The Phonetics and Phonology of "Definitive Accent" in Tongan

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The so-called definitive accent (DA) in Tongan has been analyzed in various ways in the literature: as stress shift from penultimate to final vowel, as simultaneous stress reduction on a penult and stress addition on an ultima, and as addition of a syllable by repetition of the final vowel. This study investigates each of these analyses empirically in order to establish the phonology of DA in Tongan. Our findings support Melenaite Taumoefolau's proposal that definite NPs are formed by repetition of the NP-final vowel, and thus a morphological analysis of DA as reduplicative suffixation. Moreover, our findings substantiate an account of Tongan in which stress is unexceptionally penultimate in a foot, and in which "long vowels" and "diphthongs" are to be considered sequences of two syllables, as suggested by Taumoefolau.

1. INTRODUCTION.[1] Unlike most Polynesian languages, which indicate the difference between definite and indefinite noun phrases (NPs) morphologically, Tongan has frequently been analyzed as using a phonological means of differentiating between the two types of NPs.[2] However, the nature of this phonological marking has been controversial. On one hand, Churchward's 1953 Tongan grammar treats the difference as a stress shift: "Normally the stress falls on the last vowel but one. Examples: *móhe,* to sleep, *mohénga,* bed; *haéʻi*, to tear, *maháe,* torn…. In the following cases, however, it falls on the last vowel: (*a*) When the last vowel is long. Thus, in *kʉmā*, rat, it falls on the *ā*; in *hangē*, to be like, on the *ē* …. (*b*) Before an enclitic[3] …. (*c*) In what we shall call the definitive accent" (4). "When a nounal or pronominal group is definite, … the main stress is shifted from the last vowel but one to the very last vowel …" (6–7).

On the other hand, Taumoefolau (2002) proposes that "definitive accent is really the repetition of the final vowel" (349). Stress assignment is unexceptional, in this view, with main stress occurring on a penultimate vowel. The relevant operations for a word containing short vowels are schematized in (1).

1. The authors thank the Tongan speakers who participated in this study; Albert J. Schütz for valuable comments on a previous version of this paper; members of the Austronesian Circle at the University of Hawaiʻi; Sang Yee Cheon and Diana Stojanovic for helpful contributions in measuring durations; and an anonymous reviewer for constructive suggestions. Any errors are our responsibility.

2. Niuafoʻou, a language spoken on the northernmost of Tonga's islands, uses the same strategy as Tongan (Tsukamoto 1994).

3. All enclitics in Tongan contain a single, short vowel.

Oceanic Linguistics, Volume 45, no. 1 (June 2006)

(1)

Churchward 1953		Taumoefolau 2002	
$[\ldots{}^{\text{l}}\text{CVCV}]_{\text{NP}} \rightarrow$	$[\ldots\text{CV}^{\text{l}}\text{CV}]_{\text{NP}}$	$[\ldots{}^{\text{l}}\text{CVCV}]_{\text{NP}} \rightarrow$	$[\ldots\text{CV}^{\text{l}}\text{CVV}]_{\text{NP}}$
[–def. acc.]	[+def. acc.]	[–def. acc.]	[+def. acc.]

In this paper, primary and secondary stress are indicated following IPA convention; that is, by superscripted and subscripted lines, respectively (e.g., *ˌmafaˈtua*, 'sneeze'). Also, while a long vowel is variously symbolized in the literature as V̄, V:, or VV, here we use either standard Tongan orthography (usually V̄), or VV as necessary, for clarity of exposition in discussing the location of stress.

The central goal of the current study is to establish the phonology of definitive accent in Tongan by empirically investigating the claims of Churchward, Taumoefolau, and others. Does definitive accent involve rightward stress shift, or the addition of a vowel, or some other mechanism? The paper is organized as follows. Section 2 presents relevant morphological characteristics of Tongan that have to do with the referentiality and definiteness of NPs, and introduces the phenomenon known as definitive accent (hereafter DA). Section 3 reviews previous analyses of DA in Tongan. Section 4 summarizes this study's experimental methods and procedures for analysis. We present results in section 5, and discuss implications for the phonology of Tongan syllable structure and metrical stress in section 6. Concluding remarks are given in section 7.

2. RELEVANT TONGAN MORPHOLOGY

2.1 INDEFINITE *ha* AND DEFINITE *e*. Tongan has two articles, *ha* and *e*,[4] that are traditionally called the "indefinite article" and "definite article", respectively. These labels, however, are somewhat misleading. To be more precise, the two articles are distinguished from each other in terms of referentiality rather than definiteness. The article *ha* simply indicates nonreferentiality. In this sense, *ha* corresponds to English *any,* rather than the English indefinite article *a*, in that the latter implies a referential, indefinite, and singular NP. According to our language consultants, *ha* can be used in interrogative and negative constructions, but not in declaratives, as illustrated in (2).[5]

(2) a. Te ke fakatau ha ika?
FUT 2.SG buy NREF fish
'Are you going to buy any fish?'

b. 'E 'ikai te u fakatau ha ika.[6]
FUT NEG COMP I.SG buy NREF fish
'I am not going to buy any fish.'

c. *Te u fakatau ha ika.
FUT I.SG buy NREF fish
'I am going to buy any fish.'

4. The definite article *e* has an allomorph *he*, which appears after *'e* (ERG marker), prepositions *ki* (to), *'i* (in, on), and *mei* (from).
5. The following abbreviations are used in addition to those of the Leipzig Glossing Rules: DA, definitive accent; DIR, directional; REF, referential; TNS, tense.
6. Standard Tongan orthography uses the inverted apostrophe (') to indicate the glottal stop.

On the other hand, a Tongan NP that is referential, indefinite, and singular is marked with *e* rather than *ha*. In other words, *e* corresponds better to English *a* than it does to the English definite article *the*. See (3) below.[7]

(3) a. Ko e hā ē?
PRED REF what that
'What is that?'

b. Ko e me'alele.
PRED REF car
'It's a/*the car.'

Churchward (1953:25) cites the sentences below to illustrate the difference between *ha* and *e*.

(4) a. Ha'u mo ha afo.
come with NREF fishing.line
'Bring a fishing line (i.e., any fishing line).'

b. Ha'u mo e afo.
come with REF fishing-line
'Bring a fishing line (i.e., not a spear).'

In (4), if the referential article *e* is used, the NP is contrasted with other entities, while the use of the nonreferential article *ha* simply indicates that the NP can refer to any fishing line of all possible fishing lines. However, *e afo* 'a fishing line' in (4b) still does not refer to a specific entity. In sum, the so-called "definite article" *e* in Tongan is unmarked for definiteness, but simply indicates referentiality.

2.2 DEFINITIVE ACCENT. Definiteness, on the other hand, is indicated not by means of articles, but appears to be indicated phonologically. Compare the (referential) indefinite NP in (5a) with the (referential) definite NP in (5b), as indicated in standard Tongan orthography, with an acute accent over the last vowel in the NP.

(5) a. Ko e me'alele.
PRED REF car
'It's a/*the car.'

b. Ko e me'alelé.
PRED REF car.DA
'It is the/*a car.'

c. Ha'u mo e afó.
come with REF fishing-line.DA
'Bring the (i.e., that particular) fishing line.'

Sentence (5b) cannot mean 'It is a car.' Instead (5b) must signify a specific car, whose reference is clear to both the speaker and the addressee. Similarly, (5c) contrasts with (4b): in (5c) it is clear to both the speaker and the addressee which fishing line *e afó* signifies.

It should be noted that DA applies to a relevant NP, rather than a noun per se. In each definite NP in (6), the primary prominence is realized on the last word of the NP, whether or not that word is the noun. Each example in (6) places broad focus on 'car'.

(6) a. Ko e [me'alelé].
PRED REF car.DA
'It's the car.'

7. Note also that replacing *e* with the nonreferential article *ha* results in ungrammaticality. See (i) below.

(i) *Ko ha me'alele.
PRED NREF car
Intended: 'It's a car.'

b. Ko e [me‘alele kulokulá].
PRED REF car red.DA
‘It’s the red car.’

c. Ko e [me‘alele kulokula ‘a Sioné].
PRED REF car red of Sione.DA
‘It’s Sione’s red car.’

d. Ko e [me‘alele kulokula [na‘e fakatau ‘e Sioné]].
PRED REF car red PST buy ERG Sione.DA
‘It’s the red car Sione bought.’

e. Ko e [me‘alele kulokula [na‘e fakatau ‘e Sione.
PRED REF car red PST buy ERG Sione
‘i he ta‘u kuo‘osí]].
in REF year last.DA
‘It’s the red car Sione bought last year.’

Table 1 summarizes the morphological and phonological devices that mark referentiality and definiteness in Tongan.

3. PREVIOUS ANALYSES OF DA IN TONGAN. Besides the analyses of Churchward and Taumoefolau, we will briefly summarize the analyses of Clark (1974), Condax (1989), and Schütz (2001), with respect to DA.

Clark (1974) notes that the demonstratives *-ni* ‘this’ and *-na* ‘that’ are enclitics, forming part of the preceding noun. Their clitic status is shown by their effect on word stress, illustrated in (7).

(7) a. ˈmoko ‘gecko’
b. moˈko-ni ‘this gecko’
c. moˈko-na ‘that gecko’

In Tongan, nonclitic demonstratives come in three forms rather than just two: *eni* ‘this (near speaker)’, *ena* ‘that (near addressee)’, and *ē* ‘that (away from both)’.

(8) a. ˌmoko ˈeni ‘this gecko’
b. ˌmoko ˈena ‘that gecko (near you)’
c. ˌmoko ˈē ‘that gecko’

Observing the synchronic lack of enclitic corresponding to nonclitic *ē,* Clark proposes that the missing enclitic is what gave rise to DA in the history of Tongan. He reconstructs the missing enclitic as **-a*. Clark then proposes that, like other instances of Proto-Polynesian unstressed **a*, this enclitic underwent raising in the environment of nonlow vowels, giving rise to words of the shape in (9).

TABLE 1. REFERENTIALITY AND DEFINITENESS IN TONGAN

REFERENTIALITY	DEFINITENESS	ARTICLE	DEFINITIVE ACCENT
[–ref]	[–def]	ha	–DA
[+ref]	[–def]	e	–DA
[+ref]	[+def]	e	+DA

(9)	*púha	'box'	*puha	+	* a	→	*puhá-a	'that box'
	*fále	'house'	*fale	+	* a	→	*falé-e	'that house'
	*móko	'lizard'	*moko	+	* a	→	*mokó-o	'that lizard'

Such forms allowed for a reinterpretation of the enclitic *-*a* as vowel lengthening, with an effect on word stress similar to that of the enclitics in (7). Clark allows that subsequent vowel shortening would account for the current form of DA as described by Churchward, but leaves open the possibility that the final vowels in such forms remain long in modern Tongan. As he mentions in a footnote:

> While recognising the distinction between long and short vowels, and the fact that final long vowels are stressed, Churchward does not consider definitive-accented vowels as long (4). It has been suggested by Andrew Pawley (personal communication) that they are, in fact, long. Such an analysis seems to be assumed also by Pulu (1970), a native speaker of Tongan. The question requires a careful phonetic analysis, which I have not been able to undertake. If it is correct, that, for example, the final vowel of *molí* "orange", with the definitive accent, is the same length as that of *kulī* "dog", with normal stress, then it is possible synchronically to interpret the accent as a process of vowel lengthening, or a reduplicative suffix, stress being assigned by the normal rules. (105, footnote 8.)

Clark's question regarding the length of final vowels in words bearing DA motivated a phonetic study of DA by Condax (1989). Condax compares "long vowels and definitive-accented vowels" (429), and concludes by supporting Clark's analysis that DA derived from a historical enclitic. However, Condax finds that the mean duration of a short vowel bearing DA falls between that of a short vowel not bearing DA, and that of a long vowel (not bearing DA).[8] Specifically, she claims that a short vowel bearing DA has the duration that "would be expected for a stressed vowel plus an unstressed enclitic" (427); by "stressed vowel", Condax intends "stressed, short vowel" in this context. Moreover, she interprets her data to indicate that a short vowel in the position immediately preceding a definitively accented short vowel is also of greater duration than a stressed (short) vowel.[9] In other words, Condax would predict that each vowel in the definitively accented *molí* 'orange' is of greater duration than the *o* in normally stressed *móli.* Thus, instead of espousing any of the synchronic analyses of DA offered in Clark (1974), (i.e., stress shift, vowel lengthening, or addition of a reduplicative suffix), Condax suggests that when a word like *móli* becomes definitively accented, the penult undergoes some stress reduction, and the final vowel undergoes some stress addition. Noting that Tongan stress is "composed of at least two components, duration and pitch, and that each can occur independently of the other to some extent" (428), she proposes that stress reduction on the penult consists in removing the pitch excursion normally associated with the last stressed syllable in a sentence, but not removing the increased duration that accompanies such a syllable. Stress addition on the ultima consists in adding this pitch excursion, and adding duration to the vowel.

8. Unfortunately, none of the long vowels involved in this comparison bears DA. All of the short vowels in the comparison do bear DA. Thus, two independent variables that are likely to affect vowel duration (i.e., length and definitive accent) are conflated in Condax's study.
9. However, this observation could be an artifact of lengthening in phrase-final position.

Condax suggests that her data are most consistent with Morton's (1962) proposal that DA involves secondary stress on the penult and primary stress on the last vowel.

Schütz (2001), in analyzing alternating prominence on syllables in Tongan, proposes a prosodic hierarchy involving "measures" and "phrases". A "measure" is a rhythmic unit having one of the shapes in (10) or (11).

(10)	CV:	as in	*fā* 'four'	*tō* 'fall'
		or	*fai* 'do'	*fāi* 'plod'
	CVCV	as in	*fale* 'house'	*mata* 'eye'
	CV:CV	as in	*ngāhi* 'PL'	*māma* 'light'
		or	*mausa* 'emit smell'	*māuku* 'subside'

or "each of these preceded by an unaccented syllable," as in (11):

(11)	CVCV:	as in	*kulī* 'dog'	*kumā* 'rat'
		or	*fo'ou* 'new'	
	CVCVCV	as in	*fetu'u* 'star'	*fefine* 'woman'
	CVCV:CV	as in	*sipōti* 'sports'	*ki māma* 'to the light'[10]

In Schütz's terms, the "accent" (i.e., stress) in a measure "will fall on any long syllable, with its peak either a long vowel or a diphthong (short or long), or, if there are no long syllables, on the penultimate syllable" (315).[11] Measures combine to form phrases; in each phrase, an additional "phrase accent" occurs on the last "root measure" (the last measure containing a content morpheme), again for rhythmic reasons. In considering Condax's (1989) phonetic results, Schütz suggests that "the functional explanation of definitive accent is fairly simple: because phrase accent emphasizes the last root measure in the phrase (which is demarcative), definitive accent is a way to put a different kind of accent on the same measure" (321). In other words, Schütz analyzes DA as an additional form of prominence, applied at the phrase level, whose use imparts special meaning to a phrase that already has rhythmic phrase accent. In Schütz's view, the cumulative effects of these different levels and types of accent explain Condax's finding that in a definite NP such as *molí*, both vowels are of greater duration than stressed short vowels elsewhere. DA adds duration to the final vowel, and rhythmic phrase accent adds duration to the penultimate vowel.

Like Schütz, Taumoefolau (2002) (T hereafter) considers the alternating strength of syllables in phrases and longer utterances, rather than just in single words. Although not an empirical study, T's account benefits from native-speaker intuition. She proposes that DA in Tongan simply involves the addition of a syllable at the end of the NP-final word, with primary phrasal stress then falling unexceptionally on the penultimate syllable, as it does in other NPs. She provides examples both in orthography, and crucially, parsed into "stress groups" (equivalent to Schütz's "measures"). Her examples (9) and (10) (349) are reproduced in (12) below:

10. Examples and orthography in (10) and (11) are reproduced from Schütz (2001:315). In Churchward's (1959:432) dictionary, 'sports' is listed as *'sipoti'*, with a short vowel. Moreover, *'ki māma'* is a phrase (PP) rather than a word; monomorphemic words of this shape seem to be extremely rare, but an example is *mofuike* 'earthquake'.

11. The syllable structure implicit in Schütz's analysis is a matter for debate, and we will return to syllable structure in section 6. However, none of these comments is crucial to the point about DA being made here.

(12) a. Na'e holo 'a e falɛ.
TNS collapse ABS REF house
/ná-'e hó-lo 'á-e fá-lɛ/ T'S TRANSCRIPTION
['na.ʔe 'ho.lo 'ʔa.e 'fa.lɛ] IPA
'A house collapsed.'

b. Na'e holo 'a e falé.
TNS collapse ABS REF house.DA
/ná-'e hó-lo 'á-e fa=lé-e/ T'S TRANSCRIPTION
['na.ʔe 'ho.lo 'ʔa.e fa 'le.e] IPA
'The house collapsed.'

An advantage of T's analysis is its explicit characterization of Tongan syllable structure. "The structure of the Tongan syllable is always either CV or V… . Contrary to Biggs's (1978:699) generalization that two kinds of syllables, short and long, need to be distinguished in Polynesian languages, *in this analysis*, a syllable in Tongan is neither long nor short [as] it centers on a single vowel sound; all vowel sounds being equal in length" (342–43; emphasis added). In this view, what have been called "long vowels" and "diphthongs" are taken to consist of vowel sequences in separate syllables.

4. PHONETIC INVESTIGATION

4.1 RELEVANT PHONOLOGY. Tongan exhibits phonological characteristics typical of Polynesian languages. Closed syllables do not occur (*VC, *CVC). Moreover, contrasts like those in (13) are common.

(13) a. kaka 'to climb'
kakā 'parrot'
kākā 'cunning'

b. tata 'to scoop up'
tatā 'hat'
tātā 'to blow continuously…'

c. ngaue 'to move'
ngāue 'to work'

Most scholars have taken examples like those in (13) to show that vowel length is phonemic; that is, that long vowels contrast with short vowels in Tongan. Although Churchward (1953), Clark (1974), Condax (1989), and Schütz (2001) do not explicitly discuss syllable structure, we assume that, unlike Taumoefolau, they would consider "long vowels" to be monosyllabic—in other words, dominated by a single syllable node. We discuss the implications of our study for conclusions about Tongan syllable structure in section 6. In the meantime, we continue to use the terms "long," "short," and "phonological length" for convenience.

4.2 DATA SET. The data collected for this study are shown in (14) through (25), with target words italicized. Each target word contains target sequences of the shape *ka, kau,* or *kā.*

(14) Na‘a ne [*kakau*]VP.
‘He swam.’

(15) Na‘a ne [*kaka*]VP.
‘He climbed.’

(16) Na‘a ne [*kākā*]AP.
‘He was cunning.’

(17) Na‘a ne [*kakau* ki ai]VP.
‘He swam there.’

(18) Na‘a ne [*kaka* ki ai]VP.
‘He climbed up there.’

(19) Na‘a ne [*kākā* ‘aupito]AP.
‘He was very cunning.’

(20) Na‘a nau sio ki [he tamasi‘i na‘e *kakaú*]NP.
‘They saw the swimming boy.’

(21) Na‘a nau sio ki [he tamasi‘i na‘e *kaká*]NP.
‘They saw the climbing boy.’

(22) Na‘a nau sio ki [he tamasi‘i *kākā́*]NP.
‘They saw the cunning boy.’

(23) Na‘a nau sio ki [he tamasi‘i na‘e *kakaú*]NP pea ui ki ai.
‘They saw the swimming boy and called to him.’

(24) Na‘a nau sio ki [he tamasi‘i na‘e *kaká*]NP pea ui ki ai.
‘They saw the climbing boy and called to him.’

(25) Na‘a nau sio ki [he tamasi‘i *kākā́*]NP pea ui ki ai.
‘They saw the cunning boy and called to him.’

Data were chosen in order to systematically vary several factors that potentially affect phonetic duration: vowel length (long/short), DA (present/absent), primary phrasal stress on the fragment (present/absent), and position-in-utterance (prepausal/nonprepausal). At the same time, we limited our inventory of speech segments to [k], [a], and [u], in order to prevent different intrinsic properties of consonants and vowels from affecting measurements.

Recall that DA applies only to Noun Phrases. Thus, in order to investigate the effects of phonological length and primary phrasal stress on phonetic duration, apart from the effects of DA on duration, we first placed the test sequences in Verb Phrases or Adjective Phrases (sentences [14] through [19]). Sentences (14) through (16) were designed to illustrate phonetic realizations of length contrasts where the test sequence occurred in a prepausal word; (17) through (19) were designed to illustrate the same properties where the test sequence occurred in a nonprepausal word. In the last six sentences, we placed the test sequences in referential, definite NPs to investigate the effect of DA on duration. Again, test sequences were placed both in prepausal and nonprepausal words.

4.3 PREDICTIONS. We formulate the following hypotheses based on the treatments of DA summarized in sections 1 and 3:

(Hypothesis A): Per Churchward, DA involves a change in the location of stress from penult to final vowel, with no change in phonemic vowel length.

(Hypothesis B): Per Taumoefolau, DA involves the addition of a syllable by repetition of the final vowel, with no change in stress location.

(Hypothesis C): Per Condax, DA involves simultaneous stress reduction on a penult and stress addition on an ultima.

Clarification of the meaning of "stress" in each of these hypotheses is in order. Churchward (1953:3) alludes to duration as a phonetic correlate of stress. "Even normal vowels vary a little in length, being somewhat longer when stressed than when unstressed. But the symbols *ā, ē, ī, ō,* and *ū* represent the same sound lengthened still further." T believes that "the native speaker's intuitive knowledge of stress groups may be the most important thing about stress in Tongan. One may actually pronounce words without any perceived stress, and the phonetic properties of syllables may vary a great deal in actual speech, but … the utterances of native speakers are always analysable into stress groups, suggesting that native speakers' utterances are organised in their minds into stress groups". (352) As noted in section 3, Condax (1989) mentions that Tongan stress is "composed of at least two components, duration and pitch, and that each can occur independently of the other to some extent" (428). Each of these statements touches on the lack of invariance among phonetic correlates of stress, and for T, its rhythmic nature. In the current study, following Hayes (1995), we employ increased duration and attraction of intonational pitch accents as phonetic diagnostics of stress.

In testing Hypotheses A, B, and C, one set of crucial comparisons involves the durations of the italicized sequences in the four sentences below.

(26) Na'a ne [ka*ka*]VP. (SHORT VOWEL WITHOUT DA)
'He climbed.'

(27) Na'a nau sio ki [he tamasi'i na'e ka*ká*]NP. (SHORT VOWEL WITH DA)
'They saw the climbing boy.'

(28) Na'a ne [kā*kā*]AP. (LONG VOWEL WITHOUT DA)
'He was cunning.'

(29) Na'a nau sio ki [he tamasi'i kā*ká*]NP. (LONG VOWEL WITH DA)
'They saw the cunning boy.'

If DA involves stress shift (Hypothesis A), the final vowel in (27) will be longer in duration than that in (26), because stress tends to increase duration. Importantly, however, the vowel in (27) will remain substantially shorter in duration than the phonologically long vowel in (28).

As for the italicized vowels in (28) and (29), Churchward (1953) makes brief mention of phonologically long vowels that fall in position to receive DA: "the long vowel expands into a double vowel, with the stress on its second element. … With the definitive accent, *hū* becomes *huú*, *fakahā* becomes *fakahaá*, and *pō* becomes *poó*…. Such double vowels… aris(e)… through the analysis or splitting into two of one long vowel …" (11, 12). It is unclear whether Churchward would predict a durational difference between the italicized vowels in (28) and (29). "Expansion" of the long vowel into a double vowel in (29) may or may not imply added duration. Moreover, as both (28) and (29) involve stress, they may or may not be equally affected by its durational effects.

If DA involves addition of a syllable, (Hypothesis B), (27) will be of greater duration than (26), but unlike Hypothesis A, (27) and (28) will be of similar duration, as both consist of two syllables. The italicized vowels in (28) and (29) will also differ considerably, given that we expect both short and long vowels to add a syllable under the influence of DA.

If Hypothesis C is correct, duration of the vowel in (27) will be intermediate between that of (26) and (28) (as in Hypothesis A), and the mean durations for the three vowels will be statistically distinct. Condax does not address the effect of DA on long vowels.

It is not possible to differentiate between Hypotheses A and C on the basis of the comparisons in (26–29) above. To do that, we turn to a comparison of the following italicized sequences in (30–33):

(30) Na‘a ne [*ka*ka]VP. (SHORT STRESSED VOWEL, NOT PRECEDING DA)
‘He climbed.’

(31) Na‘a nau sio ki [he tamasi‘i na‘e *ka*ká]NP. (SHORT UNSTRESSED VOWEL, PRECEDING DA)
‘They saw the climbing boy.’

(32) Na‘a ne [*kā*kā]AP. (LONG STRESSED VOWEL, NOT PRECEDING DA)
‘He was cunning.’

(33) Na‘a nau sio ki [he tamasi‘i *kā*ká̄]NP. (LONG STRESSED VOWEL, PRECEDING DA)
‘They saw the cunning boy.

If DA involves stress shift (Hypothesis A), the stressed vowel in (30) will be of longer duration than the unstressed vowel in (31). Hypothesis C predicts the reverse: (30) will be shorter in duration than (31), in line with Condax’s 1989 results. While Hypothesis C does not make predictions about the relative durations of the italicized long vowel sequences in (32) and (33), both A and B are consistent with the long vowels in (32) and (33) being of similar duration, because both are long and stressed.

4.4 DATA COLLECTION. Two female and two male native speakers of Tongatapu Tongan participated in the study. Their ages ranged from 25 to 50 years. Each speaker made four recordings of the data set. In each repetition of the set, sentences appeared in different semi-randomized orders. Participants were not made aware of the purpose of the study, but were given time to familiarize themselves with each version of the data set before reading the sentences aloud.

Each speaker was recorded in a separate session in a quiet room. Recordings were made with a Sony TCM-5000 EV analog cassette recorder and a Shure SM-10A close-recording headset microphone. Utterances were digitized at 11.025 kHz with the *MacQuirer* sound analysis program. Time-aligned displays of waveforms and spectrograms like those in figure 1 were used to measure the duration of each target sequence, from the stop burst of [k] to the end of the short vowel, long vowel, or diphthong. The end of the vowel was taken to be the last glottal pulse during which F1, F2, and F3 could reliably be seen.

In order to confirm the location of primary phrasal stress, pitch measurements were taken for target sequences occurring inside a prepausal word. Though speakers were not instructed on how to say the sentences, each of them used an intonational tune involving a high nuclear pitch accent followed by a fall on the last word in the sentence. From time-aligned waveform and pitch displays like those in figure 2, we recorded the pitch minimum and maximum for the word, as well as the relative position of the pitch maximum with respect to the word’s end. Given that the position of primary stress is the common landing site for intonational nuclear pitch accents, we took this pitch maximum to reflect the location of primary stress.

5. RESULTS

5.1 POSITION IN UTTERANCE. In sentences (17–19), target words were intended to be nonprepausal, and as expected, speakers did not place pauses within the VP or AP in most of these utterances (46 of 48). On the contrary, in sentences (23–25), in which target words were again intended to be nonprepausal, speakers did place a pause after the NP bearing DA, in 45 of 48 cases. This pause insertion may have been due to the fact that in (23–25), the NP bearing DA marks the end of a clause, and is followed by the coordinating conjunction. Because of this prosody, (23–25) do not offer data that is directly comparable with (17–19). Thus, in the following analyses we leave aside the question of effects of medial versus final position in an intonational phrase, and consider only the balanced set of prepausal data; that is, sentences (14–16), and sentences (20–22).

5.2 DURATION: ANALYSIS AND RESULTS. Table 2 summarizes the results of a two-way, repeated-measures analysis of variance (ANOVA), that compares durations of the (italicized) prepausal sequences given in (26) through (29). The two factors are

FIGURE 1. TIME-ALIGNED WAVEFORM AND SPECTROGRAM DISPLAY USED TO MEASURE DURATIONS OF TARGET SEQUENCES

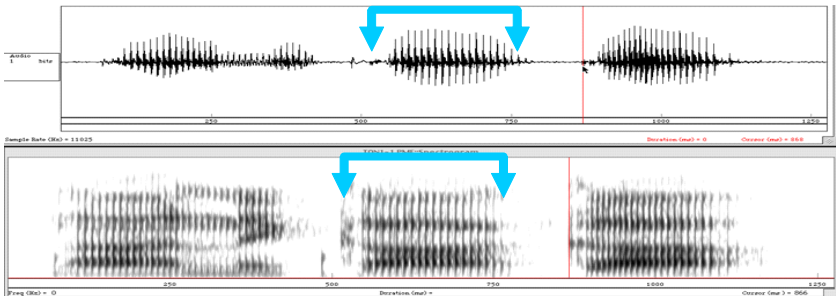
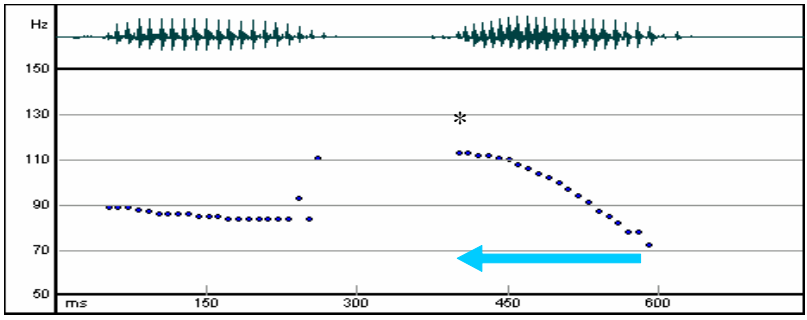


FIGURE 2. TIME-ALIGNED WAVEFORM AND PITCH TRACK USED TO MEASURE PITCH RANGE AND POSITION OF PITCH MAXIMUM (ASTERISKED) WITH RESPECT TO WORD'S END



vowel length (short/long) and DA (absent/present). Each data point in the analysis consists of the within-speaker mean of four measures of the same sequence. Table 2 shows significant main effects of both phonological vowel length and DA on sequence duration, and a trend toward an interaction effect between these factors that does not quite reach significance.

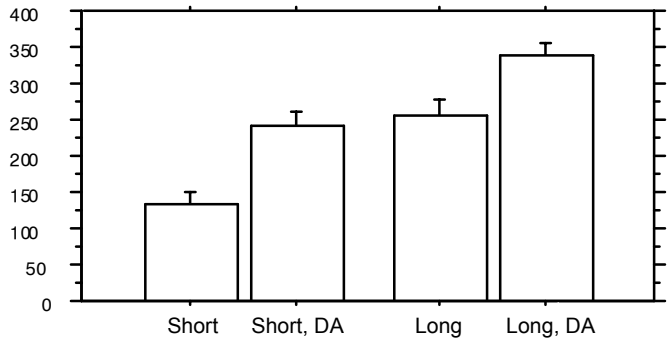
Figure 3 summarizes descriptive statistics for this analysis. As expected, phonological vowel length is a strong determinant of vowel duration. Moreover, short and long vowels both increase in duration when definitively accented. Short vowels increase by a factor of 1.8 with the addition of DA, from a mean of 132 ms (milliseconds) to 240 ms. Long vowels increase by a factor of 1.3 (from a mean of 254 ms to 338 ms). Note that the nearly significant interaction effect means that there may be a larger lengthening effect of DA on short vowels than on long vowels.

The crucial comparison in figure 3 involves the two center columns. In ANOVA post-hoc tests, short vowels bearing definitive accent are statistically indistinguishable

TABLE 2. TWO-FACTOR REPEATED-MEASURES ANOVA FOR EFFECTS OF VOWEL LENGTH (VL) AND DEFINITIVE ACCENT (DA) ON DURATION OF TARGET SEQUENCES

	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	P-VALUE	LAMBDA	POWER
SUBJECT	3	6460.303	2153.434				
VL	1	48207.691	48207.691	13.330	.0355	13.330	.687
VL * SUBJECT	3	10849.449	3616.483				
DA	1	36984.098	36984.098	67.794	.0038	67.794	.999
DA * SUBJECT	3	1636.605	545.535				
VL * DA	1	589.073	589.073	9.263	.0557	9.263	.544
VL * DA * SUBJECT	3	190.783	63.594				

FIGURE 3. MEAN DURATIONS OF SHORT FINAL VOWELS (LEFTHAND PAIR OF COLUMNS) AND LONG FINAL VOWELS (RIGHTHAND PAIR) WITHOUT DA AND WITH DA, RESPECTIVELY*



* Error bars show 1 standard error.

in duration from long vowels without DA.[12] These results strongly support Hypothesis B. As T suggests, the italicized final vowel in (27), ka*ká*, behaves as though it has been repeated under the influence of DA, such that its duration is indistinguishable from the long final vowel in (28), kā*kā*. Moreover, the statistically significant increase in the long vowel's duration under the influence of DA also supports Hypothesis B, that DA consists of adding a syllable. Note that the lack of a significant durational distinction between short vowels bearing DA and long vowels not bearing DA undermines both Hypothesis A and Hypothesis C.

Turning to the comparison among the italicized penultimate sequences in (30) through (33), table 3 sums up results of a two-way, repeated-measures ANOVA in which the two factors are phonological vowel length, and whether or not the target sequence precedes DA. Table 3 shows a significant main effect of phonological vowel length, but no effect of the target sequence's position with respect to DA, and no interaction effect between the factors.

Figure 4 presents duration means and variances for each italicized sequence in (30) through (33). ANOVA post-hoc tests show that the short vowels in the two lefthand columns are not statistically distinguishable (Scheffé's *F:* p = .2954); nor are the long vowels in the two righthand columns (Scheffé's *F:* p = .5410). This result is at odds with Hypothesis C: that DA involves penultimate and final vowels that are both of greater duration than stressed short vowels.

Two additional analyses secure the argument in favor of Hypothesis B. The first involves four target sequences in sentences (14) and (21) of the data set, repeated here as (34) and (35). The ANOVA below compares the four italicized or underlined sequences in (34) and (35).

(34) Na'a ne [*ka*<u>kau</u>]$_{VP}$.
'He swam.' (*short vowel*, <u>diphthong without DA</u>)

TABLE 3. TWO-FACTOR REPEATED-MEASURES ANOVA FOR EFFECTS OF VOWEL LENGTH (VL) AND WHETHER THE TARGET SEQUENCE PRECEDES DA

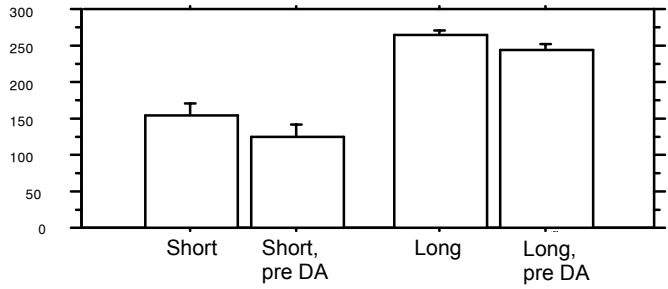
	DF	SUM OF SQUARES	MEAN SQUARE	F-VALUE	P-VALUE	LAMBDA	POWER
SUBJECT	3	3583.396	1194.465				
LENGTH	1	51927.016	51927.016	154.702	.0011	154.702	1.000
LENGTH * SUBJECT	3	1006.977	335.659				
PRE DA	1	2500.000	2500.000	3.684	.1507	3.684	.269
PRE DA * SUBJECT	3	2035.743	678.581				
LENGTH * PRE DA	1	60.710	60.710	.410	.5673	.410	.075
LENGTH * PRE DA * SUBJECT	3	443.735	147.918				

12. Post-hoc tests of the following types were generated by the StatView statistical package: Fisher's Protected Least Significant Difference, Scheffé's *F,* Tukey's Honestly Significant Difference, and the Student-Newman-Keuls Test. In each of these tests, every paired comparison between columns showed a significant difference, except for the comparison of short vowels bearing DA and long vowels not bearing DA. This latter pair were indistinguishable in every test, with high 'p' values (e.g., p = .9649 on Scheffé's *F.*)

(35) Na'a nau sio ki [he tamasi'i na'e *ka*ká]$_{NP}$.
'They saw the climbing boy.' (*short vowel*, short vowel bearing DA)

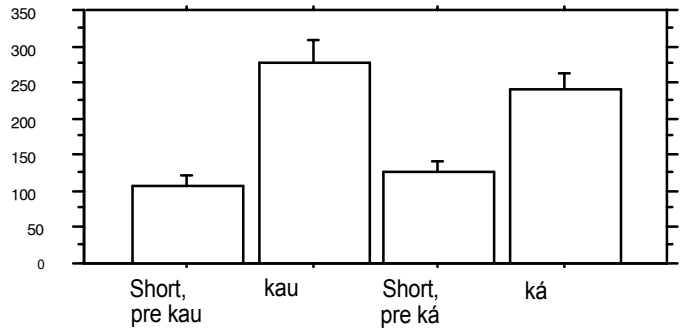
In a one-way, repeated-measures ANOVA, we find a significant main effect of target sequence (F[3,9] = 15.924, p = .0006). In post-hoc tests we find that the two italicized sequences, *ka*kau and *ka*ká, are not significantly differentiable (Scheffé's *F:* p = .9318); neither are the two underlined sequences, kakau and kaká (Scheffé's *F:* p = .7005). Figure 5 displays duration means and variances for this analysis. Once again, results controvert Hypothesis C. The latter predicts that the italicized sequence in *ka*kau, where DA is not involved, will be shorter than the italicized sequence in the definitively accented *ka*ká. Instead, the two italicized sequences are of statistically indistinguishable duration. Likewise, under Hypothesis C, the two underlined sequences in kakau and kaká should not have equivalent duration; kau should be significantly longer than ká. However, again our results show them to be statistically indistinguishable.

FIGURE 4. MEAN DURATIONS OF SHORT VOWELS (LEFTHAND PAIR OF COLUMNS) AND LONG VOWELS (RIGHTHAND PAIR)*



* In each pair, the column on the right represents a sequence that precedes a DA sequence. Error bars show 1 standard error.

FIGURE 5. MEAN DURATIONS OF *ka*(kau), (ka)kau, *ka*(ká), AND (ka)ká*



* Error bars show 1 standard error.

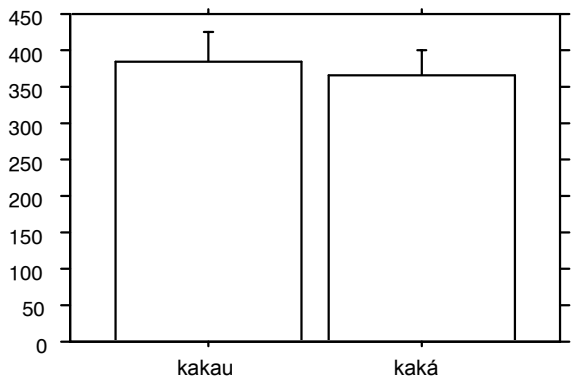
Finally, let us compare the durations of the words kakau and kaká in (34) and (35). Figure 6 depicts this comparison: taken as whole words, kakau and kaká are not statistically differentiable in duration. This strongly suggests that the two words are structurally similar, exactly what Hypothesis B would claim: namely, that both words consist of three syllables.

5.3 LOCATION OF PITCH PEAK: ANALYSIS AND RESULTS. Results of the preceding section lead us to conclude that DA does not involve the shift, reduction, or addition of stress. Rather, the empirical analyses above are consistent with T's view that DA involves the addition of a final syllable. It remains, however, to adduce empirical evidence for the second part of T's claim; namely, that stress always occurs on a penultimate syllable. In this section we use attraction of intonational nuclear pitch accent to diagnose stress location.

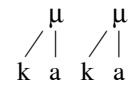
Neither Churchward (1953), Clark (1974), Condax (1989), Schütz (2001), nor T mentions moras in their accounts of Tongan phonology. However, given that T allows (C)V as the only licit syllable structure, her analysis implies that syllable and mora are coextensive. In this section our goal will be to show that primary stress occurs on a penultimate *mora*. We leave until section 6 the question of the inventory of permitted syllable shapes in Tongan.

As mentioned in section 4.4, speakers placed a high accent followed by an utterance-final fall on the last word of each sentence. Let us first consider the VP and AP cases in sentences (14–16). Uncontroversial mora parses for the phrase-final words of these sentences are given in (36–38):

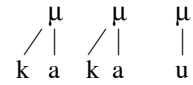
FIGURE 6. MEAN DURATIONS OF THE WORDS kakau AND kaká



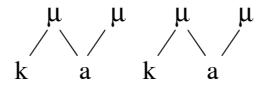
(36) [kaka]$_{VP}$ 'climbed'



(37) [kakau]$_{VP}$ 'swam'



(38) [kākā]$_{AP}$ 'was cunning'



In each of these cases, we expect the high nuclear pitch accent to land on the primary stressed (i.e., penultimate) mora. The examples in figures 7, 8, and 9 show that it does. An asterisk shows the position of the pitch maximum in each word. (Microprosodic raising effects of [k] on the pitch track were excluded for purposes of determining pitch maxima.)

FIGURE 7. ALIGNMENT OF PITCH MAXIMUM WITH BEGINNING OF PENULTIMATE MORA IN [kaka]$_{VP}$

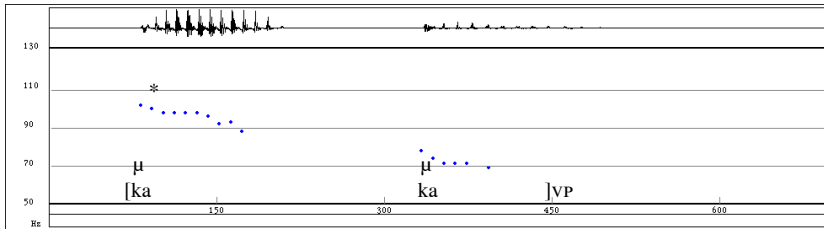


FIGURE 8. ALIGNMENT OF PITCH MAXIMUM WITH BEGINNING OF PENULTIMATE MORA IN [kakau]$_{VP}$

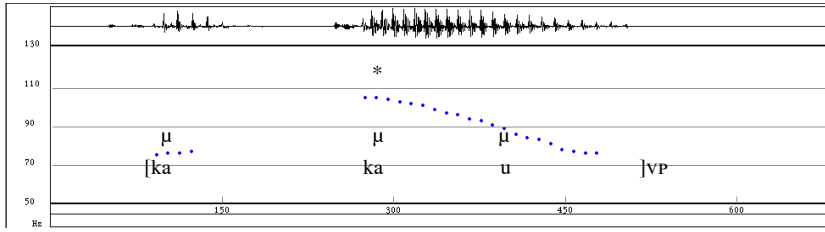
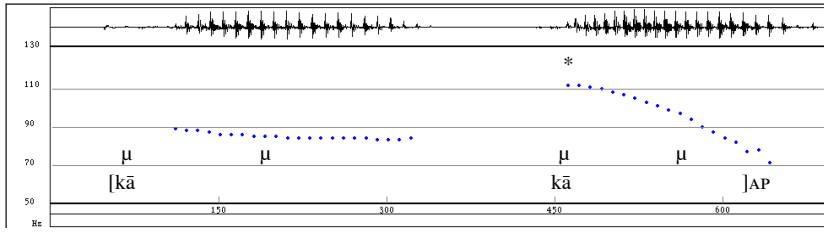
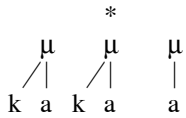


FIGURE 9. ALIGNMENT OF PITCH MAXIMUM WITH BEGINNING OF PENULTIMATE MORA IN [kākā]$_{VP}$

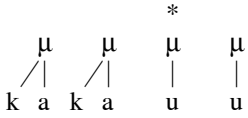


Let us now inspect the same three phrase-final words in definitively accented NPs. In T's analysis, a syllable (= mora) is added to the end of the final word of a definite NP. Modeling the words in this way, we predict the locations of the high nuclear pitch accent (*) in sentences involving DA to be as given in (39–41):

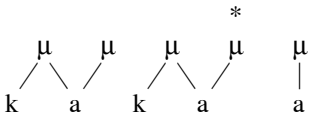
(39) […kaká]$_{NP}$ 'the climbing boy'



(40) […kakaú]$_{NP}$ 'the swimming boy'



(41) […kākā́]$_{NP}$ 'the cunning boy'



Figures 10, 11, and 12 show sample pitch tracks for these phrase-final words in definitively accented NPs. In each case, outcomes agree with our predictions; the pitch maximum falls within what we model to be the penultimate mora. This result is statistically very robust. In a one-way, repeated-measures ANOVA we found a significant main effect of target sequence type on the location of the pitch maximum in the sequence ($F[5,15] = 18.066$, $p < .0001$). Figure 13 gives means and standard error for each sequence type in the analysis. The y-axis shows where the pitch maximum falls as a percentage of the total distance from the end of the word leftward to the release of [k] in the underlined sequences [kaka]$_{VP}$, [kakau]$_{VP}$, [kākā]$_{AP}$, […kaká]$_{NP}$, […kakaú]$_{NP}$, and […kākā́]$_{NP}$.

FIGURE 10. POSITION OF PITCH MAXIMUM IN […kaká]$_{NP}$

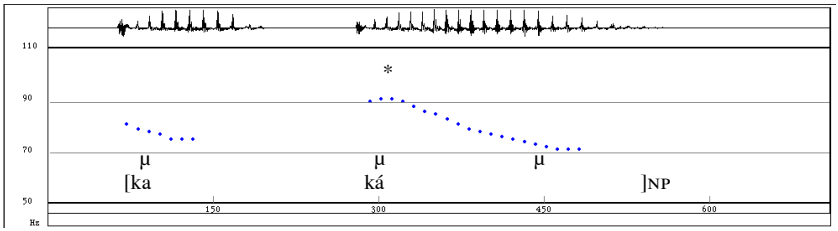
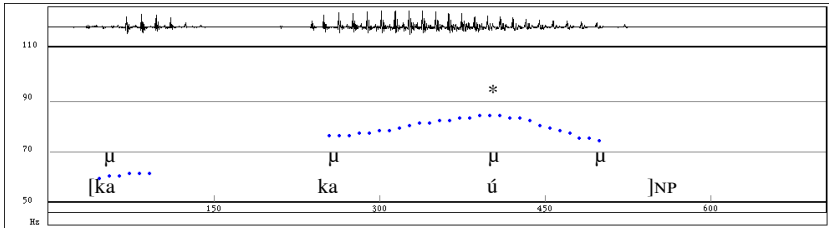


FIGURE 11. POSITION OF PITCH MAXIMUM IN […kakaú]$_{NP}$



Post-hoc tests confirm that the four leftmost columns are not statistically differentiable from each other; neither are the two rightmost columns. However, each of the two columns on the right differs significantly from each of the four on the left. In [kaka]$_{VP}$, [kakau]$_{VP}$, [kākā]$_{AP}$, and […kaká]$_{NP}$, the pitch maximum falls near the beginning of the sequence (in terms of figure 13, nearly 100 percent of the distance from the end of the vowel to the burst of the relevant [k]). On the other hand, in […kakaú]$_{NP}$ and […kākā́]$_{NP}$, the pitch maximum comes about a third of the way through the sequence (i.e., 64.5 and 61.5 percent, respectively, from the end of the sequence). Each result is consistent with stress on a penultimate mora in view of the fact that the first four target sequences involve two moras, while the last two target sequences involve three moras.

In sum, our pitch results also constitute evidence in favor of T's analysis of definitive accent. Finally, in the next section, we examine T's claim that short vowels, long vowels, and diphthongs do not exist; in other words, that (C)V is the only possible syllable shape in Tongan.

FIGURE 12. POSITION OF PITCH MAXIMUM IN [kākā́]$_{VP}$

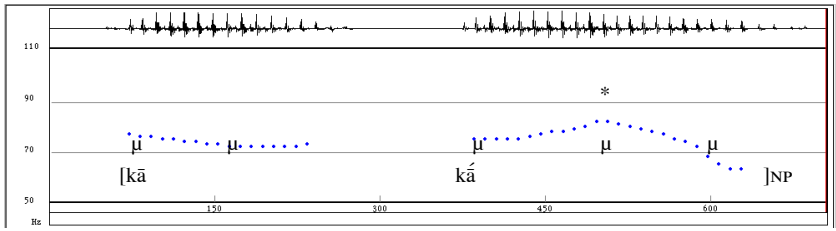
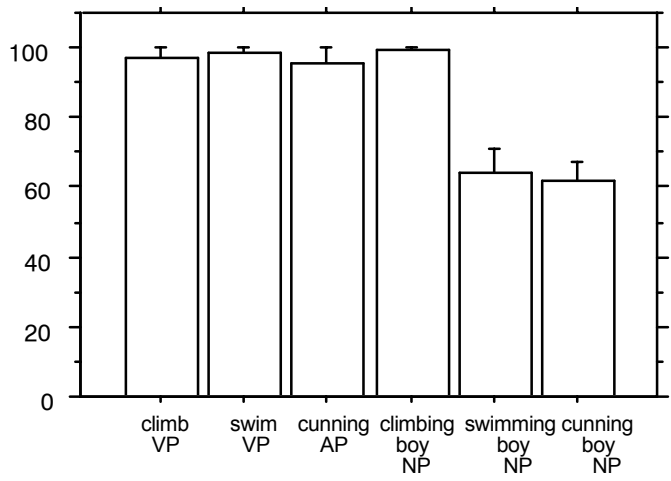


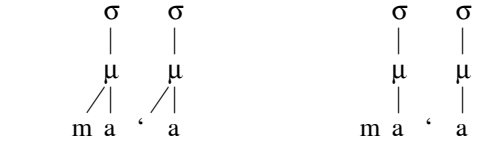
FIGURE 13. MEANS AND VARIANCES FOR LOCATION OF PITCH MAXIMUM FROM END OF TARGET SEQUENCE



6. SYLLABLE SHAPE AND FOOT STRUCTURE IN TONGAN. Consider the structures in (42). In the lefthand column, we hypothesize that long vowels and diphthongs are single syllables containing two moras. In the righthand column, we illustrate Taumoefolau's analysis, in which "long vowels" and "diphthongs" are sequences of two syllables.

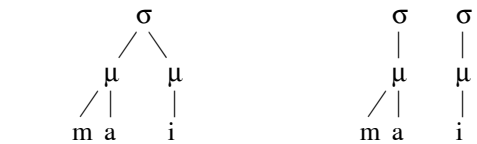
(42) LONG VOWELS ARE: MONOSYLLABIC DISYLLABIC

ma'a [ˈmaʔa] 'pure'

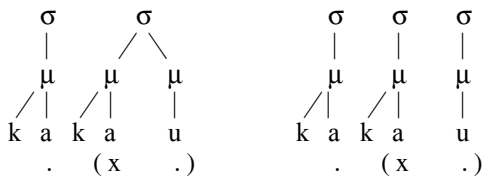


mā [ˈmā] 'bread'

mai [ˈmai] 'to bring'



kakau [kaˈkau] 'to swim'



Foot structure for each word in (42) is also given, as it will prove crucial to our decision between the two analyses. As mentioned in section 3, Schütz (2001) and T discuss the need for the "measure" or "stress group" in accounting for alternating stress in Tongan. Hayes (1995), in his comprehensive model of parametric metrical stress in a wide array of typologically different languages, considers the basic rhythmic unit ("foot") in Tongan to be "the moraic trochee" (i.e., a pair of moras with a strong first mora and a weak second mora). In Hayes's terms, trochees are constructed from right to left in a Tongan phonological word. After feet are assigned, "End Rule Right" gives additional prominence to the rightmost stress in the phonological phrase.

T (345) provides the examples reproduced in (43) to illustrate the fact that the basic rhythmic unit may consist of either two or three syllables (= moras), with penultimate stress in each unit. As long as these two conditions are met, stress placement can vary in an utterance. Thus, (43) can be produced as either (43a) or (43b).

The presence of both bimoraic and trimoraic rhythmic units in T's examples translates to the observation, in Hayes's terms, that phonetic material need not be parsed exhaustively into proper feet. (Moreover, the fact that these single syllables never bear stress constitutes evidence that degenerate feet are banned, and that these syllables remain unfooted.) Refer to the IPA transcriptions of (43), in which such skipped material is italicized.[13]

(43) a.

'O ka	ke	ka	'alu	leva		pea	ke	ui	mai.
if if	2.SG	FUT	go	then		and	2.SG	call	DIR.2
'ó-ka	ké-ka		'á-lu	lé-va		pe=á-ke		ú-i	má-i[14]
2	2		2	2		3		2	2
[ˈʔo.ka	ˈke.ka		ˈʔa.lu	ˈle.va		*pe* ˈa.ke		ˈu.i	ˈma.i]

'When you leave, call me.'

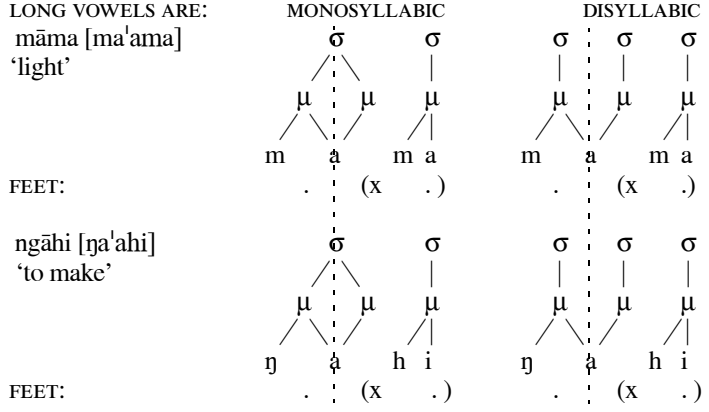
b.

'O ka	ke	ka	'alu	leva	pea	ke	ui	mai.	
if if	2.SG	FUT	go	then	and	2.SG	call	DIR.2	
/'o=ká-ke		ka='á-lu		lé-va	pé-a	ke=ú-i		má-i /	
3		3		2	2	3		2	
[ʔo ˈka.ke		*ka* ˈʔa.lu		ˈle.va	ˈpe.a	*ke* ˈu.i		ˈma.i]	

'When you leave, call me.'

Hayes (1995) independently motivates two basic tenets of Metrical Stress Theory that bear on the question of Tongan syllable structure. First, "only syllables, not moras, can serve as landing sites of stress—the stress-bearing unit is universally the syllable" (Hayes 1995:49). Second, "rules of foot construction may not split syllables; for example, we cannot allow the first part of a heavy syllable to belong to one foot and the second part to belong to the next" (50). For words like those in (42), the analysis in either of the two columns will serve, because in each case, syllable boundaries coincide with foot boundaries. However, cases like those in (44) militate against the structures on the left. In words like *māma* 'light' and *ngāhi* 'to make', the second mora of the "long vowel," rather than the first, is in metrically strong position (i.e., bears stress and, if utterance-final, attracts intonational nuclear pitch accents).

(44) LONG VOWELS ARE:



13. The effects of "End Rule Right" are not shown in (43), as the utterance can be phrased in different ways.

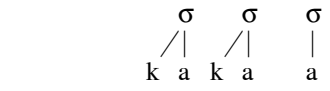
14. Lines 3–5, respectively, of these examples give T's transcription, the number of syllables (= moras) per stress group, and an IPA transcription grouped into moraic trochees.

An analysis of long vowels as monosyllabic violates the rule that foot construction may not split syllables, whereas an analysis of long vowels as sequences of two syllables does not. The structures on the left might be preserved by positing that moras, and not syllables, receive stress. However, this would violate the principle that only syllables may serve as landing sites of stress. In other words, the only tenable analysis under Metrical Stress Theory is one in which the stressed mora in words like (44) is coterminous with a syllable. This is T's analysis.

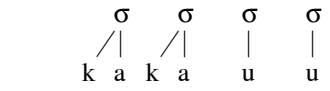
An interesting fact about Tongan orthography supports this conclusion. It was Churchward who instituted the spelling of words like *māma* and *ngāhi* as *maama* and *ngaahi*, with "double vowels" (A. Schütz, pers. comm.). This distinction implies some intuition on his part that long vowels in which the second mora was strong were not long vowels in the usual sense, and in this he was correct.

In (45) through (47), then, are phonological representations of the definitively accented target words examined in this paper, showing syllable and foot structure. (Syllables and moras are conflated.)

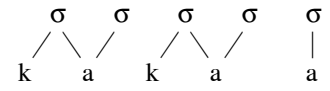
(45) [...kaká]$_{NP}$ 'the climbing boy'



(46) [...kakaú]$_{NP}$ 'the swimming boy'



(47) [...kākā́]$_{NP}$ 'the cunning boy'



7. CONCLUSION. This study has used acoustic phonetic measures of duration and pitch on careful speech data to investigate the phonology of definitive accent in Tongan. We began by reviewing previous accounts of DA, and setting out several hypotheses based on these accounts. Our findings support Taumoefolau's (2002) analysis (and the last of Clark's 1974 scenarios): DA involves reduplicative suffixation—the repetition of the final vowel in an NP. We also conclude that Tongan stress is unexceptionally penultimate in a foot. Third, we adduce support from Metrical Stress Theory (Hayes 1995) for Taumoefolau's analysis of Tongan syllable shape. "Long vowels" and "diphthongs" are to be considered sequences of two syllables. Moras and syllables are coextensive, and all Tongan syllables have the structure (C)V.

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