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THE TONES OF KAIRI

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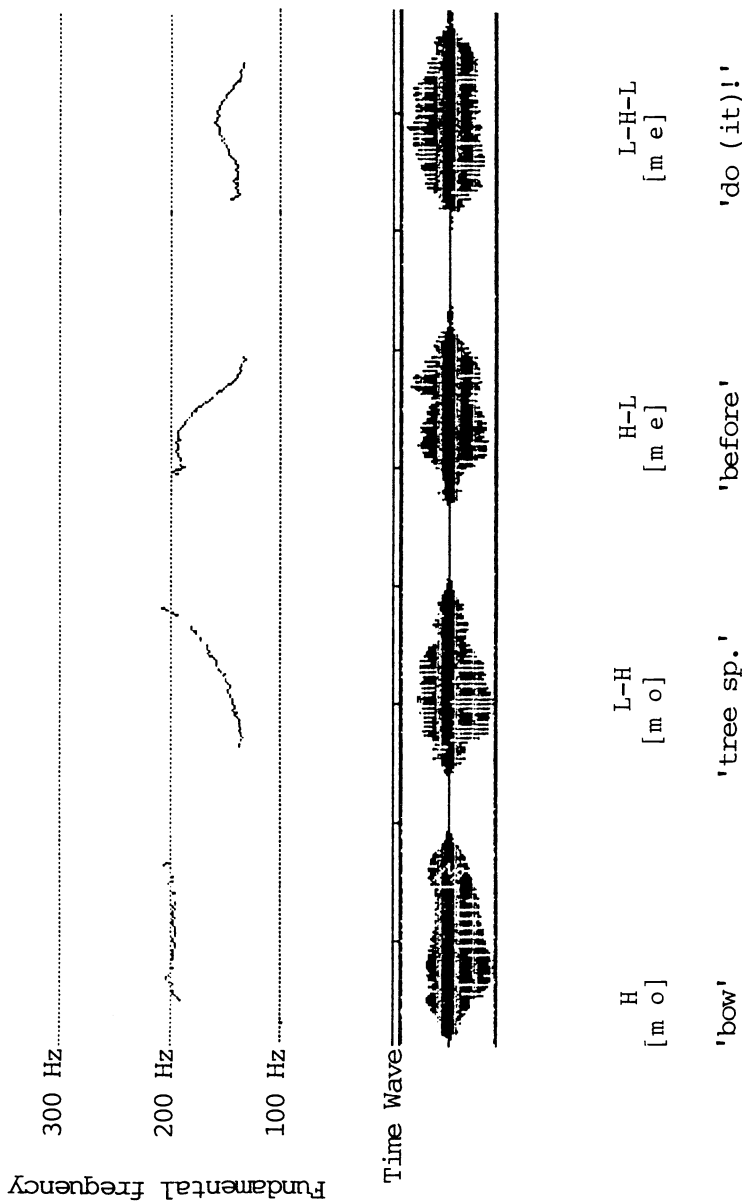
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1. INTRODUCTION¹. Kairi² has distinctive tones which function as a pitch-accent system: there is one syllable in each morpheme, described as the “accented syllable,” which must have its tonal properties specified; once the accented syllable and its tone type have been specified, the tonal properties of the remaining syllables in the morpheme are assigned in a rule-governed way. In Section 2, we show how the pitch-accent properties of Kairi morphemes can be elegantly described in terms of autosegmental theory. Section 3 deals with tone sandhi and other tone rules which apply when morphemes are combined into larger units.

2.1 BASIC TONE PATTERNS. The four basic tone patterns of Kairi are H (high level), LH (rising), HL (falling), and LHL (rising–falling). These are the only tone patterns which occur in monomorphemic one-syllable words. The four patterns will be indicated by a diacritic over the vowel of the tone-bearing unit (the first vowel sign in the case of a diphthong): zero (high level), ´ (rising), ` (falling), and ^ (rising–falling). The appropriateness of these descriptions and the specifications in terms of H and L can be appreciated by examining the pitch plots of the four monomorphemic one-syllable words in Figure 1.³ Obviously, the absolute Hz value of the H and L will vary, depending on the speaker, style, type of segment, and so forth, but the range of possible contours remains just these four. There is a tendency for the LHL to peak at a relatively lower pitch compared with the other tones. In Figure 1, for example, the LHL peaks at about 150 Hz, whereas the H of the other tones is around 200 Hz. (Even in the case of this speaker, however, LHL forms were elicited where the H peaked around 180 Hz.) Rather than introduce a mid pitch level for a “LML” contour, it is simpler to recognize only H and L at a phonological level and attribute the relatively lower realization of H in the monosyllabic LHL environment to a

FIGURE 1: PITCH PLOTS OF FOUR MONOSYLLABIC WORDS



rule of phonetic detail. This illustrates the general strategy we will adopt throughout our analysis, which will be couched in terms of only H and L. The four tone patterns are exemplified by the forms in (1):

(1) One-syllable-word tone patterns:			
H	LH	HL	LHL
ke 'pitpit' (vegetable)	ké 'shellfish sp.'	kè 'crescent shell'	kê 'tree sp.'
pa 'pulverized'	pá 'split'	pè 'by, with'	pâ 'tree sp.'
ho 'tree sp.'	hó 'bag'	hè 'blow'	hô 'grub sp.'

2.2 TWO-SYLLABLE WORDS. When we turn to two-syllable morphemes, we find here too that the majority of forms fall into one of four tone patterns. (Since all the discussion in Section 2 concerns single morphemes, apart from the exceptional cases discussed in 2.6, we will simply refer to two-syllable words, three-syllable words, etc., rather than “two-syllable morphemes,” etc.) Pitch plots of four representative words are given in Figure 2, spoken by the same speaker as for the words in Figure 1. Once again, the phonetic facts can be represented phonologically by sequences of H and L:

H H L L-H H H-L L H-L

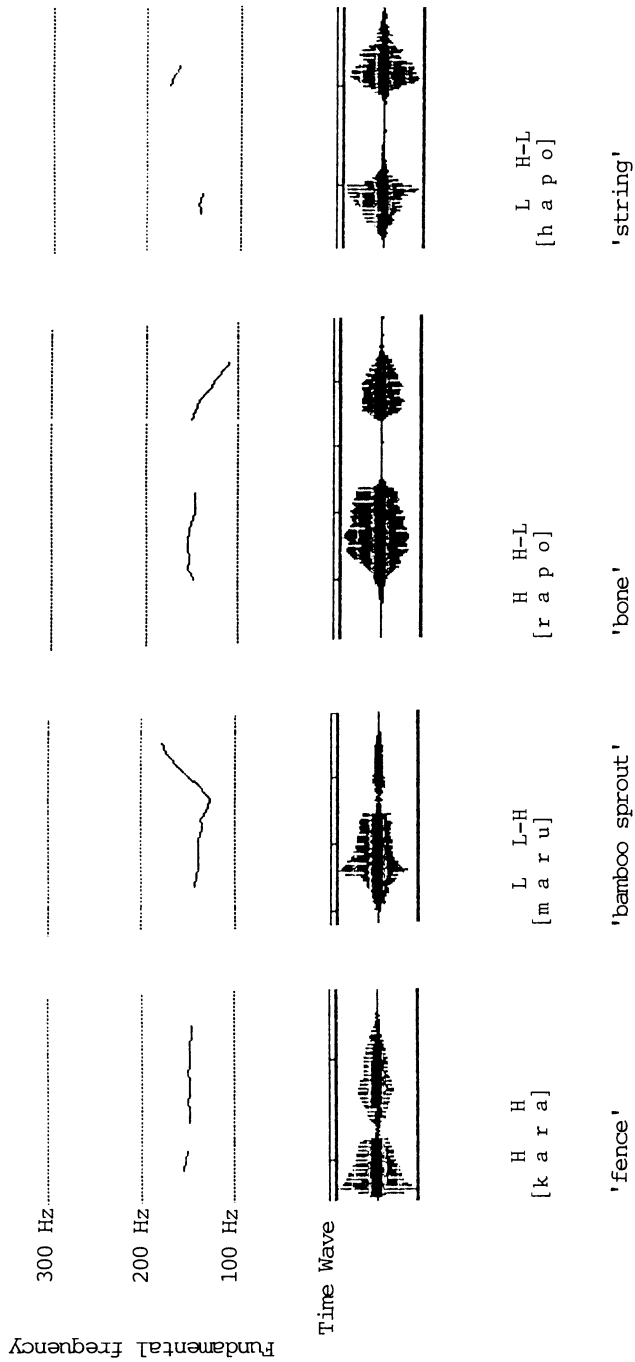
The patterns L L-H and H H-L suggest quite natural assimilation rules (cf. Hyman 1975:221–222), as in (2). These assimilation processes create rising and falling contours on syllables.

- (2) Assimilation:
- L H → L L-H / ____
- H L → H H-L / ____

It will be seen in the derivations in (6) that L does not spread onto a syllable already associated with the complex tone H-L. Although there are syllables with a L-H-L contour, as in (1), such contours do not come about as a result of Assimilation. Rather, the L-H-L contour in such cases is associated with a monosyllabic morpheme through basic Tone Mapping rules to be introduced below. To prevent unwanted spreading by Assimilation, we may formulate a general condition on (2), namely, that a tone does not spread onto a syllable already associated with more than one tone.

Accepting these assimilation rules, the H and L sequences found with

FIGURE 2: PITCH PLOTS OF FOUR BISYLLABIC WORDS



two-syllable words are now identical to the four basic tone patterns established in Section 2.1, namely H throughout, rising, falling, and peaking. As for the one-syllable words, there is no evidence of a dipping HLH pattern. We use the same diacritics as for one-syllable words, then, to indicate the tone class of the two-syllable words, with the diacritic marked on the vowel of second syllable (the locus of the pitch change). Examples of two-syllable words are given in (3):

(3) Two-syllable-word tone patterns:

H	LH	HL	LHL
hono ‘clan’	hɔnɔ́ ‘garden’	hɔnɔ̀ ‘husk’	hɔmɔ̂ ‘a poison’
oro ‘mist’	ohó ‘tongue’	ɔrɔ̀ ‘cheek’	ɔrɔ̂ ‘tidemark’
huni ‘termite’	pikú ‘turtle’	tuhì ‘fear’	tuhî ‘lid’

At this point it is convenient to introduce Goldsmith’s (1976*a*) apparatus of autosegmental theory, conveniently summarized in Goldsmith (1976*b*). The Kairi facts discussed so far lend themselves to description in terms of autosegmental theory, since the four tonal patterns can be seen as existing in their own right, independent of the length of the words to which they attach. In this respect Kairi resembles the Mende case used by Goldsmith (following an earlier analysis by Leben) in support of the autosegmental analysis. The relevant facts about Mende, a language of Sierra Leone, can be found in Leben (1978:186–187) and Kenstowicz and Kisseberth (1979:274–275). In this language there are five basic tone patterns which occur in words, regardless of the number of syllables in the word. The association of a single tone pattern H L to the three Mende words in (4) comes about by application of conventions introduced by Goldsmith which spread the tones across segments in a well-defined way. The basic pattern H L, for example, can be associated with one-, two-, or three-syllable words, resulting in the associations shown in (4):

(4)	H-L	H L	H L L
	mbu ‘owl’	ngila ‘dog’	felama ‘junction’

We adopt, then, the approach of autosegmental phonology which accounts so elegantly for the facts of Mende and, as we shall see, Kairi. While the theory now exists in various versions, all versions build on the original key idea that phonological representation separates a “tonal tier” in which the basic tonal information is located, and a “segmental tier” in which the remaining segmental information about words is dis-

played. The various versions of the theory differ with respect to the way in which these two tiers come to be associated (see, for example, the discussion in van der Hulst and Smith [1982: 12–17]). Since the original proposals of Goldsmith account satisfactorily for (most of) the Kairi facts, we therefore adopt the original convention of tone mapping:

(5) Tone Mapping:

- a. Associate the first tone with the first syllable, the second tone with the second syllable, and so on, until all tones or syllables are exhausted.
- b. Tones or syllables not associated as a result of (a) are subject to the well-formedness conditions:
 - i. Every tone is associated with some syllable.
 - ii. Every syllable is associated with some tone.
 - iii. Association lines may not cross.

Tone Mapping, together with Assimilation, gives the desired results for two-syllable words without any ad hoc modifications to the theory. The derivation of the observed tones from the basic tone patterns is shown in (6), where X stands for a syllable (either a single vowel or diphthong in a syllable).

(6) Derivation of tone patterns:

Basic Tone Pattern	H	L H	H L	L H L
Segmental Tier	X X	X X	X X	X X
Tone Mapping	H \	L H 	H L 	L HL ∨
	X X	X X	X X	X X
Assimilation	–	L L-H ∨	H H-L ∨	–
		X X	X X	

2.3 THREE-SYLLABLE WORDS. In the majority of cases, three-syllable words will have one of the following four tonal patterns:

H H H L L L-H H H H-L L L H-L

Once again, the tones involved in each case (H, L and H, H and L, L and H and L) are exactly the tonal sequences of the four basic tone patterns and once again we would like to see these derived from the four basic tone patterns. The rules introduced so far give the correct results for the H H H but not for the other three patterns. Applying just the rules developed so far would give the incorrect patterns L L-H H, H H-L L, and L L-H H-L, as shown below:

(7) Incorrect derivations:

Tone Mapping	L H	H L	L H L
	\	\	
	X X X	X X X	X X X
Assimilation	L L-H	H H-L	L L-H H-L
	^ \	^ \	^ \
	X X X	X X X	X X X
	(incorrect!)	(incorrect!)	(incorrect!)

In these cases, it is necessary to associate the second tone of the basic tone pattern with the *final* syllable, rather than the second syllable. Once that association is made, the rest follows from the rules given above. We now begin to see more clearly the pitch-accent nature of the Kairi tonal system, that is, there are words where one of the syllables in the word must be associated with a particular tone while the other tone-bearing units in the word receive their tones in a predictable way. The syllable which must be so designated is the *accented* syllable of the word. In terms of autosegmental theory, the tone and the syllable which must be associated in this way are shown with a star (*) over each and an Accent Association rule pairs the two starred elements as the first step in the derivation. For the time being we will simply accept the stars as “given” in the appropriate places in the tonal and segmented tiers, but we will return to this later. The correct derivation of these patterns proceeds then as follows:

(8) Correct derivations:

Accent Association	L [*] H	H [*] L	L [*] H L
	\	\	
	X X X	X X X	X X X

Tone Mapping	L [*] H			H [*] L			L [*] H L		
		X	X		X	X		X	X
Assimilation	L			L-H			H		
		X	X		X	X		X	X

Note that Tone Mapping in these two cases spreads the first (non-starred, “floating” or “unlinked”) tone rather than the second (starred) tone. While there is nothing in Goldsmith’s theory which prevents the spreading of a starred tone (see, for example, the discussion of English intonation in Goldsmith 1976*b*:36–37), a prohibition on the spreading of a starred tone is proposed in Halle and Vergnaud (1982:73) in their analysis of Tonga accents and we adopt this prohibition here too. The Tone Mapping rule applies therefore only to nonstarred tones.

In this way, the tone patterns of three-syllable words are again reduced to the four basic ones. Again, we can continue to use the same diacritics, now shown on the last syllable of three-syllable words. Examples of three-syllable words are given in (9).

(9) Three-syllable-word tone patterns:

H	LH	HL	LHL
kirima ‘fish sp.’	emehí ‘breadfruit’	ehenè ‘fight’	ehikô ‘dish’
ketepo ‘darkness’	howarí ‘wallaby’	horokô ‘snort’	katamî ‘morning’
ekemu ‘conch shell’	hotukú ‘armpit’	hakanè ‘grasshopper’	arawè ‘post’

2.4 FOUR-SYLLABLE WORDS. Four-syllable monomorphemic words are rare, but the occurring ones show the four tone patterns:

H H H H L L L L-H H H H H-L L L L H-L

To account for the correct placement of contours in four-syllable words, one must again recognize certain syllables as accented, as was done in the previous section. Schematic derivations are shown in (10):

(10) Derivations:

Accent	H	L H [*]	H L [*]	L H [*] L
Association	X X X X	X X X X [*]	X X X X [*]	X X X X [*]
Tone Mapping	H	L H [*]	H L [*]	L H [*] L
	X X X X	X X X X [*]	X X X X [*]	X X X X [*]
Assimilation	—	L L-H	H H-L	—
		X X X X [*]	X X X X [*]	

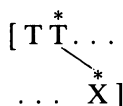
The tone patterns of such words are reduced therefore to the basic tone patterns. An example of each of these categories is given in (11):

(11) Four-syllable-word tone patterns:

H	LH	HL	LHL
harakanea 'prawn sp.'	rarakané 'palate'	pepeherò 'peg'	aramerâu 'basket type'

2.5 KAIRI PITCH-ACCENT. It may appear that we have made rather arbitrary use of the star device in accounting for the facts of Kairi, but an inspection of the positions in which the star appears will show that it is by no means arbitrary. On the segmental tier, the star only occurs over the *last* syllable; on the tonal tier, the star only occurs over the *second* tone of the basic tone pattern. Schematically, the Accent Association rule works as follows:

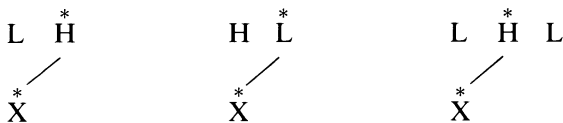
(12) For accented words:



The use of the star in our account is therefore governed by extremely simple principles. As it stands, however, our account is not entirely satisfying, because the use of the star does not correspond exactly to what would usually be taken as the “accented syllable” of a pitch-

accent language. The accented syllable would normally be associated with a change in pitch and in the case of Kairi this means the last syllable in *all* the words discussed so far, except those which have a H tone throughout. Our account, however, was as parsimonious as possible, and the star was only used for those words where the normal association rules did not give correct results, which is a subset of the words one would like to call “accented.” This discrepancy is easily avoided if we extend the use of the star to all cases involving L H, H L, and L H L, even though this is not strictly necessary in the light of the Tone Mapping rules. In other words, the second tone on the tonal tier and the last syllable on the segmental tier are starred for all words where this is possible (i.e., all forms except those with the basic tone pattern H, where there is no second tone to be starred). This means that all the word types shown in (13) will now be subject to Accent Association in the way indicated. The reader can easily confirm that further application of Tone Mapping and Assimilation will result in exactly the same outcomes as before. We take schema (12) then to represent the initial step in the derivation of *all* forms except those with the basic tone pattern H.

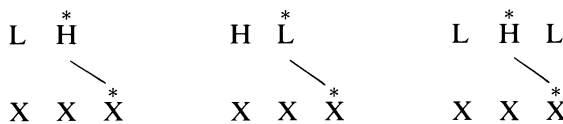
(13a) One-syllable words:



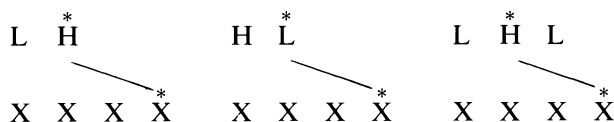
(13b) Two-syllable words:



(13c) Three-syllable words:



(13d) Four-syllable words:

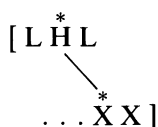


In this way, the star in the autosegmental account corresponds to the usual interpretation of “accent” or “accented syllable,” that is, the syllable where there is a linguistically significant change of pitch. Although this use of the star is not the most economical in terms of autosegmental theory, it gives an intuitively more satisfying result in that the presence of the star now corresponds exactly to the concept of accented syllable in a pitch-accent language.⁴

The basis of the diacritic conventions used to represent Kairi tone patterns should now be evident. The one accented syllable in each word is marked with a diacritic. Words which have no pitch change have no accented syllable and consequently no diacritic. The diacritic conventions are not only in accord with the (modified) autosegmental account, but make sense in layman’s terms too: at a vowel marked with a diacritic, the “voice” will rise or fall; otherwise there is no change.

2.6 EXCEPTIONS. The rules given in the preceding sections account for the overwhelming majority of tone patterns in monomorphemic words, but there are some exceptions. Most of the exceptions form a well-behaved class involving penultimate accent and the L H L pattern. Accent Association in these cases takes place in the way shown in (14):

(14) For words with penultimate accent:



Some words exhibiting this pattern are listed in (15). They include both two-syllable and three-syllable forms, but the number of such forms is relatively small. In a count of all the three-syllable monomorphemic words in the corpus (246), it was found that only 21, or approximately 8.5 percent, exhibited the exceptional L H L pattern. In the case of two-syllable words, there appears to be only a handful showing penultimate accent, although there are hundreds of bisyllable forms, so the percentage of exceptions is even smaller for the bisyllable words. (The penultimate-accent class does, however, include the two common words for ‘mother’ and ‘father’.)

(15a) âna ‘mother’; âita ‘father’; kôhi ‘punishment’; wâura ‘bamboo sp.’

(15b) kakîha ‘bamboo sp.’; apîko ‘tree sp.’; imîni ‘clever’; ipûtu ‘drill’; kaitûpi ‘type of song’

Note that the only exceptional feature of these words is the penultimate position of the accent. Once this is specified, along with the appropriate basic tone pattern, then the spreading of the tones proceeds in exactly the same way as described for the “regular” cases, as illustrated in (16):

(16) Derivation of penultimate-accent words:

	‘mother’	‘bamboo sp.’
Accent Association	L [*] H L a na	L [*] H L ka ki ha
Tone Mapping	L [*] H L a na	L [*] H L ka ki ha
Assimilation	L-H H-L a na	L L-H H-L ka ki ha

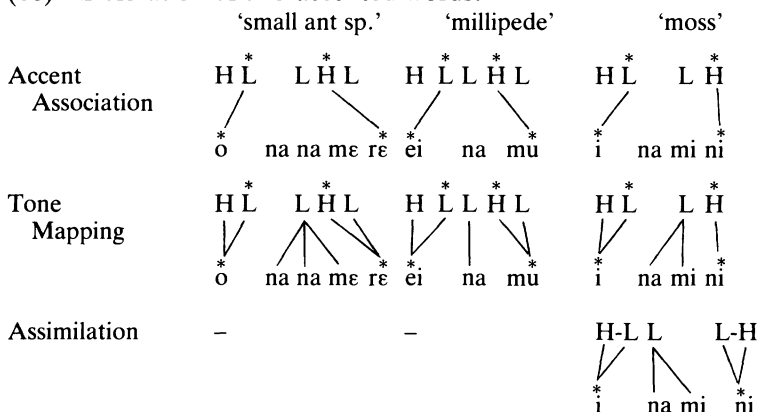
Apart from these cases of penultimate accent, there is just a handful of remaining exceptions:

- (17a) H-L L L L H-L
o na na mɛ rɛ ‘small ant sp.’
- (17b) H-L L H-L H-L L H-L
ei na mu ‘millipede’ ho yɛ rɛ ‘white cockatoo’
- (17c) H-L L L L-H
i na mi ni ‘moss’
- (17d) H-L L L H-L L L
pa ka ri ‘with’ pa ka re ‘to’

These forms are exceptional in that the first syllable is associated with a H-L pattern, while the rest of the word appears to have its own separate pattern. The sequences of tones (a), (b), and (c) exhibit in fact a dipping contour which is otherwise quite alien to Kairi. The (a), (b), and (c) patterns can, however, be accounted for within the autosegmental

approach by positing an accent on the first syllable as well as on the last, with the other rules applying as before. This solution is sketched in (18).

(18) Derivation of two-accented words:



In effect, then, the words in (17a)–(17c) must be treated as though they consist of two morphemes—the first syllable being one morpheme and the rest of the word the second. Notice that the Accent Association links stars in exactly the same way as was done for words with last-syllable accent, that is, the second tone on the tonal tier is linked with the last syllable on the segmental tier, in accordance with schema (12). Analyzed in this way, the tonal patterns can be reduced to the concatenation of two perfectly regular accent patterns.

There is in fact some reason to think that the forms in (17a)–(17c) are derived historically from combinations of morphemes (apart from the fact that they are unusually long). Although we are not in a position to give complete morphemic decompositions of these words, some likely etymological relationships are given in (19):

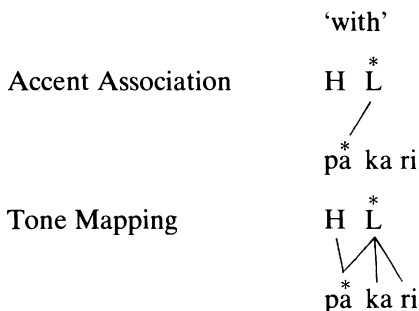
- (19) $\dot{o}nanamer\acute{e}$ ‘small ant sp.’ : \dot{o} ‘mouth’; $nan\grave{a}$ ‘eat’
 $h\acute{o}yer\acute{e}$ ‘white cockatoo’ : $h\acute{o}$ ‘white’
 $\grave{i}namini$ ‘moss’ : \grave{i} ‘tree’

More conclusive evidence of the polymorphemic status of $\dot{o}nanamer\acute{e}$ ‘small ant sp.’ can be found in the violation of vowel harmony rules within the word. In Kairi, the lower mid vowels ϵ and ɔ are mutually exclusive with the higher mid vowels e and o within the same morpheme. So, for example, $\acute{e}hik\acute{o}$ ‘dish’ and $ketepo$ ‘darkness’ exist, but not forms such as $*\acute{e}hik\text{ɔ}$ or $*ketep\text{ɔ}$. In $\dot{o}nanamer\acute{e}$, there is a clear violation of this

constraint in the co-occurrence of the vowels *o* and *ε*, strongly supporting the hypothesis that the vowels belong in some sense to separate morphemes.

The two forms in (17d) remain to be accounted for. In these cases, one can recognize the basic tone pattern H L which could be associated in the following way:

(20) Derivation from one basic tone pattern:



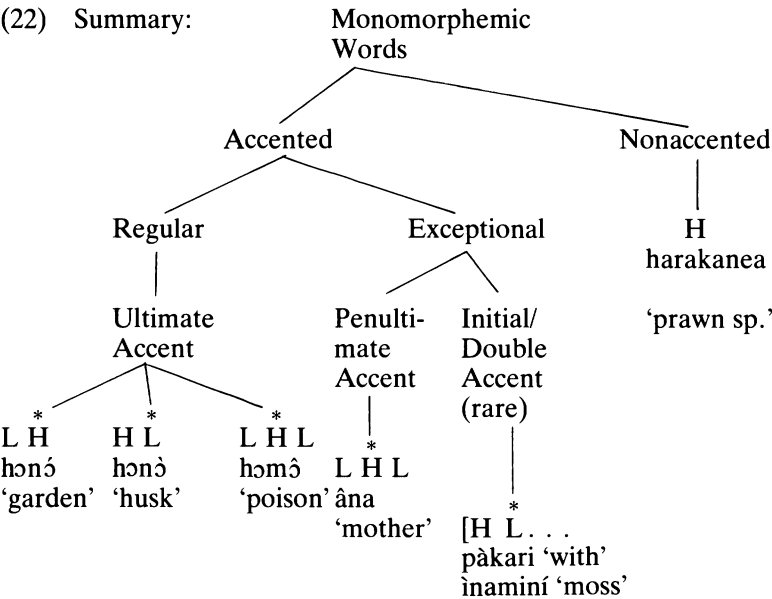
This derivation is less than desirable for two reasons. First, these would be the only two words of Kairi requiring antepenultimate accent, whereas for reasons of simplicity we would prefer to have to recognize no more than a (large) class of ultimate-accent words and a (very small) class of penultimate-accent words. Secondly, the derivation requires the spreading of the starred L tone rightwards, violating the convention we have adopted throughout, whereby only unstarred tones spread by the rule of Tone Mapping. Rather than introduce unfortunate complications into our analyses on account of just these two words, we propose an alternative solution which treats them like the other words in (17). That is to say, we analyze them as being associated with two basic tone patterns—the first syllable associated with the first tone pattern and the rest of the word with the second tone pattern (in this case unaccented), as shown in (21). The change of H L H to H L L (actually H L !H, to be discussed in Section 3.1) is a tonal change which is evident elsewhere in Kairi compounds and is not an ad hoc creation for the sake of these two forms. (Since the Downstep applies to Hs in consecutive syllables, it is not applicable to the other words in (17).) Note also that Assimilation does not apply across the two basic tone patterns.

(21) Derivation from two basic tone patterns:

	‘with’	‘to’
Accent Association	$\begin{matrix} H & L^* & H \\ & / & \\ p\grave{a} & ka & ri \end{matrix}$	$\begin{matrix} H & L^* & H \\ & / & \\ p\grave{a} & ka & re \end{matrix}$
Tone Mapping	$\begin{matrix} H & L^* & H \\ \vee & & \\ p\grave{a}^* & ka & ri \end{matrix}$	$\begin{matrix} H & L^* & H \\ \vee & & \\ p\grave{a}^* & ka & re \end{matrix}$
Downstep (section 3.1)	$\begin{matrix} H-L & !H & !H \\ \vee & & \\ p\grave{a}^* & ka & ri \end{matrix}$	$\begin{matrix} H-L & !H & !H \\ \vee & & \\ p\grave{a}^* & ka & re \end{matrix}$

Here too there are suggestive lexical relationships with the word *pà* ‘by (instrumental/agentive marking)’ and possibly *kari* (H tones!) ‘assign portions, dish out’, which lend support to the hypothesis of an originally bimorphemic word.

A summary of our account of accent is given below:

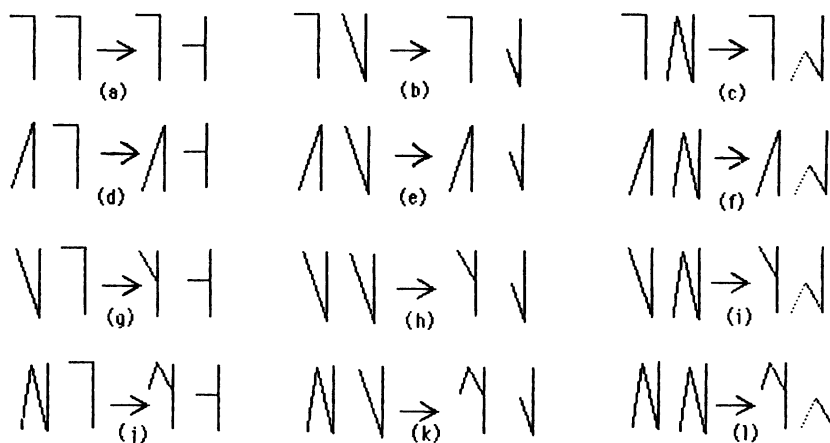


3.1 TONES IN COMBINATION. When morphemes combine to form words or constructions in Kairi, the basic tone patterns associated with the individual morphemes may be modified. In this section we will examine these modifications and the syntactic domains relevant to their application. Since our main interest here is to elucidate the way in which the tonal phonology and the syntax interface, we will ignore certain tone changes which are restricted to particular inflectional categories of the verb paradigm. So, for example, the imperative form in some verb classes requires a change in the basic tone pattern of the verb root from H to LH when the imperative suffix is added. Allotonic changes of this sort, restricted as they are to the verbal morphology (and only some verb classes at that), will not be discussed in any detail here.

The tone changes which take place in an extensive and regular way are of two types: (1) tone sandhi, which may drastically alter basic tone patterns in certain tone combinations in ways which must be spelled out by tone sandhi rules of a very language-specific nature; and (2) downstep, a general phonetic tendency in tone languages, which brings about a gradual lowering of pitch in sequences of tones, such that the basic tone patterns are more or less preserved but with an altered pitch range (see Schuh 1978:238–239). A further point of difference between these two types of tone change in Kairi is that downstep can be implemented in varying degree (it may not be present in slow, carefully enunciated speech; it can be overridden by stress, etc.) whereas tone sandhi is virtually obligatory when the conditions of application are met. Our interest lies mainly in the tone sandhi processes, but some remarks on downstep are in order.

The changes brought about by Downstep, as it applies to sequences of two tone patterns, are summarized in Figure 3. Tones are indicated by horizontal or diagonal lines to the left of a vertical stave, with the bottom of the stave representing the lowest pitch level and the top of the stave representing the highest pitch level. To some extent, Figure 3 is an idealization, since we have not been able to confirm all the phonetic details shown. We are confident, however, that Figure 3 does correctly capture the overall tendencies. Downstep applies to H tones in successive syllables, bringing about a lowering of pitch level. It applies within phrases (NP, PP, and VP) and so may affect longer strings than just two-tone sequences, in which case Downstep applies successively to all the tone patterns of the phrase, creating a gradual lowering effect. A sequence of H !H (where !H indicates a downstepped H) will have the perceptual effect of a H Mid (or L); a sequence of H !H !H will be heard as H Mid L, and so forth. It will be noticed that the summary of Downstep does not include a LH rising tone as the right member of a pair. This is because a rising tone on the right-hand side of a phrase is always

FIGURE 3: SUMMARY OF DOWNSTEP IN KAIRI



subject to specific tone sandhi changes (and is dealt with in Section 3.2). Downstep applies in the manner of a phonetic detail rule, taking effect after tone sandhi rules have applied. Special mention must be made of the changes to the LHL tone when it occurs on the right-hand side, as in (c), (f), (i), and (l). Not only is the pitch range of the second tone pattern lower than the first, but in addition the LHL can be, and under certain conditions must be, simplified to HL. The dotted lines in the diagrams indicate this variability. This change in contour could be seen as a strategy for avoiding “dipping” contours involving a change from a relative H to a relative L and then back again to a relative H. In this way Downstep brings about phrasal contours which match the basic tone patterns, in that the sequence HLH is consistently avoided. One could isolate this corrective strategy and give it the status of an independent rule, L-Drop, which deletes one or two Ls when flanked by Hs:⁵

$$(23) \text{ L-Drop: } H L(L)H \rightarrow H \emptyset H$$

3.2 MAJOR TONE SANDHI. The major tone sandhi (TS) processes in Kairi are summarized in (24). (Minor tone sandhi processes will be described in Section 3.3.) Underlining indicates tone sandhi has taken place with the H and L specifications changed accordingly, though the underlying accent mark in each word will not be altered. The statement of TS, as for the minor tone sandhi processes, is couched in terms of basic tone patterns. After TS (and Downstep) has applied, Tone Mapping will spread the tones across syllables in the appropriate way for each word.

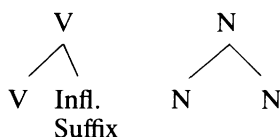
(24) Major Tone Sandhi (TS):

	Tone patterns of separate words		Tone patterns after sandhi
(a)	LH LH	→	<u>L</u> LH
	LH HL	→	<u>L</u> HL
	LH LHL	→	<u>L</u> LHL
(b)	H LH	→	H <u>HL</u>
	HL LH	→	H(L) <u>HL</u>
	LHL LH	→	LH(L) <u>HL</u>

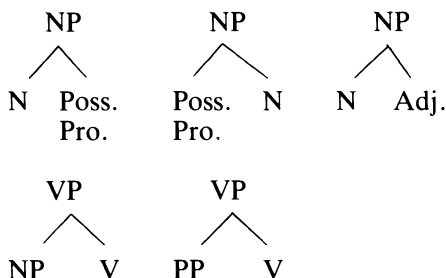
Looking just at the structure of the processes, it can be seen that TS targets the LH rising tone and alters its contour. As a left member of a pair of tone patterns, LH changes to L; as a right member of a pair, LH inverts to HL. The inverted HL tone which comes about via TS is perceptually very salient, the H in this case being phonetically extra high. This extra high H is resistant to spreading by the assimilation rules of Section 2. In (24b) some Ls are shown as optional, although there are situations where the L must not appear. So, for example, when the first word ends with a HL fall on the last syllable, the L must be omitted before a following H. Also, the L is very likely to drop before the extra high H in the inverted HL which comes about by Tone Sandhi, compared with a downstepped !H. However, we will not try to spell out these conditions in rule form. The omission of the L in these cases is undoubtedly part of the same general “tonotactic” constraint against HLH mentioned in connection with Downstep, and one could account for the omission of Ls in (24b) by invoking L-Drop. However, we will treat the changes in (24) as all part of tone sandhi in order to simplify our descriptive account. Also (24b) provides a nice contrast with (24a) in terms of whether LH is at the beginning or end of the sequence.

As far as the domain of application is concerned, TS occurs at both the word and phrase level. Example (25) lists the structural configurations in which TS applies:

(25a) Word-level TS domain:



(25b) Phrase-level TS domain:



To illustrate the stages by which the final contour of the structure in question comes about, we show the sequence of TS and Tone Mapping applying in NPs in (26). The tonal diacritics representing the basic tone patterns of the words (as spoken in isolation) are left unchanged; underlining represents tone sandhi processes have applied. Assimilation, rule (2), does not apply across words.

(26a) TS and Tone Mapping applied to NPs with rising-tone head noun:

L H hurí 'boy'	L H wəpí 'big'	→ TS	<u>L</u> L H <u>hurí</u> wəpí	→ Tone Mapping & Assimilation	<u>L</u> <u>L</u> L L-H <u>hurí</u> wəpí
L H hurí 'boy'	H L nà 'my'	→ TS	<u>L</u> H L <u>hurí</u> nà	→ Tone Mapping	<u>L</u> <u>L</u> H-L <u>hurí</u> nà
L H hurí 'boy'	L H L kahô 'good'	→ TS	<u>L</u> L H L <u>hurí</u> kahô	→ Tone Mapping	<u>L</u> <u>L</u> L L-H-L <u>hurí</u> kahô

(26b) TS and Tone Mapping applied to NPs with rising-tone adjectives:

H hɛ 'betelnut'	L H wəpí 'big'	→ TS	H <u>H L</u> hɛ <u>wəpí</u>	→ Tone Mapping	H <u>H L</u> hɛ <u>wəpí</u>
H L kəu 'pig'	L H wəpí 'big'	→ TS	H <u>H L</u> kəu <u>wəpí</u>	→ Tone Mapping	H <u>H L</u> kəu <u>wəpí</u>

L H L	L H		L H	<u>H L</u>		L-H	<u>H L</u>
wâi	wɔpí	→	wâi	<u>wɔpí</u>	→	wâi	<u>wɔpí</u>
‘cassowary’	‘good’	TS					Tone Mapping

Exactly the same procedure is followed in other structures, such as those in (27).

(27) TS and Tone Mapping applied to other structures:

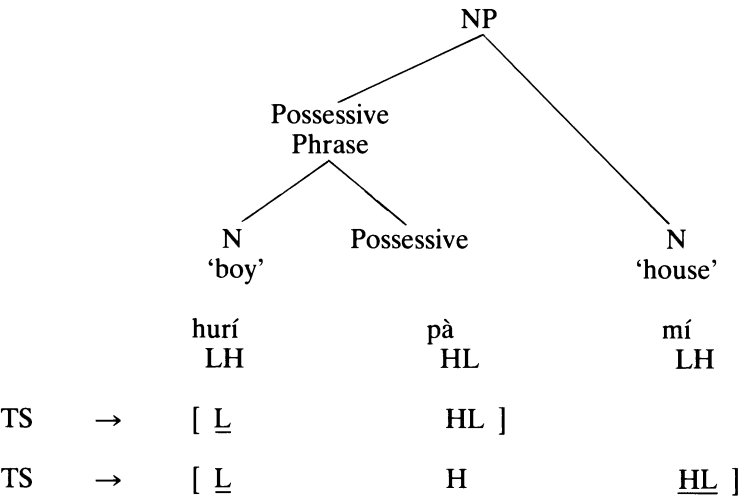
ɛnê	wɔtú	→	ɛnê	<u>wɔtú</u> (NP)
‘my’	‘head’			
(CF. the postnominal form of ‘my’ in (26a) above.)				
kɛɛ	kaitú	→	kɛɛ	<u>kaitú</u> (VP)
‘up here’	‘reached’			
kó	nàna	→	<u>kó</u>	nàna (VP)
‘thing’	‘having eaten’			
mí	té	→	<u>mí</u>	té (PP)
‘house’	‘in’			
ì	wɔtú	→	ì	<u>wɔtú</u> (Noun Compound)
‘fire’	‘head’			‘firebrand, matches’
hé	tuhî	→	<u>hé</u>	tuhî (Noun Compound)
‘hand’	‘lid; four’			‘“big” fingers (index finger and long finger)’
hé	rò	→	<u>hé</u>	rò (Noun Compound)
‘hand’	‘stern; rear’			‘“little” fingers (little finger and ring finger)’
hóɛ	mòi	→	<u>hóɛ</u>	mòi (Verb + Suffix)
‘wash’	‘negative future’			‘will not wash’

Note that in all cases it is the rising LH tone which undergoes TS, regardless of whether it is on the head of the construction or not. So, for example, it is the head noun in (26a) which undergoes TS because it has the rising tone, whereas it is the modifying adjective in (26b) which undergoes TS because it is the adjective which has the rising tone.

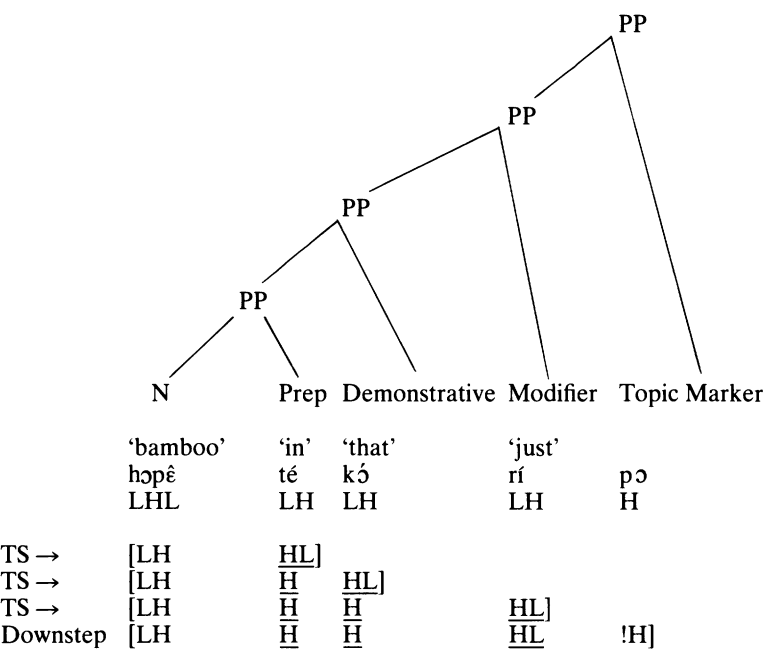
TS and Downstep, though formulated only for pairs of tone patterns, apply to successively larger constituents parallel to the hierarchical syntactic structure. We illustrate this with a complex NP in (28) and a complex PP in (29). We have shown TS as applying cyclically in both (28)

and (29), although it is really only necessary in (29). In (28), the same result could be achieved by a simultaneous application of rules to the whole string.

(28) TS applied to a complex NP:



(29) TS applied to a complex PP:



Note that it would be wrong in (29)—as well as (28)—to try to account for the final phrasal contour by simply invoking L-Drop. L-Drop would delete the Ls as shown in (30). The result would be incorrect since there must be a HL fall on the second last syllable.

(30) L-Drop applied to (29):

	LHL	LH	LH	LH	H
→	*LH∅	∅H	∅H	∅H	H

The domain of TS and Downstep encompasses everything within the VP or the subject NP, but does *not* extend over both the subject NP and the VP. Thus, in (31), the subject NP and the VP constitute two separate tonal units. If they combined to make one larger tonal unit, then one would expect the H tone on *kɛi* ‘sago’ to show the effect of Downstep, that is, to become phonetically a mid level tone. In point of fact, the word is pronounced at the high pitch one expects of a H-tone word at the beginning of a sentence. Furthermore, the LHL tone on the subject NP is clearly preserved before the H of the following word, showing that L-Drop does not take place here.

(31) [NP *ɛnɛ*] [VP [NP *kɛi*] *pekà umo*].
 I sago chip/cut go
 ‘I go and make sago.’

This division between the subject NP and the VP (or topicalized phrase and the remainder of the clause) is observed whether or not there is an object NP intervening between the subject and the verb. Thus, a verb together with its direct-object argument forms a tonal unit for the purposes of TS/Downstep, whereas the VP together with its subject does not. This contrasts with some tonal languages (e.g., Mandarin) where a verb together with either a subject or object argument constitutes the appropriate domain for tone sandhi rules. It also constitutes counter-evidence to hypotheses about tone grouping which insist on making the right edge of every NP, VP, AdvP, and S the boundary of a tone group (cf. Chen 1987: 117 ff). The right edge of the object NP in (31) does not coincide with the right boundary of a tone group for the purposes of the tone sandhi processes.

3.3 MINOR TONE SANDHI. There is a relatively minor type of tone sandhi found in compounds containing an adverbial element. The

adverbial element has to be one from the closed set: *kéa*, *kè* ‘upriver; up’ and *róa*, *ré* ‘downriver; down’. It combines with another element from the same adverbial set or a verb to form complex adverbial or verbal forms. In this case, the two tone patterns of the morphemes are replaced by one of the four basic tone patterns, with accent (where there is one) on the last syllable. The changes involved are summarized in (32). Sometimes vowel qualities are modified in the compound forms.

(32) TS(Adv):

Tone patterns of separate morphemes			Tone pattern of compound
H(L)	LH	→	<u>H</u>
LH	LH	→	<u>L</u> H
H(L)	HL	→	<u>H</u> <u>L</u>
LH	HL	→	<u>L</u> H <u>L</u>

(33) TS(Adv) applied to certain adverbial compounds:

<i>hà</i> ‘look’	<i>kéa</i> ‘upriver’	→	<u><i>hakea</i></u> ‘look upriver/up ahead’
<i>ma</i> ‘sit’	<i>róa</i> ‘downriver’	→	<u><i>maroa</i></u> ‘sit back’
<i>kè</i> ‘up’	<i>kó</i> ‘there’	→	<u><i>kekó</i></u> ‘up there’
<i>há</i> ‘throw’	<i>kéa</i> ‘upriver’	→	<u><i>hakéa</i></u> ‘throw upriver, upfield’
<i>réi</i> ‘put in’	<i>róa</i> ‘downriver’	→	<u><i>reirúa</i></u> ‘put in lower down (in a canoe etc.)’
<i>rá</i> ‘downriver’	<i>ré</i> ‘here’	→	<u><i>raré</i></u> ‘a little way down- river’

The tonal properties of the resulting words are exactly the same as for monomorphemic words as discussed in Section 2, associated as they are with one of the four basic tone patterns. This can be seen as reflecting the tight integration of the two morphemes, creating in effect a separate morpheme in its own right. The changes brought about by TS(Adv) can in fact be attributed to L-Drop (together with the Obligatory Contour Principle), so that there is no need to specially state tone sandhi rules for these cases. The difference between compounding with TS as in Section 3.2 and compounding without TS in the case of adverb-like compounds can be brought out in the case of the sequence of basic tone patterns HL LH. The noun compounds with this pattern show inversion to HL, whereas the adverb-like compounds show merely H over the whole compound:

(34) TS vs. TS(Adv) applied to HL LH tone sequences:

HL	LH		H	<u>HL</u>		H	<u>H L</u>
ì	wotú	→	ì	<u>wotú</u>		ì	<u>wotú</u>
'fire'	'head'	TS					Tone Mapping
HL	LH		<u>H</u>	<u>hakea</u>		<u>H</u>	<u>H</u>
hà	kéa	→					<u>hakea</u>
'look'	'upriver'	TS(Adv)		'look upriver/ look up ahead'			Tone Mapping

It is necessary to recognize another set of tone sandhi rules for certain compounds. The compounds in question are coordinate structures of the type noun + noun, verb + verb, numeral + numeral, many (but not all) resulting from reduplication. The specific tone sandhi rules required, TS(Co), are given in (35).

(35) TS(Co):

LHL	LHL	→	LH	<u>HL</u>
LH	LH	→	LH	<u>HL</u>

In the case of doubled LHL pattern, the site of the tone sandhi is shown as the second member of the sequence. This is because the pitch of the H in HL is extra high and resists spreading by Assimilation—characteristics of tone sandhi changes. The behavior of the two LHs in TS(Co) is peculiar to TS(Co), and so all three types of sandhi can be formally distinguished as follows:

(36)	TS types:				TS	TS(Adv)	TS(Co)
	LH	LH	→ <u>L</u>	LH	yes	yes	no
	HL	LH	→ H	HL	yes	no	no

(37) TS(Co) applied to compounds:

Tone patterns of separate words			Tone patterns within compound after sandhi			Derived patterns after Tone Mapping	
LHL	LHL	→	LH	<u>HL</u>	→	L H	<u>H L</u>
pitî	pitî		pitî	<u>pitî</u>		pitî	<u>pitî</u>
			'cross-legged'				
L H L	L H L	→	L H	<u>H L</u>	→	L H	<u>H L</u>
hakâ	haeâ		hakâ	<u>haeâ</u>		hakâ	<u>haeâ</u>
			'throw from side to side'				
L-H	L-H	→	L-H	<u>H-L</u>	→	L-H	<u>H-L</u>
tái	tái		tái	<u>tái</u>		tái	<u>tái</u>
			'two by two, in pairs'				
L H	L H	→	L H	<u>HL</u>	→	L H	<u>HL</u>
kahé	yaké		kahé	<u>yaké</u>		kahé	<u>yaké</u>
			'lying dead'				

One can be more precise about the nature of the compounds which are subject to TS(Co). The compounds involved, like the examples in (37), are not just combinations of the same syntactic category (noun + noun, verb + verb, etc.), but are semantically coordinate as well. That is, the two elements which make up the compound function like Head + Head. This contrasts with the compounds subject to TS in (27). Although the noun compounds in (27) also involve noun + noun combinations, the semantic relation between the two component nouns is different. Compounds such as 'fire' + 'head' = 'firebrand' and 'hand' + 'stern, rear' = 'the two little fingers' reveal a Modifier + Head relation: 'firebrand' is a 'head' consisting of 'fire', 'the two little fingers' is the 'stern' of the 'hand'. The two tone sandhi rules, TS(Co) and TS, thus serve to differentiate coordinate (Head + Head) and subordinate (Modifier + Head) compounds. The different phonological effects of the two rules can be seen by comparing the coordinate verbal structure pá herà 'split and drop (split off)' and the subordinate NP structure hé rò 'the

two little fingers'. In both cases, the basic tone patterns are LH + HL. Only the subordinate NP structure undergoes tone sandhi (by TS); the coordinate structure in this case is unaffected by tone sandhi, though it is subject to Downstep.

(38) TS applied to subordinate but not coordinate structures:

LH	HL	→	<u>L</u>	H-L
hé	rò		hé	rò (Modifier + Head)
'hand'	'stern'		the two	little fingers'
LH	HL	→	L-H	!H !H-L
pá	herà		pá	herà (Head + Head)
'split'	'drop'		'split off (i.e., split and let drop)'	

4. CONCLUSION. Insofar as the autosegmental approach to tone systems purports to have cross-linguistic validity, it is important to test the claims of the theory against as wide a selection of languages as possible. The Papuan languages which have tonal properties provide rich opportunities to further test these claims, although as yet comparatively little attention has been given to analyzing these tone systems (cf. the brief discussion of tone systems in Foley 1986: 63–64). The fact that we have been able to account for a large body of facts about the tones of Kairi morphemes within the autosegmental framework with a minimum of ad hoc adjustments lends further support to the framework. The exceptional cases in Section 2.6, where the Tone Mapping rules do not automatically give the desired results, prove to be interestingly complex, with an apparently polymorphemic structure.

When it comes to looking at the combinations of the basic tone patterns in compounds and phrases, we must recognize the relevance of a variety of syntactic and semantic facts. Not surprisingly, it becomes much harder to make cross-linguistic generalizations about the way in which tones combine (apart from low-level phonetic effects such as Downstep). The Kairi distinction between tone sandhi rules required for coordinate compounds and other tone sandhi rules required for subordinate compounds, for example, is not a distinction which has to be made in all tone languages. Nor is it true of all tone languages that an object NP together with the following verb constitute one tone group for the purposes of tone sandhi rules. Nevertheless, generalizations about the interfacing of tone and syntax need to be attempted and tested, and it is hoped that the Kairi facts presented here may contribute towards that larger goal.

NOTES

1. We wish to thank Matthew Chen and an anonymous *Oceanic Linguistics* reviewer for helpful comments on an earlier draft of this paper.
2. Kairi is a Papuan (i.e., non-Austronesian) language spoken by approximately 700 people in the vicinity of Kikori in the Gulf Province of Papua New Guinea. We refer to the language as Kairi since this is the name used for official government purposes such as census taking, but the language is also referred to by other names in the literature, including Rumu, Tumu, and Dumu. The people themselves refer to their language as Rumu Hei. The language is assigned to the Turama-Kikorian stock by Laycock and Wurm (1974), along with Ikopi and Mena. While both of these other languages also appear to have phonemic tones, their tone systems appear to be simpler than the Kairi system. The data on which this paper is based were collected by one of the authors (R.G.P.) during his stay with the Kairi people over a period of three years (1984–87).

The phonemic inventory of Kairi consists of /p, t, k, m, n, h, r, y, w, i, e, ε, u, o, ɔ, a/, plus phonemically distinctive tones discussed in the body of the paper. The pitch-accent nature of Kairi tones would appear to be typical of Papuan tone systems (cf. Foley 1986: 63–64). Native words conform to strict phonotactic constraints: there are no consonant clusters, and only open syllables are permitted. There are numerous diphthongs which function as single units for the purposes of tone assignment.

3. The pitch plots were carried out at Massey University using MacSpeech Lab software on a MacPlus. The speech input was digitized by the MacADIOS Model 411 Hardware Unit manufactured by GW Instruments, Cambridge, Mass.
4. One could in fact generalize further in that, for all the words discussed so far, one could posit a final starred syllable and a starred tone without affecting the outcome of the association of tones and segments. Obviously in the case of the basic tone pattern \bar{H} , there is no second tone which can be starred, so in this case the single \bar{H} is starred, that is, the rule refers to $(T) \bar{T}$. The more generalized schema of Accent Association would then be (i):

(i) For all words:

$$\begin{bmatrix} (T) & \overset{*}{T} & \dots \\ & \searrow & \\ & & \overset{*}{X} \end{bmatrix}$$

We see no particular advantage to starring all words in this way. One would be able to say that all words are starred on the last syllable, but the star would not correspond to the position of accent as normally understood. It is an unnatural approach which would only be motivated by dubious considerations of formal simplicity.

5. If one accepts that the Obligatory Contour Principle (OCP) applies wherever possible, sequences of Ls and Hs would of course be reduced to single tones. L-Drop could then be simply formulated as $L \rightarrow \emptyset / H_H$. It is convenient, however, to keep the tone patterns and Tone Mapping separate for each word even after tone sandhi applies, so we will not simplify a sequence of identical tones across morphemes in this way.

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