaning ('very', non-subject marking, etc.), or indicate boundary phenomena (Kimball's phrase-terminal marker). No two nouns are ever distinguished based on the oral or nasal quality of a vowel. At the same time, it is clear that speakers attend to the oral/nasal distinction in interpreting the meaning of inflected forms. It seems more straightforward to transcribe the auditory cue that signals the change in meaning (whether that meaning is lexical or grammatical).⁴

3.1. Vowel quality. The frequencies of the first three formants for short and long vowels were measured over a 25-millisecond window centered in each vowel targeted for measurement. Formant values were collected using

³ There appear to have been additional allophones of the vowels in the 1930s. Haas (1938–39) transcribes short *i* as [ɛ] in final position, where it is accompanied by falling (emphatic) intonation. She transcribes *i:* as [e:] in all positions. We have not observed either of these processes.

⁴ A separate question is whether it is necessary to distinguish short nasalized vowels from long nasalized vowels. Our practice is to record long nasalized vowels in the nasalizing grade and short nasalized vowels elsewhere.

a Praat script and checked visually against a wideband spectrogram. In some cases, values had to be recalculated using different measurement parameters. Target vowels appeared word-medially in open syllables between the consonants *k* and *l*. All vowels occurred in prominent syllables: either long vowels in heavy syllables, short vowels in stem-final position (in the data here before the future suffix *-laho*, which appears as *lahō* word-finally), or an odd-numbered short vowel in a string of light CV syllables, i.e. strong syllables in trochaic feet (see 5.3 below for discussion of metrical structure in Koasati). An attempt was made to compare vowels in words of roughly equivalent length: with the exception of one tetrasyllabic word, words containing the target vowels had either five or six syllables.

The words in (3) were used in the phonetic study of the vowels. Two speakers (MS2 and MS3) had different pronunciations of the target vowel in *pakpakilahō* ‘it will bubble’: for these speakers, we measured the third vowel in *afitika* ‘rope’ instead.

- (3) Words containing the vowel (in boldface) targeted for measurement
VOWEL	SHORT	LONG
<i>a</i>	<i>wali:kalahō</i> ‘s/he will run’	<i>ataka:lilahō</i> ‘s/he will hang it’
<i>i</i>	<i>pakpakilahō</i> ‘it will bubble’	<i>pa:fiki:lilahō</i> ‘s/he will set (2+) down’
<i>o</i>	<i>iskolahō</i> ‘s/he will drink’	<i>loko:lilahō</i> ‘they (3+) will stand’

Average values for the first three vowels were taken for the 14 speakers. Values appear in figure 1. Each box delimited by thick lines contains data from a single speaker. Speakers are coded numerically and according to their gender (FS for female speakers and MS for male speakers); FS1 indicates female speaker 1, FS2 indicates female speaker 2, and so on. Formant values are for the first three formants (listed in columns) averaged over the two tokens recorded for each speaker.

Formant values for individual tokens produced by all the female speakers are plotted together in figure 2, while those uttered by the male speakers appear in figure 3. As figures 2 and 3 show, both the female and male speakers clearly differentiate the three long vowels from each other. The short vowels are also distinguished, though they are centralized relative to their long counterparts. This tendency to centralize is particularly apparent in the male speaker data. Centralization is more apparent in the front–back dimension than the height dimension for the low vowel, while the two long non-low vowels are more peripheral than their short counterparts in both the height and the front–back dimensions. The front and back non-low vowels differ only slightly in height, with the front vowel being slightly higher than its back counterpart.

As noted above in n. 3, Haas (1938–39; 1944) transcribed the short vowels *a*, *i*, and *o* with more central phonetic values [ʌ] (equivalent to IPA [ɐ]), [ɪ] (but [ɛ] finally), and [ʊ]. She transcribed the long vowels *a*:, *i*:, *o*: with the

Speaker & Vowel	Length	F1	F2	F3	Speaker & Vowel	Length	F1	F2	F3
FS1					FS8				
<i>i</i>	Short	440	2205	3310	<i>i</i>	Short	453	2017	2579
	Long	362	2639	3264		Long	382	2492	2568
<i>a</i>	Short	753	1670	2902	<i>a</i>	Short	727	1552	2686
	Long	897	1452	2704		Long	810	1352	2423
<i>o</i>	Short	511	1206	2504	<i>o</i>	Short	469	1135	2712
	Long	441	797	2646		Long	395	840	2780
FS2					MS1				
<i>i</i>	Short	449	2176	2497	<i>i</i>	Short	436	1584	2331
	Long	382	2553	2972		Long	316	1973	2432
<i>a</i>	Short	701	1752	2279	<i>a</i>	Short	498	1308	2335
	Long	935	1407	2751		Long	630	1156	2454
<i>o</i>	Short	517	1246	2724	<i>o</i>	Short	447	1171	2457
	Long	445	886	2626		Long	364	735	2538
FS3					MS2				
<i>i</i>	Short	460	2019	2336	<i>i</i>	Short	349	1878	2407
	Long	399	2363	2888		Long	276	2247	2695
<i>a</i>	Short	555	1690	2384	<i>a</i>	Short	470	1452	2436
	Long	658	1298	2524		Long	599	1361	2176
<i>o</i>	Short	481	1240	2208	<i>o</i>	Short	395	1322	2240
	Long	411	825	2804		Long	359	969	2455
FS4					MS3				
<i>i</i>	Short	416	1977	2861	<i>i</i>	Short	499	1874	2378
	Long	405	2357	3034		Long	401	2127	2524
<i>a</i>	Short	690	1675	2752	<i>a</i>	Short	595	1541	2492
	Long	910	1372	2556		Long	793	1242	2096
<i>o</i>	Short	481	1188	2429	<i>o</i>	Short	554	1097	2076
	Long	416	1977	2861		Long	398	779	2546
FS5					MS4				
<i>i</i>	Short	412	2429	2844	<i>i</i>	Short	436	1941	2133
	Long	400	2358	2760		Long	352	1992	2198
<i>a</i>	Short	632	1643	2800	<i>a</i>	Short	558	1518	2194
	Long	831	1414	2644		Long	662	1231	2280
<i>o</i>	Short	500	1116	2502	<i>o</i>	Short	486	1172	2053
	Long	432	883	2503		Long	386	733	2398
FS6					MS5				
<i>i</i>	Short	396	2316	2732	<i>i</i>	Short	366	1957	2485
	Long	364	2540	2916		Long	336	1992	2600
<i>a</i>	Short	785	1599	2768	<i>a</i>	Short	542	1507	2333
	Long	851	1402	2502		Long	661	1211	2347
<i>o</i>	Short	497	1197	2631	<i>o</i>	Short	470	1298	2158
	Long	396	779	2891		Long	366	715	2417
FS7					MS6				
<i>i</i>	Short	460	2057	2912	<i>i</i>	Short	483	1986	2605
	Long	371	2078	2868		Long	328	2183	2664
<i>a</i>	Short	890	1656	2963	<i>a</i>	Short	650	1312	2475
	Long	1025	1486	3058		Long	747	1184	2258
<i>o</i>	Short	535	1332	2780	<i>o</i>	Short	489	999	2377
	Long	439	1042	3009		Long	410	798	2446

FIG. 1.—Formant values for Koasati short and long vowels from 14 speakers (two tokens averaged together for each speaker).

FIG. 2.—Plot of the first two formants for phonemic long (on top) and short (on bottom) vowels for eight female speakers.

phonetic values [a:], [e:], and [o:]. The closest correspondence between our data and Haas's transcriptions is for the low vowel. In the case of the two non-low vowels, Haas's transcriptions suggest a slightly lower quality for the long member of each pair, i.e., long [e:] vs. short [ɪ] and long [o:] vs. short [ʊ]. The centralization she describes is supported by figures 2 and 3, except that we see no lowering of *i:* to [e:]. It is also interesting that the qualitative relationship between short and long vowels differs substantially between the female speakers in figure 2 and the male speakers in figure 3. Other differences between men and women have been described for Koasati (Haas 1944 and Kimball 1991), but degree of vowel centralization is not one of them.

FIG. 3.—Plot of the first two formants for phonemic long (on top) and short (on bottom) vowels for six male speakers.

The patterns visible in the formant plots are corroborated by statistical analyses of the data by gender. We first consider the results for the female speakers. An analysis of variance (ANOVA) with vowel quality as the independent variable and the first and second formant as the dependent factors was conducted for the long vowels produced by the female speakers. There was a significant main effect of vowel on both F1 ($F(2, 47) = 257.412, p < .001$) and F2 ($F(2, 47) = 593.297, p < .001$). Bonferroni post hoc tests indicated that all three vowels were reliably differentiated (at $p < .001$) in all pairwise comparisons except F1 for *i* vs. *o*, which were not distinguished.

An ANOVA conducted over the short vowels showed that the three short vowels were also distinguished for the female speakers along both the F1

(main effect: $F(2, 47) = 75.495$, $p < .001$) and F_2 (main effect: $F(2, 47) = 198.228$, $p < .001$) dimensions. Bonferroni post hoc tests showed that all three vowels were reliably differentiated at the $p < .001$ level in all pairwise comparisons except F_1 for *i* vs. *o*, which narrowly achieved significance ($p = .034$).

In order to examine the effect of phonemic length on vowel quality, ANOVAs were also conducted for individual vowel qualities with phonemic length category as the independent variable and the first two formants as dependent variables. The low vowel was distinguished in both F_1 ($F(1, 31) = 14.942$, $p = .001$) and F_2 ($F(1, 31) = 96.472$, $p < .001$) as a function of length. The high front vowel was also differentiated based on phonemic length for both formants: for F_1 , $F(1, 31) = 26.390$, $p < .001$; for F_2 , $F(1, 31) = 16.051$, $p < .001$. Short and long back vowels also differed from each other for both formants: for F_1 , $F(1, 31) = 44.060$, $p < .001$; for F_2 , $F(1, 31) = 97.784$, $p < .001$.

For the male speaker data, separate ANOVAs conducted for the short and long vowels indicated a significant effect of vowel quality on the first two formants for both phonemic lengths: for F_1 for the long vowels, $F(2, 34) = 157.842$, $p < .001$; for F_2 for the long vowels, $F(2, 34) = 490.750$, $p < .001$; for F_1 for the short vowels, $F(2, 33) = 9.996$, $p < .001$; for F_2 for the short vowels, $F(2, 33) = 72.752$, $p < .001$.

For the long vowels, Bonferroni post hoc tests showed that all three vowels were reliably differentiated at the $p < .001$ level in both F_1 and F_2 for all pairwise comparisons except for F_1 in the comparison of *i* vs. *o*, which did not reach significance. The short vowels were all reliably differentiated from each other along the F_2 dimension according to pairwise post hoc tests ($p < .001$). For F_1 , *i* vs. *o* were not distinguished, while other pairwise comparisons reached significance at $p < .01$.

For the male speaker data, ANOVAs were also conducted for individual vowel qualities with phonemic length category as the independent variable and the first two formants as dependent variables. The low vowel was distinguished in both F_1 ($F(1, 23) = 20.383$, $p = .001$) and F_2 ($F(1, 23) = 28.791$, $p < .001$) as a function of length. The high front vowel was also differentiated based on phonemic length for both formants: for F_1 , $F(1, 20) = 27.045$, $p < .001$; for F_2 , $F(1, 20) = 11.170$, $p = .003$. Short and long back vowels also differed from each other for both formants: for F_1 , $F(1, 23) = 26.111$, $p < .001$; for F_2 , $F(1, 23) = 63.816$, $p < .001$.

In summary, long vowels are more peripheral than their short counterparts, where the effect is quite strong along both the front-back and height dimensions for the front and back vowels. For the low vowels, the centralization of short vowels is most apparent in the front-back plane but still statistically robust in the height dimension. Nevertheless, despite the tendency for short

FIG. 4.—Duration (in seconds) of phonemic short and long vowels averaged over 14 Koasati speakers. Whiskers represent 95% confidence intervals.

vowels to be less peripheral than their long counterparts, they are still reliably distinguished from each other. Overall, the vowel inventory is quite symmetrical, with the low vowel occupying the center of the vowel space (somewhat farther back in the case of the long vowels) and the two non-low vowels differing only slightly in height (a difference which was only robust in our data for the short vowels produced by the female speakers).

The phonetic data on vowel quality from Koasati closely mirror results from related languages with similar vowel inventories. In both Creek (Johnson and Martin 2001) and Chickasaw (Gordon, Munro, and Ladefoged 2000 [henceforth Gordon et al. 2000]), short vowels are centralized relative to their long counterparts, a common cross-linguistic pattern (Lehiste 1970). Furthermore, the high front vowel is slightly higher than its back counterpart in both languages, as in Koasati, though the difference in height is slightly larger in Creek than in either Koasati or Chickasaw.

3.2. Vowel duration. We also measured the duration of the target short and long vowels in the words in (3) using a waveform in conjunction with a time-aligned wideband spectrogram. Average duration values collapsed over the 14 speakers are shown in figure 4, followed by individual speaker values in figure 5.

	<i>a</i>		<i>i</i>		<i>o</i>	
Speaker	Short	Long	Short	Long	Short	Long
FS1	74	146	83	119	73	165
FS2	52	150	54	123	65	127
FS3	46	152	71	130	54	143
FS4	55	151	73	124	55	155
FS5	48	137	69	113	66	114
FS6	59	125	68	115	54	134
FS7	77	155	82	122	55	135
FS8	68	148	78	114	72	150
MS1	55	125	69	97	57	128
MS2	84	93	77	90	48	87
MS3	59	133	46	94	45	110
MS4	38	123	63	88	42	124
MS5	63	118	47	81	52	118
MS6	67	117	73	91	48	90
Means	60	134	68	108	56	127

FIG. 5.—Duration (in milliseconds) of short and long vowels by speaker.

The phonemic long vowels are considerably longer than the short vowels, particularly in the case of the two non-front vowels. The long low vowel and long back vowel averaged more than twice the length of their short counterparts across speakers: long *a*: was 2.23 times as long as short *a*, and long *o*: was 2.27 times as long as its short analog. The duration ratio between the short and long front vowel is not as great: 1.59:1 pooled across speakers. All speakers have a clear length distinction for all three vowel qualities, though the magnitude of the difference varies between speakers. A two-factor ANOVA (vowel quality and phonemic length) conducted over the data from both genders confirmed the robustness of the effect of phonemic length on phonetic duration: ($F(1, 166) = 533.9, p < .001$), while post hoc tests corroborated the length distinctions between pairs of vowels.

It is interesting to note that duration differences between short and long vowels observed for the two non-low vowels are considerably larger than those found in Chickasaw or Creek. Gordon et al. (2000) found that phonemic long *a*: in Chickasaw was 1.78 times longer than its short counterpart and phonemic long *o*: was 1.72 times as long as short *o*. Chickasaw and Koasati have in common, however, that the duration ratio between long *i*: and short *i* is smaller than for the other two vowel qualities: 1.55:1 in Chickasaw and

	Bilabial	Labio-dental	Dental/alveolar	Post alveolar	Labial-velar	Velar	Glottal
Stops	<i>p b</i>		<i>t</i>	<i>ʃ</i>		<i>k</i>	
Nasals	<i>m</i>		<i>n</i>				
Fricatives		<i>f</i>	<i>s, ʈ</i>				<i>h</i>
Approx.			<i>l</i>	<i>j</i>	<i>w</i>		

FIG. 6.—The consonants of Koasati.

1.59:1 in Koasati. Johnson and Martin (2001) report a 1.81:1 long:short ratio for Creek collapsed across vowel qualities, considerably shorter than that observed for the two non-front pairs in Koasati.

The ANOVA also revealed an effect of vowel quality on duration ($F(2, 166) = 3.825, p = .024$), as well as an interaction between phonemic length and vowel quality: $F(2, 166) = 16.603, p < .001$. This interaction was attributed to the fact that the low vowel was slightly longer than the high front vowel on average ($p = .014$ in a Bonferroni post hoc test), whereas other pairwise comparisons of vowels did not reach significance. Interestingly, as the figures show, the greater length of the low vowel relative to the high vowel was only found in the long vowel series and not for the short vowels.

4. Consonants. We present the consonant phonemes of Koasati in figure 6, agreeing closely with Haas (1944:n. 2). All of the consonants have contrastive long counterparts, a property we examine in 4.1.

Note that, as in most related languages, there is only one voiced stop (*b*). Haas's (1947) explanation of this asymmetry is that a Proto-Muskogean labial-velar stop **k^w* developed as *b* in all the languages except Creek, where it yielded *k* or *p*. Thus Proto-Muskogean **k^wihi* 'mulberry' develops as *bihi* in Koasati but as *kí:* in Creek.

Kimball (1991:20) differs in a few details. He describes the voiceless stops and affricate as aspirated in initial and medial position. Voice-onset-time (VOT) values for initial voiceless stops in our data range from roughly 10 milliseconds to 40 milliseconds, where the lower values are typical for bilabial and dental/alveolar stops and the higher values for velars. These values place Koasati in the region straddling the "unaspirated" and "slightly aspirated" categories according to Cho and Ladefoged's (1999) classification based on a study of VOT in 18 languages. Kimball describes the voiceless fricative *s* as palato-alveolar in his consonant chart but says that it has dental, alveolar, and palatal allophones. We find it is generally alveolar but post-alveolar in the sequence *sʃ* (pronounced [ʃʃ]).

FIG. 7.—Production of a labiodental fricative by speaker FS9.

One striking feature of Koasati phonology is the pronunciation of *h*. The sequence VhCV is generally pronounced V:CV when C is a voiced consonant. A form like *a:sihlilahō* ‘he/she will wash (something)’ is thus pronounced [a:si:lilahō]. The *h* in the stem surfaces in a command, however, when the final vowel is deleted: thus, *a:sîhl* ‘wash it!’ is pronounced [a:sîh̥].

Kimball (1991:20) describes *f* as bilabial. Haas (1938–39) also recorded a voiceless bilabial fricative, but the speakers we have observed closely have a labio-dental fricative (though there may be some coarticulatory rounding before *o*). Figure 7 shows a representative frame from a video taken of the word *foho* ‘bee’ (produced by speaker FS9, a woman in her 70s) showing contact between the upper teeth and lower lip for *f*.

It is plausible that the labio-dental articulation of *f* is a relatively recent innovation. A similar shift from bilabial *f* to labio-dental *f* has been documented for Creek (Martin 2011).

4.1. Duration of intervocalic short and long consonants. In order to assess the robustness of consonant length contrasts, the duration of several short vs. long consonant pairs in the environment *a* __ *a* was measured from a waveform with the aid of a time-aligned spectrogram. Measured pairs included *p*, *t*, *k*, *s*, *l*, and *f*. The words from which the measurements were taken appear in (4) below. Of the forms with long consonants, two (*fahap:ă:kan* ‘five’ and *haŋf:alî:fîlahō* ‘s/he will detain (one)’) are long as a result of the rising-geminating grade and thus marked with an IPA length mark. The other words are all underlyingly long. Long consonants of both types were included after a phonetic comparison indicated their durational equivalence (see 5.2). Two tokens of each consonant were measured for the target words in most cases, with a few exceptions. For speaker MS6, short *k* was measured in *ostă:kan* ‘four’ instead of *atakapkalahō* ‘it will snag’,

since the *k* in the latter word was lenited to a voiced stop. For this same speaker as well as for speaker FS3, the long *kk* was measured in *takka* ‘catfish’ since both speakers pronounced the target word *biyakka* ‘chicken hawk’ with a *kh* cluster. One token of *takka* was substituted for the target word for speaker FS4, since she pronounced the target word *biyakka* ‘chicken hawk’ once with a *kh* cluster and once with a long *kk*.

- (4) Words used for comparing the duration difference between short and long consonants

C	SHORT	LONG
<i>p</i>	<i>apala</i> ‘light, lamp’	<i>ʃahap:ǎ:kan</i> ‘five’ (rising-geminating grade)
	<i>tapatʃka</i> ‘quilt’	
<i>t</i>	<i>ataffo</i> ‘grasshopper’	<i>satta</i> ‘turtle’
	<i>albata</i> ‘alligator’	
<i>k</i>	<i>batʃaka</i> ‘ribbon’	<i>biyakka</i> ‘chicken hawk’
	<i>atakapkalahō</i> ‘it will snag’	
<i>s</i>	<i>asa:la</i> ‘basket’	<i>ʃassi</i> ‘corn’
<i>l</i>	<i>palana</i> ‘bean’	<i>hallaki</i> ‘bat (animal)’
<i>ʃ</i>	<i>haʃa:liʃilahō</i> ‘s/he will stand (one) up’	<i>haʃ:alī:ʃilahō</i> ‘s/he will detain (one)’ (rising-geminating grade)

Duration data for the short vs. long pairs are summarized graphically in figure 8, with individual speaker data appearing in figure 9. In considering the results, note that for *s*, the duration data may be confounded by the fact that the word containing the geminate has only two syllables whereas the word containing the singleton has three. This could increase the absolute duration difference between single and geminate consonants if the duration of individual sounds in a word is inversely correlated with the total duration of the word (see Fletcher 2010 for an overview of compression and other timing effects).

All of the short vs. long pairs are clearly distinguished durationally, though the relative duration of the two members of each pair varies depending on the consonant and the speaker. As figure 8 shows, long *tt*, *kk*, and *ll* are more than twice the length of their short counterparts averaged over all speakers. Long *ʃʃ* (phonetically [t:ʃ]) is less than twice the length of short *ʃ* averaged (1.82:1), but the closure phase of the long affricate is more than twice the duration (2.41:1) of the short affricate. The bilabial stop *p* and the fricative *s* also display average long:short ratios of less than 2:1. There is no obvious difference between the length of long consonants resulting from the rising-geminating grade (*ʃahap:ǎ:kan* ‘five’ and *haʃ:alī:ʃilahō* ‘s/he will detain (one)’) and long consonants in underlying forms (see 5.2 for further analysis).

The variation between Koasati consonants in their long:short ratios is mirrored by cross-linguistic data. In many languages, phonemic long consonants

FIG. 8.—Consonant duration (in seconds) for six short vs. long consonant pairs (in the case of the affricate, closure plus frication) averaged over 14 speakers. Whiskers indicate 95% confidence intervals.

are at least twice as long as short consonants, e.g., Finnish (Lehtonen 1970), Estonian (Lehiste 1966 and Ojamaa 1976), Bengali (Lahiri and Hankamer 1988), Japanese (Han 1994), Italian (Farnetani and Kori 1984), Turkish (Lahiri and Hankamer 1988), Hungarian (Meyer and Gombocz 1908), Toba Batak (Cohn, Ham, and Podesva 1999), Malayalam (Local and Simpson 1999), Thurgovian Swiss German (Kraehenmann 2001), Tashlhiyt Berber (Ridouane 2010), and Levantine Arabic (Miller 1987). In a substantial minority of languages, however, long:short ratios fall below 2:1, e.g., Dogri (Ghai 1980), Icelandic (Orešnik and Pétursson 1977), Norwegian (Fintoft 1961), Sinhala (Letterman 1994), Buginese (Cohn, Ham, and Podesva 1999), Madurese (Cohn, Ham, and Podesva 1999), Maltese Arabic (Hume et al. 2010), and Cypriot Greek (Arvaniti and Tserdanelis 2000).

The differences between short and long consonants in Koasati are generally greater than those observed in Chickasaw, where most long consonants are less than twice the duration of their corresponding singletons (Gordon et al. 2000).

Speaker	<i>p</i>	<i>pp</i>	<i>t</i>	<i>tt</i>	<i>k</i>	<i>kk</i>	<i>ʃ</i>		<i>ʃʃ</i>		<i>s</i>	<i>ss</i>	<i>l</i>	<i>ll</i>
							Clo	Fri	Clo	Fri				
FS1	104	131	105	240	95	162	82	51	185	71	127	250	79	188
FS2	107	190	103	260	89	300	64	71	163	80	126	217	74	215
FS3	81	182	91	208	83	160	53	51	104	68	111	223	53	112
FS4	100	219	97	226	81	187	68	57	163	47	120	242	75	176
FS5	93	158	105	161	55	193	54	48	120	75	118	177	60	120
FS6	99	197	99	235	82	144	69	60	157	59	109	228	69	169
FS7	117	194	109	248	87	244	78	59	192	70	142	236	81	174
FS8	133	189	113	274	97	208	88	53	128	76	141	217	75	163
MS1	76	165	69	206	60	136	30	64	97	106	107	206	57	151
MS2	76	168	88	197	60	127	56	45	109	38	90	173	54	---
MS3	94	191	79	203	64	157	55	45	144	68	116	194	62	151
MS4	109	168	74	217	93	141	48	66	158	52	108	228	73	163
MS5	116	161	121	239	64	154	82	56	219	41	102	283	55	182
MS6	68	211	50	177	49	160	27	51	120	56	96	183	48	117
Means	98	180	93	221	76	177	61	56	147	65	115	218	65	160
Ratio	1.84:1		2.37:1		2.34:1		1.82:1		1.90:1		2.45:1			

FIG. 9.—Consonant duration (in milliseconds) for short vs. long consonant pairs for 14 speakers.

For many consonants, Gordon et al. in fact report long:short ratios of less than 1.5:1. Perception of the short vs. long contrast in Chickasaw, however, is facilitated in many contexts by a process of iambic vowel lengthening (absent in Koasati) that is blocked before long but not short consonants (see 5.3 for discussion of metrical structure in Muskogean).

4.2. Word-final consonant clusters. As in other Muskogean languages, most logically possible combinations of two consonants are attested in clusters word-medially.⁵ Word-initially, as in Creek (Martin 2011), aphæresis in Koasati has led to many *sC* clusters, e.g., *stintijapka* ‘can opener’, *smokafka* ‘adornments (e.g., jewelry, decorations)’, *shajka* ‘eraser’. These invariably include the instrumental applicative prefix, which has the form *s-* before consonants and *st-* before vowels (Kimball 1991:140). Peripheral fricative + C clusters of this type, although rare in some of the Muskogean languages, are common cross-linguistically, much like the initial and final clusters in English *streets*, *stamps*.

⁵ Kimball (1991:29) provides a chart of permissible clusters.

Particularly striking from a typological perspective is the rich array of clusters that Koasati possesses word-finally, owing to a process of final vowel deletion in statements (5a) and commands (5b). This process is suppressed in questions (5c). Note that commands end in a sharp pitch fall indicated by ^{HL} in the transcription.

- (5a) *hò:kf*
 put.on:LGR
 ‘s/he is putting (clothing) on’
- (5b) *hokf^{HL}*
 put.on
 ‘put it on!’
- (5c) *hò:kfǎ*
 put.on:LGR
 ‘is s/he putting (clothing) on?’

Final vowel deletion potentially allows all intervocalic clusters to surface word-finally, thereby greatly expanding the possible syllable types. Of particular interest are several rising sonority clusters that constitute potential violations of the Sonority Sequencing Principle (Hooper 1976, Selkirk 1984, Clements 1990, and Blevins 1995), according to which syllables are required to have a single sonority peak. In final clusters with rising sonority, the higher sonority second member of the clusters constitutes a second sonority peak in addition to the vowel preceding the cluster. In the word *bì:tl* ‘s/he is dancing’, for example, the final lateral is higher in sonority than the preceding voiceless stop, thereby creating a second sonority maximum after the vowel nucleus. Similar rising sonority clusters occur in words like *hò:fn* ‘s/he is smelling it’, *tàlw* ‘s/he is singing’, and *hò:kb* ‘s/he’s stringing them’.

Interestingly, our data suggest that final clusters that phonemically appear to introduce a second sonority peak create production problems for speakers and are realized phonetically in ways that reduce or eliminate the syllable-final sonority rise. One strategy for mitigating these sonority violations involves final devoicing. Clusters that consist of a voiceless stop followed by a voiced consonant spread their voicing regressively from the voiced consonant to the preceding voiceless consonant. This regressive assimilation is, in fact, a more general process affecting intervocalic clusters as well as intervocalic singleton stops and even, on rare occasions, the fricative *s*. Thus, *bì:tl* ‘I am dancing’ is characteristically realized with a voiced [d], i.e., [bì:dl̩], and *hò:kb* ‘s/he is stringing them’ with a voiced [g], i.e., [hò:gbl̩]. There is an interesting twist on this voicing assimilation process in final position, where voicing spreads to the first member of the cluster but the second member of a cluster devoices either completely or partially. Thus, *bì:tl* ‘s/he is dancing’ is typically realized

tʃ o f ò d l í l

FIG. 10.—Regressive voicing of *t* in *fotlil* 'I'm jumping' as produced by speaker MS6.

as [bì:dʃ] and *hò:kb* as [hò:gp].⁶ The combination of regressive voicing coupled with final devoicing creates a voiced + voiceless cluster of falling sonority that eliminates the second sonority peak. Figures 10 and 11 depict representative examples of an intervocalic and final *tl* cluster, respectively.

Unlike stops, oral fricatives preceding a voiced consonant do not undergo voicing assimilation, e.g., *kolòsna:ni* 'rooster', *hò:fnál* 'I am smelling it'. Final devoicing still applies after fricatives, however. Thus, *hò:fn* 's/he is smelling it' is typically realized with a voiceless final nasal, i.e., [hò:fɲ̥].

Another rising sonority cluster occurring word-finally is *lw*, as in *tàlw* 's/he is singing'. We have observed two different speaker-dependent strategies for eliminating the rising sonority profile of this lateral + glide cluster. One is for an epenthetic [ə] to be inserted between the lateral and glide. With anticipatory rounding, this sounds very much like [o], i.e., [təlow]. The insertion of the epenthetic vowel creates an additional syllable, which serves to correct the second sonority peak.

Other speakers time the lip rounding associated with the glide such that it overlaps with virtually the entire lateral and even a portion of the preceding

⁶ Speakers make a clear distinction between [ʃ] and [ʒ].

FIG. 11.—Regressive voicing of *t* and final devoicing of *l* in *ʃofot^{HL}* ‘jump!’ as produced by speaker MS6.

vowel. The result is essentially a labialized lateral, i.e., [təl^w], rather than a true cluster of lateral plus glide.

Acoustic and video displays (made using an iPhone with a temporal resolution of 33 milliseconds) of two representative pronunciations of the root *talw* excerpted from the word *intalw^{HL}* ‘sing for her/him!’, one with an epenthetic vowel and the other with a labialized glide, are shown in figures 12 and 13, respectively. Figure 12 shows a spectrogram depicting the first variant as produced by speaker FS6 along with two video frames showing the commencement of visible lip rounding (indicated by a dashed arrow) in the second half of the lateral and the phase of maximal lip rounding (indicated by a solid arrow) during the glide following the epenthetic vowel. Figure 13 illustrates a strategy employed by speaker FS9 to merge the lateral and labial-velar. The initiation of visible lip rounding in this token is nearly synchronized with the start of the lateral (considerably earlier than in the token with an epenthetic vowel in figure 12) before peak rounding is reached during the labialized lateral.

In summary, several strategies are used by speakers to mitigate potential violations of the Sonority Sequencing Principle. A process of final devoicing

FIG. 12.—Excerpt showing epenthetic vowel in the final cluster in *intalw^{HL}* ‘sing for her/him!’ as produced by speaker FS6. Approximate time of initial lip rounding is indicated by a dotted arrow and of maximal lip rounding is indicated by a solid arrow.

in words like *hò:kb* ‘s/he is stringing them’ reduces the sonority of word-final stops and nasals, while an accompanying process of regressive voicing assimilation targeting stops increases the sonority of the first member of a phonemic voiceless + voiced cluster. For final clusters like [lw], speakers may merge the lateral plus labial-velar glide into a labialized lateral or epenthesize a vowel between the liquid and glide.⁷

4.3. Word-final length distinctions. Final vowel deletion also impressionistically leads to neutralization of length distinctions in final position, as a comparison of the forms in (6) and (7) suggest:

- (6a) *hà:tí*
 put.on.shoes:LGR
 ‘is s/he putting on (shoes)?’

⁷ We have also observed one speaker who simply deleted final *w* in final *lw* clusters.

FIG. 13.—Excerpt showing labialized lateral in *intalw^{HL}* ‘sing for her/him!’ as produced by speaker FS9. Approximate time of initial lip rounding is indicated by a dotted arrow and approximate time of maximal lip rounding is indicated by a solid arrow.

- (6b) *hà:t*
 put.on.shoes:LGR
 ‘s/he is putting on (shoes)’

- (7a) *pà:tí*
 split.LGR
 ‘is s/he splitting it?’

- (7b) *pà:t*
 split.LGR
 ‘s/he is splitting it’

After final vowel deletion, a stem like *ha:ti-* ‘put on (shoes)’ and a stem like *patti-* ‘split’ sound like *hà:t* ‘s/he is putting (shoes) on’ and *pà:t* ‘s/he is

splitting it': that is, the contrast between *l* and *ʔ* is neutralized in coda position. This impression requires quantitative verification, however. The realization of length in final *b* is of special interest, as aerodynamic forces (Westbury and Keating 1986) militate against even short final voiced obstruents (cf. languages such as German and Russian with final devoicing), let alone long final voiced obstruents.

As part of our study of length distinctions, we compared the phonetic duration of representative pairs of short and long consonants occurring in final position with their short and long counterparts in intervocalic position. The measured consonants all appeared immediately following a stressed vowel (see 5.3 on metrical structure). The words targeted for study appear in (8). Words were analyzed for six speakers (four women and two men).

- (8) Words used for comparing the duration of short and long consonant pairs in word-final and intervocalic positions. Final *bb*, *ll*, and *ʔ* are transcribed here to show underlying length rather than phonetic length.

C	INTERVOCALIC		WORD-FINAL	
	SHORT	LONG	SHORT	LONG
<i>b</i>	<i>ì: bɪl</i> 'I am killing it'	<i>tò: bbɪl</i> 'I'm punching holes'	<i>ì: b</i> 's/he is killing it'	<i>tò: bb</i> 's/he is punching holes'
<i>l</i>	<i>palana</i> 'bean'	<i>intà: llɪl</i> 'I am building it for him'	<i>tàl wàl</i> 'S/he is singing'	<i>intà: ll</i> 's/he is building it for him'
<i>ʔ</i>	<i>hà: ʔɪl</i> 'I'm putting on (shoes)'	<i>pà: ʔɪl</i> 'I'm splitting it'	<i>hà: ʔ</i> 's/he is putting on (shoes)'	<i>pà: ʔ</i> 's/he is splitting them'

Duration results pooled across speakers are shown graphically in figure 14, with individual speaker results following in figure 15.

As figure 14 shows, the difference in duration between short and long consonants is much smaller in final position than in intervocalic position, due primarily—at least in the case of the laterals—to an overall lengthening effect on short consonants in final position, a common cross-linguistic pattern (Wightman et al. 1992). The failure of short *b* to lengthen is perhaps not surprising since aerodynamic factors make prolonged voicing in final obstruents articulatorily difficult (Westbury and Keating 1986). There was considerable interspeaker variation with no speaker reliably distinguishing all three short vs. long pairs in final position. In fact, for certain speakers, some of the word-final short consonants are longer than their word-final counterparts, reversals that are not observed in the case of intervocalic short vs. long pairs. In keeping with this interspeaker variability, t-tests pooled over all speakers for each pair of short and long consonants in final position failed to reveal a significant difference in length for any of the pairs, confirming impressionistic observations that consonant length contrasts are neutralized in word-final position.

FIG. 14.—Duration results for three short vs. long consonant pairs in intervocalic and final position averaged over six speakers. Whiskers represent 95% confidence intervals.

Speaker	Intervocalic						Final					
	<i>l</i>		<i>b</i>		<i>t</i>		<i>l</i>		<i>b</i>		<i>t</i>	
FS1	Sh	Lg	Sh	Lg	Sh	Lg	Sh	Lg	Sh	Lg	Sh	Lg
FS2	79	226	106	248	186	313	188	164	103	124	223	306
FS6	74	234	101	256	138	264	155	176	82	142	205	173
FS9	69	208	120	216	158	261	184	201	174	156	218	259
MS1	78	188	87	2065	147	206	143	118	165	112	214	243
MS7	57	158	76	186	139	207	155	153	110	122	294	305
Means	74	178	91	204	137	212	138	121	190	155	223	—
Means	75	199	97	217	151	244	161	156	135	133	230	257

FIG. 15.—Duration of short vs. long consonant pairs in intervocalic and final position for six speakers.

5. Prosody. Koasati displays a complex prosodic system featuring intonation, lexical and grammatical tone, and predictable stress.⁸ Although our investigation is still not complete, several generalizations have emerged through a combination of instrumental study and impressionistic evaluation of recordings of about 2,000 words made by Jack Martin for a digital dictionary. We begin with nouns, which are prosodically simpler than verbs.

5.1. Accent in nouns. In the context of elicitation, most nouns are often pronounced with high pitch on the last syllable, though other patterns are attested, including a final high-low pattern apparently associated with slight emphasis.⁹ These different melodies are phrase-final rather than lexical. When a noun is compounded, for example, a phrase-final high melody appears on the last word: *pala:na^H* ‘dish’, *pala:na kofokbi^H* ‘bowl’ (‘dish’ + ‘deep’).

We believe the choice of phrase-final tonal melody depends on context: in elicitation, one person may favor final low pitch, while another person might favor final high pitch. This is evident in the pitch traces in figures 16 and 17.

Figures 16 and 17 show the pitch of the word *pala:na* ‘dish’ spoken in isolation by speaker FS6 and speaker FS4, respectively. The tokens vary considerably in their pitch patterns. The token produced by speaker FS6 in figure 16 displays a gradual declination in pitch ending in a terminal fall. In contrast, the token produced by speaker FS4 in figure 17 is characterized by a steep terminal rise in pitch. The pitch traces in these figures support our representation of these patterns as *pala:na^L* and *pala:na^H*, respectively.¹⁰

Nouns may also have lexical tonal accent, however. A small number of underived nouns have rising pitch on the penult. The words in (9) are near minimal pairs for accent in this small group of nouns.

(9) Pitch contrasts in nouns

<i>okwa:la</i>	‘toad’	<i>okwǒ:ti</i>	‘blueberry’
<i>pala:na</i>	‘dish’	<i>pałǎ:ta</i>	‘popcorn’
<i>shajka</i>	‘eraser’	<i>sǎjki</i>	‘turkey vulture’

Depending on the intonation used, these may be pronounced with final high pitch, final low pitch, rising pitch, etc.

Nominalizations are a larger class of nouns (10) commonly having rising pitch on the penult (sometimes accompanied by lengthening of the penultimate vowel):

⁸ Kimball (1991:26–28) also describes a system of pitch accent, but it is quite different from what we hear. He does not distinguish the nouns in (9), for example.

⁹ The final vowel of a noun may be pronounced with glottal closure or with slight aspiration. Kimball (1991:24) states that women pronounce glottal stops after word-final vowels. We have recorded women using glottal closures and aspiration and are not sure what governs the choice.

¹⁰ As mentioned previously, nouns in isolation may be pronounced with final glottal closure or final aspiration.

FIG. 16.—Falling intonation in *pala:na^L* ‘dish’ as produced by speaker FS6.

- (10) Nominalizations with rising pitch on penult
hopö:ni ‘a cook’ (from *hopo:ni*- ‘cook’)
na:ĩ:ka ‘speaker’ (from *na:ĩ:ka*- ‘speak’)
sobajli:fĩ ‘teacher’ (from *sobajli:fĩ*- ‘teach’)
ahifä:fĩ ‘guard’ (from *ahifä:fĩ*- ‘take care of’)

This pattern could be considered part of the larger system of grades in Koasati, in which different pitch patterns affect the penultimate syllables of verbs to convey grammatical aspect (see discussion below).

Loanwords (11) sometimes have rising accent, presumably reflecting stress in the source language:

- (11) Loanwords with rising accent
mobĩ:la ‘car’ (from English *automobile*)
pastä:li ‘Pentecostal’ (from English *apostolic*)
kapö:ta ‘coat’ (from French *capote*)

Finally, some noun compounds consisting of a noun followed by a modifying verb (12) have rising accent on the penultimate syllable of the modifying verb:

p a l a: n a^H

FIG. 17.—Rising intonation in *pala:na^H* ‘dish’ as produced by speaker FS4.

(12) Noun compounds with rising accent

palanhõmma ‘kidney bean’ (from *palana* ‘bean’ + *hõmma*- ‘red’)

ʃfonhătka ‘bucket’ (from *oʃona* ‘metal’ + *hătka*- ‘white’)

Modifying verbs are not always accented, however: of the color terms, *-hõmma* ‘red’, *-hătka* ‘white’, *-lă:na* ‘yellow’, and *-okʃăkko* ‘blue, green’ are normally accented, but *-loʃa* ‘black’ is not, possibly because the penultimate syllable is light (CV).

As the examples above show, rising pitch affects vowel length. When a syllable with rising pitch is closed by a sonorant, the vowel is always short. When a syllable with rising pitch is open, the vowel is always long or lengthened (thus *sobajliʃi*- ‘teach’ is lengthened in the nominalization *sobajli:ʃi* ‘teacher’). When a syllable with rising pitch is closed by an obstruent, however, the vowel may be slightly lengthened (with some variation among speakers). A word like *ʃfonhătka* ‘bucket’ may thus be pronounced [ʃfõnhătka] (half long with rising pitch) or [ʃfõnhătka] (short and centralized with high pitch), depending on the speaker.

FIG. 18.—Pitch accent in *hopõ:nĩᵀ* ‘a cook’ as produced by speaker FS6.

Figure 18 shows a representative pitch trace of *hopõ:nĩᵀ* ‘a cook’ as produced by speaker FS6. A comparison of FS6’s pronunciation of *hopõ:nĩᵀ* in figure 18 with the same speaker’s pronunciation of *pala:naᵀ* in figure 16 confirms our impressionistic description of a rise in accented nouns. The pitch peak in accented syllables is realized in the latter half of the accented rime (on a coda sonorant, the second half of a long vowel, or even during the onset of the next syllable as in figure 18). Pitch peak delays are longer for accents associated with a syllable containing a short vowel followed by an obstruent coda, particularly if the vowel is not lengthened.

5.2. Accent and duration in verb grades. Intonation and tone in verbs is considerably more complex than in nouns. One of the most salient features of verbs in Koasati and other Muskogean languages is the marking of aspectual differences, termed “grades” in the Muskogeanist literature, through different tone patterns associated with the penultimate syllable of the stem.

We discuss here the phonetic realization of two of the most common grades: the lengthened/low-tone grade (l-grade) and the geminating/rising-tone grade

(g-grade). Briefly, the l-grade is used for events (happenings, whether in the present or past) and is signaled by assigning low tone to the penult (with lengthening of short open penults and partial lengthening of penults with obstruent codas). The g-grade expresses resulting states and is signaled by assigning a rising pitch to the penult (with lengthening of short open penults). If the penultimate syllable begins with an intervocalic onset, the onset is noticeably lengthened. Both of these grade patterns also have high pitch on the stem-final vowel, but this accent is deleted in the g-grade at the end of a word.

The forms in (13) show these patterns before the first-person singular agentive suffix *-li* (realized as *-l* with final vowel deletion). A future form is also given to illustrate the “zero-grade” (corresponding to the underlying stem) counterpart to the l- and g-grades.

(13) L-grade and g-grade forms of verbs

STEM	<i>isi-</i> ‘take’	<i>halatka-</i> ‘grab’	<i>sobajli-</i> ‘learn’
FUTURE	<i>isilahō</i> ‘s/he will take it’	<i>halatkahō</i> ‘s/he will grab it’	<i>sobajlihō</i> ‘s/he learn’
L-GRADE	<i>ì:si-l</i> ‘I am taking’	<i>halà:tká-l</i> ‘I am grabbing hold’	<i>sobàjlí-l</i> ‘I am learning’
G-GRADE	<i>ĩ:si-l</i> ‘I am holding it’	<i>hal:ǎtka-l</i> ‘I am holding on’	<i>sob:ǎjli-l</i> ‘I know’

Figures 19 and 20 show representative pitch traces for the l-grade form *sobàjlí-l* ‘I am learning’ and its g-grade counterpart *sob:ǎjlil* ‘I know’, both pronounced by speaker FS6.

A comparison of figures 19 and 20 reveals the dramatic pitch difference between the l-grade and g-grade forms, with a fall to low pitch in the penult of the l-grade in figure 19 and a sharp rise to high pitch in the penult of the g-grade in figure 20. The lengthening of the onset of the penultimate syllable in the g-grade is also apparent.

Although lengthening effects associated with different grades are found in all the Muskogean languages, there have not been any quantitative studies of duration triggered by grade formation. It thus unclear whether grade-induced lengthening is neutralizing or not, i.e., whether the lengthened vowels and consonants are durationally equivalent to their phonemically long counterparts. In order to explore this issue in Koasati, we compared the length of segments in accented syllables (the penultimate syllables of stems) of l-grade and g-grade verb forms. We examined the onset consonant and the vowel of the penultimate syllable of the stem in two l-grade vs. g-grade pairs of verbs. In one of the verbs, the penultimate vowel of the stem was underlying short: l-grade *halà:tká-l* ‘I am grabbing hold’ vs. g-grade *hal:ǎtka-l* ‘I am holding on’ (cf. *halatka-lahō* ‘s/he will grab hold of it’, showing the bare stem). In the other pair, the penultimate vowel was underlying long: l-grade *balà:ká-l* ‘I am getting into a lying position’ vs. g-grade *bal:ǎ:ka-l* ‘I am in a lying

FIG. 19.—The l-grade verb *sobàjlíl* ‘I am learning’ as produced by speaker FS6.

position’ (cf. *bala:ka-lahō* ‘s/he will get into a lying position’). In both pairs of words, the onset of the penultimate syllable of the stem contained a short *l*. Three tokens of each vowel and consonant were measured from a total of six speakers (four women and two men). The duration values were compared with their phonemic short and long counterparts not appearing in a special grade. These control sounds all appeared in trisyllabic words parallel to the l-grade and g-grade forms and with similar surrounding segments. Short *l* was measured in *palana* ‘bean’ and long *ll* in *hallaki* ‘bat’. Both short and long *a* appeared before a voiceless consonant (for most speakers, the second vowel in the word *falakfi* ‘wing’ and the first vowel in the word *pa:satta* ‘armadillo’), except for one speaker (FS2) for whom long *a:* appeared before a lateral in the word *asa:la* ‘basket’. Duration results by speaker are presented in figure 21.

Results largely confirmed impressionistic judgments about duration, especially in the case of the onset consonant. The onset of the accented penultimate syllable in the g-grade forms was substantially longer than the onset of the accented penult in the l-grade: 195 milliseconds vs. 84 milliseconds averaged across speakers. This difference was highly significant in a t-test: $t(48.6) = 12.666$, $p < .001$ (corrected for inequality of variances). In fact, the onset of

FIG. 20.—The g-grade verb *sob:ǎjli-l* ‘I know’ as produced by speaker FS6.

the penult in the l-grade form was roughly the same (statistically equivalent) in duration to the short *l* in *palana* ‘bean’ (75 milliseconds), while the onset of the penult in the g-grade was statistically equivalent in duration to the long *ll* in *hallaki* ‘bat’ (174 milliseconds).

Turning to accented vowels, we see that the l-grade exerted the greatest effect on the duration of phonemic short vowels. Thus, the phonemic short vowel in the penult of the l-grade form *halà:tká-l* (stem *halatka-*) averaged 100 milliseconds, while the same vowel in the penult of the g-grade form *hal:ǎtka-l* averaged only 68 milliseconds. The latter is statistically equivalent in a t-test to the 72 milliseconds of the short *a* in *falakǎi* ‘wing’ serving as a control. The difference between the short vowel in the l-grade and both its g-grade and non-grade counterparts was significant according to t-tests: for l-grade vs. g-grade, $t(34) = 5.243$, $p < .001$; for l-grade vs. zero-grade, $t(28) = 3.8$, $p = .001$. The lengthening effect on short vowels in the l-grade, however, was not sufficiently large to produce a vowel that was equivalent in length to an underlying long vowel. Thus, the lengthened vowel in *halà:tkál* was still much shorter than a phonemic long vowel ($t(30) = 4.072$, $p < .001$, according

	<i>a</i>						<i>l</i>			
	Non-Gr		L-Gr		G-Gr		Non-Gr		L-Gr	G-Gr
Speaker	Sh	Lg	Sh	Lg	Sh	Lg	Sh	Lg	Sh	Lg
FS1	101	174	106	220	83	198	79	188	109	257
FS2	59	187	60	176	43	155	74	215	76	231
FS6	68	137	114	158	67	163	69	169	97	226
FS9	60	138	101	135	61	132	78	169	75	141
MS1	63	146	120	158	76	157	57	151	54	150
MS7	82	150	101	147	77	145	84	162	96	166
Means	72	153	100	166	68	158	75	174	84	195

FIG. 21.—Duration of nucleus and onset of accented syllables (in milliseconds) in l-grade and g-grade relative to their non-grade counterparts for six speakers.

to a t-test), which averaged 153 milliseconds. One potentially problematic issue in the comparison of the penultimate vowel in l-grade *halà:tkál* with the underlying long vowel in *pa:satta* ‘armadillo’ is the fact that the former appears in a closed syllable and the latter in an open syllable. This difference is plausibly causing an underestimation of the lengthening effect in the l-grade, since vowels in closed syllables are characteristically shorter than those in open syllables (Maddieson 1985). In order to explore this possible confound, a comparison of the penultimate long *i:* in an open syllable in the disyllabic word *fí:to* ‘turkey’ was compared with the penultimate lengthened *i:* (also in an open syllable) in the disyllabic l-grade form *ì:pá-l* ‘I am eating’ for the two speakers, FS9 and MS7, who provided both forms. The vowel in the former form was still slightly longer (142 milliseconds vs. 131 milliseconds) averaged over both speakers, though this lengthening effect was smaller than the one found for the comparison of *halà:tkál* and *pa:satta*.

Finally, phonemic long vowels were virtually identical (statistically equivalent according to t-tests) in length in the l-grade (166 milliseconds), the g-grade (158 milliseconds), and non-grade forms (153 milliseconds).

Overall results indicate that lengthening under grade formation is neutralizing in the case of an accented onset consonant, which in the g-grade becomes equivalent in length to an underlying long consonant. In the case of vowel lengthening in the l-grade, however, results are less conclusive. A comparison of the lengthened vowel in the l-grade form *halà:tkál* with the phonemic long vowel in *pa:satta* suggests that vowel lengthening is non-neutralizing. This finding may, however, be at least partially an artifact of the fact that the lengthened vowel in *halà:tkál* appears in a closed syllable, whereas the comparison long vowel in *pa:satta* occurs in an open syllable.

5.3. Metrical structure. From the perspective of other Muskogean languages, one of the unusual features of the Koasati prosodic system is the apparent lack of iambic rhythm. Thus, Chickasaw, Choctaw, and Creek display elements of iambic metrical structure in one of three guises: stress in Chickasaw (Gordon 2004), rhythmic vowel lengthening in Chickasaw and Choctaw (Munro and Ulrich 1984, Munro and Willmond 1994; 2005, Munro 1996; 2005, Gordon and Munro 2007, and Broadwell 2005; 2006), or pitch accent in Creek (Haas 1977, Martin and Johnson 2002, and Martin 2011). In Chickasaw, for example, a system of left-to-right iambs leads to stress and lengthening of the second vowel in a sequence of adjacent light (CV) syllables. The locus of stress and lengthening falls out from an analysis in which heavy syllables, which also bear stress in Chickasaw, form a monosyllabic foot and two adjacent CV syllables form an iambic foot consisting of a metrically weak syllable followed by a strong syllable. Thus Chickasaw *asabikatok* 'I was sick' has the metrical representation (a'sa)(bi'ka)(tok), and *fipisalitok* 'I looked at you' is parsed as (ʃi'pi)(sa'li)(tok) (Gordon and Munro 2007).

Creek nouns and zero-grade forms of verbs have a similar left-to-right iambic stress system, though the primary cue to stress is pitch rather than duration. In Creek, level high pitch spreads from the first stressed syllable to the last: (i'fa) 'dog', (no'ko)si 'bear', (no'ko) (so'ʃi) 'bear cub', (a'wa) (na'ji)ta 'to tie to' (Martin 2011).

There does not appear to be evidence from stress, lengthening, or tone for a productive synchronic process of iambic footing in Koasati. Rather, the first syllable of a word characteristically is most prominent in terms of duration and intensity, a prominence that is plausibly interpreted as stress (as distinct from the lexical tone accent discussed above). Impressionistically, heavy syllables (CVC and CVV), stem-final syllables, and the first in a sequence of two consecutive light syllables sound prominent, where inspection of acoustic displays suggests that this perceived prominence is a function of increased intensity and duration (and, in the case of stem-final vowels, potentially pitch). Interestingly, the prominence on the first rather than the second syllable in a sequence of two light syllables suggests a trochaic parse for Koasati, e.g.: (a'ʃi)(tika) 'rope', (wa:)(kasi) 'calf', (ok)(ʃos)(bani) 'type of turtle'. This analysis should be regarded as tentative, however, as we are not yet in a position to offer a definitive account of stress and its relationship to lexical accents. It is nevertheless clear that stress does not provide any evidence for iambic footing in Koasati, unlike in Chickasaw, Choctaw, and Creek.

6. Conclusions. This paper has provided a quantitative description of a number of phonetic properties of Koasati, some of which are typical of Muskogean languages and some of which are unusual. The phonemic contrast in length typical of both consonants and vowels within the Muskogean family was shown to be phonetically robust in Koasati. Another common feature of the family, centralization of short vowels, was also verified for Koasati through formant analysis.

More unusual within Muskogean is Koasati's extensive inventory of word-final consonants and consonant clusters created by final vowel deletion. We documented several strategies for mitigating sonority sequencing violations in typologically rare word-final clusters. Evidence also suggested that long consonants that wind up in final position due to apocope are equivalent in length to final short consonants.

Prosodically, Koasati is typical of Muskogean languages. For example, the other Muskogean languages all distinguish eventive aspect from resultative stative aspect by means of grades (14). We may now add Koasati to this list:¹¹

- (14) Eventive aspect in various Muskogean languages
Creek	<i>lejk-ís</i> 's/he is getting seated' (lengthened grade)
<i>lêjk-is</i> 's/he is seated' (falling tone grade)
Mikasuki	<i>ʃokōl-om</i> 's/he is getting seated' (nasalized grade)
<i>ʃokô: l-om</i> 's/he is seated' (falling-tone grade)
Alabama	<i>ʃoko:li</i> 's/he is getting seated' (zero grade)
<i>ʃókkô:li</i> 's/he is seated' (geminating grade)
Koasati	<i>ʃokô:l</i> 's/he is getting seated' (lengthened/low-tone grade)
<i>ʃókkô:l</i> 's/he is seated' (geminating/rising-tone grade)
Chickasaw	<i>bini:li</i> 's/he is getting seated' (zero grade)
<i>bínni?li</i> 's/he is seated' (geminating grade)
Choctaw	<i>bini:li-h</i> 's/he is getting seated' (zero grade)
<i>biníli-h</i> 's/he is seated' (nasalized grade)

As these forms show, the rising tone found on the penultimate syllable of the g-grade in Koasati is cognate with falling tone in Creek, Mikasuki, and Alabama, and with an internal glottal stop in Chickasaw.

We find a similar correspondence in nominalization (15):

- (15) Nominalizations in various Muskogean languages
Creek	<i>notéjʃ-</i> 'cook (verb stem)'
<i>notéjʃ-a</i> 'a cook'
Mikasuki	<i>noha:ʃi-</i> 'cook (verb stem)'
<i>impi:k-nohâ:ʃ-i</i> 'a cook'
Alabama	<i>talwa</i> 'sing (verb)'
<i>tâlwa</i> 'singer'
Koasati	<i>hopo:ni-</i> 'cook (verb stem)'
<i>hopô:ni</i> 'a cook'
Chickasaw	<i>hopo:ni</i> 'cook (verb)'
<i>îhopo?ni?</i> 'a cook'
Choctaw	<i>hopo:ni-h</i> 'cook (verb)'
<i>hopó:ni</i> 'a cook'

¹¹ The Chickasaw forms in (14) and (15) are from Munro and Willmond (1994). Other forms are based on Martin's fieldwork. An earlier discussion of the geminating grade in Koasati and its cognates in the other languages was presented in Martin (2013).

Here again, the rising accent we documented in Koasati is cognate with falling tone in Mikasuki and Alabama and with an internal glottal stop in Chickasaw.

The correspondences in (14) and (15) suggest that Proto-Muskogean used falling tone for resultative stative aspect and for nominalizations. Falling tone yielded a glottal stop in Chickasaw. In Koasati, however, the cognate of falling tone is rising tone. We believe this development was caused by peak delay: examination of the pitch trace for *hopô:ni* 'a cook' in figure 18 reveals that the rise on the penult is followed by a fall, as though falling tone in an earlier form **hopô:ni* has simply shifted rightward. This change may have taken place within the past 75 years. Mary R. Haas's fieldnotes from the 1930s (Haas 1938–39) show falling tone on syllables where we hear rising tone.

We have attempted in this paper to document the basic properties of vowels, consonants, and word-level prosody in Koasati. Our findings show that Koasati closely resembles other Muskogean languages, but small changes over time have led to consonant clusters and tone melodies that are absent from related languages.

REFERENCES

- ARVANITI, AMALIA, AND GEORGIOS TSERDANELIS. 2000. On the phonetics of geminates: Evidence from Cypriot Greek. *Proceedings of the Sixth International Conference on Spoken Language Processing*, vol. 2, pp. 559–62. Beijing.
- BLEVINS, JULIETTE. 1995. The syllable in phonological theory. *The Handbook of Phonological Theory*, ed. John A. Goldsmith, pp. 206–44. Cambridge, Mass.: Blackwell.
- BOERSMA, PAUL, AND DAVID WEENINK. 2010. Praat: Doing Phonetics by Computer. Version 5.1.42. <www.praat.org>.
- BROADWELL, GEORGE AARON. 2005. Choctaw. *Native Languages of the Southeastern United States*, ed. Heather Hardy and Janine Scancarelli, pp. 157–99. Lincoln: University of Nebraska Press.
- . 2006. *A Choctaw Reference Grammar*. Lincoln: University of Nebraska Press.
- CHO, TAEHONG, AND PETER LADEFOGED. 1999. Variation and universals in VOT: Evidence from 18 languages. *Journal of Phonetics* 27:207–29.
- CLEMENTS, G. N. 1990. The role of the sonority cycle in core syllabification. *Papers in Laboratory Phonology 1: Between the Grammar and Physics of Speech*, ed. John Kingston and Mary E. Beckman, pp. 283–333. Cambridge: Cambridge University Press.
- COHN, ABIGAIL; WILLIAM HAM; AND ROBERT PODESVA. 1999. The phonetic realization of singleton–geminate contrasts in three languages of Indonesia. *Proceedings of the Fourteenth International Congress of Phonetic Sciences*, pp. 587–90. San Francisco.
- FARNETANI, EDDA, AND SHIRO KORI. 1984. Effects of syllable and word structure on segmental durations in spoken Italian. *Quaderni del Centro di Studio per le Ricerche di Fonetica* 3:143–88.
- FINTOFT, KNUT. 1961. The duration of some Norwegian speech sounds. *Phonetica* 7:19–39.
- FLETCHER, JANET. 2010. The prosody of speech: Timing and rhythm. *The Handbook of Phonetic Sciences*, ed. William Hardcastle, John Laver, and Fiona Gibbon, pp. 523–602. Malden, Mass.: Wiley-Blackwell.
- GHAJ, VED KUMARI. 1980. Contributions to Dogri phonetics and phonology. *Annual Report of the Institute of Phonetics* 14, pp. 31–94. Copenhagen: University of Copenhagen.
- GORDON, MATTHEW. 2004. A phonological and phonetic study of word-level stress in Chickasaw. *IJAL* 70:1–32.

- GORDON, MATTHEW, AND PAMELA MUNRO. 2007. A phonetic study of final vowel lengthening in Chickasaw. *IJAL* 73:293–330.
- GORDON, MATTHEW; PAMELA MUNRO; AND PETER LADEFODEG. 2000. Some phonetic structures of Chickasaw. *Anthropological Linguistics* 42:366–400.
- HAAS, MARY R. 1938–39. Koasati field notes. Ms., American Philosophical Society, Philadelphia.
- . Men's and women's speech in Koasati. *Language* 20:142–49.
- . 1947. The development of Proto-Muskogean *k^w. *IJAL* 13:135–37.
- . 1977. Tonal accent in Creek. *Studies in Stress and Accent*, Southern California Occasional Papers in Linguistics 4, ed. Larry Hyman, pp. 195–208. Los Angeles: University of Southern California.
- HAN, MIEKO. 1994. Acoustic manifestations of mora timing in Japanese. *Journal of the Acoustical Society of America* 96:73–82.
- HOOPER, JOAN B. 1976. *An Introduction to Natural Generative Phonology*. New York: Academic Press.
- HUME, ELIZABETH; SAMANTHA GETT; LARK HOVEY; KRISTEN SCUDIERI; AND MICHAEL SPAGNOL. 2012. Cues to word-final geminate consonants in Maltese. Poster presented at Laboratory Phonology 12, Albuquerque, N.M.
- JOHNSON, KEITH, AND JACK B. MARTIN. 2001. Acoustic vowel reduction in Creek: Effects of distinctive length and position in the word. *Phonetica* 58:81–102.
- KIMBALL, GEOFFREY D. 1991. *Koasati Grammar*. Lincoln: University of Nebraska Press.
- . 1994. *Koasati Dictionary*. Lincoln: University of Nebraska Press.
- . 2010. *Koasati Traditional Narratives*. Lincoln: University of Nebraska Press.
- KRAEHEMANN, ASTRID. 2001. Swiss German stops: Geminate all over the word. *Phonology* 18:109–45.
- LAHIRI, ADITI, AND JORGE HANKAMER. 1988. The timing of geminate consonants. *Journal of Phonetics* 16:327–38.
- LEHISTE, ILSE. 1966. *Consonant Quantity and Phonological Units in Estonian*. Bloomington: Indiana University Press.
- . 1970. *Suprasegmentals*. Cambridge, Mass.: The M.I.T. Press.
- LEHTONEN, JAAKKO. 1970. Aspects of Quantity in Standard Finnish. Jyväskylä: K. J. Gummerus Osakeyhtiön Kirjapaino.
- LETTERMAN, REBECCA. 1994. A phonetic study of Sinhala syllable rhymes. *Working Papers of the Cornell Phonetics Laboratory* 9:155–82.
- LOCAL, JOHN, AND ADRIAN SIMPSON. 1999. Phonetic implementation of geminates in Malayalam nouns. *Proceedings of the Fourteenth International Congress of Phonetic Sciences*, pp. 595–98. San Francisco.
- MADDIESON, IAN. 1985. Phonetic cues to syllabification. *Phonetic Linguistics: Essays in Honor of Peter Ladefoged*, ed. Victoria Fromkin, pp. 203–21. New York: Academic Press.
- MARTIN, JACK B. 2011. *A Grammar of Creek (Muskogee)*. Lincoln: University of Nebraska Press.
- . 2013. The geminating grade in Koasati and Muskogean. Paper presented at the Annual Meeting of the Society for the Study of Indigenous Languages of the Americas (SSILA), Boston.
- MARTIN, JACK B., AND KEITH JOHNSON. 2002. An acoustic study of “tonal accent” in Creek. *IJAL* 68:28–50.
- MEYER, E. A., AND Z. GOMBOCZ. 1908. Zur phonetik der ungarischen sprache. *Le Monde Oriental* 2:122–87.
- MILLER, ANN. 1987. Phonetic characteristics of Levantine Arabic geminates with differing morphemes and syllable structures. *Ohio State University Working Papers in Linguistics* 36:120–40.
- MUNRO, PAMELA. 1996. *The Chickasaw sound system*. Ms., University of California, Los Angeles.
- . 2005. Chickasaw. *Native Languages of the Southeastern United States*, ed. Heather Hardy and Janine Scancarelli pp. 114–56. Lincoln: University of Nebraska Press.

- MUNRO, PAMELA, AND CHARLES ULRICH. 1984. Structure-preservation and Western Muskogean rhythmic lengthening. *West Coast Conference on Formal Linguistics* 3:191–202.
- MUNRO, PAMELA, AND CATHERINE WILLMOND. 1994. *Chickasaw: An Analytical Dictionary*. Norman: University of Oklahoma Press.
- . 2005. *Chikashshanompa' Kilanompoli'*. Los Angeles: UCLA Academic Publishing.
- OJAMAA, KOIT. 1976. Temporal aspects of phonological quantity in Estonian. Ph.D. dissertation, University of Connecticut.
- OREŠNIK, J., AND M. PÉTURSSON. 1977. Quantity in modern Icelandic. *Arkiv för Nordisk Filologi* 92:155–71.
- RIDOUANE, RACHID. 2010. Geminate at the junction of phonetics and phonology. *Papers in Laboratory Phonology 10*, ed. Cécile Fougeron et al., pp. 61–90. New York: Mouton de Gruyter.
- RISING, DAVID P. 1992. Switch Reference in Koasati Discourse. *Summer Institute of Linguistics and University of Texas at Arlington Publications in Linguistics*, vol. 109.
- SELKIRK, ELISABETH. 1984. On the major class features and syllable theory. *Language Sound Structure: Studies in Phonology Presented to Morris Halle by His Teacher and Students*, ed. Mark Aronoff and Richard T. Oehrle pp. 107–36. Cambridge, Mass.: The M.I.T. Press.
- WESTBURY, JOHN, AND PATRICIA A. KEATING. 1986. On the naturalness of stop consonant voicing. *Journal of Linguistics* 22:145–66.
- WIGHTMAN, COLIN; STEFANIE SHATTUCK-HUFNAGEL; MARI OSTENDORF; AND PATTI PRICE. 1992. Segmental durations in the vicinity of prosodic phrase boundaries. *Journal of the Acoustical Society of America* 91:1707–17.

[Appendix with sound files available online]