AN ACOUSTIC STUDY OF "TONAL ACCENT" IN CREEK

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1. Of Mary R. Haas's many contributions to the description of southeastern languages, perhaps no single study reveals more clearly the benefits of a good ear and sound methods than her analysis of Creek pitch.[1] While missionaries, native speakers, and ethnographers had previously been aware of the importance of suprasegmentals in the language, Haas was the first to accurately record Creek, the first to develop a phonemic transcription (Haas 1940; 1977*b*), and the first to provide rules for the placement of what she called "tonal accent." It is one measure of the complexity of the system that some 36 years separate the period of her most intensive fieldwork on Creek (1936–1941) and her final description (Haas 1977*a*).

This paper reports on acoustic findings obtained through instrumental study of eight speakers (four male and four female) of the Muskogee dialect of Creek. Our data confirm virtually every aspect of Haas's description but are offered here because (1) instrumental studies can provide greater accuracy and easier comparison between languages; (2) our study was designed to be general for a group of speakers; (3) we wanted to provide a foundation for more detailed studies of modern speech; (4) Haas's study needed to be reinterpreted in light of developments in phonological theory; and (5) some of the phenomena Haas describes are so subtle that we felt a need to verify them instrumentally. **2** provides a summary of Haas's description and more recent, metrical approaches, and **3** presents the results of our acoustic study.

2. Haas's 1977 description.

2.1. Haas's phonemic description. Haas (1977*a*) analyzes Creek as having a system of "tonal accent": every word larger than a light monosyl-

[1] The phonemic transcription used in this paper follows Haas (1940; 1977*b*) closely. Creek vowels are short *a*, *i*, *o* and long *a:*, *i:*, *o:*; *e* is generally predictable, resulting when *a* is raised before tautosyllabic *y*. The consonants are *c*, *f*, *h*, *k*, *l*, *ɬ*, *m*, *n*, *p*, *s*, *t*, *w*, *y*. *c* is an alveopalatal affricate; *ɬ* is a voiceless lateral fricative. ⁿ represents nasalization. We are grateful to Lara Taylor for help with the acoustic analysis and for producing the pitch traces. We would also like to thank Margaret Mauldin for helping with the interviews, the referees for their comments, and the National Science Foundation (SBR-9809819) for providing funding. Any mistakes are ours.

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lable will have at least one "key syllable" that determines the pitch of the entire word. Each of these key syllables will have one of three phonemic tones (Haas 1977*a*:197): level (´), falling (ˆ), or extra high or slightly rising and crescendo (ˇ) (henceforth, "rising").

In finite forms, the different tonal accents function to signal differences in aspect:

(1)	*apó:ki:s*	'we are (here)'
	apô:ki:s	'we have sat down, are in a sitting position'
	apǒ:ⁿki:s	'we keep sitting and sitting'

In (1), the stem *apo:k-* 'sit (of three or more)' is given in the zero-grade, falling tone grade, and nasalizing grade.[2] The level, falling, and rising tone accents associated with these grades generally appear on the last syllable of a morphological domain known as the stem. Multiple accents are also found, sometimes because affixes have inherent accent.

Nonfinite forms (nouns, infinitives, etc.) generally only have one level tone accent on the ultimate or penultimate syllable:[3]

(2)	*ifá*	'dog'
	wá:ka	'cow'
	apo:kitá	'to sit (of three or more)'

The placement of this accent is generally predictable, described by Haas (1977*a*:202–4) in the following terms:

(3*a*) In a string of light syllables containing no fixed accents, level tone will be placed on the last even-numbered syllable:[4]

ifá	'dog'
ifóci	'puppy'
amifocí	'my puppy'

(3*b*) If the penult is a heavy syllable and the ultima is light, level tone will be placed on the penult:

cá:lo	'trout, bass'
sókca	'sack, bag'
pocóswa	'ax'

[2] The classic description of grades ("ablaut") in Creek is Haas (1940). We will not describe their formation here.

[3] A handful of nouns (e.g., *nâ:ki* 'something') have falling tone accent.

[4] Haas (1977*a*:196) defines light syllables as those that end in short vowels.

(3*c*) In a string of light syllables following a heavy syllable, level tone will be placed on the last even-numbered syllable:

aktopá	'bridge'
wa:kocí	'calf'
alpatóci	'baby alligator'

(3*d*) If the ultima is heavy, level tone will normally be placed on that syllable:[5]

fó:	'bee'
hoktí:	'woman'

We see from the data in (1)–(3) that there is a basic division in the language between finite forms, in which level, falling, and rising tone accent function to signal aspectual distinctions, and nonfinite forms, in which the presence and placement of level tone accent is largely automatic. Soon after Haas published her findings, others began to notice that level tone accent in nonfinite forms could be described insightfully as iambic stress (Halle and Vergnaud 1978, cited in Hayes 1995, Hayes 1985; 1995:64–67, and Jackson 1987). In fact, data from Creek level tone accent are now commonly cited in discussions of iambic stress.

Treatments of Creek level tone accent as stress crucially make reference to the iamb: if possible, a disyllabic foot is formed in which the first syllable is light and the second syllable may be light or heavy, but stressed (i.e., strong); if the first syllable is heavy, a monosyllabic stressed foot is formed. Iambic feet of this type are formed from left to right, giving structures like the following for the forms in (3):

(4)

(. x) *i f á* 'dog'	(. x) *i f ó ci* 'puppy'
(. x) (. x) *ami f o c í* 'my puppy'	(x) (. x) *al pat oc i* 'baby alligator'
(x) (x) *h o k t í :* 'woman'	(x) *f ó:* 'bee'

From the forms in (4), it is evident that Haas's level tone accent falls on the last stressed syllable in the word. This can be captured by positing a second

[5] Haas (1977*a*:204) claims that accent is no longer automatic when the ultima is heavy, citing contrasts like the following:

(*i*) *hátk-i:* 'white'
hoktí: 'woman'

The durative suffix *-i:* in 'white' is outside the domain of the stress. In examples like this, the stem is stressed as though it ended in a short vowel (e.g., *hátkV,* parallel to *wá:ka* 'cow').

layer of final word-level stress in such forms (Hayes's 1995 "End Rule Right"):

(5)	(x)	(x)
	(. x)	(. x)
	i f á 'dog'	*i f óci* 'puppy'
	(x)	(x)
	(. x) (. x)	(x) (. x)
	ami f o c í 'my puppy'	*al pat óci* 'baby alligator'
	(x)	(x)
	(x) (x)	(x)
	h o k t í : 'woman'	*f ó :* 'bee'

Haas's rules for the placement of level tone accent in (3) can therefore be replaced by assuming left-to-right iambic feet and final word-level stress.

Such an analysis raises possible objections, however: some assume that the term "stress" must refer to loudness. Since Haas characterizes level tone accent solely in terms of pitch, some might prefer to use the term "pitch accent" for Creek. We do not share this assumption: we follow Liberman and Prince (1977), Hayes (1994), and others in viewing stress as the rhythmic organization of syllables into higher units, a rhythm that may be manifested in terms of pitch, loudness, and/or duration in varying degrees in different languages. While our study focuses on pitch, we do not rule out the possibility that stress has effects on duration and loudness in Creek.[6]

Others question the use of nonfinal feet in forms like 'my puppy' in (5), assuming that there is no phonetic evidence for these structures. As we shall see below, we believe there is evidence for nonfinal feet both in Haas's description and in our own data.

2.2. Haas's phonetic description. To describe the phonetics of Creek pitch, Haas (1977*a*) establishes a descending scale from 1 (highest) to 5 (lowest). Initial light nonkey syllables are described as having a pitch that is slightly lower than the pitch of the following syllable, so to obviate a specific pitch value, she uses i ("initial") for syllables of this type. Similarly, medial light syllables may be lowered in certain circumstances and are assigned the value m ("medial"), and final syllables are described as d ("deep"), the lowest pitch in a word. She then proposes the following phonetic values for key syllables:

(6*a*) ´ is 2 if first and nonultimate; 3 if first and ultimate.

(6*b*) ˆ is 24 if first and nonultimate; 2d if first and ultimate.

[6] In fact, there are a few minimal contrasts in secondary stress. Words like *atòtitá* 'to send', *awòtitá* 'to vomit', and *amìfocí* 'my puppy' have a different rhythm from words like *àpataká* 'cowboy bread' and *àpataná* 'bullfrog'. Martin (in progress) provides a more detailed account.

(6*c*) ˇ is 21 or 1 if first and nonultimate.
(6*d*) An initial light nonkey syllable will have pitch i (a value slightly lower than the following syllable).
(6*e*) Any other pretonic syllable will have pitch 3.
(6*f*) A nonultimate intertonic (between key syllables) heavy syllable will have the pitch of the next level key syllable, while a light syllable in the same position will have that pitch or pitch m (slightly lowered relative to the following syllable). When the next key syllable is a falling tone accent, a heavy or light syllable will be one step below the high part of the falling key syllable.
(6*g*) Posttonic light or heavy syllables at the ends of words have pitch d (the lowest pitch).

The forms in (7) are examples of these values:

(7) *isíta* i–2–d 'one to take one'
apataná i–3–3–3 'bullfrog'
nafkitá 3–3–3 'one to hit one'
fó: 3 'bee'
nâ:ki 24–d 'something, anything, what'
ci:kôlko 3–24–d 'purple martin'
hatâm i–2d 'again'
hă:ⁿfkeys 21–d (or) 1–d 'I keep hitting'

Haas (1977*a*:200) further describes a process of "downward drift" (downstep) applying between key syllables: "Each nonfirst key syllable will be pitched one step lower than the immediately preceding key syllable. Thus if the first key syllable is 2, 24, or 2d, the second will be 3, 35, or 3d (ultima)." Examples of this process appear in (8):

(8) *pó:fká:ks* 2–3 'they are blowing (with mouth)'
náfka:kêys 2–3–3d 'they were hitting him'
sâ:sákwa 24–3–d 'goose'
atŏ:ⁿtkíccíká:łi:s i–21–3–4–5–d 'you will not be working regularly, constantly'

3. An acoustic study of Creek pitch.

3.1. Methodology. In order to evaluate Haas's description, we conducted an acoustic study of Creek pitch (voice fundamental frequency or F0) in conjunction with a study of Creek segmental phonemes (Johnson and Martin 2001). We sought (1) to establish instrumentally the phonetic correlates of contrasts Haas observed in accent placement and type (level, falling, rising) and (2) to examine the fit between Haas's description and our own acoustic data.

Eight speakers (four women and four men) participated in the study. All were native speakers of the Muskogee dialect who used the language routinely. Their ages ranged from the early fifties to the late eighties at the time of recording. One speaker was a grandson to one of Haas's consultants, so our data are in some cases two generations removed from the period of Haas's most intensive fieldwork.

We began by constructing a word list demonstrating various contrasts (vowels, consonants, word and sentence prosody). Only the portion of the word list dealing with word prosody was used in this study; it is presented in Appendix A. All data pertaining to pitch were elicited in sentences: As Appendix A shows, nouns were recorded in a frame, while verbs, as complete sentences, were recorded in isolation. This means that verbs were subject to greater declination associated with their sentence-final position.

The speakers were recorded in groups of two to four. Two repetitions of the word list were recorded for each speaker in each session. We asked Margaret Mauldin, a Creek instructor at the University of Oklahoma, to read the target form first with neutral intonation as a prompt. The other speakers were instructed to pronounce the forms in succession as they would say them.[7]

Six speakers were recorded with a Shure SM48 handheld unidirectional microphone (passed from speaker to speaker during the recording session) and a Marantz PMD 222 portable cassette recorder. One speaker was recorded using a Shure SM10 head-mounted microphone, and one speaker was recorded using a Realistic lavaliere microphone and a Marantz PMD 430 portable cassette recorder.

The acoustic analysis was done in five steps: First, the recordings were digitized with a sampling rate of 16 kHz with 16 bit accuracy. An antialiasing decimation filter removed frequency components above 8 kHz. Second, each word was digitally edited from the longer recording and stored in a separate computer file. Third, the temporal locations of vowel onsets and offsets were noted on the basis of aligned spectographic and waveform displays in a waveform editing program (Entropic XWaves). Fourth, the fundamental frequency of voicing was calculated by an algorithm that uses the normalized cross-correlation function and dynamic programming (Talkin

[7] This procedure may have led to some influences across speakers, but because some of the targeted forms are uncommon, spoken prompts were needed. Influences across speakers have been reported in the literature, but those effects have been found to occur in limited circumstances, usually involving choice of intonation pattern after 6 to 12 repetitions (Goldinger 1997).

1995). Estimates of voice F0 were calculated at 10 ms intervals throughout the word. Fifth, F0 values and time values were extracted from the raw F0 data file at three points in each of the vowels in the word: vowel midpoint (50% of the vowel duration) and at 20% and 80% of the vowel duration.[8] Finally, mistracked F0 values were corrected by hand. The number of F0 tracking errors so corrected was relatively small (228/4389 = 5.2%).

One reviewer raised a concern about our use of averaged data in the study, and particularly about combining values for men and women. Before we averaged the pitch traces to produce the graphs in this paper, we inspected the traces separately for men and women. In all cases, the pitch traces for men and women showed the same general pattern, with F0 for men averaging about 75 Hz lower than for women, and with the average male pitch traces showing a more compressed pitch range. A graph has been included in Appendix B showing a typical example of values for men, women, and combined values.

The following subsections discuss the results of our study: **3.2** is an overview of the surface contrasts and **3.3** details the acoustic correlates of tonal accent.

3.2. Establishing surface contrasts in word prosody. We first attempt to establish the surface contrasts Haas (1977*a*) observed in word prosody. Figure 1 shows the verb stem *leyk-* 'sit (of one)' in different grade forms to demonstrate near minimal contrasts between Haas's level, falling, and rising tone accents in initial position. Haas's predicted phonetic values for each syllable are given in each figure. (2–d, 24–d, etc. indicate Haas's predicted phonetic values.)

The traces in figure 1 are in accord with Haas's description, showing steady pitch, a slight fall, and a rise on the first syllable of the words. Figure 1 also shows wide differences in vowel length in the accented syllable: in *léyhkeys*, syllable-final *h* introduced by the aspirating grade acts to shorten the preceding diphthong; in *lěy^{n}keys*, nasalization triggered by the nasalizing grade has the opposite effect of lengthening the preceding diphthong.

Figure 2 uses the same verb stem to demonstrate minimal contrasts between level and falling tone accent in final position.

The contrast in the three accent patterns is perhaps clearest in medial position. Figure 3 contrasts these patterns in the penultimate syllable of four-syllable words (derived in these examples from *awanay-* 'tie to').

[8] Our procedures called for measuring F0 at three points in each vowel, but pitch contrasts are sometimes manifested in syllable-final sonorants. In the form *ancokó* 'my house' and *ânławá* 'wilderness', traces were corrected by taking values at three points in the sequence *an*.

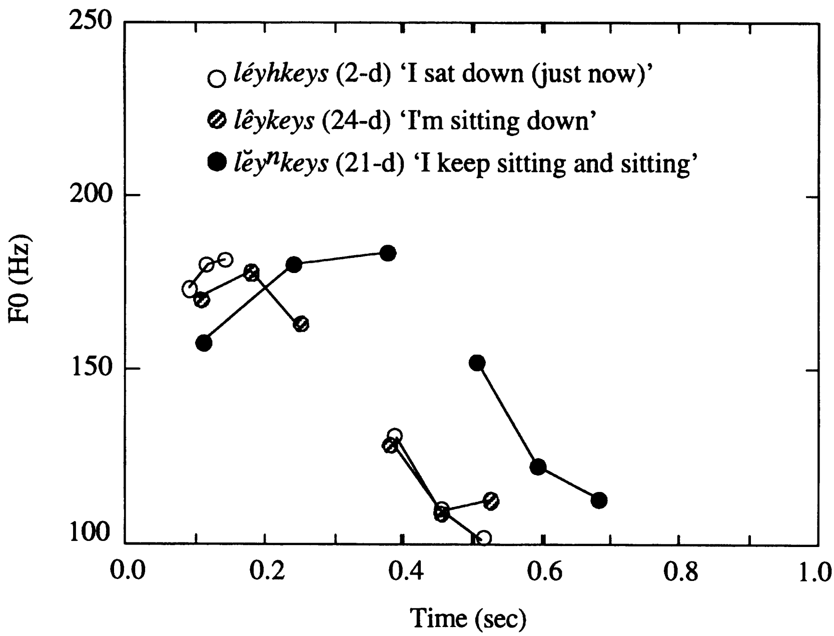

FIG. 1.—Average F0 patterns of the words (*a*) *léyhkeys* 'I sat down (just now)', (*b*) *lêykeys* 'I'm sitting down' (i.e., in a sitting position), and (*c*) *lĕyⁿkeys* 'I keep sitting and sitting', demonstrating the prosody of level, falling, and rising tone accent in initial position.

Further contrasts in word prosody result from differences in the placement and number of tonal accents. Figure 4 shows additional forms of *awanay-* 'tie to' with level tone accent on the last syllable rather than on the penult and with two level tone accents (the first triggering downstep).

Comparing figures 3 and 4, we see that four-syllable forms may have as many as five contrasting accent patterns. This is because the three tonal accents may co-occur in a single form and may occur in different positions.

Figure 5 provides additional evidence of contrasts between forms with one and two level tone accents, here based on the stem *nafk-* 'hit'.

Figure 6 adds a form with three level tone accents to the forms from figure 5. The terraced effect seen in figure 6*a* is clear evidence of downstep.

As noted in **2.1**, nonfinite forms show fewer contrasts: the vast majority of nouns have only level tone accent (placed according to the iambic rule discussed there); a handful of nouns have falling tone accent; no basic nouns are known to have the rising tone accent. Figure 7 shows contrasts in

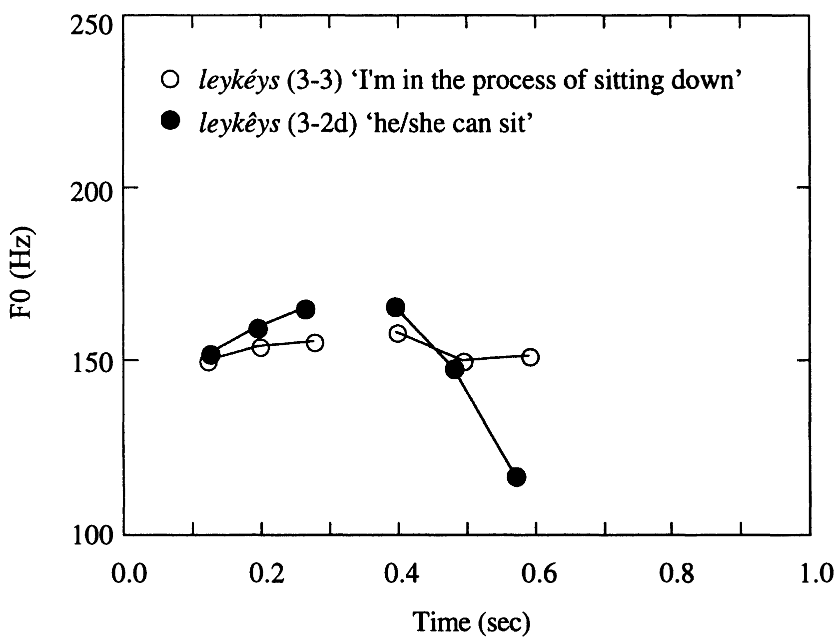

FIG. 2.—Average F0 patterns of the words (*a*) *leykéys* 'I'm in the process of sitting down' and (*b*) *leykêys* 'he/she can sit', demonstrating the prosody of level and falling tone accent in final position.

two-syllable nouns between level and falling tone accents.[9] Figures 8 and 9 show the same contrast in three-syllable nouns.

A further contrast noted by Haas results from the deletion of initial syllables. Initial light syllables (i.e., initial unstressed syllables) generally have slightly lower pitch in Creek. A word like *ací* 'corn' thus has an initial syllable that is pitched slightly lower than the following, accented syllable. Some initial syllables (particularly initial *i*) are deleted in everyday speech, however. The word *iháci* 'its tail' is thus often pronounced *háci.* Deletion of these initial syllables leads to surface contrasts in pitch, as shown in figure 10. Longer words show a similar contrast: the word *yanása* 'buffalo' thus shows lowering of the initial light syllable, while *'yanawá* (< *iyanawá*) 'his/her cheek' shows no lowering (see figure 11).[10]

[9] The final syllable of *wá:ka* 'cow' is unexpectedly high in figure 7.

[10] Haas places an apostrophe before a word-initial light syllable to signal that the following light syllable has not been lowered.

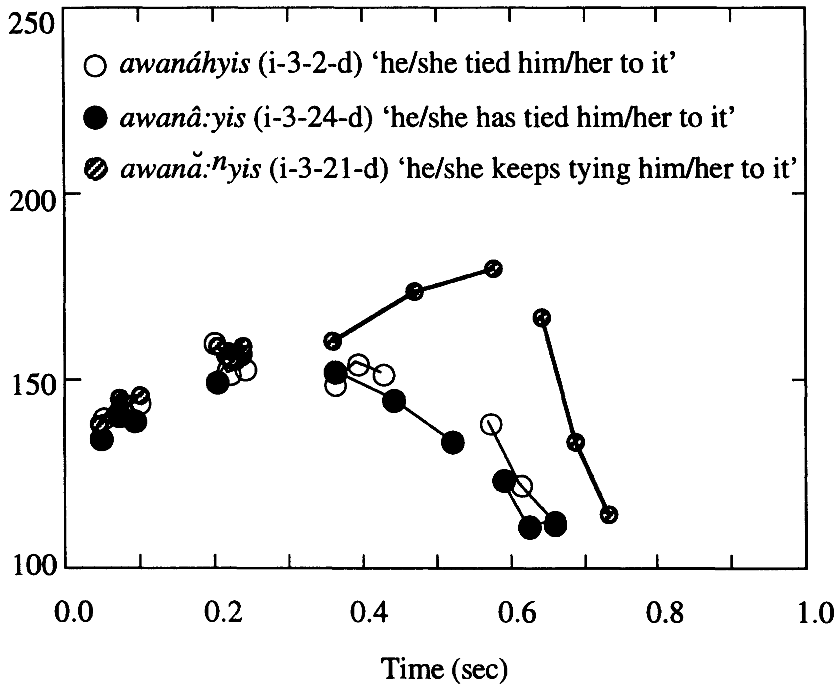

FIG. 3.—Average F0 patterns of the words (*a*) *awanáhyis* 'he/she tied him/her to it (just now)', (*b*) *awanâ:yis* 'he/she has tied him/her to it', and (*c*) *awanǎ:ⁿyis* 'he/she keeps tying him/her to it', demonstrating the prosody of level, falling, and rising tone accent in medial position.

It is evident from a comparison of figures 10 and 11 that Creek nouns show surface contrasts in the placement of level tone accent and in initial lowering, though these are predictable from more abstract (or older) forms.

3.3. The phonetics of Creek word prosody revisited. The average F0 patterns in **3.2** provide support for Haas's claim that there are three types of tonal accent in Creek and that further patterns of word prosody result from placement and multiple occurrence of these accents. We turn in this section to the phonetic realization of the three accents and the consequences of declination, spreading, margin effects, downstep, and tone spacing.

3.3.1. Level tone accent. Haas (1977*a*) states that level tone accent is 2 if first (i.e., the first accent in the word) and nonultimate, and 3 if first and ultimate. Examples relevant to this claim are figures 1*a*, 2*a*, 3*a*, 4*a*, 4*b*, 5*a*, 5*b*, 6*a*, 7*a*, 8*a*, 9*a*, 10*a*, 10*b*, 11*a*, and 11*b*.

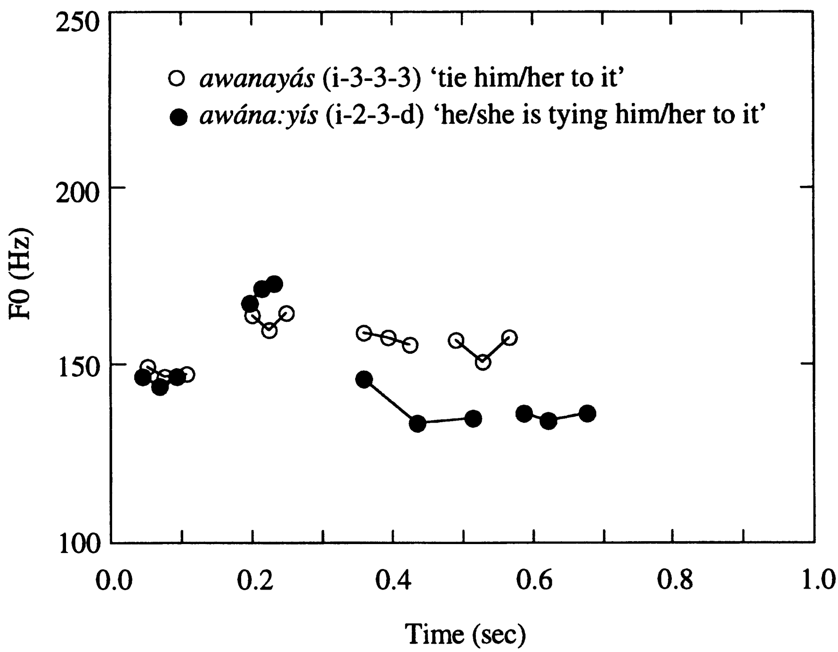

FIG. 4.—Average F0 patterns of the words (*a*) *awanayás* 'tie him/her to it' and (*b*) *awána:yís* 'he/she is tying him/her to it'. A comparison with figure 3 demonstrates contrast in placement and number of level tone accents.

Our data suggest a graded declination in the value of level tone accent from initial syllables (where it is roughly 175 Hz in figures 1*a*, 5*b*, 6*a*, and 10*b*) to final syllables (where it is roughly 155 Hz in figures 2*a*, 4*a*, 8*a*, 10*a*, and 11*b*). Medial instances have values in between (roughly 160 Hz in figures 3*a*, 9*a*, and 11*a*). This declination is most obvious when words like *háci* 'its tail' and *ací* 'corn' are contrasted (figure 10).

3.3.2. Falling tone accent. Haas (1977*a*) describes falling tone accent as 24 if first and nonultimate, 2d if first and ultimate. Relevant data in our study are presented in figures 1*b*, 2*b*, 3*b*, 7*b*, 8*b*, and 9*b*.

We find that falling tone accent in word-initial position is either rising falling (figures 1*b*, 8*b*, and 9*b*) or falling (figure 7*b*). In medial or final position, it is falling (figures 2*b* and 3*b*). As with level tone accent, we find graded declination in the word: in initial position (figures 1*b*, 7*b*, 8*b*, and 9*b*), the peak of falling tone accent is at about 175 Hz, falling 10–15 Hz. In medial position (figure 3*b*) or final position (figure 2*b*), the peak is at about 160 Hz, with a dramatic drop of roughly 25 Hz in sentence-final position.

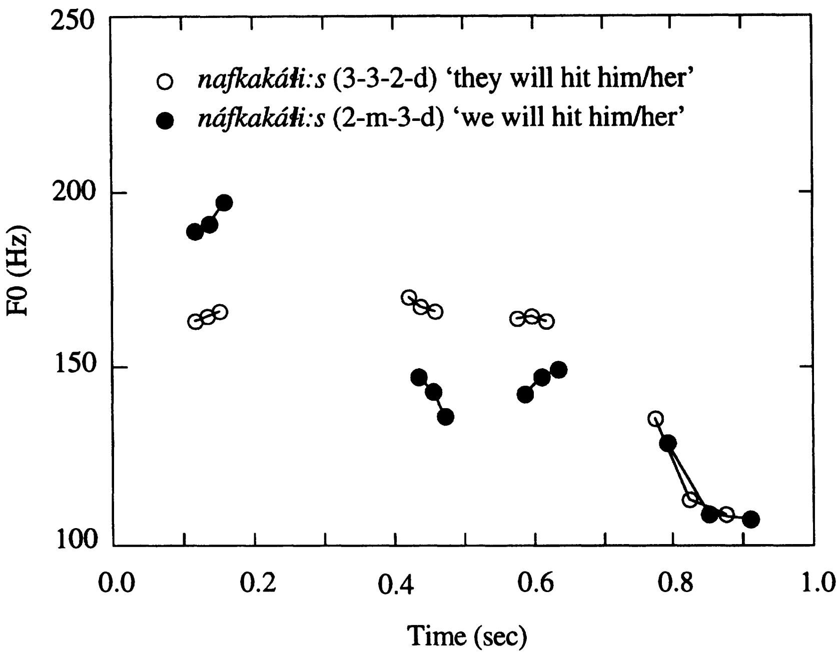

FIG. 5.—Average F0 patterns of the words (*a*) *nafkakáłi:s* 'they will hit him/her' and (*b*) *náfkakáłi:s* 'we will hit him/her', with one and two level tone accents, respectively.

3.3.3. Rising tone accent. Haas (1977*a*) describes rising tone accent as 21 or 1 if first and nonultimate. Relevant data in our study are found in figures 1*c* and 3*c*. In each case, rising tone accent begins at about 155 Hz and peaks at about 180 Hz. There is no obvious declination in these examples.

3.3.4. Spreading. Haas (1977*a*) states that any pretonic syllable (except an initial light syllable, which may be lowered) has a pitch of 3. Thus, *awanayás* 'tie him/her to it' has a pitch of i–3–3–3.

Our data suggest instead that the pitch of a key syllable spreads leftward to the first stressed syllable in the domain of word-level stress. (Usually the domain is the whole word, but if there is a preceding key syllable, the domain begins after that key syllable.) Relevant data appear in figures 2, 3, 4*a*, 5*a*, 8*a*, 9*a*, and 11*b*.

To see the effects of this process, consider *awanayás* 'tie him/her to it' in figure 4*a*. Iambic feet and word-final stress are assigned in this form, and level tone accent (H) is associated with primary stress. In final position, level tone accent has an average value of about 155 Hz. This pitch spreads to the first stressed syllable, as in (9):

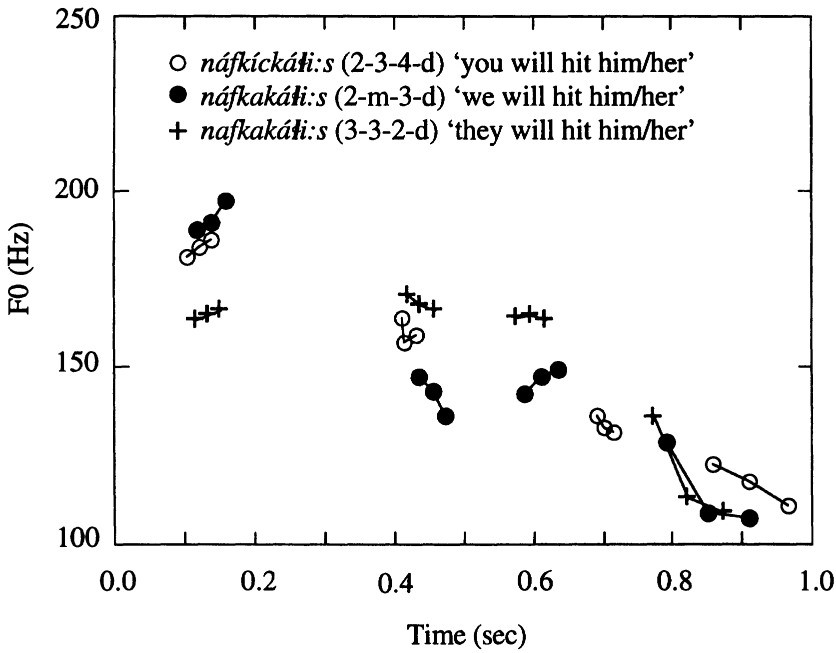

FIG. 6.—Average F0 pattern of the word (*a*) *náfkíckáłi:s* 'you will hit him/her', with three level tone accents, contrasted with the forms from figure 5.

(9) H (155 Hz)
/ | \
(x)
(. x) (. x)
awa nayás 'tie him/her to it'

This analysis corresponds closely to the trace in figure 4*a*.

Consider next the form, *nafkakáłi:s* 'they will hit him/her', in figure 5*a*. In medial position, level tone accent has a value of about 160 Hz. Again, this pitch forms a plateau, spreading leftward to the first stressed syllable:

(10) H (160 Hz)
/ | \
(x)
(x) (. x)
naf kaká łi:s 'they will hit him/her'

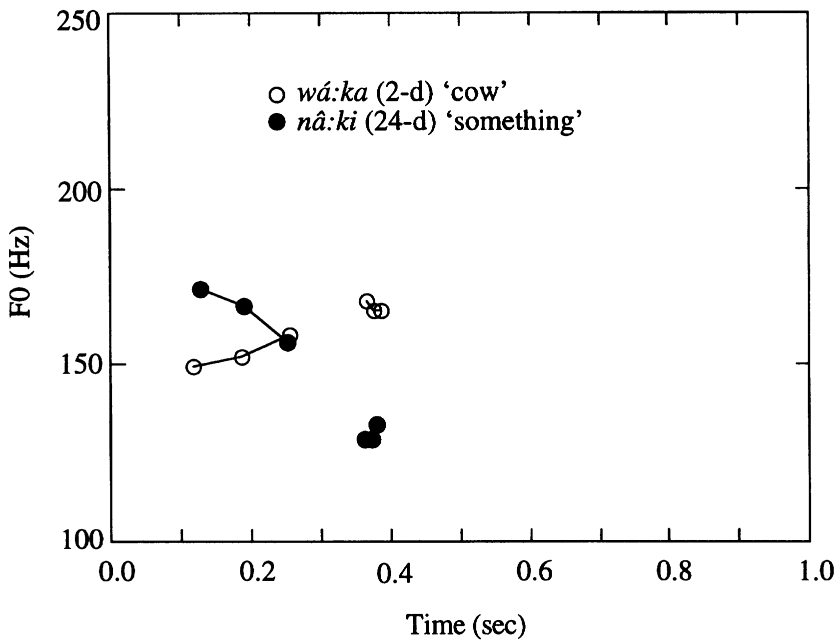

FIG. 7.—Average F0 patterns of the words (*a*) *wá:ka* 'cow' and (*b*) *nâ:ki* 'something', demonstrating the prosody of level and falling tone accent in two-syllable nouns.

Haas's description predicts a value of 3–3–2–d here, instead of the flat pattern we find, so we believe spreading more accurately describes the pitch of nonkey syllables.

3.3.5. Margin effects: initial, medial, and final lowering. Haas (1977*a*) uses the symbols i, m, and d to indicate relative pitch assigned to initial, medial, and final ("deep") syllables. Pitch i is assigned to initial light nonkey syllables and indicates a pitch slightly lower than the following syllable. Thus, *yanása* 'buffalo' has a pitch of i–2–d. Pitch m is assigned to nonultimate intertonic (between key syllables) light syllables and again signifies a pitch slightly lower than the following syllable. Haas (1977*a*) gives *atŏ:^{n}tkiyáłi:s* 'we will keep on working', with a value of i–21–m–3–d, as an example of this pitch. Pitch d (the lowest pitch) is assigned to syllables at the end of a word after the last accent. Thus, *háci* 'its tail' is predicted to have a value of 2–d.

Our data and interpretation again differ slightly. Initial light nonkey syllables are indeed lowered (about 10–20 Hz relative to the following syllable

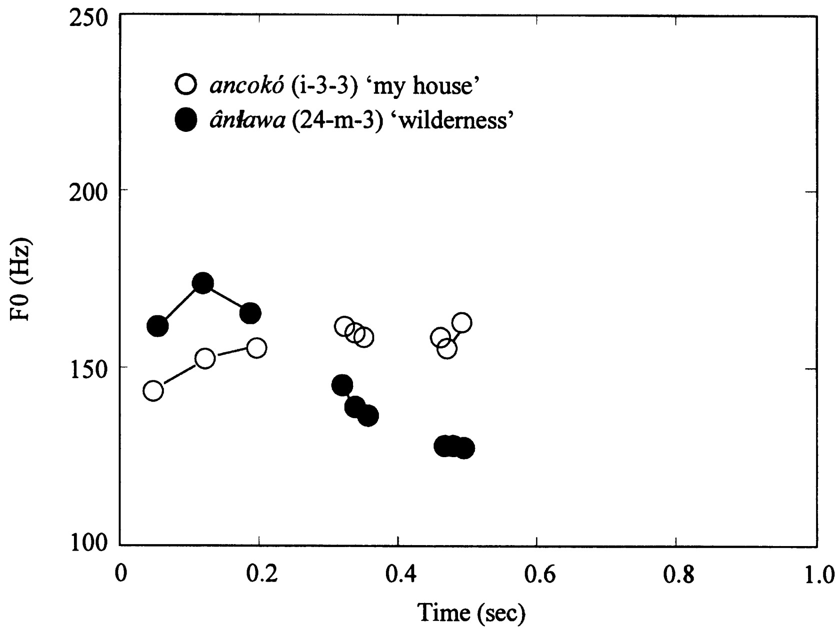

FIG. 8.—Average F0 patterns of the words (*a*) *ancokó* 'my house' and (*b*) *ânławá* 'wilderness', demonstrating the prosody of level and falling tone accent in three-syllable nouns.

in figures 3, 4, 10*a*, and 11*a*), but we find a similar effect in initial heavy syllables. A form like *i:fkánco* 'tick' (figure 9*a*) shows a rise of about 20 Hz within the first syllable, and less dramatic rises appear in the first syllables of *léyhkeys* 'I sat down (just now)' (figure 1*a*), *wá:ka* 'cow' (figure 7*a*), *ancokó* 'my house' (figure 8*a*), and *náfkakáłi:s* 'we will hit him/her' (figure 5*b*). These data suggest a general process of initial lowering: a low pitch (L) is assigned to the left edge of word-level stress domains (11), and this pitch is manifested as a rise in heavy syllables (12):

```
(11) L     H     (155 Hz)
     |   / | \
     (         x)
     (. x) (. x)
     awa  nayás   'tie him/her to it'

(12) L  H    (175 Hz)
     \ / \
     (   x)
     (x) (x)
     i:f kánco  'tick'
```

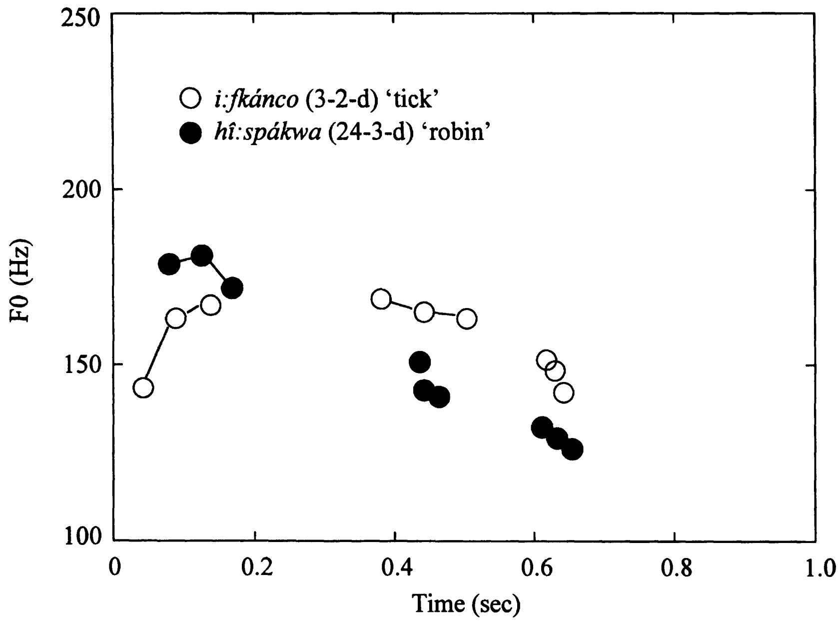

FIG. 9.—Average F0 patterns of the words (*a*) *i:fkánco* 'tick' and (*b*) *hî:spákwa* 'robin', demonstrating the prosody of level and falling tone accent in three-syllable nouns.

In heavy syllables with long vowels or vowels followed by sonorants, the rise is longer and more dramatic (figures 7*a*, 8*a*, and 9*a*). In heavy syllables with short vowels closed by obstruents, the rise, if present, is short and slight (figures 1*a* and 5*a*).

We have few data relating to pitch m, though *náfkakáłi:s* 'we will hit him/her' (figure 5*b*) is one example. Our data accord with Haas's description, showing slight lowering of the light, intertonic syllable. To account for multiple instances of level tone accent in this form, we adopt the metrical structure in (13), in which each instance of level tone accent represents a domain of word-level stress:[11]

(13) (x) (x)
     (x) (. x)
     náf ka ká łi:s   'we will hit him/her'

In (13), it is clear that Haas's "nonultimate intertonic light syllable" is in a position that is metrically parallel to the initial light syllable in *awanayás*

[11] Multiple accents sometimes arise when suffixes have inherent stress. A full description of accent placement goes well beyond the limits of this paper.

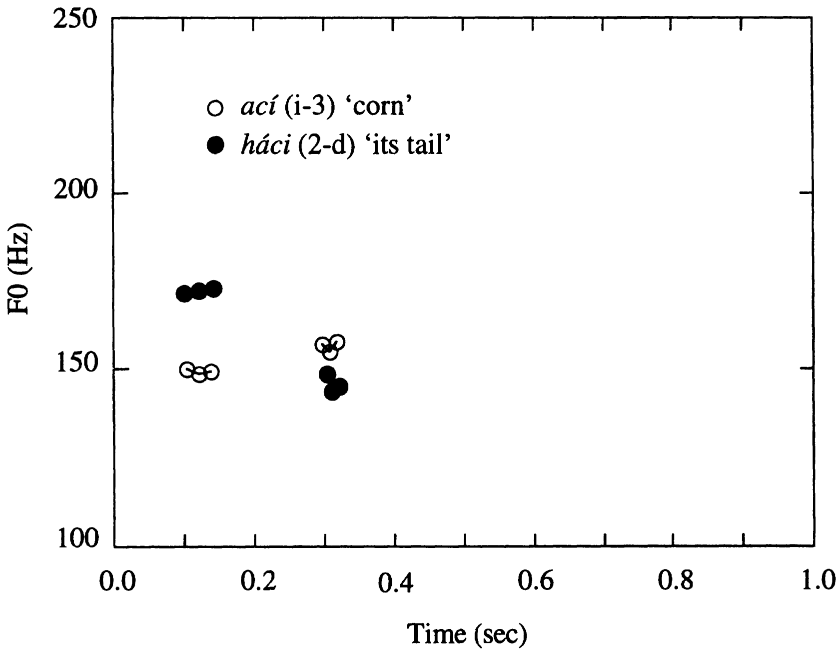

FIG. 10.—Average F0 patterns of the words (*a*) *ací* 'corn' and (*b*) *háci* (< *ihác̷i*) 'its tail', demonstrating surface contrasts resulting from loss of initial syllables.

'tie him/her to it' (11). If level tone pitch (H) is associated with syllables receiving word-level stress and low pitch (L) is assigned to the left edge of all word-level stress domains, (13) will be predicted to have the pitch values in (14):

```
(14) L  H  L  H
      \ /   |  |
     (x) (   x)
     (x) (.  x)
     náf kaká łi:s   'we will hit him/her'
```

The medial lowering seen in the second syllable of (14) thus has the same explanation as the initial lowering in (11): Haas's pitches i and m are at the left edge of a word-level stress domain in each instance.

Finally, we turn to pitch d, the deep pitch occurring in posttonic syllables at the ends of words. In our data, verbs (which were elicited in sentence-final position) show a drop to about 105 Hz. Nouns (which were elicited in sentence-medial position) show a drop to about 125 Hz. Presumably this

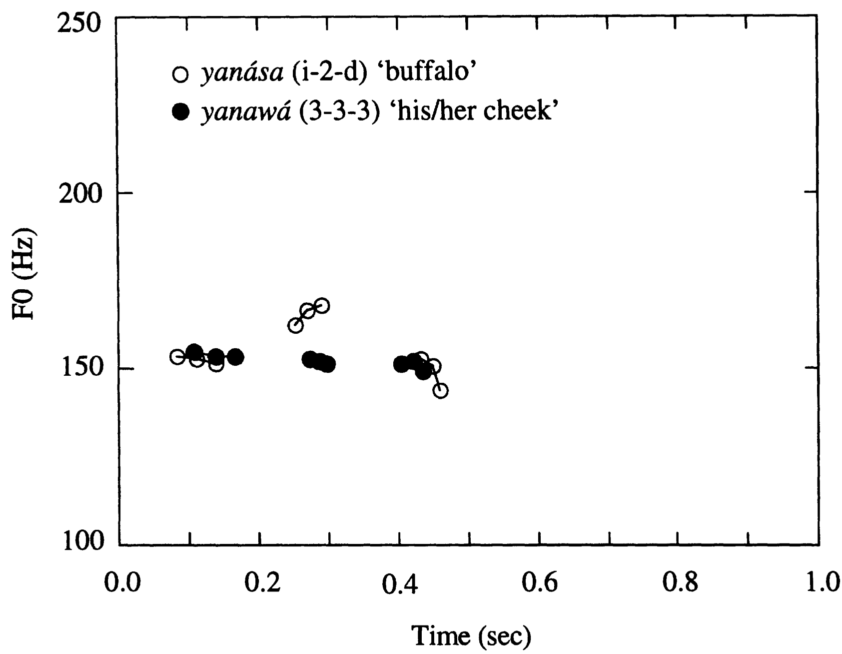

FIG. 11.—Average F0 patterns of the words (*a*) *yanása* 'buffalo' and (*b*) *'yanawá* (< *iyanawá*) 'his/her cheek', demonstrating surface contrasts resulting from loss of initial syllables.

difference is due to position, with lower pitch assigned to the ends of declarative sentences.

3.3.6. Downstep and tone spacing. In **3.3.1** and **3.3.2** we established that the pitch values associated with level and falling tone accent decline from initial to final position in words. As noted in **2.2**, Haas (1977*a*) described a separate process of "downward drift" (downstep) applying in words with more than one key syllable. According to her description, the second key syllable in a word is pitched one level lower than the first key syllable, the third key syllable is pitched one level lower than the second key syllable, and so forth. Thus, if level tone accent receives the value of 2 when first, it receives the value of 3 if second and 4 if third.

The contrast in figures 5 and 6 supports Haas's claim. In figure 5*a*, the first accented syllable has a pitch of about 160 Hz. In figure 5*b*, the first accented syllable has a higher pitch of about 195 Hz. Part of the difference between the two can be attributed to declination: we have shown that level tone accent has a higher realization in initial than in medial position. Note, however, that the pitch of the third syllable differs in the two forms in figure 5, with a value of about 160 Hz in figure 5*a* and about 150 Hz in figure 5*b*. This difference, while slight, cannot be due to declination because it is the third syllable we are comparing in each form; instead, the lower value in figure 5*b* appears to result from a preceding accent, as Haas predicts. Our data are thus consistent with the claim that Creek has downstep.

When we look at more complicated examples, we find that the specific values assigned to accented syllables diverge from Haas's description. The traces in figures 6*a*–6*c* suggest that there are additional factors at work. Specifically, the second accented syllable of *náfkíckáłi:s* (figure 6*a*) is higher in pitch than the second accented syllable of *náfkakáłi:s* (figure 6*b*). In studying these figures carefully, we conclude that pitch range is measured out based on the number of accents: when there are two level tone accents (figure 6*b*), the second is intermediate between the high and low values; when there are three (figure 6*a*), the second and third are again spaced evenly between the high and low values. Instead of describing the phenomenon as simple downstep, then, one might more accurately describe it as downstep with what might be called TONE SPACING—a division of the pitch range into equivalent steps.

We have proposed that the form in figure 6*b* has the metrical structure in (14). In line with previous assumptions, the form in figure 6*a* will have the structure in (15):

```
(15) L H   L H   L H
      \/    \/    \/
     (x)   (x)   (x)
     (x)   (x)   (x)
     náf   kíc   ká łi:s  'you will hit him/her'
```

In (15), level tone accent appears on each of the first three syllables. This is analyzed as word-level stress, associated with high pitch (H). As we saw in **3.3.5**, low pitch (L) is associated with the left edges of word-level stress domains. This low pitch is presumably what triggers downstep (and, in our data, slight lowering of the initial syllable in a domain). The phonetic values of H in (15) are calculated based on the number of downsteps in the word.

3.4. Other cues of tonal accent. As noted in **2.1**, level tone accent in Creek differs from the two other tonal accents in having the basic phonological properties of iambic stress. Haas (1977*a*) treats all three accentual phenomena together, describing these phenomena purely in terms of pitch.

The question arises whether level tone accent—analyzed phonologically as stress—differs in duration or amplitude from falling or rising tone accent.

If we compare the second syllable of the forms in figure 4, we see that level tone accent has no effect on a vowel's duration. Indeed, the only obvious cue of the first accent in figure 4*b* appears to be the downstep it induces on the third syllable. Similarly, although the first syllable of the two forms in figure 10 and the second syllable of the forms in figure 11 differ in accent and pitch, they do not differ appreciably in duration.

We have not yet examined the effect of accent on amplitude. Based on the findings presented here, however, we agree with Haas that the primary cue of level tone accent, like falling and rising tone accent, is pitch.

4. Conclusion. We have used acoustic measurements in this paper to verify the contrasts observed by Haas (1977*a*), to provide a more precise characterization of word prosody in Creek, and to demonstrate the effects of declination, downstep, and tone spacing in the language.

In our view, Creek is a language with stress (´), falling tone (ˆ), and rising tone (ˇ). Three distinct phonological phenomena—stress, tone, and intonation—interact to shape word prosody. The data in **3.3.1–3.3.4** have led us to draw certain conclusions about Creek metrical structure, tonal accent, and the phonetic processes affecting pitch:

(16*a*) STRESS: Every full word in Creek bears stress. In the simplest pattern, iambic feet are assigned left-to-right. Word-level stress (´) is assigned to the last foot and is associated with the value H. H has a value of about 175 Hz in initial position, declining to about 155 Hz in final position.

(16*b*) TONE: Falling tone (ˆ) indicates a fall from about 175 Hz to 160 Hz in initial position, from 160 Hz to 155 Hz in medial position, and from 160 Hz to 135 Hz in final position. Rising tone (ˇ) indicates a rise from about 155 Hz to 180 Hz.

(16*c*) SPREADING: Pitch resulting from stress or tone spreads leftward to the first stressed syllable in the domain.

(16*d*) MARGIN EFFECTS: The first syllable of a stress domain is lowered slightly (analyzed as resulting from the assignment of L to the left edge of word-level stress domains). The syllables at the end of a word after primary stress are also lowered, particularly at the ends of statements.

(16*e*) DOWNSTEP AND TONE SPACING: Downstep between stress domains results from the L assigned to the left edge of stress domains. The amount of downstep between domains is calculated based on the total number of downsteps.

It is interesting to compare the account outlined in (16) with Haas's description in (3) and (6) above. By and large, the two accounts agree on most details, even after two generations. In (16), however, we have tried to describe the Creek phenomena in terms of processes found in other languages with tone. We hope in this way to make the instrumental data, and our phonological account of it, more directly comparable to work on other languages.

APPENDIX A

Portion of the Questionnaire Dealing with Tonal Accent

The questionnaire used in this study was written in the traditional Creek spelling. Phonemic transcriptions have been added (right-hand column).

Mvt vcet os.	That's corn.	*mát acít ô:s*
Mvt hvcet os.	That's a tail.	*mát hácit ô:s*
Mvt wakvt os.	That's a cow.	*mát wá:kat ô:s*
Mvt naket os.	That's something.	*mát nâ:kit ô:s*
Mvt vncukot os.	That's my house.	*mát ancokót ô:s*
Mvt vnrvwvt os.	That's the wilderness.	*mát ânławát ô:s*
Mvt yvnvsvt os.	That's a buffalo.	*mát yanásat ô:s*
Mvt yvnvwvt os.	That's his cheek.	*mát 'yanawát ô:s*
Mvt ēfkvncot os.	That's a tick.	*mát i:fkáncot ô:s*
Mvt cēkulkot os.	That's a purple martin.	*mát ci:kôlkot ô:s*
Mvt hēspakwvt os.	That's a robin.	*mát hî:spákwat ô:s*
Mvt vpvtvnvt os.	That's a bullfrog.	*mát apatanát ô:s*
Mvt vpvtvkvt os.	That's cowboy bread.	*mát apatakát o:s*
Nvfketskvrēs.	You will hit him.	*náfkíckáłi:s*
Nvfkvkvrēs.	They will hit him.	*nafkakáłi:s*
Nvfkvkvrēs.	We will hit him/Let us hit him.	*náfkakáłi:s*
Likis.	I'm sitting down.	*lêykeys*
Likis.	I'm in the process of sitting down.	*leykéys*
Likis.	(Can he sit?) He can sit.	*leykêys*
Lįkis.	I keep sitting and sitting.	*lěy^{n}keys*
Lihkis.	I sat down (just now).	*léyhkeys*
Vwvnvyvs.	Tie him to it.	*awanayás*
Vwvnayes.	He is tying him to it.	*awána:yís*
Wvnayes.	He is tying him.	*wana:yís*
Vwvnayes.	He has tied him to it.	*awanǎ:yis*
Vwvnahyes.	He tied him to it (just now).	*awanáhyis*
Vwvną̣yes.	He keeps tying him to it.	*awanǎ:^{n}yis*

APPENDIX B
PITCH TRACES FOR MALE AND FEMALE SPEAKERS

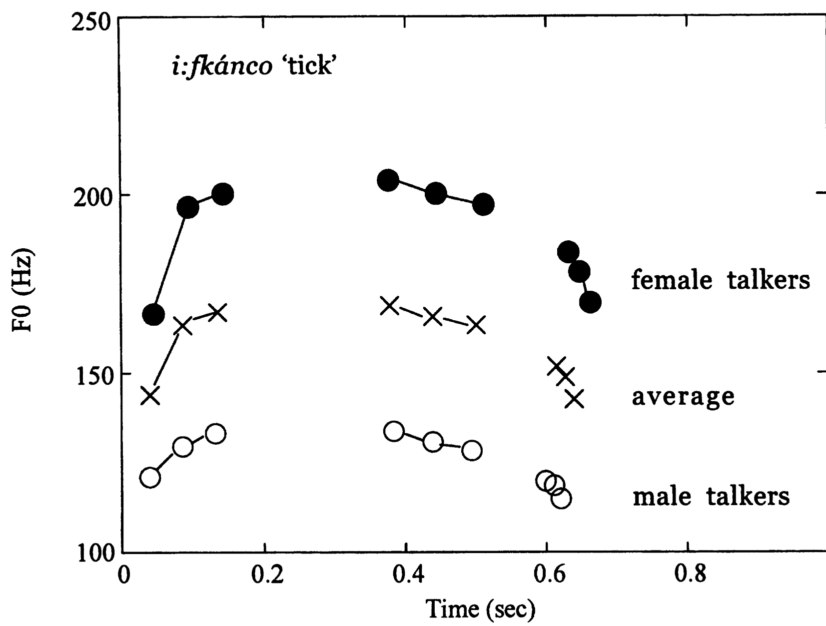

FIG. 12.—Pitch traces for male and female speakers (and the average of all speakers) for the word *i:fkánco* 'tick'. The F0 for men averages about 75 Hz lower than for women, with a more compressed pitch range.

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