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Aspects of Thai Tone

A dissertation submitted in partial satisfaction of the requirements for the degree of Doctor of Philosophy in Linguistics

by

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1976

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For Mary Jane

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The text of the manuscript consists of material which has already been published (Sections 1-4 and Section 6) and material which has been accepted for publication (Section 5 and Section 7). I want to thank the copyright owners for their permission to include the following material in the dissertation:

Section 1. Consonant Types and Tone in Siamese (1974). Journal of Phonetics 2.4:337-350. Academic Press: London.

Section 2. The Features of the Larynx: N-ary or Binary (1975). Phonetica 32.4:241-253. S Karger AG: Basel.

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ABSTRACT OF THE DISSERTATION

Aspects of Thai Tone

by

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Doctor of Philosophy in Linguistics

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This dissertation investigates a number of hypotheses within the theoretical framework of generative phonology that deal with various phonological and phonetic aspects of tone. Thai, a member of the Austro-Thai language family, is the principal language used for testing the hypotheses. Experimental phonetic data is used to explore both diachronic and synchronic questions concerning tone.

Section 1 explores the relationship between various consonant types and tone in an attempt to provide a phonetic basis for well-documented cases of tonal development among languages of Southeast Asia. It is an acoustical investigation of the effects on the fundamental frequency of a vowel caused by preceding consonants of different phonation types. It is found that (1) the fundamental frequency contour in transition to the vowel is relatively high and

falling after voiceless consonants, and relatively low and rising (- falling) after voiced consonants (2) the fundamental frequency is initially higher after voiceless unaspirated stops than for voiceless aspirated stops (3) the perturbations on the fundamental frequency caused by preceding consonants are short in comparison to data obtained from languages without lexically contrastive tones and (4) "plain" and "breathy " allophones of the voiceless aspirated stops have a differential effect on the tone of the following vowel. Implications for theories of pitch production and tonal development are discussed.

Section 2 investigates the question of the phonological representation of contour tones, i.e. whether contour tones should be represented lexically as single contour tones or as sequences of level tones. A case of tone sandhi in Lue is found that seems to require not only the contour tone feature RISING, but also the tone feature CONTOUR. Alternative solutions that do not permit underlying contour tone features are shown to obscure a general process of tonal dissimilation; that is, only by postulating classificatory contour tone features can we capture what appears to be the correct linguistic generalization.

Section 3 examines the proposal that predictable segments should always be derived by phonological rule. The glottal stop in Thai, although predictable by rule, suggests that this proposed constraint on a theory of phonology is too strong. The principal evidence in favor of including the glottal stop in underlying forms involves cooccurrence restrictions on tones and consonants. These generalizations are left unexpressed unless one permits the glottal stop to be present in underlying forms.

Section 4 takes up the issue of whether some classificatory features should be binary or multivalued. In order to provide a satisfactory explanation of the diachronic tone splits conditioned by the phonation types of syllable-initial consonants among languages and dialects of Southeast Asia, it is found necessary to posit a multivalued scalar feature 'glottal width' on the classificatory level of representation. The feature 'glottal width' consists of a linearly ordered set of terms along a single physical continuum that extends from the widest open position of the glottis to the fully closed position (i.e. glottal stop). Other proposed sets of laryngeal features are tested against this evidence and found to be inadequate. A binary feature 'vibrating' is also proposed within this theoretical framework.

Section 5 examines the issue of whether tones are to be represented segmentally or suprasegmentally in Thai. An argument that has been advanced in favor of analyzing tone segmentally in Thai - namely, the neutralization of contour tones in fast speech - is shown to be untenable. A systematic acoustic investigation of these putative cases of tone neutralization shows that RISING and FALLING contour tones are not neutralized to level tones in fast speech. Other arguments, however, can be given in favor of assigning tones to segments on the phonological level of representation as well as analyzing the contour tones as sequences of level tones.

Section 6 consists of a detailed analysis of some tone rules in Thai. It is shown that tonal neutralization on CV syllables - whereby an underlying contrast between HIGH and LOW is neutralized to MID - depends not only on the position of the CV syllable within the words, but also on the presence of an internal word boundary in the underlying forms of certain polysyllabic words. The alternate pronunciations of these polysyllabic words (one alternant exhibits the tonal neutralization whereas the other one does not) is then accounted for simply as a difference in the underlying forms. The presence of an internal word boundary blocks application of the rule that neutralizes the underlying tonal contrast.

Section 7 investigates tone errors produced by Southern Thai bidialectals when attempting to speak Central Thai, the national language of Thailand. It is shown that most of the errors are not due to dialect interference. Instead, the errors reveal that the disordering mechanisms (perseveration, anticipation, transposition) that have been proposed to handle consonant and vowel errors may be extended without modification to tone errors. The tone errors further reflect or support the independence of tone features and some proposed universals regarding tone rules.

Section 1. Consonant Types and Tone in Siamese

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Consonant types and tone in Siamese

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Abstract: This paper presents the results of an acoustical investigation of the effects of various consonant types on the tone of a following vowel in Siamese. In general, it is found that after voiceless obstruents, the fundamental frequency contour is relatively high and falling in transition to the following vowel; after voiced obstruents, the fundamental frequency contour is relatively low and rising (-falling). It is also found that the initial fundamental frequency value after the release of a voiceless unaspirated stop is higher than for a homorganic voiceless aspirated stop. For the voiceless aspirated stops, "plain" and "breathy" allophones are found that exhibit different effects on the tone of the following vowel. Implications for theories of pitch production and diachronic tonal development are discussed.

Introduction

The relationship between various consonant types and tones has been of special interest in considering the role of tone in a generative phonology. It is relevant to several theoretical issues including, among others, distinctive phonological features of tone (Halle & Stevens, 1971; Ladefoged, 1973), segmental versus suprasegmental representation of tone (Schachter & Fromkin, 1968; Leben, 1973), synchronic tone rules (Hyman, 1973; Mohr, 1973; Hyman & Schuh, 1974), and historical development of tone (Haudricourt, 1961; Matisoff, 1973; Maran, 1973).

To help resolve these theoretical issues, detailed phonetic information about the interaction between consonant types and tone studies have been done (Lehiste & Peterson, 1961; Mohr, 1971; Lea, 1973). All of these earlier studies deal primarily with the influences of preceding and following consonants on pitch. All of them are based on nonsense syllables from languages that do not have lexically contrastive pitch.

This paper presents the results of an investigation of the effects of preceding consonants on tone in Siamese, a language that has lexically contrastive pitch on individual syllables.

Of previous instrumental studies of tones in Siamese, none of them deal with consonantal influences on pitch. Abramson (1962) presents average fundamental frequency contours of tones on monosyllabic citation forms; Palmer (1969) gives the phonetic shapes of tones in a specified phonological environment in connected speech; Hiranburana (1971) analyses the phonetic shapes of tones in fast, casual speech.

The paper is divided into 4 major sections. In Section 2, the materials and methods employed in the study are presented. The results of the investigation are given in Section 3. In Section 4, some relevant theoretical issues are discussed. Further discussion of more speculative issues is presented in Section 5.

2. Procedure

2.1. Eight consonant segments from Siamese were chosen for investigation:

p	t
p^h	t^h
b	d
	s
	n

The test material consisted of nonsense syllables of the shape $CV_1^TV_2$ where $C = [p\ p^h\ b\ t\ t^h\ d\ s\ n]$, $V_1 = V_2 = [a\ i\ u]$, T = (1) mid-level (2) low-level (3) high-rising-falling (4) high-rising (5) low-rising, hereafter MID (^{h}), LOW (\`), FALLING (^), HIGH (´), RISING (ˇ), respectively.

A reading list was prepared containing 360 nonsense syllables (8 consonants × 3 vowels × 5 tones × 3 tokens).

Caa	Cii	Cuu
Caa	Cii	Cuu
Caa	Cii	Cuu
Caa	Cii	Cuu
Caa	Cii	Cuu

This list contained 15 tokens of each consonant, all placed in utterance-medial position in the frame

mii_____ "There is/are_____"

and written in the Siamese alphabet, which indicates tonal differences.

Some of the syllables used as test material were not meaningless, and actually occur in the language.

The reading list was arranged in random order and then read by a male (24 years old) native speaker of Siamese. The speaker was instructed to read the list at normal speed. The recording was made at a single session under laboratory conditions.

The tapes were then analyzed using the Pitch Extraction System at the UCLA Phonetics Laboratory. A Siemens Oscillomink paper recording device registered the fundamental frequency curves continuously, and, on separate channels, a continuous oscillogram of the wave form and amplitude.

A phonetic transcription from the tapes was added to the oscillogram. Segmentation was based on characteristic features of the recorded wave forms and fundamental frequency curves.

Frequency values were read off the oscillogram with a pitch scale (0·5 mm = 2·5 Hz) prepared from the calibration curves of the instruments.

2.2. The fundamental frequency contour from immediately before (for voiced consonants) or after (for voiceless consonants) the release of the preceding consonant to the end of the nonsense syllable was divided into (1) CC ("consonantal contour")—that stretch of the pitch curve affected by preceding consonants and (3) TC ("tonal contour")—that stretch of the pitch curve not affected by preceding consonants. In Fig. 1 below, the part of the chart to the left of the dashed line represents CC, the part of the chart to the right of the dashed line TC.

Four fundamental frequency parameters were defined—(1) F(closure), (2) F(onset), (3) F(peak), (4) F(tone), as illustrated in Fig. 1.

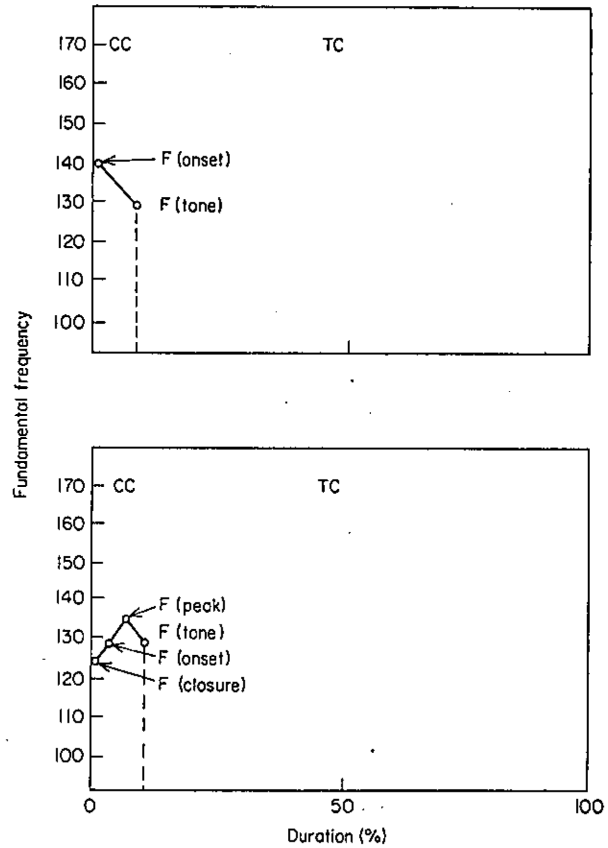

Figure 1 Pitch curves illustrating definitions of F parameters for (a) voiceless and (b) voiced consonants.

(1) F(closure)—lowest fundamental frequency value before release of voiced consonant
(2) F(onset) —initial fundamental frequency value after release of consonant
(3) F(peak) —highest fundamental frequency value after release of voiced consonant
(4) F(tone) —fundamental frequency value at beginning of stretch of pitch curve not affected by preceding consonant

In Fig. 2, the F parameters are illustrated on pitch curves from actual oscillograms.

The location of each point was determined by visual inspection of the pitch curve for MID, LOW, FALLING, HIGH, RISING tones preceded by each consonant segment. That stretch of the pitch curve that did not vary with different types of preceding consonants was taken to be TC, its beginning point F(tone). Tracings from oscillograms of the pitch curve for MID tone and RISING tone preceded by different consonant types, presented in Figs 3 and 4, illustrate how this was done. The dashed line represents F(tone). It may be seen that the shape of the curve to the right of the dashed line is very similar in all these utterances. There are differences in absolute level from utterance to utterance which will be discussed later. The two different kinds of aspirated stops will also be discussed later in the paper.

The extent of influence of preceding consonants on tone (in percentage), for each consonant type-tone group, was determined by calculating the average percentage of duration of CC to that of CC + TC. TC was measured from F(tone) to the end of the nonsense

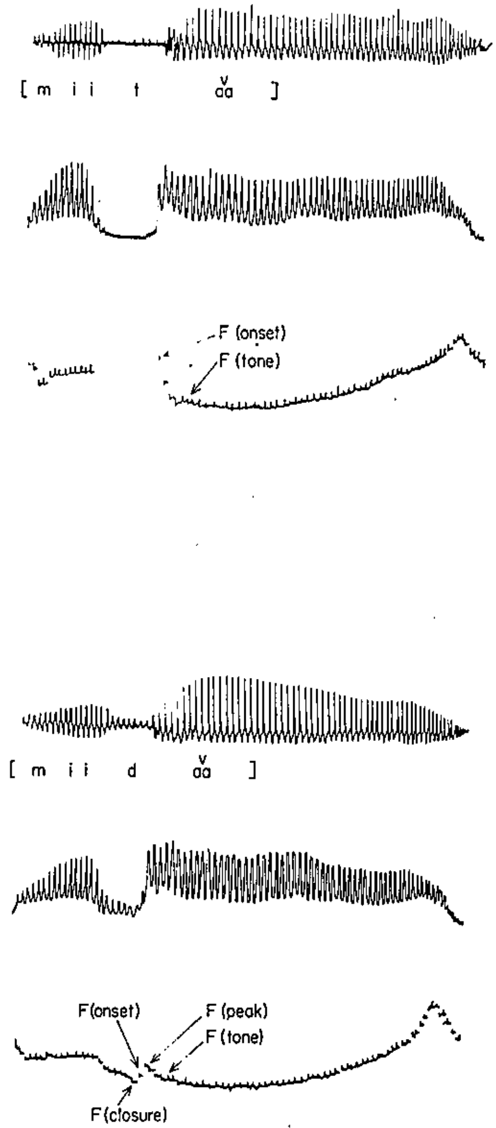

Figure 2 Oscillograms illustrating definitions of F parameters for (a) voiceless and (b) voiced consonants.

syllable for all consonant types; CC was measured from F(onset) to F(tone) for voiceless consonants, from F(closure) to F(tone) for voiced consonants. Six tokens of each member of a consonant type-tone group were selected for measurement—2 tokens for each of the 3 vowels [a i u]. Due to artifacts introduced by the Pitch Extraction System, not all nine tokens for each consonant type-tone group could be used for measurement. In addition, the average duration (in milliseconds) of CC was calculated.

3. Results

3.1. The selection of the F(tone) point appears to be valid. No strict measurement beyond F(tone) is found to be necessary for determining consonantal influences on pitch.

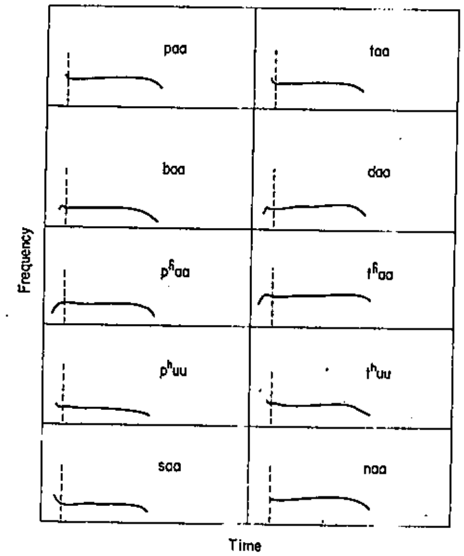

Figure 3 Fundamental frequency contours for MID tone.

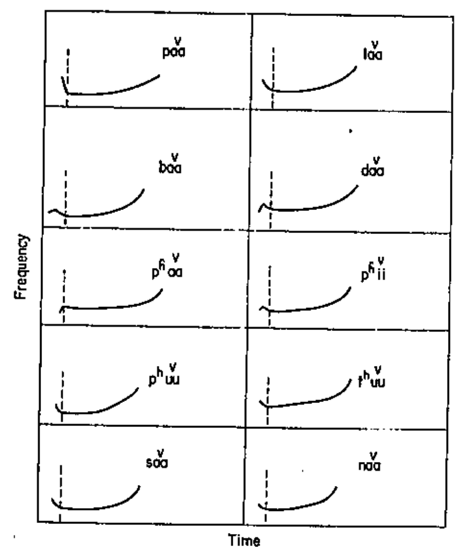

Figure 4 Fundamental frequency contours for RISING tone.

Visual inspection of the TC contours indicates that they are uniform and consistent for each tone (i.e. MID LOW FALLING HIGH RISING) irrespective of preceding consonant type.

More importantly, if one can show that there is no significant difference in pitch at F(tone) for a given tone when preceded by different consonant types, then it follows that no point beyond F(tone) is significantly affected by different types of preceding consonants.

The results of a grouped data T Test, presented in Table I, show that there is no significant difference in F(tone) values on any of the tones for voiceless [p t] and voiced [b d] consonants.

Table I Results of grouped data T test for F(tone) values of voiceless unaspirated and voiced stops

	Group 1 [p t]		Group 2 [b d]		
	Mean F(tone)	Standard Deviation	Mean F(tone)	Standard Deviation	T Score
MID	117·08	14·53	122·08	11·95	−0·9204
LOW	108·33	12·99	106·11	14·09	0·3478
FALLING	131·15	10·83	138·07	8·30	−1·8292
HIGH	132·91	11·76	125·83	14·59	1·3091
RISING	115·00	12·24	109·28	10·35	1·3333

Due to the splitting of the voiceless aspirated consonants into two groups (cf. Section 3.2) with an uneven distribution depending on the tone and following vowel, it is not possible to show that there is no statistical difference for any class of consonants.

The average F(tone) values for tones preceded by alveolar consonants are given in Table II. Again, due to the uneven distribution of the two groups of aspirated consonants, these average F(tone) values are based on only two tokens for each consonant, both tokens followed by either [i] or [u]. No tokens of [tʰ] occur before a HIGH tone.

Table II Average F(tone) values for alveolar consonants

	MID	LOW	FALLING	HIGH	RISING
t	123	115	134	138	120
tʰ	126	114	140	—	109
tʱ	126	116	142	134	112
d	123	114	139	133	112
s	117	116	141	135	114
n	124	120	139	140	110
Combined Avg.	123	116	139	136	113

3.2. The Average F(onset) values for stops and F(peak) values for voiced stops are given in Table III. For the aspirated stops, two qualitatively different consonantal contours were observed—(1) high-falling slope into the vowel (2) low-rising-(falling) slope into the vowel. The latter contour accompanies a "breathy" pronunciation of the aspirated stops. Throughout the paper, it will be necessary to treat the "plain" and "breathy" allophones of the Siamese aspirated stops as separate consonant types.

Table III Average F(onset) values for stops, F(peak) values for voiced stops

	[p t]	[pʰ tʰ] (1)	[pʱ tʱ] (2)	[b d]	
	F(onset)	F(onset)	F(onset)	F(onset)	F(peak)
MID	136	132	123	120	126
LOW	136	116	114	109	114
FALLING	148	140	136	133	142
HIGH	146	—	128	123	132
RISING	137	124	113	114	118

The average F(onset) value for voiceless unaspirated stops is 15% higher than for voiced stops, 13% higher than for the "breathy" aspirated stops, 8% higher than for the "plain" aspirated stops. The average F(onset) value for voiceless unaspirated stops is 10% higher than the F(peak) value for voiced stops.

3.3. Immediately after voiceless consonants, the fundamental frequency contour is high and falling. The distance of the fall in pitch, however, varies depending on the initial height on the following vowel. The longer falls in pitch tend to occur before lower pitch heights, the shorter falls in pitch before higher pitch heights. The average falls in pitch for voiceless unaspirated stops, "plain" aspirated stops, and voiceless alveolar fricative are presented in Fig. 5. No occurrences of "plain" aspirated stops before HIGH tone were found in the data.

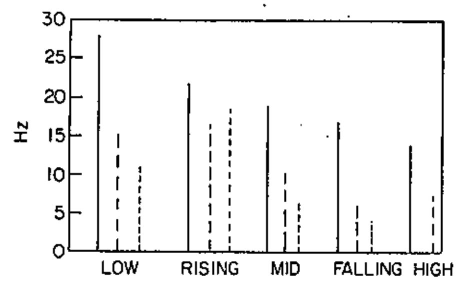

Figure 5 Average fall in pitch between F(onset) and F(tone) for voiceless consonants. [p,t]———, [ph, th]– – –, [s]------.

The greatest fall in pitch accompanies voiceless unaspirated consonants. Note especially that the fall in pitch is greater for voiceless unaspirated consonants than for "plain" aspirated stops.

3.4. Immediately after the release of voiced stops, the fundamental frequency contour is rising–falling. The longer rises in pitch tend to occur before higher pitch heights, the shorter rises in pitch before lower pitch heights. The average rises in pitch for voiced stops are given in Fig. 6. The fall in pitch from F(peak) to F(tone) averages 6 Hz across all tones.

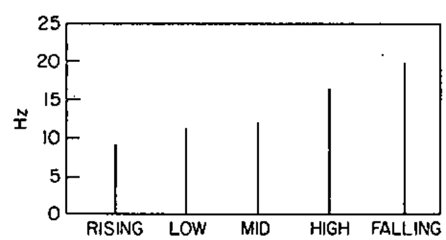

Figure 6 Average rise in pitch between F(closure) and F(peak) for voiced stops.

3.5. Average fundamental frequency contours for voiceless unaspirated stops [p t] and voiced stops [b d] followed by MID, LOW, FALLING, HIGH, RISING tones are represented in Fig. 7(a–j).

Unlike Lea's (1973, p. 35) findings, a slight rise before the fall in slope after voiceless consonants was *not* evident for any of the voiceless consonants investigated.

3.6. Average fundamental frequency contours for voiceless alveolar fricative [s] followed by MID, LOW, FALLING, HIGH, RISING tones are represented in Fig. 8.

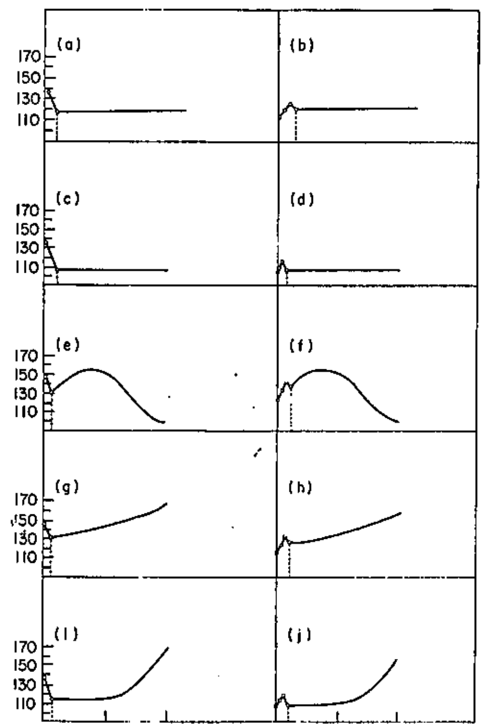

Figure 7 Average pitch curves for voicelesss unaspirated stops (a c e g i) and voiced stops (b d f g j) preceding MID LOW FALLING HIGH RISING tones.

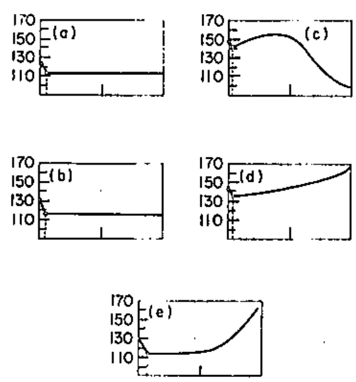

Figure 8 Average pitch curves for voiceless alveolar fricative preceding (a) MID (b) LOW (c) FALLING (d) HIGH (e) RISING tones.

3.7. The voiced nasal [n] has no noticeable effect preceding MID, FALLING and HIGH tones, i.e. for these tones F(onset) and F(tone) are coterminous. When it precedes LOW and RISING tones, [n] shows a falling slope into the vowel. The average fundamental contours for [n] preceding LOW and RISING tones are represented in Fig. 9 (cf. Abramson, 1972, p. 127).

3.8. Fundamental frequency contours for "plain" aspirated stops are similar to those for voiceless alveolar fricatives on MID, LOW, FALLING, and RISING tones (cf. Fig. 8, Section 3.6). An average pitch curve for the "breathy" allophone preceding HIGH tone is provided in Fig. 9 below for comparison with Fig. 7(g–h) (cf. Section 3.5) and Fig. 8(d) (cf. Section 3.6).

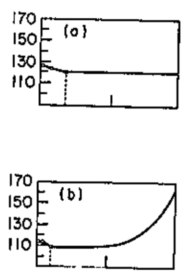

Figure 9 Average pitch curves for voiced alveolar nasal preceding (a) LOW and (b) RISING tones.

3.9. As pointed out in Section 3.2, Siamese has a "breathy" allophone of the aspirated stops. Its distribution, as compared to the "plain" allophone, on MID, LOW, FALLING, HIGH, RISING tones is given in Fig. 11.

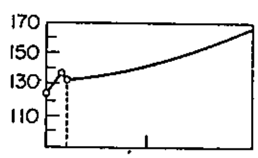

Figure 10 Average pitch curve for "breathy" allophone of aspirated stops preceding HIGH tone.

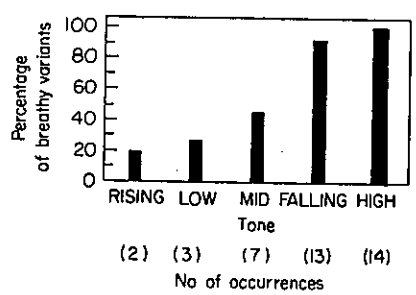

Figure 11 Distribution of breathy variant of aspirated stops by tone.

The "breathy" allophone occurs more frequently before tones that start at higher pitch heights. The higher the tone, the more likely it is to occur. Ranking the tones of Siamese—RISING LOW MID HIGH FALLING—in order from lowest to highest initial pitch height (cf. Table II, Section 3.1—see also Abramson 1962, p. 127) agrees closely with a ranking of the tones in order from lowest to highest percentage of "breathy" allophones of the aspirated stops.

3.10. Since Siamese has lexically contrastive pitch, it is posible to see clearly the extent of influence of preceding consonants on pitch. Table IV presents the results of measurements of CC relative to TC for voiceless unaspirated and voiced stops, and the voiceless alveolar fricative.

For [p t] the average number of milliseconds for CC is 24·2, for [s] 19·6, for [b d] 35·4.

Table IV Average duration of CC for voiceless and voiced consonants in percentage of duration of total contour and actual number of milliseconds

	[p t] Distance from F(onset) to F(tone)		[s] Distance from F(onset) to F(tone)		[b d] Distance from F(closure) to F(tone)	
	%	ms	%	ms	%	ms
MID	6·5	30	4·4	20	11·0	50
LOW	5·7	30	4·0	21	9·3	41
FALLING	4·6	18	2·8	10	10·5	46
HIGH	4·3	17	4·0	16	10·0	40
RISING	6·0	26	7·3	31	9·5	50

4. Discussion

4.1. The F(onset) values given in Table I (Section 3.1) more or less agree with earlier studies. Lea (1973, p. 43), using a larger set of consonants from English, found that F(onset) values are about 20% higher when the preceding consonant is voiceless, as compared to when the consonant is voiced, and that peak fundamental frequency values [F(onset) for voiceless consonants, F(peak) for voiced consonants] in stressed vowels are about 10% higher when preceded by voiceless consonants than when preceded by voiced consonants. Lehiste & Peterson (1961) also using a set of consonants from English, likewise found that higher fundamental frequencies occurred after a voiceless consonant and considerably lower fundamental frequencies occurred after a voiced consonant.

These F(onset) values would seem to support the hypothesis that voiceless consonants are associated with high pitch, voiced consonants with low pitch (Halle & Stevens, 1971). But when one considers the shortness of the consonantly perturbed portion of the fundamental frequency contour, the Halle-Steven's hypothesis that the same articulatory gesture produces high tones and voiceless consonants, low tones and voiced consonants, appears less plausible.

Their hypothesis predicts an absence of effect when voiced consonants are followed by a low tone or voiceless consonants are followed by a high tone. The results of this experiment, however, show that a fall in pitch after the release of voiceless consonants and a rise–fall in pitch after the release of voiced obstruents is still evident when followed by a high tone and a low tone, respectively.

4.2. Immediately after the release of voiced obstruents, the fundamental frequency rises from the low values it has within the consonant, to yield *rising–falling* fundamental frequency contours at the boundaries between voiced obstruents and the following vowel. This rising–falling contour occurs with voiced obstruents regardless of the tone of the following vowel. Thus, it is to be considered the "intrinsic" fundamental frequency contour for voiced obstruents.

Lea (1973) found that the fundamental frequency contour was simply *rising* for voiced obstruents. However, in his investigation the consonants preceded a stressed vowel in final position which invariably yielded a falling contour. Since the falling contour was constant for all the test items, it was not possible to decide nonarbitrarily whether to attribute part of the falling contour to the voiced obstruent or not.

4.3. As shown in Fig. 5 (Section 3.3) the fall in pitch after the release of voiceless consonants is related to the initial pitch level of the TC of the following vowel. The shorter falls in pitch occur when the voiceless consonant is followed by a vowel that has a higher initial pitch level; the longer falls in pitch occur when the voiceless consonant is followed by a vowel that has a lower initial pitch level. Indeed, the order of the voiceless consonants ranked from greatest to least fall in pitch, corresponds closely to the order of the Siamese tones ranked from lowest to highest initial pitch level (cf. Abramson (1962, p. 127).

It appears that there is a target laryngeal configuration for a given type of consonant which remains constant regardless of the pitch level on the following vowel. This target for each type of consonant is a pitch determinant.

Surprisingly, the fall in pitch after voiceless unaspirated stops is greater than after the "plain" aspirated stops. The unaspirated stops have higher F(onset) values than the aspirated ones. Why this is so is not entirely clear. We would expect the airflow to be grea er for the "plain" aspirated stops, and consequently expect them to have a greater tone raising effect than corresponding voiceless unaspirated stops (cf. Ladefoged, 1973; Hyn an & Schuh, 1974).

4.4. Precise measurements of average fundamental frequency contours for the tones of Siamese pronounced on monosyllabic citation forms are presented in Abramson (1962). The TC presented in this apper mostly agree with Abramson's but do not show an initial drop in pitch on the LOW and RISING tones or the final fall in pitch on the MID and HIGH tones. That Abramson found a fall at the beginning of LOW and RISING tones can now be seen to be due to the influence of a preceding nasal consonant [cf. Fig. 9 (a–b), Section 3.7] in the forms that Abramson used. The fall after MID and HIGH tones in Abramson's examples can be attributed to the environment before pause since it does not appear when these tones occur in non-final position.

5. Further Discussion

5.1. In historical-comparative studies of Tai languages and dialects, modern p and p^h that show one series of tone reflexes from earlier voiced consonants have been commonly assumed to come from *b (Li, 1954; Gedney, 1973; Sarawit, 1973). Similarity, for t and t^h, k and k^h. They are assumed to come from *d and *g, respectively. Instead of *b *d *g, I propose murmured stops *b̤ *d̤ *g̤ (see also Egerod, 1960, pp. 76–7).

Instrumental data on aspirated stops in Siamese (cf. Sections 3.2, 3.8, 3.9) clearly suggest vestigial traces of breathy voiced stops. These "breathy" allophones of aspirated stops have also been found in other Tai dialects, particularly among those dialects spoken in southern Thailand (Egerod, 1960, p. 66, f.n. 17).

If we reconstruct *b, then it becomes possible to posit the following natural line of phonetic development—*b → $p^ɦ$ → p^h → p. If, on the other hand, we reconstruct *b, we must allow for the highly unnatural sound change *b → p^h.

Most Tai languages and dialects have traveled the complete route, i.e. they show voiceless unaspirated stops as reflexes of earlier breathy voiced stops. Out of 18 representative Tai dialects, 14 dialects have p as the modern reflex, only 4 dialects have p^h (data taken from Sarawit, 1973).

Interestingly a similar kind of breathy aspirated sound is reported to occur in Wu dialects of Chinese (Egerod, 1960, p. 66, f.n. 17), which led Karlgren to reconstruct "voiced aspirated" sounds for Ancient Chinese (Karlgren, 1954, p. 220).

5.2. In the historical development of tone languages much evidence has been given (Haudricourt, 1961; Li, 1966; Matisoff, 1973) in support of the hypothesis that higher tonal reflexes more often follow original voiceless consonants than voiced consonants. This hypothesis assumes that, at an earlier stage of a language, a higher pitch and a lower pitch redundantly mark voiceless and voiced consonants, respectively. These differences in pitch become contrastive just in case the distinction in voicing between the consonants is lost.

It is necessary then to state explicitly what part of the fundamental frequency contour associated with voiceless and voiced consonants could lead to an interpretation of the tone on the following vowel as high and low, respectively. As shown in Fig. 1 (cf. Section 2.2), the typical slope into the vowel is falling for voiceless consonants, rising–falling for voiced consonants.

Lea (1973, p. 64) suggests that perception of high versus low tone cannot depend on the relative fundamental frequency values of the preceding slope *into the vowel*, but instead must depend on relative values *within the vowel*. Results of measurements of F(tone) values (cf. Table II, Section 3.1) and CC durations (cf. Table IV, Section 3.10) for voiceless and voiced consonants, however, makes Lea's hypothesis implausible. If Lea's hypothesis were correct, we would expect to find a significant difference in F(tone) values for voiceless and voiced consonants on MID, LOW, FALLING, HIGH, RISING tones. The results of measurements of F(tone) values as presented in Tables I and II (cf. Section 3.1), however, suggest that this is not always the case.

Thus, we must look at the relative fundamental frequency values of the preceding slope *into the vowel* after voiceless and voiced consonants for possible perceptual cues for high and low tone, respectively. It is unlikely that the speaker cues on the rise of the slope [from F(closure) to F(peak)] in voiced consonants and the fall of the slope [from F(onset) to F(tone)] in voiceless consonants. Otherwise, we would expect voiced consonants to lead to high tone, voiceless consonants to low tone.

It is more likely that a speaker of a non-total language, that is a potential candidate for developing into a tonal language, cues on either (1) the F(onset) values associated with voiceless and voiced consonants or (2) the F(onset) values of the voiceless consonants versus F(peak) values of voiced consonants (cf. Table III, Section 3.2) for the interpretation of high and low tone, respectively.

5.3. It is interesting to speculate on the development of falling and rising contour tones. Lea (1973, pp. 65–6) hypothesizes that it is an extension of the preceding slope into the vowel that could lead to the development of falling and rising tones. Thus, we would expect falling tones to develop from earlier voiceless consonants and rising tones from earlier voiced consonants.

A cursory examination of the distribution of falling and rising contour tones in modern Tai dialects (Haudricourt, 1961; Brown, 1965; Sarawit, 1973), however, makes Lea's suggestion implausible as an explanation for the origin of contour tones in Tai languages and dialects. One does not find a correlation between falling and rising tones in modern Tai dialects and Proto-Tai voiceless and voiced initials (Li, 1954; Gedney, 1967; Sarawit, 1973), respectively.

A more plausible hypothesis, for the Tai language family at least, is that lexical contour tones develop from already existing level tones in order to maximize perceptual distance in the tone system. Tonal systems that contain lexical contour tones normally have 4 or more contrastive tones. Practically all Tai languages and dialects have lexical contour tones. Thus, it is not at all surprising that Gedney (1973, p. 424) reports that "no Tai dialect has been found with fewer than 5... contrastive tones..." It is surely not accidental that lexical contour tones are found most frequently in tonal systems with a greater number of contrastive tones.

A mechanism for the development of falling contour tones that immediately suggests itself is based on the observation that all tones tend to fall in pitch before pause. Suppose then, at an earlier stage, a language had 4 contrastive tones. In order to maximize perceptual distance, the fall in pitch is exaggerated on one or more of the level tones, later becoming a contrastive falling tone.

This mechanism would not account for the development of rising contour tones. Rising tones appear to be secondary developments in a further attempt at maximizing perceptual distance. Their "marked" status as compared to falling tones is suggested by the following: falling tones far outnumber rising tones (Ohala, 1973), falling tones may require less physiological effort (Ohala & Ewan, 1973).

Although the above remarks have been mostly speculative, they clearly suggest a number of tone perception experiments involving discrimination of level versus contour tones (cf. Gandour, 1974*b*).

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References

Abramson, Arthur S. (1962). The vowels and tones of standard Thai: acoustic measurements and experiments. *IJAL*, Publication 20.

Brown, J. Marvin (1965). *From Ancient Thai to Modern Dialects.* Bangkok: Social Science Association Press of Thailand.

Egerod, S. (1961). Studies in Thai dialectology. *Acta Orientalia* **26** (1–2), 43–91.

Gandour, J. (1974*a*). The features of the larynx: N-ary or binary? Paper to be presented at 4th Annual California Linguistics Conference, University of Southern California.

Gandour, J. (1974*b*). Level and contour tones: phonological space. In preparation, UCLA.

Gedney, W. J. (1967). Thailand and Laos. In (T. Sebeok, Ed.), *Current Trends in Linguistics, Vol. III, Linguistics in South-East Asia.* The Hague: Mouton.

Gedney, W. J. (1973). A checklist for determining tones in Tai dialects. In (M.E. Smith, Ed.) *Studies in Linguistics in Honour of George L. Trager.* The Hague: Mouton.

Haudricourt, A. G. (1961). Bipartition et tripartition des systèmes de tons dans quelques langues d'Extrême-Orient. *Bulletin de la Société de Linguistique de Paris* **56** (163), 80.

Halle, M. & Stevens, K. N. (1971). A note on laryngeal features. *Quarterly Progress Report* No. 101, 198–213. Research Laboratory of Electronics, M.I.T.

Hiranburana, S. (1971). *The Role of Accent in Thai Grammar.* Unpublished doctoral dissertation, University of London.

Hyman, L. (Ed.) (1973). *Consonant Types and Tone* (Southern California Occasional Papers in Linguistics No. 1) Los Angeles: Linguistics Program of University of Southern California.

Hyman, L. & Schuh, R. (1974). Universals of tone rules: evidence from West Africa. *Linguistic Inquiry* **5**, (1), 81–115.

Karlgren, B. (1954). Compendium of phonetics in ancient and archaic Chinese. *BMFEA* **22.**

Ladefoged, P. (1973). Features of the larynx. *Journal of Phonetics* **1** (1), 73–83.

Lea, W. A. (1973). Segmental and suprasegmental influences on fundamental frequency contours. In (Larry M. Hyman, Ed.), *Consonant Types and Tone* (Southern California Occasional Papers in Linguistics No. 1), pp. 15–70. Los Angeles: Linguistics Program of USC.

Leben, W. R. (1973). *Suprasegmental Phonology.* Unpublished doctoral dissertation, M.I.T.

Lehiste, I. & Peterson, G. (1961). Some basic considerations in the analysis of intonation. *Journal of the Acoustical Society of America* **33**, 419–25.

Li, Fang-Kuei (1954). The relationship between tones and initials in Tai. In (Norman Zide, Ed.), *Studies in Comparative Austroasiatic Linguistics.* pp. 82–88. The Hague: Mouton.

Mohr, B. (1971). Intrinsic variations in the speech signal. *Phonetica* **23**, 65–93.

Maran, L. (1973). On becoming a tone language: a Tibeto-Burman model of tonogenesis. In (Larry M. Hyman, Ed.) *Consonant Types and Tone* (Southern California Occasional Papers in Linguistics No. 1), pp. 97–114. Los Angeles: Linguistics Program, University of Southern California.

Matisoff, J. (1973). Tonogenesis in Southeast Asia. (In Larry M. Hyman, Ed.), *Consonant Types and Tone* (Southern California Occasional Papers in Linguistics No. 1), pp. 71–95. Los Angeles: Linguistics Program at University of Southern California.

Mohr, B. (1973). Tone rules and the phonological representation of tones. Paper presented to the Sixth International Conference on Sino-Tibetan Language and Linguistics, University of California at San Diego.

Ohala, J. & Ewan, W. (1973). Speed of pitch changes (Abstract). *Journal of the Acoustical Society of America* 53, 345.

Palmer, A. (1969). Thai tone variants and the language teachers. *Language Learning* 19 (3–4), 287–299.

Sarawit, M. (1973). *The Proto-Tai Vowel System.* Unpublished doctoral dissertation, University of Michigan.

Schachter, P. & Fromkin, V. (1968). *A Phonology of Akan: Akuapem, Asante, and Fante.* (Working Papers in Phonetics No. 9) UCLA.

Section 2. The Features of the Larynx: N-ary or Binary?

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The Features of the Larynx: N-ary or Binary?[1]

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Abstract. Multivalued features have generally not been permitted on the classificatory level of representation by generative phonologists. It is found necessary, however, to posit a multivalued scalar feature 'glottal width' on the classificatory level of representation in order to provide a satisfactory explanation of the diachronic tone splits conditioned by the phonation type of the syllable-initial consonants among the languages and dialects of the Tai language family in Southeast Asia. The feature 'glottal width' consists of a linearly ordered set of terms along a single physical continuum that extends from the widest open position of the glottis to the fully closed position (i.e. glottal stop). Other proposed sets of laryngeal features are tested against this evidence and found to be inadequate. A binary feature 'vibrating' is also proposed within this theoretical framework.

Introduction

According to the theory of generative phonology as presented by Chomsky and Halle [1968], all phonetic features are binary on the classificatory level of representation. Only on the phonetic level of representation may these features be specified with more than two values. In this paper, I will attempt to show that phonological theory must necessarily permit n-ary features on the classificatory level of representation as well.

As to whether some classificatory features are n-ary or not, it is important to keep in mind what the empirical issues are. Ladefoged [1971, p. 98] said: 'The issue of whether classificatory features should be binary ... or multivalued ... is not in itself very relevant to a choice

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between feature systems. Any multivalued feature can be reinterpreted in terms of a number of binary features; and any binary system can be supplied with marking conventions so that it acts as if it contained multivalued features. What is far more relevant to a comparison is the difference in the claims that each system makes both about the phonological relations between sounds and the phonetic facts.'

An exclusively binary system makes the claim that linearly ordered sets of speech sounds along a single continuum do not exist in language. Much evidence [LADEFOGED, 1971], however, has already been given that points to the need for multivalued classificatory features for 'vowel height' and 'place of articulation' for consonants. Evidence will be given in this paper that points to the need for a multivalued classificatory feature for 'width of the glottal aperture'.

The evidence has to do with the historical development of tone in languages and dialects of the Tai language family of Southeast Asia – in particular, tonal splitting conditioned by the phonation type of initial consonants. Two earlier proposed sets of laryngeal features – one by HALLE and STEVENS [1971], the other by LADEFOGED [1973] – will be tested against this evidence and shown to be inadequate. Two new laryngeal features will be proposed that enable us to provide a descriptively adequate account of the Tai data. One, a feature *vibrating* with two values; the other, a multivalued feature *glottal width*. Moreover, these features will be justified by phonetic principles independent of the data in question.

Overview of Tonal Development in the Tai Language Family

First, let us begin with an overview of the historical development of tone in the Tai language family.

The parent language, Proto-Tai, has been commonly assumed to have had three tones on non-stopped syllables and a fourth non-contrastive tone on stopped syllables. The three tones on non-stopped syllables have been reconstructed simply as the tonal categories A, B, and C; similarly, the fourth tone on stopped syllables is reconstructed simply as the tonal category D. As of yet, none of the phonetic or phonological shapes for these tonal categories has been reconstructed. Tonal category D is not relevant to the questions dealt with in this paper and will be omitted from further discussion.

The sound changes that are believed to have taken place from Proto-Tai to the modern Tai languages and dialects are described by GEDNEY [1969, p. 428]: 'At some time after the period of Proto-Tai unity ... a wave of drastic sound changes ... swept most of Southeast Asia ... In tonal languages such as those of the Tai family, these sound changes involved splits in the tonal system, with the splits conditioned by the phonetic nature of initial consonants of the syllables ... in general what happened was that each of the original tones ... split into two or more tones ...'

The phonetic classes of reconstructed initial consonants that are commonly assumed [HAAS, 1958; LI, 1966; GEDNEY, 1969; SARAWIT, 1973] to be necessary to account for the different kinds of tone splits are given below.

Consonant class		Mnemonic symbol
1	voiceless aspirated stops+h	ph
2	voiceless fricatives and voiceless sonorants	f
3	voiceless unaspirated stops	p
4	glottal stop+preglottalized stops and preglottalized glides	ʔ
5	voiced obstruents and sonorants	b

When they are arranged in this particular order, it will be shown that the classes of consonants needed to account for the tone splits consist of only adjacent subclasses. The phonetic principles that appear to motivate this linear order will be taken up later in the paper.

Tone Splits in Tai

Tone splits reported for the Tai language family [BROWN, 1965; LI, 1966; GEDNEY, 1970; SARAWIT, 1973] include three cases involving a split of the original Proto-Tai tone(s) into two tones (hereafter called 'binary splits'), two cases involving a split of the original Proto-Tai tone(s) into three tones (hereafter called 'ternary splits'). No cases of tone splits have yet been reported in which four or more tonal reflexes result from the splitting of the Proto-Tai tones. One representative Tai language or dialect has been selected to illustrate each case.

White Tai, a Tai dialect spoken in the western part of North Vietnam, illustrates the most common binary split. The historical sources of the White Tai tonal reflexes and the classes of initial consonants that figured in the tone split are given below [data from SARAWIT, 1973].

White Tai

Initials at time of tone splits		Proto-Tai tones		
class	symbol	A	B	C
1	ph			
2	f	22 ˨˨	45 ˦˥	23 ˨˧
3	p			
4	ʔ			
5	b	44 ˦˦	343 ˧˦˧	31 ˧˩

These diagrams [developed by GEDNEY, 1969] provide a convenient way of organizing the data on tone splits. At the head of each column are given the Proto-Tai tonal categories A, B, and C; to the left of each row are given the numbered subclasses of initial consonants that lead to the series of tonal reflexes appearing in that row; at the intersection of a given row and column, then, is the tonal reflex that developed from the Proto-Tai tonal category when preceded by that particular class of initial consonants. The tonal reflexes themselves are represented in the CHAO [1930] tone-letter notation, in which the normal pitch range of a speaker's voice is plotted on the vertical axis from 5 (the highest pitch) to 1 (the lowest pitch); the changes in pitch level throughout the duration of the tone are plotted on the horizontal axis.

Note that in White Tai one of the classes of consonants that leads to the same series of tonal reflexes is composed of the phonetic subclasses represented by the symbols ph, f, p, and ʔ.

The Tai dialect, Lung Ming – spoken in the southwestern part of Kwangsi province, China – illustrates another way the original Proto-Tai tones split into two modern tonal reflexes. The historical sources of the Lung Ming tones are given below [data from SARAWIT, 1973].

Lung Ming

Initials at time of tone splits		Proto-Tai tones		
class	symbol	A	B	C
1	ph			
2	f	55 ˥	45 ˦˥	33 ˧
3	p			
4	ʔ	21 ˨˩		
5	b		11 ˩	212 ˨˩˨

Of special interest here is the binary split of the A tone. Note that the subclasses represented by ph, f, and p fall into one class, whereas the subclasses represented by ʔ and b fall into another. The binary split of the B and C tones, on the other hand, is based on the same classes of initials as in White Tai. Again, the linear order of these classes of initials is confirmed; under the A tone, phonetic subclasses (1)–(3) yield one tonal reflex and subclasses (4) and (5) another.

Siamese, the national language of Thailand, illustrates yet another kind of binary split. The historical sources of the Siamese tones are given below [data from Sarawit, 1973].

Siamese

Initials at time of tone splits		Proto-Tai tones		
class	symbol	A	B	C
1	ph	24 ˨˦		
2	f		22 ˨	41 ˦˩
3	p			
4	ʔ	33 ˧		
5	b		41 ˦˩	453 ˦˥˧

Under the A tone, the phonetic subclasses represented by ph and f fall together into one class; those represented by p, ʔ, and b fall into another. The binary split of the B and C tones is based on the same class of initials as in White Tai and Lung Ming. Again, the linear order of the initials is confirmed; under the A tone, phonetic subclasses (1) and (2) make up one class, subclasses (3)–(5) another.

Ternary splits, although less common than binary splits, have occurred frequently throughout the Tai-speaking domain, particularly among those Tai dialects spoken in the southern peninsula of Thailand. The Songkhla dialect of southern Thailand illustrates a common ternary split across all tonal categories. The historical sources of the Songkhla tones are given below [data from BROWN, 1965].

Songkhla

Initials at time of tone splits		Proto-Tai tones		
class	symbol	A	B	C
1	ph	45 ˦˥	45 ˦˥	43 ˦˧
2	f			
3	p	24 ˨˦	24 ˨˦	32 ˧˨
4	ʔ			
5	b	31 ˧˩	22 ˨˨	21 ˨˩

Here we find it necessary to set up the same classes of initial consonants as in Siamese, the difference being that each class leads to different tonal reflexes under each of the Proto-Tai tones A, B, and C. Once again the linear order of the phonetic classes of initials is confirmed.

The Tai dialect of Nung, spoken at the village of Bac Va in north-eastern North Vietnam, illustrates another kind of ternary split. The historical sources of the Nung tones are given below [data from GEDNEY, 1970].

Nung, Bac Va

Initials at time of tone splits		Proto-Tai tones	
class	symbol	A	B and C
1	ph	low rising	no description
2	f	high	of tones
3	p	rising	provided in
4	ʔ		reference
5	b	mid level	source

Under the A tone, we can see that it is now necessary to treat the voiceless aspirated stops and h as a separate class and those phonetic subclasses represented by f, p, and ˀ as another class. The binary split of the B and C tones is again based on the same classes of initials as found in White Tai. Of particular interest is the fact that the linear order of the phonetic classes yet remains intact.

A description of tone splitting in Tai, then, must reveal the generalization that the classes of initial consonants that conditioned the tone splits form a linearly ordered set. Let us next test earlier proposed sets of laryngeal features against the Tai data.

Halle *and* Stevens' *[1971] Proposal*

Halle and Stevens [1971] have proposed four binary laryngeal features, shown below, that represent two variables: (1) degree of stiffness of the vocal cords, and (2) degree of constriction of the glottis, with a convention that neither [+stiff, +slack] nor [+spread, +constricted] can occur.

Variable 1	Variable 2
± Stiff ± Slack	± Spread ± Constricted

The same pair of features – *stiff* and *slack* – is claimed to govern both pitch levels in vowels and voicing in obstruents. Accordingly, three types of obstruents are claimed to occur in language: 'voiceless, voiced, and intermediate; the first corresponding to the high pitch vowels, the second to the low pitch vowels, and the third to vowels with mid pitch [Halle, 1972, p. 181].' Vowels and obstruents, then, would be specified as shown below.

	Vowels			Obstruents		
	V́	V̀	V	voiceless	voiced	intermediate
Stiff	+	–	–	+	–	–
Slack	–	+	–	–	+	–

In favor of their features, HALLE [1972] points to historical development of tonal systems in Far Eastern languages which purportedly shows a direct correlation between pitch levels in vowels and voicing in obstruents. This correlation, however, is not as straightforward as HALLE would lead us to believe. True, one can find numerous cases among these languages where a low pitch is the reflex of earlier voiced consonants and a high pitch is the reflex of earlier voiceless consonants. But, for the Tai language family at least, one can find just as many cases where this prediction is not borne out [BROWN, 1965; LI, 1966; SARAWIT, 1973]. Tonal reflexes like we find in Siamese and Nung are not all uncommon. To the extent that tonal systems do not reflect the correspondence of voiceless, voiced and intermediate obstruents with high, low and mid tones HALLE's [1972] characterization of tonal development as an instance of assimilation in which the feature *stiff* or *slack* in the consonant is assimilated by the following vowel is inadequate.

Somewhat puzzling, too, is HALLE's [1972] reference to HAUDRICOURT's oft-cited paper on tone splitting in Far Eastern languages, in which HALLE claims to have found considerable support for his framework. My own inspection of HAUDRICOURT's data would lead me to just the opposite conclusion.

Another claim made by their feature framework, that is not borne out by historical development of tonal systems in the Tai family, is that the features *spread* and *constricted* are irrelevant to tonal processes. Take the case of tone-splitting in Nung under tone A where it becomes necessary to separate out the class (1) initials. As shown below, the only way this can be done in HALLE and STEVENS' [1971] theoretical framework is to refer to the feature *spread*. But their system predicts that the feature *spread* is irrelevant to tonal phenomena.

	ph	f	p	ʔ	b
Spread	+	—	—	—	—
Stiff	+	+	+	+	—

Indeed, of all the cases of tone splitting in the Tai language family, the features *stiff* and *slack* can divide the classes of initials correctly only for the simplest case – that exemplified in White Tai. Notice, however, that even here the correlation between tonal reflexes and consonant types is opposite to HALLE and STEVENS' [1971] prediction.

In addition, and more significantly for the Tai data under discussion, the generalization that the classes of initials form a linearly ordered set is, in principle, ruled out in HALLE and STEVENS' binary system.

Other serious problems with HALLE and STEVENS' set of laryngeal features – both phonetic and phonological – have already been pointed out [LISKER and ABRAMSON, 1971; FROMKIN, 1972; LADEFOGED, 1973]. For the purposes of this paper, suffice it to say that tonal development in Far Eastern languages cannot be used to support their features.

LADEFOGED's *[1973] Proposal*

LADEFOGED [1973] has proposed a set of laryngeal features that includes 3 n-ary features – *glottalicness, voice onset, and glottal stricture,* and additional pitch features. Of these laryngeal features, it is the n-ary feature *glottal stricture* that we are mainly interested in.

First, it should be pointed out that the lack of a single correlation between pitch in vowels and voicing in obstruents in the development of tonal systems in Far-Eastern languages is correctly predicted by LADEFOGED's feature framework in which pitch and glottal stricture are set up as independent features – a clear advantage over the HALLE-STEVEN's [1971] feature framework. This is not to say that there is no relationship between the degree of stiffness of the vocal cords and pitch, but that other factors are involved as well. Experimentally, it has been shown that a rise in pitch may result from either an increase in the tension of the vocal cords or an increase in the air pressure below them [LADEFOGED, 1963, 1967, 1971] or an increase of medial compression of the vocal cords [VAN DEN BERG, 1960].

LADEFOGED's [1973] feature that is of immediate relevance – *glottal stricture* – is as follows: (1) spread; (2) voiceless; (3) murmur; (4) slack (= lax voice); (5) voice; (6) stiff (= tense voice); (7) creaky; (8) closed.

It is a multivalued scalar feature that consists of a linearly ordered set of states of the glottis. It is supposed to constitute a single physical scale, making the claim that there is a continuum extending from the most closed position, a glottal stop, to the most open position observed in speech, that in voiceless aspirated sounds.

This feature predicts that sets of speech sounds can be classified by glottal stricture *only* by collapsing adjacent members of the set of terms within this feature. For example, it predicts that natural phonological rules would not refer to a class of speech sounds that included terms 1 and 8 on this scale without including any of the intervening terms if they occurred in the language.

Let us now see how this prediction is borne out by the Tai data. From the cases of tone splitting presented earlier, it is clear that we must be able to arrange the classes of initial consonants in the order shown below, if only adjacent subclasses of initials are to be grouped together: ph, f, p, ʔ, b.

When we do this, however, it becomes immediately apparent that LADEFOGED's proposed linear order of the states of the glottis is incorrect. To account for the Tai data, it would be necessary to reverse terms (5) and (8) on LADEFOGED's scale.

One obvious attempt to salvage the feature *glottal stricture* would be to simply rearrange the linear order of the states of the glottis so that we obtain the correct results for the Tai data. This could be done, but it would be a purely *ad hoc* nonexplanatory solution [GEDNEY, 1970]. We would no longer be able to claim that the feature constitutes a single physical scale, i.e. we would no longer have a principled reason for the proposed linear order.

Having shown that neither the HALLE-STEVEN's [1971] feature framework nor LADEFOGED's [1973] can adequately handle the Tai data, let us now consider an alternative hypothesis.

An Alternative Proposal

I would like to propose two laryngeal features that could easily be incorporated into a theoretical framework that permitted n-ary-valued classificatory features: (1) a binary feature *vibrating* (±) and (2) an n-ary feature *glottal width* (spread, voiceless, tightened, closed).

These features are hierarchically-ordered. The n-ary feature *glottal width* is relevant only to the nonvibrating state of the vocal cords.

Those speech sounds that have fundamental frequency are classified +vibrating, those that do not −vibrating. For the former set of speech sounds, some portion of the vocal cords is vibrating; for the latter, no portion of the vocal cords is vibrating. This is an inherently binary distinction and is not open to scalar quantification.

The n-ary feature *glottal width* is a multivalued scalar feature that consists of a linearly ordered set of terms along a single physical scale. The continuum extends from the widest open position of the glottis, that associated with voiceless aspirated stops [KIM, 1970; LADEFOGED, 1973], to the fully closed position, that associated with the glottal stop. That such a physical continuum exists receives support from photographs that have been taken of various states of the glottis [LADEFOGED, 1973].

The third term 'tightened' on the *glottal width* scale gains independent support from KIM's [1970] cineradiographic study of the three types of Korean stops – unaspirated, slightly aspirated, heavily aspirated. In this study KIM found a direct correlation between degree of glottal opening at time of release and degree of aspiration, i.e. the wider the glottal opening, the greater the amount of aspiration. To account for the three Korean stops, then, it is necessary to specify three degrees of glottal width – the unaspirated stops being specified 'tightened'. The Tai unaspirated stops would be similarly specified.

As presented earlier, the Tai data indicate that it is frequently necessary to divide initials between phonetic subclasses (4) and (5). The binary feature *vibrating* easily accounts for that division, i.e. between speech sounds that are classified –vibrating as opposed to those classified +vibrating.

	–Vibrating				+Vibrating
Class	1	2	3	4	5
Symbol	ph	f	p	ʔ	b

When we arrange the classes of initials (1)–(4) along the *glottal width* scale, as shown below, the linear order of the classes, evident in the tone splits, is correctly predicted.

Classes	Symbols	States
1	ph	spread
2	f	voiceless
3	p	tightened
4	ʔ	closed

The feature *glottal width* makes interesting predictions about what to expect in both diachronic and synchronic phonology. To the extent that other evidence confirms the linear order proposed here, it must be taken as support for n-ary features on the classificatory level of representation.

Zusammenfassung

Larynxmerkmale: n-är oder binär?

Mehrwertige Merkmale sind allgemein von generativen Phonologen auf der klassifikatorischen Darstellungsebene nicht zugelassen worden. Es erweist sich jedoch als notwendig, ein mehrwertiges skalares Merkmal «glottale Weite» auf der klassifikatorischen Darstellungsebene anzusetzen, um eine zufriedenstellende Erklärung für diachronische Tonspaltungen, hervorgerufen durch den Phonationstyp der silbeninitialen Konsonanten in den Sprachen und Dialekten der Tai-Familie in Südostasien, zu liefern. Das Merkmal «glottale Weite» besteht aus einer Klasse linear geordneter Werte entlang einem einzigen physikalischen Kontinuum, das sich von der am weitesten geöffneten Position der Glottis bis zur völlig geschlossenen (d.h. zum Glottalverschluß) erstreckt. Andere vorgeschlagene Klassen von Larynxmerkmalen werden im Lichte dieser Befunde überprüft; sie stellen sich als inadäquat heraus. Ein binäres Merkmal «schwingend» wird ebenfalls innerhalb dieses theoretischen Rahmens vorgeschlagen.

Résumé

Les traits laryngaux: multiples ou binaires?

En phonologie générative, l'usage de traits distinctifs à valeurs multiples au niveau de la classification de la représentation n'a généralement pas été admis. Il est nécéssaire cependant, à ce niveau, de supposer un tel trait à valeurs scalaires multiples – l'aperture glottique – si l'on veut expliquer de façon satisfaisante les divisions de tons diachroniques conditionnées par le type de phonation des consonnes initiales des syllabes dans les langues et les dialectes thaï de l'Asie du Sud-Est. Ce trait se compose d'un ensemble de caractéristiques ordonnées linéairement suivant un continuum physique unique qui s'étend de la position la plus ouverte de la glotte à la position la plus fermée, c'est-à-dire l'occlusion glottique. Les autres ensembles de traits laryngaux proposés s'avèrent inadéquats lorsqu'on les examine sous cet angle. Un trait binaire «vibrant» est aussi proposé dans le cadre de cette théorie.

References

BROWN, J. M.: From ancient Thai to modern dialects (Social Science Foundation Press of Thailand, Bangkok 1965).

CHAO, Y. R.: A system of tone letters. Le Maître phonétique *45:* 24–27 (1930).

CHOMSKY, N. and HALLE, M.: The sound pattern of english (Harper & Row, New York 1968).

FROMKIN, V.: Tone features and tone rules. Studies in African Linguistics *3:* 47–76 (1972).

GEDNEY, W.: A checklist for determining tones in Tai dialects; in SMITH Studies in linguistics in honor of George L. Trager, pp. 423–437 (Mouton, The Hague 1969).
GEDNEY, W.: A spectrum of phonological features in Tai. Proc. 3rd Annu. Meet. of the Conference on Sino-Tibetan Reconstruction (Cornell University, Ithaca 1970).
HAAS, M.: The tones of four Tai dialects. Bull. Inst. History Philol. Acad. Sin. *29:* 817–826 (1958).
HALLE, M.: In defense of the number two; in PULGRAM Studies presented to Joshua Whatmough on his sixtieth birthday, pp. 67–72 (Mouton, The Hague 1957).
HALLE, M.: Theoretical issues in phonology in the 1970's; in RIGAULT and CHARBONNEAU Proc. 7th Int. Congr. of Phonetic Sciences, pp. 179–204 (Mouton, The Hague 1972).
HALLE, M. and STEVENS, K. N.: A note on laryngeal features. Q. Prog. Rep. Res. Lab. Electron. MIT *101:* 198–213 (1971).
KIM, C.-W.: A theory of aspiration. Phonetica *21:* 107–116 (1970).
LADEFOGED, P.: Some physiological parameters in speech. Lang. Speech *6:* 109–119 (1963).
LADEFOGED, P.: Research possibilities in phonetics. A. Bull. Res. Inst. Logoped. Phoniat., Tokyo *1:* 31–34 (1967).
LADEFOGED, P.: Preliminaries to linguistic phonetics (University of Chicago Press, Chicago 1971).
LADEFOGED, P.: The features of the larynx. J. Phonet. *1:* 73–83 (1973).
LI, F. K.: The relationship between tones and initials in Tai; in ZIDE Indo-Iranian monographs. Studies in comparative Austro-Asiatic linguistics, pp. 82–88 (Mouton, The Hague 1966).
LISKER, L. and ABRAMSON, A. S.: Distinctive features and laryngeal control. Language *42:* 767–785 (1971).
SARAWIT, M.: The Proto-Tai vowel system; unpublished Ph.D. diss. Ann Arbor (1973).

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Section 3. The Glottal Stop in Siamese: Predictability in Phonological Description

THE GLOTTAL STOP IN SIAMESE: PREDICTABILITY IN PHONOLOGICAL DESCRIPTION *

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* * *

INTRODUCTION

According to the "standard theory" of generative phonology (Chomsky and Halle 1968), segments that are predictable must be derived by phonological rule; such segments are not allowed in underlying forms. The glottal stop in Thai, however, suggests that this proposed constraint on a theory of phonology is too strong. In this paper I will attempt to show that even though the glottal stop could be derived by phonological rule, it must still be present in underlying forms; otherwise linguistically significant generalizations are either obscured or left totally unexpressed.

There has been much disagreement among Thai linguists over whether the glottal stop is present in underlying forms (or their equivalent) or not. Those who have assumed the former include Henderson (1949), Haas

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(1964), Warotamasikkhadit (1967), and Surintramont (1973); those who have assumed the latter include Gedney (1947), Gillette (1955), Abramson (1962), Noss (1964), and Warutamasintop (1973).

In the first section of the paper I present the facts and compare two alternative solutions to the problem of the glottal stop. One solution omits the glottal stop from underlying forms; the other solution includes it. In the second section, I give internal linguistic evidence that supports the solution that includes the glottal stop in underlying forms.

ALTERNATIVE SOLUTIONS

In monosyllabic forms like those in (1), the glottal stop occurs phonetically in both initial and final position.

(1)

Initial Position		Final Position	
baw	'be light'	phùt	'to emerge'
?aw	'to take'	phù?	'be rotten'
fay	'fire'	sàp	'vocabulary'
?ay	'stream'	sà?	'to shampoo'
tòk	'to fall'	lák	'to steal'
?òk	'breast'*	lá?	'to abandon'

The glottal stop could be inserted in final position after a single vowel when no other final segment is present, and in initial position before a vowel when no other initial segment is present.

(2) $\emptyset \rightarrow ʔ \;/\; \#\_\_\_ V$

(3) $\emptyset \rightarrow ʔ \;/\; CV \_\_\_ \#$

In the polysyllabic forms in (4) the glottal stop occurs in medial position in citation forms only. (The citation form is used when speaking in a slow deliberate style of speech or when carefully pronouncing the word in isolation; the surface form is used when speaking in a normal conversational style of speech.)

(4)

Citation Form		Surface Form
kàʔwii	'poet'	kawii
sàʔtaaŋ	(Thai monetary unit)	sataaŋ
máʔláʔkɔɔ	'papaya'	malakɔɔ
ʔàʔnúʔyâat	'to allow'	ʔanúyâat
máʔphráaw	'coconut'	maphráaw
tàʔkray	'scissors'	takray

The citation forms could be derived by inserting the glottal stop after short open syllables.

(5) $\emptyset \rightarrow ʔ \;/\; V\_\_\_ \; C \; \left(\begin{Bmatrix} l \\ r \\ w \end{Bmatrix}\right) \; V$

In other polysyllabic forms such as those in (6) the glottal stop also occurs in medial position in surface forms.

(6)

Citation Form		Surface Form
sà??àat	'be clean'	sa?àat
lá??ìat	'be detailed'	la?ìat
chà??ɔ̂ɔn	'to coax'	chà?ɔ̂ɔn
sà??ew	'waist'	sa?ew

The surface forms could be derived by inserting a glottal stop after a short open syllable followed by a vowel.

(7) $\emptyset \rightarrow ? \ / \ CV\_\_\_V$

Still another rule would be required to geminate the glottal stop in this environment in citation forms.

On the other hand, if the input forms to the abovementioned rules contain a syllable boundary, we can reformulate rules (2) and (3) as (8) and eliminate rules (5) and (7).

(8) $\emptyset \rightarrow ? \ / \ \begin{cases} \$\_\_\_V & \text{(i)} \\ CV\_\_\_\$ & \text{(ii)} \end{cases}$

Sample derivations for the citation forms are given in (9) (a morpheme boundary (+) includes a syllable boundary ($), see Hooper 1972).

(9)					
	Underlying Form:	+aàn+ 'to read'	+sà + 'to shampoo'	+à$nú$yaât+ 'to allöw'	+sà$aàt+ 'be clean
	Rule 8 (i)	+?aàn+	--	+?à$nú$yaât+	+sà$?aàt+
	Rule 8 (ii)	--	+sà?+	+?à?$nú?$yaât+	+sà?$?aàt+
	Citation Form:	?aàn	sà?	?à?nú?yaât	sà??àat

To derive the correct surface forms (11), however, another rule (10) is required that deletes word-medial occurrences of the glottal stop.

$$(10)\quad ? \rightarrow \emptyset \; / \; CV\_\_C \; \left(\begin{Bmatrix} l \\ r \\ w \end{Bmatrix}\right) \; V$$

(11) Surface Form: ?aàn sà? ?anúyaât sa?aàt

So far, I have shown that it is possible to predict the occurrences of the glottal stop with a syllable boundary and two phonological rules—the glottal stop insertion rule (8) and the glottal stop deletion rule (10).

Next I want to consider an alternative solution that assumes the glottal stop is present in underlying forms. This solution requires only one rule (12) that deletes word-medial occurrences of the glottal stop in the derivation of surface forms.

$$(12)\quad ? \rightarrow \emptyset \; / \; \_\_C$$

Sample derivations are given in (13)

(13)

Underlying Form:	+?àan+ 'to read'	+sà?+ 'to shampoo'	+?à?nú?yâat+ 'to allow'	+sà??àat+ 'be clean'
Citation Form:	?àan	sà?	?à?nú?yâat	sà??àat
Rule (12)	--	--	?anúyâat	sa?àat
Surface Form:	?àan	sà?	?anúyâat	sa?àat

The polysyllabic forms in (14) that contain internal morpheme boundaries show clearly that rule (12) also applies across morpheme boundaries.

(14)

Underlying Form:	phǒnlá? +máay 'fruit' 'wood' 'fruit'	rátthà? +sàat 'state' 'science' 'political science'	má?nútsà?yá?+châat 'man' 'nationality' 'mankind'
Citation Form:	phǒnlá?máay	rátthà?sàat	má?nútsà?yá?châat
Surface Form:	phǒnlamáay	rátthasàat	manútsayáchâat

I have now presented two alternative solutions to the problem of the glottal stop in Thai. One solution excludes the glottal stop from underlying forms, the other solution includes it in underlying forms. Both solutions can account for the same data. In the next section, I will show, however, that the internal linguistic evidence supports the latter solution.

EVIDENCE IN SUPPORT OF AN UNDERLYING GLOTTAL STOP

I this section five arguments are given in favor of the solution that includes the glottal stop in underlying forms.

(a) To select the glottal stop as the segment to be inserted by rule is totally arbitrary. One could just as easily have chosen to insert one of the other segments that occurs in syllable-initial or syllable-final position. For example, among the obstruents only /p t k ʔ/ occur in syllable final position. If /p/ were selected as the segment to be inserted by rule, one could say that /p/ occurs in syllable-final position after a single vowel when no other final segment is present.

(b) If a glottal stop is present in underlying forms, the statement of distribution of the five lexical tones in Thai can be simplified.

All five tones–mid, low, falling, high, rising–may occur on a syllable that ends in a vowel, nasal, or semi-vowel. Only a low or high tone may occur on a syllable that ends in a stop (p t k ʔ) preceded by a short vowel; only a low or falling tone may occur on a syllable that ends in a stop (p t k) preceded by a long vowel or diphthong.

A summary of the restrictions on the distribution of the five lexical tones and examples is presented in Table I ('+' indicates that the tone (column) may occur on the syllable structure (row); '–' indicates that the tone may not occur.) Examples are given in Table II.

TABLE I

	Mid	Low	Falling	High	Rising
CVV	+	+	+	+	+
CV(V)N	+	+	+	+	+
CV(V)G	+	+	+	+	+
CVS	−	+	−	+	−
CVʔ	−	+	−	+	−
CVVS	−	+	+	−	−

N = m n ŋ
G = w y
S = p t k

Note that the tonal restriction on a syllable that ends in a glottal stop preceded by a single vowel is identical to the restriction on a syllable that ends in /p t k/ preceded by a single vowel. If the glottal stop is present in syllable-final position in underlying forms, then the tonal restriction can be stated in a straightforward manner: only low or high tone may occur on a syllable that contains a single vowel followed by a stop. If the glottal stop is not present in syllable-final position in underlying forms, then we are left to explain the peculiar distribution of the low and high tone. Why should a CV syllable carry only a low or high tone, while other syllables that end in a sonorant segment carry all five tones? Moreover, why should a CV syllable have the same restriction on tones as a CVS syllable? These anomalous restrictions disappear if the glottal stop is present in underlying forms.

TABLE II

Mid	Low	Falling	High	Rising
maa 'to come'	khaà 'galangal'	khaâ 'to kill'	ruú 'to know'	sǐa 'tiger'
pen 'to be'	sàn 'to vibrate'	tôn 'tree'	naám 'water'	phǒn 'result'
fay 'fire'	kày 'chicken'	lâw 'liquor'	raáy 'be evil'	khaǎy 'to sell'
	sàp 'vocabulary'		ráp 'to receive'	
	sàt 'animal'		rát 'state'	
	phàk 'vegetable'		lák 'to steal'	
	tè? 'to kick'		lá? 'to abandon'	
	baàp 'sin'	ruûp 'picture'		
	baàt 'Thai monetary unit'	riît 'to iron'		
	dɔɔ̀k 'flower'	phaâk 'region'		

(c) In citation from there are a large number of disyllabic morphemes in which the initial syllable has the shape CV? and carries low tone, and the final syllable begins in a sonorant segment. In this environment, the final syllable carries rising tone if it ends in a sonorant segment, low tone if it ends in /p t k ?/. This morpheme structure condition does not apply if either the initial syllable carries high tone or the final syllable begins in a nonsonorant segment. Examples are given in (15).

(15)	Citation Form		Surface Form
	sàʔwǎn	'heaven'	sawǎn
	thàʔnǒn	'road'	thanǒn
	chàʔlǝ̌ǝy	'to answer'	chalǝ̌ǝy
	sàʔmùt	'ocean'	samùt
	càʔrìt	'conduct'	carìt
	sàʔnùk	'be fun'	sanùk
	sàʔràʔ	'vowel'	saràʔ
but	sàʔphaa	'assembly'	saphaa
	sàʔkun	'family line'	sakun
	pháʔlaŋ	'power'	phalaŋ
	cháʔlǝǝy	'prisoner of war'	chalǝǝy

Most of the exceptions are non-Indic loanwords. Gedney (1947, 59) notes one word of Pali-Sanskrit origin that violates this constraint—*samaakhom* 'club' /+ sàʔmaa + khom +/.

If no syllable-final glottal stop is present in underlying forms, then the morpheme structure condition would have to be complicated in order to handle forms like /saràʔ/ 'vowel'. Rather than simply saying that a low tone accompanies a final syllable that ends in a stop consonant, the morpheme structure condition would have to say that a low tone accompanies a final syllable that ends in a stop consonant or a single vowel. Why should this be so? Once again, the presence of the glottal stop in the underlying form permits a phonetically-motivated, economical generalization.

(16) ʔɔ́ksicen 'oxygen'
kúuk 'call of a nightbird'
báa 'bah!'

(d) Co-occurrence restrictions that obtain between tone and syllable initial consonants also point to a glottal stop in the underlying form.

No high or rising tone occurs on a syllable that begins in an unaspirated stop consonant (p b t d c k ʔ). Forms such as *tǎa *bǎa *ʔúu are not allowed. The exceptions to this restriction fall into well-defined morpho-syntactic classes: non-Indic loanwords, onomatopoeic words, and exclamations.

The glottal stop then behaves like other syllable-initial consonants of the same type. With a glottal stop present in the underlying form, the environment for this tonal restriction is simply $\$ \left\{\begin{matrix} -\text{sonorant} \\ -\text{continuant} \\ -\text{aspirated} \end{matrix}\right\}$;

otherwise, the environment would also have to include a vowel. We are then left to explain why a syllable that begins in either a vowel or an unaspirated stop should have the same effect on tone.

(e) With a glottal stop present in the underlying form, every syllable on the phonological level of representation begins with a consonant and every short syllable ends with a consonant. The structure of the phononological syllable may be symbolized as (17).

$$(17) \quad \$ \quad C \quad (C) \quad \left\{ \begin{matrix} VC \\ VV(C) \end{matrix} \right\}$$

Without a glottal stop present in the underlying form, syllables that begin and end in a vowel would also have to be allowed for. A CV syllable does of course occur on the phonetic level of representation.

CONCLUSION

Whether a segment should be present in the underlying form or not depends on more than one part of the grammar. A segment that can be derived by phonological rule must not necessarily be abstracted out of the underlying form. The Thai glottal stop is just such a segment. Unless it is present in the underlying form, certain linguistically significant generalizations are either obscured or lost altogether.

REFERENCES

Abramson, Arthur S. (1962), "The vowels and tones of Standard Thai : acoustical measurements and experiments," *International Journal of American Linguistics* 28.2 (part 3).

Chomsky, Noam and Morris Halle (1968), *The Sound Pattern of English*, Harper and Row, New York.

Gedney, William J. (1947), *Indic Loanwords in Spoken Thai*, Unpublished doctoral dissertation, Yale University.

Gillette, Josephine A. (1955), *Prosodic Feutures of Bangkok Thai*, Unpublished master's thesis, Georgetown University.

Haas, Mary R. et. al. (1964), *Thai-English Student's Dictionary*, Stanford University Press.

Hooper, Joan (1972), "The syllable in phonological theory," *Language* 48.3:525-540.

Noss, Richard B. (1964), *Thai Reference Grammar*, U.S. Government Printing Office, Washington, D.C.

Surintramont, Aporn (1973), "Some aspects of underlying syllable structure in Thai : evidence from Khamphuan–a Thai word game," *Studies in the Linguistic Sciences*, 3.1:121-142.

Warotamasikkhadit, Udom (1967), "Some phonological rules in Thai," *Journal of the Americam Oriental Society* 87.4:541-574.

Warutamasintop, Worawut (1973), "The syllable boundary in Thai phonology," Unpublished paper, UCLA.

Section 4. On the Representation of Tone in Siamese

ON THE REPRESENTATION OF TONE IN SIAMESE[1]

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Introduction

It has recently been suggested for Siamese (or Standard Thai, the national language of Thailand) that phonological tone be represented as a feature on segments (Hiranburana 1971, Leben 1971a, 1971b, 1973a, 1973b) and that phonological contour tones be represented with sequences of level tone features.

Unfortunately, the facts upon which both authors base their arguments are incorrect. Their arguments depend crucially on the simplification of contour tones to level tones in certain positions in fast, casual speech. The results of acoustical measurements of tones in these positions in fast, casual speech (cf. Section 2), however, indicate that the contour tones do not change to level tones, thus making their arguments un-acceptable. Nonetheless, there are other facts in the language that do lend support to their position (cf. Section 3). This paper will argue for treating tones segmentally in Siamese and contour tones as sequences of level tones on the phonological level of representation.

There are 4 main sections in this paper. In Section 1, facts on the phonetic shapes of tones on monosyllabic citation forms are presented. In Section 2, the results of acoustical investigation of tones in certain positions in fast, casual speech are discussed. In Section 3, the other facts are cited that do support a segmental analysis of tone in Siamese, and a sequential analysis of contour tones. In Section 4, a case of tone neutralization is examined in view of different proposed sets of distinctive features of tone.

1. Phonetic shapes of tones in slow, deliberate speech

Siamese has 5 contrastive tones on 'smooth' syllables (i.e., those syllables ending in a nasal, glide, or vowel): (1) mid-level MID ( ), (2) low-level LOW (\`), (3) high-rising-falling FALLING (^), (4) high-rising HIGH (´), (5) low-rising RISING (ˇ).

(1) khaa 'be stuck'

(2) khàa 'a kind of spice'

(3) khâa 'to kill'

(4) kháa 'to engage in trade'

(5) khǎa 'leg'

The average fundamental frequency contours for these 5 contrastive tones pronounced on monosyllabic citation forms containing double vowels are represented graphically in Figure 1 (adapted from Abramson 1962: 127).

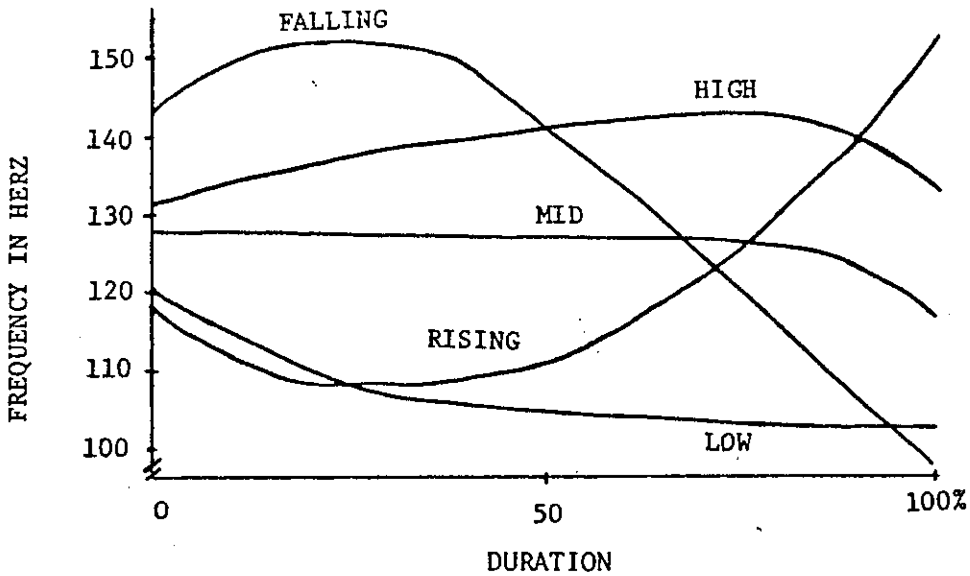


Figure 1
Average Fundamental Frequency Contours for Tones on Double Vowels

For a discussion of consonantal influences on these fundamental frequency contours, see Gandour (1974a).

On 'checked' syllables (i.e., those syllables ending in p t k ʔ) there are only 3 contrastive tones. For 'short' checked syllables (i.e., those checked syllables containing a short vowel) a low-level tone contrasts with a high-level tone; for 'long' checked syllables (i.e., those syllables containing a long vowel or diphthong), a low-level tone contrasts with a high-rising-falling tone. The tones on these checked syllables may be regarded as phonetics variants of the contrastive tones on the smooth syllables--the low-level tone being associated with (2) LOW, the high-level tone being associated with (4) HIGH, the high-rising-falling tone being associated with (3) FALLING.

(2)	phìt	'be wrong'
(4)	phít	'poison'
(2)	yàak	'to want'
(3)	yâak	'be difficult'

Interestingly enough, such an analysis based on the principles of phonetic similarity and complementary distribution agrees with the 'traditional' numbering of tones in Siamese (Gedney 1969: 424). However, whether or not one chooses to identify the tones on the checked syllables with those that occur on smooth syllables is not relevant to the theoretical questions raised in this paper.

The MID and RISING tones never occur on checked syllables. The FALLING tone occurs on short checked syllables in only a few words, e.g., k^hlâk 'be crowded'; the HIGH tone occurs on long checked syllables in only onomatopoetic and non-Indic loanwords, e.g. kúuk 'call of a night-bird', káat 'gas'.

2. Phonetic shapes of tones in fast, casual speech

2.1 Conflicting presentations of the facts

The facts concerning the phonetic shapes of tones in fast, casual speech have been disputed by Siamese scholars. The disagreement revolves around the *number* and *type* (level or contour) of contrastive tones possible in certain unstressed positions. No less than four different presentations of the facts have appeared in the literature (Henderson 1949, Noss 1964, Hiranburana 1971, Surintramont 1973, among others).

Table I below gives a summary of the four different presentations. The tones listed in the leftmost column are the lexical tones (i.e. those tones that occur on monosyllabic citation forms); the tones listed in columns (i), (ii), (iii), and (iv) are the sandhi tones (i.e. those tones that are reported to occur in certain positions in connected speech). At the intersection of a given column and row is the sandhi tone corresponding to the lexical tone in the same row.

LEXICAL TONES	SANDHI TONES			
	(i) Henderson (1949) Leben (1973)	(ii) Gillette (1955) Noss (1964)	(iii) Hiranburana (1971)	(iv) Warotamasik-khadit (1967) Surintramont (1973)
HIGH	HIGH	HIGH	HIGH	HIGH
FALLING	MID	HIGH	HIGH	FALLING
RISING	MID	HIGH	HIGH/LOW	RISING
MID	MID	NONHIGH	MID	MID
LOW	LOW	NONHIGH	LOW	LOW

Table 1
Sandhi tones in fast casual speech: four presentations

LEXICAL TONES	SANDHI TONES (i)	(ii)	(iii)	(iv)
pùu + naa 'Grandfather Naa' 'paternal 'name' grandfather'	LOW	NONHIGH	LOW	LOW
puu + naa 'landcrab' 'crab' 'field'	MID	NONHIGH	MID	MID
mɔ̂ɔ + yaa 'medicine pot' 'pot' 'medicine'	MID	HIGH	HIGH	FALLING
mɔ̌ɔ + yaa 'doctor' 'doctor' 'medicine'	MID	HIGH	HIGH	RISING
khɔ̂ɔ + tɔ̀ɔ 'joint' 'point' 'to connect'	MID	HIGH	HIGH	FALLING
khɔɔ + tɔ̀ɔ 'nape' 'neck' 'to connect'	MID	NONHIGH	MID	MID
nâa + náam 'riverbank' 'front' 'water'	MID	HIGH	HIGH	FALLING
náa + náam 'Aunt/Uncle Nam' 'younger' 'name' aunt or uncle'	HIGH	HIGH	HIGH	HIGH
khɔ̌ɔŋ + hæ̂æŋ 'dry foodstuffs' 'thing' 'to be dry'	MID	HIGH	LOW	RISING
thɔɔŋ + thæ̂æŋ 'gold ingots' 'gold' 'bar'	MID	NONHIGH	MID	MID
mǎa + khæ̀ŋ 'race dog' 'dog' 'to compete'	MID	HIGH	HIGH	RISING
máa khæ̀ŋ 'racehorse' 'horse' 'to compete'	HIGH	HIGH	HIGH	HIGH

Table 11
Sandhi tones on the first member of bisyllabic noun compounds according to (i), (ii), (iii), and (iv).

Analyses of tone sandhi phenomena in Siamese have differed considerably depending on which account of the facts the author accepts. Henderson (1949) and Leben (1971a, 1971b, 1973a, 1973b) base their analysis on (i), Gillette (1955) and Noss (1964) on (ii), Hiranburana (1971) on (iii) and Warotamasikkhadit (1967) and Surintramont (1973) on (iv).

(i), (ii), (iii), and (iv) represent different claims about the number and type of sandhi tones that contrast in fast, casual speech. (i) claims that three level sandhi tones contrast--HIGH, MID, and LOW with the FALLING and RISING contour tones changing to the MID level tone; (ii) claims that only 2 level sandhi tones contrast--HIGH and NONHIGH, with FALLING and RISING contour tones changing to HIGH level tone and LOW and MID merging into NONHIGH; (iii) claims that three level sandhi tones contrast--HIGH, MID, and LOW, with the FALLING contour tone changing to a HIGH level tone, the RISING contour tone changing to a HIGH level tone on syllables that begin with a voiced consonant and a LOW level tone on syllables that begin with a voiceless consonant; (iv) claims that the contrast between all five lexical tones is maintained in fast, casual speech.

All the authors mentioned above who accept (i), (ii), or (iii) agree that the neutralization of contour tones in fast casual speech takes place on the unstressed initial syllable (containing a *long* vowel) of bi-syllabic noun compounds. The list of minimal/near-minimal pairs of noun compounds in Table II illustrates the different claims made by (i), (ii), (iii), and (iv). The tones in the numbered column are the sandhi tones that are supposed to occur on the first member of the noun compound in fast, casual speech according to the different analyses.

2.2 Methods and materials: acoustical investigation of tones in fast, casual speech

In order to test which one of the 4 accounts is correct, pairs of bisyllabic noun compounds distinguished minimally or near-minimally by the lexical tone that occurs on the initial syllable were selected as test material. For each compound, the initial syllable contained a long vowel.

The list included as many pairs of noun compounds that could be found with a minimal contrast in lexical tones on the first member followed by a MID, LOW, FALLING, HIGH, RISING tone on the second member of the compound. 45 such pairs of bisyllabic noun compounds are possible; 29 were found. Only words that actually occur were used in the study. They are given in Table III. Parenthesized numbers indicate that no actually occurring minimal pair of noun compounds could be found with that particular combination of tones.

Each pair of noun compounds was placed in an identical sentence context, for example:

chǎn 'I'	chôop 'like'	khâawthay 'Thai rice' chaawthay 'Thai people'
man 'it'	pen 'is'	khôotòo 'joint' khootòo 'nape of neck'

A reading list was prepared containing 164 sentences (3 tokens of each of the 58 members of 29 pairs of noun compounds) and written in the Siamese alphabet.

The reading list was arranged in random order and then read by the speaker, first at a slow speech tempo, and then at a fast speech tempo. For the former, the speaker was told to "speak in a slow, deliberate speech style"; for the latter, the speaker was told to "speak as fast as you can while maintaining a natural speech rhythm".

Recordings were made from the speech of 3 Thai nationals speaking Siamese--2 male (24 and 34 years old) and 1 female (28 years old). The female subject and the younger male subject were born and raised in the capital city of Bangkok. The older of the male subjects came from Nakhon Phanom province in the northeastern part of Thailand.

The tapes were then analyzed by the pitch extraction system at the UCLA Phonetics Laboratory. A Siemens Oscillomink paper recording device registered the fundamental frequency curves continuously and, on a separate channel, a continuous oscillogram of the wave form. A phonetic transcription from the tapes was added to the oscillogram. Segmentation was based on characteristic features of the recorded wave forms and fundamental frequency curves. Frequency values were read off the oscillogram with a pitch scale (0.5 mm = 2.5 hz) prepared from a tape with pure tones of known frequency.

Measurements of duration of the initial syllable in the noun compounds were made from oscillograms as well as narrow-band spectrograms (made from a Kay Sound Spectrograph). Only those fast speech tokens whose durations were less than or equal to half of the average duration of the 3 slow speech tokens were selected for pitch measurements. By this procedure, fast speech was operationally defined as being at least twice as fast as slow speech. Both oscillograms and narrow-band spectrograms were used for comparing the pitch curves of the slow and fast speech tokens of each member of a pair of noun compounds.

1st Member of Noun Compound	M	L	F	H	R
		2nd Member of Noun Compound			
LOW/MID	1	(2)	(3)	4	(5)
HIGH/MID	(6)	7	8	(9)	(10)
FALLING/HIGH	11	(12)	13	14	(15)
FALLING/MID	16	17	18	19	20
FALLING/LOW	21	(22)	(23)	(24)	25
FALLING/RISING	26	27	28	29	30
RISING/HIGH	(31)	32	33	34	(35)
RISING/MID	36	37	38	(39)	40
RISING/LOW	41	42	43	(44)	(45)

1. pùunaa 'Grandfather Naa'
   puunaa 'landcrab'

(2)

(3)

4. pòoŋmáay 'hollow log'
   pooŋmáay 'wooden bell'

(5)

(6)

7. máapàa 'wild horse'
   naapàa 'cultivable land'

8. cháaŋbâan 'domesticated elephant'
   thaaŋbâan 'person(s) at home'

(9)

(10)

11. nâataa 'looks'
    náataa 'Aunt/Uncle Taa'

(12)

13. nâabâan 'front of house'
    máabâan 'domesticated horse'

14. nâamáay 'crossbow'
    náamáay 'Aunt/Uncle May'

(15)

16. khâawthay 'Thai rice'
    chaawthay 'Thai people'

17. khôɔtɔ̀ɔ 'joint'
    khɔɔtɔ̀ɔ 'nape'

18. nâabâan 'front of house'
    naabâan 'lawn'

19. nâanáam 'riverbank'
    naanáam 'waterfield'

20. khôɔhǎa 'charge'
    khɔɔhɔ̌y 'throat'

21. pâadææŋ 'Aunt Daeng'
    pàadææŋ 'deciduous forest'

(22)

(23)

(24)

25. khâawsǎan 'husked rice'
    khàawsǎan 'news'

26. môɔyaa 'medicine pot'
    mɔ̌ɔyaa 'doctor'

27. môɔkhày 'pot for eggs'
    mɔ̌ɔkhày 'Dr. Khay'

28. môɔkhâaw 'rice pot'
    mɔ̌ɔkhâaw 'Dr. Khaaw'

29. khôɔtháaw 'ankle'
    khɔ̌ɔŋáaw 'a kind of weapon'

30. môɔphǐi 'mystery pot'
    mɔ̌ɔphǐi 'witch doctor'

(31)

32. mǎakhæ̀ŋ 'racedog'
    máakhæ̀ŋ 'racehorse'

33. mǎabâan 'dog'
    máabâan 'domesticated horse'

34. mǎamáay 'a kind of squirrel'
    máanáam 'seahorse'

(35)

36. khɔ̌ɔŋcham 'dry foodstuffs'
    thɔɔŋkham 'gold'

37. mǎapàa 'wolf'
    naapàa 'cultivable land'

38. khɔ̌ɔŋwâan 'snack'
    thɔɔŋyɔ̂ɔn 'title of Thai song'

(39)

40. khɔ̌ɔŋluǎŋ 'property of royal family'
    thaaŋluǎŋ 'public highways'

41. mǔudææŋ 'a pork dish'
    mùudææŋ 'Sgt. Daeng'

42. khǎaʔɔ̀ɔn 'thigh'
    khàaʔɔ̀ɔn 'a kind of spice'

43. mǔubâan 'domesticated pig'
    mùubâan 'village'

(44)

(45)

Table 111
List of noun compounds used as test material according to tonal combinations on first and second member of compound.

2.3 Results: acoustical investigation of tones in fast, casual speech

Acoustical measurements of tones on the first syllable in bisyllabic noun compounds show that none of the tone neutralizations implied in (i), (ii), or (iii) ever occur, i.e. the contrast between all 5 lexical tones is maintained in fast, casual speech. In other words, (iv) is correct.

In particular, the FALLING and RISING contour tones do not neutralize to MID level tone. They simply become progressively shorter in shorter stretches of time.

Oscillograms and narrowband spectrograms of representative fast speech tokens for a few pairs of noun compounds are given in Figure 2 below. The number accompanying each pair corresponds to the number of the noun compound pair in the list given in Table III.

2.4 Discussion: acoustical investigation of tones in fast casual speech

Earlier investigations of sandhi tones in fast, casual speech apparently were not carried out with the use of systematically controlled sentence frames. Thus, we find enormous discrepancies in the presentation of the facts from author to author.

With the aid of reliable instruments, however, we see that the tonal distinctions are preserved in the fast style of speech, as correctly observed by native Thai scholars like Warotamasikkhadit (1967) and Surintramont (1973). No instruments had been used in the earlier investigations.

Some might object that the subjects simply were not speaking at a rate that would normally be associated with the fast, casual speech style. The operational definition of fast speech 'twice as fast as slow speech'. However, seems quite reasonable. In a study of English diphthongs, Gay (1968) found the same order of magnitude between the mean diphthong durations for slow speech and fast speech, i.e. the diphthongs in slow speech are approximately twice as long (in msec) as in fast speech.

3. Theoretical issues regarding tone in Siamese

In this section, various theoretical issues currently being debated on the role of tone in a generative phonology (Woo 1969,

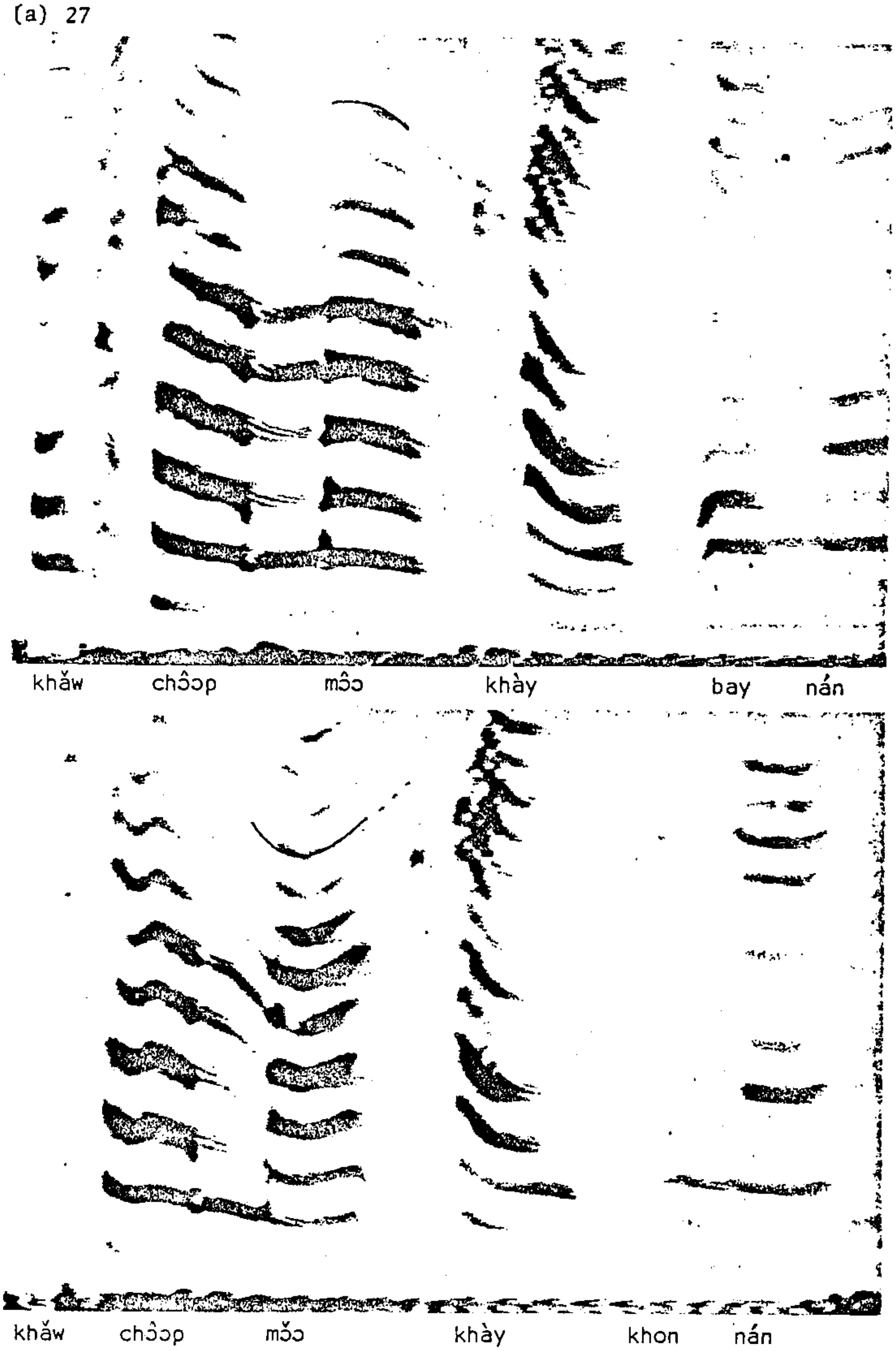
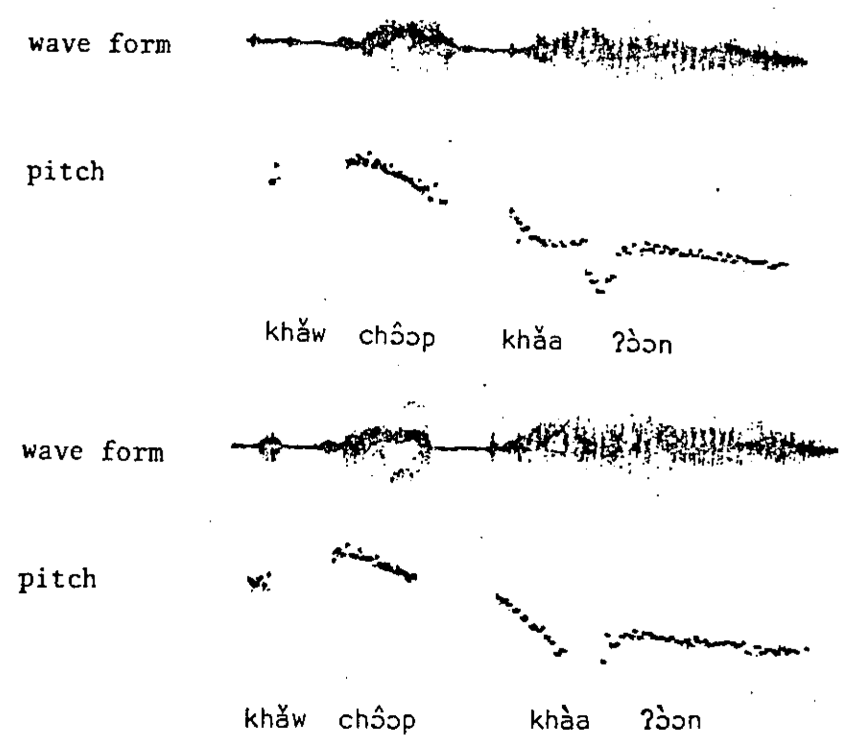


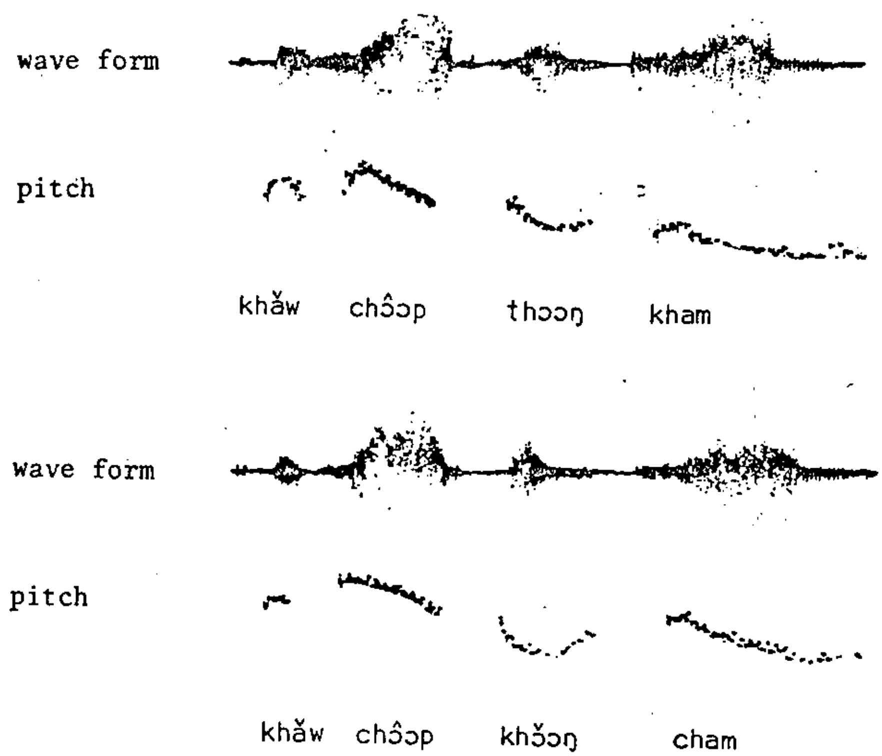
Figure 2
Narrowband spectrograms (a) and oscillograms (b-f) of representative fast speech tokens of pairs of noun compounds.

(b) 42.



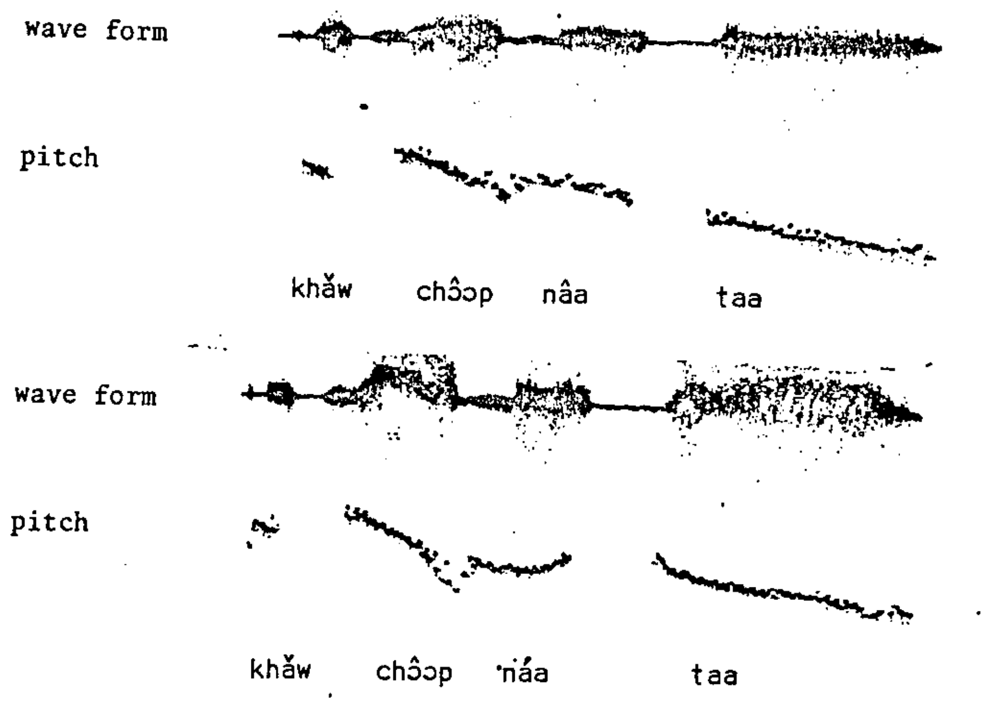
wave form
pitch
khǎw chôɔp khǎa ʔɔ̀ɔn
wave form
pitch
khǎw chôɔp khàa ʔɔ̀ɔn

(c) 36.

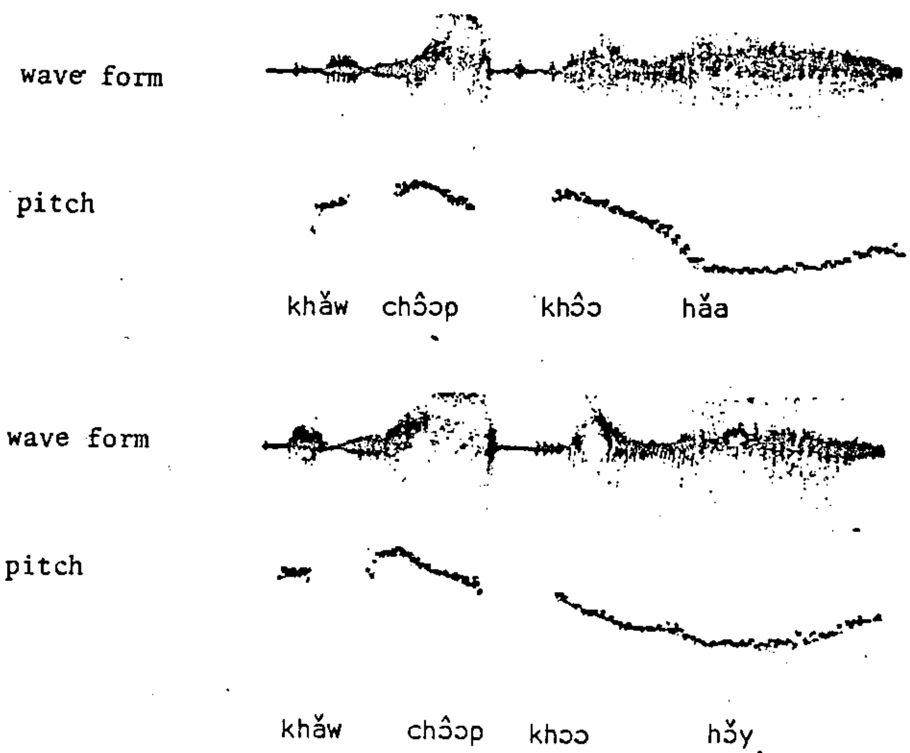


wave form
pitch
khǎw chôɔp thɔɔŋ kham
wave form
pitch
khǎw chôɔp khɔ̌ɔŋ cham

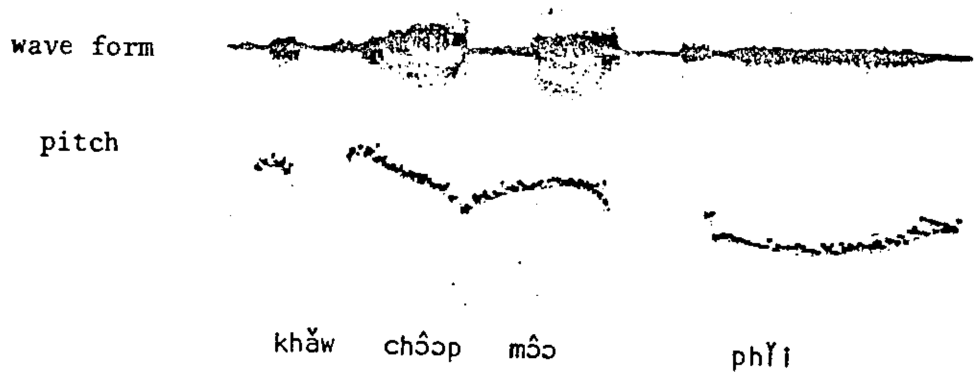
(d) 11.

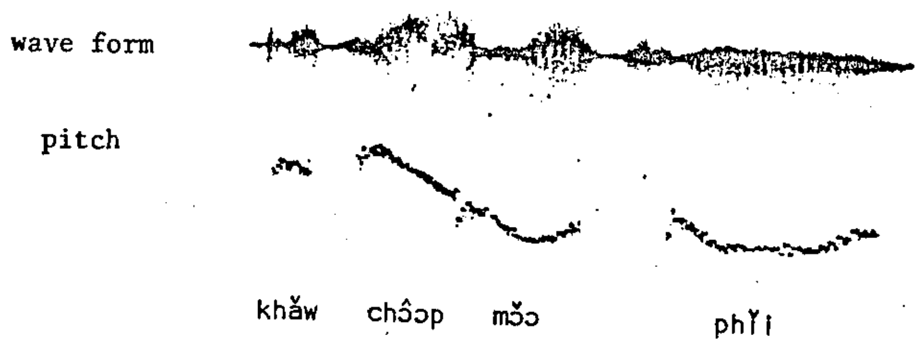

wave form
pitch
khǎw chɔ̂ɔp nâa taa
wave form
pitch
khǎw chɔ̂ɔp náa taa

(e) 20.


wave form
pitch
khǎw chɔ̂ɔp khɔ̂ɔ hǎa
wave form
pitch
khǎw chɔ̂ɔp khɔɔ hɔ̌y

(f) 30.





Maddieson 1970; Halle and Stevens 1971, Fromkin 1972, Leben 1973, among others) are discussed. In Section 3.1, the arguments advanced by Leben (1971a, 1971b, 1973a, 1973b) and Hiranburana (1971) for a segmental representation of tone in Siamese are shown to be inadequate, since they depend crucially on the simplification of contour tones in fast casual speech (cf. Section 2.3). Nevertheless, other arguments for a segmental representation of tone in Siamese can be made. These arguments are presented as well as arguments for representing contour tones as sequences of level tone features in Section 3.2.

3.1 Previous arguments for segmental tone features in Siamese

Traditionally, tone in Siamese has been considered to be a property of the syllable. More recently, it has been proposed (Leben 1971a, 1971b, 1973a, 1973b, Hiranburana 1971) that tone is a property of an individual voiced segment, not the syllable.

According to Leben (1973b) tone must be analyzed as a feature on segments if and only if at some point in the derivation it is sensitive to phonological rules that either (1) contain information about surrounding segments or (2) collapse two or more segments into one.

Regarding the second type of phonological rule, the collapsed segment is in some sense to be interpreted as a "compromise" (Leben's term) between the original underlying segments, i.e., the collapsed segment is composed of some of the features of each of the original underlying segments. Leben cites nasalized vowels in French as an example of a collapsed segment that results from a compromise between a vowel and a following nasal consonant. A schematic representation of such a vowel nasalization rule is given below:

$$\begin{array}{lccccc} \text{segments} & V & + & N & \rightarrow & \tilde{V} \\ \text{features} & \begin{bmatrix} +\text{vocalic} \\ -\text{nasal} \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} & & \begin{bmatrix} -\text{vocalic} \\ +\text{nasal} \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} & \Longrightarrow & \begin{bmatrix} +\text{vocalic} \\ +\text{nasal} \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} \end{array}$$

The collapsed segment that results from the application of this rule--the nasalized vowel--has inherited the +vocalic feature of the V, the +nasal feature of the N, thus is a compromise between the underlying segments V and N.

A more familiar example to which Leben's compromise convention would apply is the contraction of ai to æ in Sanskrit where the collapsed segment keeps the lowness of the first vowel and the backness of the second vowel.

Xhosa is cited as an example of a tone language where tone behaves segmentally according to his first criterion. Leben (1973b, 23) gives the following description of a phonological rule: "a high tone is realized as rising when preceded by a depressor consonant, such as bɦ, mbɦ, mɦ, v, ɦ, but not when preceded by consonants like p, ph, t, ɓ, m, f, h...a falling tone...is realized as rising-falling...when preceded by a number of this same class of depressor consonants".

Siamese is cited as an example of a tone language where tone behaves segmentally according to the second criterion. Before looking at the particular rule Leben proposes, however, let us first consider the data and assumptions on which the rule depends.

Leben's data, taken from Henderson (1949), includes so-called 'compound' forms pronounced in a slow deliberate speech style and a fast casual speech style. They are listed below--the (a) forms occurring in slow speech, the (b) forms occurring in fast speech (examples taken from Leben 1971a).

	1.	(a)	thîi HL	nǎy LH	'where?'	(b)	thi M	nǎy LH
	2.	(a)	sǐi LH	khǎaw LH	'white'	(b)	si M	khǎaw LH
	3.	(a)	wâaŋ HL	wâaŋ HL	'at your leisure'	(b)	waŋ M	wâaŋ HL
	4.	(a)	sǎaw LH	sǎaw LH	'young girls'	(b)	saw M	sǎaw LH
	5.	(a)	náam H	chaa M	'tea'	(b)	nám H	chaa M
but	6.	(a)	tôŋ HL	kaan M	'want'	(b)	tôŋ HL	kàan L
	7.	(a)	thâw HL	ray M	'how much'	(b)	thâw HL	rày L

A few remarks must be made about these data. First, even though Leben (1973b: 20) acknowledges that some length is retained on vowels not followed by a consonant or glide in forms (1b) and (2b) as indicated in the original phonetic transcription (Henderson 1949: 97), he goes on to assume without any justification that the vowel is simply equivalent to a short vowel. Secondly, the indicated change from a M to L tone in forms (6b) and (7b) should probably be attributed to phrase final lowering of MID. A final LOW tone is also lowered. The presence of a falling tone preceding is not required for the lowering to occur. Thirdly, these data are incorrect as shown by the results of acoustical measurements of tones in fast casual speech (cf. Section 2.3).

Nonetheless, it is still instructive to consider the type of argument he presents. Leben's assumptions include:

(a) tone features are assigned to individual voiced segments in the syllable,

(b) long vowels are represented as sequences of two identical vowels,

(c) contour tones are represented as a sequence of level tone features,

(d) phonological tones are M L HL H LH for tone numbers 1 2 3 4 5, respectively (cf. Section 1), and

(e) the (a) forms above are underlying, the (b) forms are derived.

With this set of assumptions and the above set of data, Leben formulates a phonological rule that effects a compromise between a HL or LH sequence of tones when they occur on short vowels in fast casual speech.

(Vowel shortening) VV → V

This rule simply reduces a double vowel to a single vowel. Implicit to its operation, however, is a 'compromise convention' that produces a MID tone as the 'normal' result of a collapsing of a sequence of HL or LH tones.

$$
\begin{array}{lccccc}
\text{segments} & V & + & V & \rightarrow & V \\
\text{features} & \left\{ \begin{array}{c} \begin{bmatrix} +H \\ -L \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} \begin{bmatrix} -H \\ +L \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} \\ \text{(or)} \\ \begin{bmatrix} -H \\ +L \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} \begin{bmatrix} +H \\ -L \\ \cdot \\ \cdot \\ \cdot \end{bmatrix} \end{array} \right\} & & & \Rightarrow & \begin{bmatrix} -H \\ -L \\ \cdot \\ \cdot \\ \cdot \end{bmatrix}
\end{array}
$$

Consider now how the rule applies to forms (1) through (7). It simplifies the underlying contour tones to MID in derived forms (1b), (2b), (3b), and (4b). Because the underlying tone is level, no simplification occurs in derived form (5b). The underlying contour tones do not simplify in derived forms (6b) and (7b) because they do not occur on double vowels. If tones are assigned to segments and if the normal result of compromise between a sequence of HL or LH is M, then the simplification of contour tones follows automatically from the reduction of a double vowel to a single vowel. Even assuming the correctness of Leben's data, his explanation is still unsatisfactory.

First, there is evidence from other tone languages (cf. Maddieson 1972) as well as Siamese that the result of a compromise of a LH or HL sequence of vowels is more often H or L than M. In Siamese, a common variant pronunciation of the question particle rɨ̌ɨ is rɨ́, not *rɨ. The normally unstressed personal pronouns chǎn 'I', phǒm 'I (male)', and khǎw '3rd person' are pronounced chán, phóm, and kháw, respectively. The word for 'city hall,' however, would conform to Leben's compromise convention for sequences of level tone features. It is written in the Siamese alphabet with a RISING tone on the first syllable sǎalaaklaaŋ but normally pronounced with a MID tone on the first syllable [sələklaaŋ].

In this case, it does appear that a LH sequence has been restructured as a MID according to Leben's convention. But what about the word for 'book'? It is written in the Siamese alphabet as nǎŋsɨ̌ɨ, but pronounced as either [náŋsɨ̌ɨ] or [naŋsɨ̌ɨ].

Second, no formal definition of the compromise convention is provided by Leben, a conspicuous omission in view of his emphasis on formalism in grammar (Leben 1973b: 19). What are the constraints on its application? What types of segments and features may be compromised? How many features may be compromised?...

As stated, the compromise convention does not make a unique prediction. For example, in Ogoja Yala, a West African tone language, the compromise between a high tone followed by a low tone separated by a word boundary is a high tone, not a mid tone as Leben's convention would predict (data taken from Maddieson 1972: 958).

H # L (H) → H (H) e.g., má ɔ̀chí mɔ́chí 'see tree'

Maddieson (1972) gives numerous examples like the one from Ogaja Yala that strongly suggest that tones are arranged in a hierarchy of dominance. The dominance relationship between tones then determines which tone will appear in the contracted syllable. Until Leben states some such principles to motivate the output of his convention, it is not of any theoretical interest.

As extralinguistic evidence in favor of a segmental analysis, Leben (1973a, 1973b) cites one example taken from Haas (1969) from the Siamese word game khamphǔan 'word-reversal,' in which the syllable finals of adjacent words or syllables are interchanged.

regular form:	k → [ôn]	y → [ày]	'big bottom'
game form:	k → [ày]	y → [ôn]	

In this particular example, note that the tones move along with the segments. This is just what we would expect, according to Leben, if tone is a property of segments in Siamese.

Unfortunately, the one example cited by Leben is not representative of the game rules. Many examples can be found where the tone does *not* move with the shifted syllable-final segments (cf. Gandour, 1974c). For more examples from khamphǔan where the tone does not move along with the shifted syllable-final segments, see Surintramont (1973).

So, the word game data from Siamese is inconclusive. It neither argues for nor against a segmental analysis of tone. The cases where the segments shift independently of the tone demonstrate that tone features may behave differently from other segmental features. But it does not necessarily follow that just because tone features exhibit properties not shared by some of the other segmental features that tone must be established as a suprasegmental phenomenon.

Next let us consider the arguments advanced by Hiranburana (1971) in support of a segmental analysis of tone in Siamese. Based on data obtained from her own instrumental study of the phonetic shapes of tones in non-phrase-final positions (including initial syllables of bisyllabic noun compounds) in fast casual speech, Hiranburana, like Leben, cites putative neutralizations of contour tones as evidence is support of a segmental representation of tone in Siamese. Unlike Leben, however, she claims that the FALLING contour tone simplifies to HIGH level tone and the RISING contour tone simplifies to a HIGH or LOW level tone depending on the syllable-initial consonant.

Unfortunately, the results of her instrumental study are at best inconclusive. Six supposed examples illustrating the simplification of FALLING to HIGH (Hiranburana 1971: 181-84) are given. In 5 out of the 6 examples, the oscillograms do not support her point; the falling contour is clearly evident. The remaining example is the negative morpheme mây that is often realized phonetically as máy in unstressed positions. This is correct, but in no way represents an example of a regular productive phonological rule of the language. Eight supposed examples illustrating the simplification of RISING to either HIGH or LOW level tones (Hiranburana 1971: 185-89) are given. None, however, are instances of a regular rule. Two of her examples are náŋsɨ̌ɨ 'book' and the 3rd person pronoun kháw (cf. above). Another example náaw năaw yùu 'I'm cold' is an instance of an emphatic reduplication rule (cf. Abramson 1962: 16), not a regular tone simplification rule. In 3 of the 8 examples, the oscillograms fail to support her point; the rising contour is clearly present.

Her claim that the RISING tone is realized as LOW after voiceless consonants and HIGH after voiced consonants is immediately suspect based on results of instrumental investigations of the effect of preceding consonant types on pitch which indicate that voiceless and voiced consonants tend to raise and lower pitch, respectively (Lehiste and Peterson 1961, Lea 1973, Gandour 1974b). In particular, the first part of the RISING tone becomes higher not lower after voiceless consonants in Siamese (Gandour 1974b). Furthermore, the examples cited occur in totally different syntactic and prosodic contexts.

More examples of deficiencies in her experimental design could be pointed out, but suffice it to say that no conclusions can be drawn from her data.

Next consider her analysis itself. The notion 'optional pitch height' plays a crucial role. Optional pitch heights are "those which do not apply when the lexical item concerned does not contain the maximum number of sonorant segments" (Hiranburana 1971: 149). This is the way she tries to account for the restrictions on the distribution of MID, LOW, FALLING, HIGH, RISING tones (cf. Section 1.1). Her lexical tones for Siamese are shown in Table IV below. The distinctive features for tone are adopted from Woo (1969); the optional pitch heights are enclosed in parentheses.

	MID	LOW	FALLING	HIGH	RISING
HIGH	- - -	- (-) -	(+) + -	(+)(+) +	- - +
LOW	- - -	+ (+) +	(-) - +	(-)(-) -	+ + -
MODIFY	- - -	- (-) -	(-) - -	(-)(-) -	- - -

Table IV
Lexical tones in Siamese (Hiranburana 1971)

The optional pitch heights are supposed to explain why the FALLING tone occurs on syllables that contain either 2 or 3 sonorant segments, but not on syllables that contain only 1 sonorant segment (for example, khâa 'to kill,' khâaw 'rice,' but not *khâp), and similarly why LOW or HIGH tones occur on syllables containing 1, 2, or 3 sonorant segments (for example, phàk 'vegetable', màak 'betel', khàaw 'news', nók 'bird', máa 'horse', and cháaŋ 'elephant'). For the MID and RISING tones, on the other hand, all 3 pitch heights are obligatory. This is necessary in order to rule out the possibility of a MID or RISING tone occurring on a long checked syllable.

Such an analysis has undesirable consequences, however. It forces one to represent 2-sonorant segment syllables carrying a MID or RISING tone with an underlying string of 3 sonorant segments since all 3 pitch heights are obligatory for the MID and RISING tones, resulting in hypothetical lexical entries that never surface phonetically.

/*khaaa/ MMM	'a kind of grass'	[kha:]
/*khaaa/ LLH	'leg'	[khǎ:]
/*khaww/ LLH	'mountain'	[khǎu]
/khaaw/ LLH	'white'	[khǎ:u]

Implicit in this analysis is a contrast between long and short glides as well as long and short vowels. This is clearly an unnecessary artifact of the segmental analysis.

Neither of the two earlier proposed segmental analyses of tone in Siamese can be accepted. Both fail to reach even the level of observational adequacy and both crucially depend on an ad-hoc contrivance --the "compromise convention" for Leben, the "optional pitch height" for Hiranburana. Despite their failure to do so, it is still possible to justify a segmental representation of tone in Siamese (cf. Section 3.2).

3.2 On the segmental nature of tone in Siamese

This section deals primarily with the question of whether tone features in Siamese are to be assigned to the segment or to some larger linguistic unit, such as the syllable, morpheme, word, etc.

Restrictions on the distribution of tones in Siamese indicate that tone is a property of the segment. If the domain of phonological tone is the segment and if the FALLING and RISING contour tones are analyzed as sequences of level tones, then we have a principled reason for excluding contour tones on syllables containing a single vowel followed by a voiceless stop p t k ʔ. A summary of the distribution of tones on various types of syllable structures in Siamese is presented in Table V. below. An 'X' indicates that the lexical tone at the top of the column may occur on the syllable structure in that same row; a 'O' indicates that the tone may not occur. Syllable structures (1) and (2) are the smooth syllables, (3) and (4) the checked syllables (cf. Section 1.1).

SYLLABLE STRUCTURES	LEXICAL TONES: MID	LOW	HIGH	FALLING	RISING
(1) CVV	X	X	X	X	X
(2) CV(V)C_f C_f= mnŋwy	X	X	X	X	X
(3) CVVC_f C_f= ptk	0	X	0	X	0
(4) CVC_f C_f= ptkʔ	0	X	X	0	0

Table V
Distribution of lexical tones in different types of syllable structures in Siamese

The absence of a RISING tone on long checked syllables (3) is considered to be a language-specific fact about Siamese. But this is not surprising. Statistically, falling tones outnumber rising tones (Ohala 1973: 3). A higher incidence of falling tones over rising tones is reported for Chinese (Cheng 1973). Furthermore, it has been suggested (Ohala and Ewan 1973) that more physiological effort is required for the production of RISING tones as compared to FALLING tones. They report that for a given pitch interval a subject could execute a falling pitch faster than a rising pitch. Accordingly, the absence of a RISING tone does not argue against a segmental analysis of tone in Siamese. On the other hand, if tones in Siamese are assigned to a larger unit than the segment (the only plausible candidate is the syllable), then the absence of a FALLING contour tone on short checked syllables (4) appears to be purely accidental.

In the Indic (Pali-Sanskrit) portion (approx. 60%) of the Siamese lexicon, a noninitial syllable (in polysyllabic morphemes) beginning with a sonorant segment and following a short checked syllable carrying LOW tone, carries LOW tone if it ends in a stop, otherwise RISING tone. This generalization has to be stated at the lexical level of representation because HIGH and LOW tones on short checked syllables are neutralized to MID tone in this position in everyday speech (cf. Section 4).

sàʔwǎn	'heaven'	sàʔmùt	'ocean'
sàʔmǎy	'period, age'	sàʔlèet	'phlegm'
khàʔnǒm	'candy'	khàʔnòt	'coils (of a snake)'
thàʔnǒn	'road'	càʔrìt	'conduct'
thàʔnɔ̌ɔm	'to cherish'	càʔrùat	'rocket'
chàʔlɔ̌ɔn	'to celebrate'	sàʔnùk	'to be amusing'
chàʔlǎəy	'to answer'	sàʔràʔ	'vowel'

but

sàʔtaaŋ	'Thai monetary unit'
sàʔkun	'family line'
sàʔphaa	'assembly, congress'
pháʔlaŋ	'power'
kháʔnɛɛn	'grade, vote'
cháʔləəy	'prisoner of war'

These polysyllabic morphemes clearly show that tone in Siamese is sensitive to surrounding segments (Leben's (1) criterion for segmental tone, cf. Section 3.1), thus evidence in support of a segmental representation of tone in Siamese.

There is additional evidence for Leben's (1) criterion for segmental tone in Siamese. No HIGH or RISING tone occurs on syllables that begin with p t c k ʔ. Thus, syllables like *páa *kǎa *táam *ʔǎaw are not permitted, once again illustrating the close interaction between tones and segments in Siamese. The only exceptions that I know of are non-Indic loanwords, onomatopoeic words, exclamatory expressions, and a few intensifying 'particles', egs. pǔy 'fertilizer (Chinese)', ʔóok 'oak (English)', kúuk 'call of a nightbird' báa 'bah!', dampǐi 'coal-black'.

As shown above in Table V (cf. Section 3.1), a syllable in Siamese may consist of 1, 2, or 3 tone-bearing segments. If tones are assigned to segments, then it is necessary to state restrictions on the permitted sequences of tones. This can be done easily for syllables containing 1 or 2 sonorant segments, butt not for syllables containing 3 sonorant segments.

I know of no crucial evidence that would force us to choose between a solution (a) that required identity between the first and second segments or a solution (b) that required identity between the second and third segments in a string of 3 sonorant segments (the underlined tones are considered to be redundant)

(a)		(b)
M M M		M M *M*
L L L		L L *L*
H H H		H H *H*
H H L		H L *L*
L L H		L H *H*

Perhaps in favor of solution (a) is the fact that the phonetic pitch change on contour tones is concentrated at the end. Whether solution (a) or (b) turns out to be correct, we can see that it would be relatively easy to state permitted tone sequences in a segmental analysis of tone in Siamese without resorting to an ad-hoc contrivance like "optional pitch height" (cf. Section 3.1).

As far as I know, there are no tone sandhi rules in Siamese that require information about surrounding segments. Mohr (1973) uses the absence of such rules as a criterion for establishing tone as a suprasegmental phenomenon in a particular language. But this appears to be a pseudo-issue regarding the segmental or suprasegmental nature of tone. Other things being equal, one could just as easily formulate conventions for application of phonological rules that ignore extraneous intervening material in the domain of the rule.

3.3 On the sequential nature of contour tones in Siamese

This section is concerned with the phonological representation of the FALLING and RISING contour tones. Are they best represented with unit contour tone features or sequences of level tone features?

If the domain of phonological tone is the segment, the absence of FALLING and RISING contour tones in short checked syllables is automatically accounted for if they are represented as sequences of level tones (cf. also Section 3.2). This generalization is missed if they are represented with unit contour tone features. Only if we assign tones to segments do we have a principled reason for excluding contour tones on syllables containing a single vowel. For instance, syllables like *phǎk or *phâk are excluded because RISING (=LH) and FALLING (=HL) tones require a sequence of 2 vowels on the phonological level of representation. If tones are not assigned to segments in Siamese, we are left with no principled explanation for the distributional restrictions on contour tones. Other minor points that might be made in favor of a sequential analysis of contour tones are given below.

Other things being equal, a solution that makes use of fewer features is to be preferred. If the FALLING and RISING contour tones are analyzed as sequences of independently-motivated level tone features HL and LH, respectively, then there is no need to introduce additional unit contour tone features.

I know of no productive phonological *rules* in Siamese that require decomposition of the FALLING and RISING contour tones into sequences of level tone features. In particular, there are no tone copying rules of the kind reported for numerous African tone languages (Leben 1973, Fromkin 1972, Hyman and Schuh 1972) where the sequential nature of the contour tones becomes immediately apparent.

A few shreds of morphological evidence suggest a sequential analysis of contour tones: níi 'this' / nîi 'this one,' nán 'that' / nân 'that one,' nóon 'that farther away' / nôon 'that one farther away'.

I know of no cases where contour tones cross a morpheme or even a syllable boundary. Some might argue that this testifies to the unitary nature of the contour tones. To the contrary, it is exactly what one might expect in a language that has no derivational morphology and no vowel-initial syllables. Again, *lack* of evidence neither argues for or against a sequential analysis of contour tones in Siamese.

4. A case of tone neutralization in Siamese

The HIGH and LOW tones are neutralized to MID on unstressed short checked syllables (those ending in a glottal stop only)

underlying form		citation form	derived form
thá?hǎan	'soldier'	thá?hǎan	thəhǎan
thà?nǒn	'road'	thà?nǒn	thənǒn

In this section, arguments are presented against Whitaker's (1969) solution. Another solution is proposed based on Fromkin's (1972) set of tone features.

Adopting Wang's (1967) set of tone features--*High Mid Central Falling Rising Convex Contour*--Whitaker (1969: 194-5) argues for (1) as the optimal representation of lexical tones in Siamese on the basis of the formal statements (irrelevant details omitted) of the tone neutralization rules (2) and (3)

(1)

	MID	LOW	FALLING	HIGH	RISING
high	-	-	+	+	-
rise	-	-	+	+	+
fall	-	+	+	-	-

(2) $[+\text{fall}] \rightarrow [-\text{fall}]$ / env.

(3) $\begin{bmatrix}+\text{high}\\+\text{rise}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{high}\\-\text{rise}\end{bmatrix}$ /

The two separate rules (2) and (3) fail to reveal what is actually a single phonological generalization. Note what happens when w. try to collapse (2) and (3) into a single rule:

$$(4)\quad \begin{bmatrix} \alpha\text{high} \\ \alpha\text{rise} \\ -\alpha\text{fall} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{high} \\ -\text{rise} \\ \text{fall} \end{bmatrix} \Big/ \ \text{env.}$$

In the structural change of the rule, [-high] and [-rise] are required just in case the input tone is HIGH, [-fall] just in case the input tone is LOW. A collapsed rule for (2) and (3), then, cannot be written without including *redundant* features in the structural change of the rule.

Implicit also in (1) is the claim that Siamese has 4 underlying contour tones--LOW, FALLING, HIGH, RISING and 1 underlying level tone--MID. Such an analysis gives us no principled reason for permitting LOW and HIGH but not FALLING and RISING tones on short checked syllables.

I propose an alternative solution based on Fromkin's (1972) set of tone features--*High Mid Low.* Using this set of features, the level lexical tones of Siamese could be represented as either.

(5)

	HIGH	MID	LOW
high	+	-	-
low	-	-	+

or (6)

	HIGH	MID	LOW
high	+	-	-
mid	-	+	-

Formal statements of the tone neutralization rules (7) and (8), based on (5) and (6), respectively, indicate that (6) is to be preferred.

$$(7)\quad \begin{bmatrix} \alpha\text{high} \\ -\alpha\text{low} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{high} \\ -\text{low} \end{bmatrix} \Big/ \ \text{env.}$$

$$(8)\quad [-\text{mid}] \rightarrow [+\text{mid}] \ / \ \text{env.}$$

Rule (7) abbreviates the two subrules (9a) and (b) (parenthesized features in structural change of rule are redundant):

$$(9)\quad \begin{array}{ll} \text{(a)} & \begin{bmatrix} +\text{high} \\ -\text{low} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{high} \\ (-\text{low}) \end{bmatrix} \\ \text{(b)} & \begin{bmatrix} -\text{high} \\ +\text{low} \end{bmatrix} \rightarrow \begin{bmatrix} (-\text{high}) \\ -\text{low} \end{bmatrix} \end{array} \Bigg/ \ \text{env.}$$

The fact that one cannot write the tone neutralization rule based on (5), without specifying redundant features in the structural change of the rule, leads us to choose (6).

Note, however, that (6) implies that the MID tone is closer to

LOW than HIGH, MID differs from LOW by 1 feature, from HIGH by 2 features. I do not know of any phonological evidence to support this claim. Note also that (8) requires the application of the sequence structure condition--If [+mid] THEN [-high] - in order to derive the correct surface forms. Nonetheless, this solution is to be preferred because it permits us to state a single phonological generalization in a single rule.

Optimal solutions constructed with other sets of distinctive features for tones--Wang 1967, Woo 1969, Maddieson 1970, Halle and Stevens 1971--would also require that a lexical redundancy reapply to the output of the tone neutralization rule.

5. Summary

An argument that has been advanced in favor of analyzing tone segmentally in Siamese--namely, the neutralization of contour tones in fast, casual speech--is untenable. A systematic acoustic investigation of these putative cases of tone neutralization shows that RISING and FALLING contour tones are not neutralized to level tones in fast, casual speech. Other arguments, however, can be given in favor of assigning tones to segments on the phonological level of representation as well as analyzing contour tones as sequences of level tones. Further, a solution is proposed for a real case of tone neutralization--HIGH and LOW tones neutralize to MID on short checked syllables--and this is shown to be preferred over competing alternative solutions.

REFERENCES

Abramson, A. S. 1962. The Vowels and Tones of Standard Thai: Acoustic Measurement and Experiments. Bloomington.

Benedict, P. K. 1948. "Tonal Systems in Southeast Asia." Journal of American Oriental Society. 68.4.

Cheng, C. C. 1973. "A Quantitative Study of Chinese Tones." Journal of Linguistics. 1.

Fromkin, V. A. 1972. "Tone Features and Tone Rules." Studies in African Linguistics. 3.1. Los Angeles.

Gandour, J. 1974a. "The Glottal Stop in Siamese: Predictability in Phonological Description." UCLA Working Papers in Phonetics. 27.

__________ . 1974b. "Consonant Types and Tone in Siamese." UCLA Working Papers in Phonetics. 27.

__________ . 1974. "Some Remarks on Siamese Word Games." UCLA Working Papers in Phonetics. 27.

Gay, T. 1968. "Effect of Speaking Rate on Diphthong Formant Movements." Journal of the Acoustical Society of America. 44.6.

Gedney, W. J. 1969. "A Checklist for Determining Tones in Tai Dialects." in Studies in Linguistics in Honor of George L. Trager. Edited by M. Estellie Smith. The Hague.

Gillette, J. A. 1955. Prosodic Features of Bangkok Thai. Unpublished MA thesis, Georgetown University.

Haas, M. R. 1956. The Thai Systems of Writing. Washington, D. C.

__________. 1969. "Burmese Disguised Speech." Academia Sinica, Bulletin of the Institute of History and Philology.

Halle, M. and Stevens, K. 1971. "A Note on Laryngeal Features." M.I.T. Research Lab. of Electronics, Quarterly Progress Report. 101.

Haudricourt, A. G. 1961. "Bipartition et tripartition des systèmes de tons dans quelques langues d'Extrême-Orient." Bulletin de la Société de linguistique de Paris. 56.

Henderson, E.J.A. 1970. "Prosodies in Siamese. A Study in Synthesis." Asia Major (New Series) 1. Reprinted in Prosodic Analysis. Edited by F. R. Palmer. London.

Hyman, L. and Schuh, R. 1974. "Universals of Tone Rules." Linguistic Inquiry. 5:1.

Ladefoged, P. 1973. "Features of the Larynx." Journal of Phonetics. 1.1.

Lea, W. A. 1973. "Segmental and Suprasegmental Influence on Fundamental Frequency Contours." in Consonant Types and Tone. Southern California Occasional Papers in Linguistics. 1. Edited by Larry M. Hyman.

Leben, W. R. 1971. "On the Segmental Nature of Tone in Thai." M.I.T. Res. Lab. of Electronics, Quarterly Progress Report. 101.

__________. 1971. "Suprasegmental and Segmental Representation of Tone." Studies in African Linguistics. Supplement 2.

__________. 1973. "The Role of Tone in Segmental Phonology." in Consonant Types and Tone. Edited by Larry Hyman. Southern California Occasional Papers in Linguistics. 1.

__________. 1973. Suprasegmental Phonology. Unpublished doctoral dissertation, M.I.T.

Maddieson, I. 1970. "The Inventory of Features." Research Notes. 3:2. Ibadan.

__________. 1972. "Tone System Typology and Distinctive Features." In Proceedings of the 7th International Congress of Phonetic Sciences. Edited by A. Rigault and R. Charbonneau. The Hague.

Matisoff, J. 1973. "Tonogenesis in Southeast Asia." in Consonant Types and Tone. Edited by Larry Hyman. Southern California Occasional Papers in Linguistics. 1.

Mohr, B. 1973. "Tone Rules and the Phonological Representation of Tones." Paper presented to the 6th International Conference on Sino-Tibetan Languages and Linguistics. University of California at San Diego.

Noss, R. B. 1964. Thai Reference Grammar. Washington, D. C.

Ohala, J. 1973. "The Physiology of Tone." in Consonant Types and Tone. Edited by Larry Hyman. Southern California Occasional Papers in Linguistics. 1.

Ohala, J. and W. Ewan. 1973. "Speed of Pitch Change." (Abstract) Journal of the Acoustical Society of America. 53.

Palmer, A. 1969. "Thai Tone Variants and the Language Teachers." Language Learning. 19.3-4.

Samang Hiranburana. 1971. The Role of Accent in Thai Grammar. Unpublished doctoral dissertation, University of London.

Surintramont, A. 1973. "Some Aspects of Underlying Syllable Structure in Thai: Evidence from KHAMPHUAN, A Thai Word Game." Studies in the Linguistic Sciences. 3.1.

Wang, W. S-Y. 1957. "The Phonological Features of Tone." International Journal of American Linguistics 33.

Warotamasikkhadit, U. 1967. "Some Phonological Rules in Thai." Journal of the American Oriental Society. 87.4.

Whitaker, H. A. 1969. "Stylistic Tone-Changing Rules in Thai." Glossa. 3.2.

Woo, N. 1969. Prosody and Phonology. Unpublished doctoral dissertation, M.I.T.

Section 5. A Reanalysis of Some Phonological Rules in Thai

"A Renanalysis of Some Phonological Rules in Thai"

0. Introduction

The aim of this paper is to show that tonal neutralization on CV syllables - whereby an underlying contrast between HIGH and LOW is neutralized to MID - depends not only on the position of the CV syllable within the word, but also on the presence of an internal word boundary in the underlying forms of certain polysyllabic words. The alternate pronunciations of these polysyllabic words (one alternant exhibits the tonal neutralization whereas the other one does not) is then accounted for simply as a difference in the underlying forms. The presence of an internal word boundary blocks application of the rule that neutralizes the underlying tonal contrast.

It is also shown that despite the fact that only CV syllables arising from underlying /CVʔ/ may undergo tonal neutralization, the deletion of the glottal stop must be formulated as a separate phonological rule. The latter must also be extrinsically ordered before the tonal neutralization rule.

1. A Brief Sketch of Thai Phonology

For the benefit of those readers not already familiar with relevant background information on Thai phonology, I will briefly discuss the distribution of tones (Section 1.1), styles of speech (Section 1.2), the structure of the lexicon (Section 1.3), and rhythm at the level of the word (Section 1.4).

1.1 Tonal Distribution

Thai has 5 contrastive tones on nonstopped syllables - that is, those syllables not ending in a stop segment p t k or ? - MID (unmarked), LOW (\), FALLING (ʌ), HIGH (/), and RISING (V). On stopped syllables, however, the distribution of these tones is far more restricted. Only the FALLING or LOW [High too!] tone may occur on stopped syllables containing a long vowel or diphthong; only HIGH or LOW [falling too!] tone may occur on stopped syllables containing a short vowel. It is the latter type of stopped syllable that we will be mainly interested in throughout the paper. For more detailed discussion on the distribution of tones in Thai, see Henderson 1949, Abramson 1962, Haas 1964, Noss 1964, Anthony and others 1968, and Gandour 1974a.

For the purposes of this paper, it is necessary to draw a distinction between those short stopped syllables ending in p t or k (hereafter abbreviated as CVS) and those ending in a glottal stop (hereafter abbreviated as CV?). The motivation for this dichotomy in short stopped syllables will become apparent later in the paper.

It is further assumed that the glottal stop in CV? is present in the underlying forms. For arguments in support of this analysis of the glottal stop, see Gandour 1974b.

1.2 Speech Styles

Thai is generally considered to have 3 speech styles or tempos (Henderson 1949, Abramson 1962) - (1) an 'isolative' speech style that characterizes words as pronounced with a slow, deliberate pronunciation of each syllable. In this speech style, each syllable is fully articulated. There are no surface phonetic CV syllables and no neutralization of the underlying tonal opposition between HIGH and LOW tone on CV?

syllables; (2) a 'combinative' speech style that characterizes words as pronounced in connected speech at a moderate tempo. In this speech style, only the final syllable of a phrase is fully articulated. In non-final position surface phonetic CV syllables occur as a result of the loss of the syllable-final glottal stop. The underlying HIGH and LOW tones on these syllables are neutralized to MID; (3) a 'rapid combinative' speech style that characterizes words as pronounced in connected speech at a fast tempo. Like the combinative speech style, only the final syllable of a phrase is fully articulated. Again, there is loss of contrast between the HIGH and LOW tones on CV syllables derived from CV?; but, in addition, surface CV syllables arise from the loss of syllable-final stop segments in CVS syllables. The latter, however, do not undergo tone neutralization.

The above characterization of speech styles in Thai is not intended to be exhaustive, but simply to point out some of the more salient phonetic features that differentiate them. It should also be mentioned that there is disagreement over the number of speech styles. Hiranburana 1971 posits as many as 5. Since none of the issues raised in this paper hinges crucially on whether there are more than 3 functional speech styles, I will simply follow Henderson's 1949 original tripartite classification of speech styles - (1) isolative (2) combinative and (3) rapid combinative.

Of particular interest in this paper is the relationship between the loss of the syllable-final segment and the neutralization of the HIGH and LOW tones to MID in the 3 different speech styles - as summarized in Table 1.

Table 1. Relationship Between Loss of Final Stop Segment and Loss of Tone Contrast

Speech Style		Loss of Final Stop Segment	Loss of Tone Contrast
isolative	CV?	no	no
	CVS	no	no
combinative	CV?	yes	yes
	CVS	no	no
rapid combinative	CV?	yes	yes
	CVS	yes	no

1.3 Polysyllabic Words

The native core vocabulary of Thai is basically monosyllabic. It is this part of the Thai lexicon that is used for historical-comparative studies of the languages in the Tai family (Gedney 1973). There are, however, numerous polysyllabic words in modern Thai. Most of these words can be traced back to earlier compound formations or Pali-Sanskrit loanwords. The latter constitute a sizable portion of the Thai lexicon, roughly comparable to the Latin-Greek component of the English lexicon (Gedney 1947:ii).

From a diachronic point of view, the majority of these polysyllabic Indic loanwords are morphologically complex. Some Thai speakers, however, apparently have reanalyzed them as single morphologically-simple lexical items. As I will show in Section 4, whether or not the internal composition of the word is considered by the speaker to be morphologically simple or complex has a predictable effect of the application of the rule that neutralizes the tonal contrast on CVʔ syllables in non-final position.

1.4 Word-Level Rhythm

Previous discussions of the role of 'stress' or 'prominence' in Thai have been rather sketchy (see Noss 1964 Haas 1964 Warotamasikkhadit 1967 Hiranburana 1971 Surintramont 1973). Though there is agreement that the syllable in word-final position is the most prominent, none of the earlier discussions provide an adequate account of the fact that the observed rhythmic differences are to be attributed to a number of phonetic parameters including pitch, duration, and vowel quality.

Generally speaking, all non-final syllables in both the combinative and rapid combinative speech styles get 'reduced' with respect to the above-mentioned phonetic parameters. The particular way in which a syllable gets reduced depends on the underlying shape of the syllable, its position in the word, and, in some cases, the presence or absence of a word boundary. An underlying CVʔ in non-final position generally loses its underlying tone (HIGH or LOW) as well as the glottal stop. This reduction of CVʔ syllables is one of the principal determinants of rhythm at the word level in Thai. In the remainder of the paper, I will focus on the phonological rules that bring about the reduction of these syllables.

2. TONE REDUCTION and GLOTTAL STOP DELETION: A Single Phonological Rule?

As we proceed through the data, consider the basic claim of the paper - namely, that the neutralization of the underlying HIGH and LOW tones on CVʔ syllables to MID depends not only on its position in the word but also on whether or not it is followed by an internal word boundary.

First, observe that the neutralization of the HIGH and LOW tones does not take place on CV? syllables that occur word-finally. The isolative form appears on the left, the combinative form on the right. The isolative form is taken to be underlying (see also Warotamasikkhadit 1967 and Surintramont 1973). To simplify the presentation, changes in vowel quality on non-final syllables are not indicated since they do not appear to bear on any of the issues raised in this paper.

(1)

isolative (underlying) form		combinative form
sà?tì?	'consciousness'	satì?
kà?pì?	'shrimp paste'	kapì?
sà?là?	'to sacrifice'	salà?
kà?thá?	'skillet'	kathá?
kà?thí?	'coconut cream'	kathí?
thá?lɔ́?	'to quarrel'	thalɔ́?
thà?nǒn	'road'	thanǒn
thá?hǎan	'soldier'	thahǎan
thú?rá?	'business'	thurá?
kù?làap	'rose'	kulàap
wí?nay	'discipline'	winay
kì?laa	'sports'	kilaa

What happens to the initial CV? syllable in these bisyllabic forms in the combinative speech style is neutralization of the HIGH and LOW tone to MID and loss of the syllable-final glottal stop. Here, I must point out disagreement over the phonetic representations of the combinative forms. Of the two earlier generative phonological studies that deal with the problem of tone neutralization in such bisyllabic words, both claim that CV? syllables that contain a high vowel are not subject to the tone neutraliztion rule. Warotamasikkhadit (1967:567-569) posits 2 separate tone neutralization rules - the first applying to CV? syllables containing the low back unrounded vowel /a/, the second applying to CV? syllables containing high vowels /i u/ with LOW tone. Surintramont (1973:141, footnote 5), on the other hand, simply treats CV? syllables containing high vowels with HIGH tone as exceptions to the tone neutralization rule. Both of these analyses predict that the phonetic representation of the combinative form of the word meaning 'discipline' would be [wínay].

Quite to the contrary, I claim that the rule that neutralizes the underlying opposition between HIGH and LOW tones on CV? syllables applies without exception including CV? syllables containing high vowels with HIGH tone. Although the absolute fundamental frequency of these syllables remain higher than the others in combinative forms, I contend that whatever differences in pitch that may be recorded are to be attributed to the intrinsic pitch associated with different vowel heights (Parmenter and others 1933, Lehiste and Peterson 1960, Ladefoged 1964, Lehiste 1970, Mohr 1971, Lea 1973, Pike 1974) and/or the type of preceding consonant (Lehiste 1970, Mohr 1971, Lea 1973, Gandour 1974c). Thus, these differences in pitch that may be ascribed to different vowel heights need not complicate a particular grammar of Thai; they simply reflect intrinsic universal constraints on the speech production mechanism.

The following set of polysyllabic words indicate that CV? syllables reduce in other positions as well as penultimate.

(2)	isolative(underlying)form	combinative form
'grateful'	kà?tanyuu	katanyuu
'poor'	?à?naathǎa	?anaathǎa
'future'	?à?naakhót	?anaakhót
'sailor'	kà?laasǐi	kalaasǐi
'club'	sà?moosɔ̌ɔn	samoosɔ̌ɔn
'station'	sà?thǎanii	sathǎanii
'insignia'	?ù?naaloom	?unaaloom

The next set of words, for which the phonetic representation of the forms in all 3 speech styles are given, shows the motivation for the distinction between underlying CV? and CVS syllable structures.

(3)	isolative(underlying) form	combinative form	rapid combinative form
'dirty'	sòkkà?pròk	sòkkapròk	sòkapròk
'radio'	wítthá?yú?	wítthayú?	wíthayú?
'to emigrate'	òpphá?yóp	òpphayóp	òphayóp
'January'	mókkà?raakhom	mókkaraakhom	mókaraakhom
'July'	kà?rákkà?daakhom	karákkadaakhom	karákadaakhom
'obscene'	sàppà?don	sàppadon	sàpadon

Only CV syllables derived from CV? get their tone reduced to MID. Note, in particular, that CV syllables in the rapid combinative forms that have been derived from underlying CVS syllables preserve their original underlying tones (see Table 1 - Section 1.2).

So far, the data would seem to indicate that the deletion of the glottal stop and the neutralization of the HIGH and LOW tones to MID constitutes a single phonological process. This claim is made explicit in both of the 2 earlier generative phonological studies. Surintramont

(1973:136), for instance, says that "...the neutralized mid tone short vowels are the result of the deletion of the glottal stop in...non-final unstressed position..a syllable of the shape CVS does not undergo neutralization even though it is unstressed, simply because final stops never get deleted. The tone neutralization process is clearly a consequence...of the loss of the glottal stop at the end of the syllable... they are not two separate processes..."

This claim, however, turns out to be false as shown by the following examples, where a glottal stop has been deleted but with the underlying HIGH or LOW tone remaining in the (a) alternant of the combinative form.

(4)	isolative(underlying)form	combinative form (a)	(b)
'condition'	sà?thǎaná?kaan	sathǎanákaan	sathǎanakaan
'to protect'	?à?nú?baan	?ànúbaan	?anúbaan
'federated state'	sà?hà?rát	sahàrát	saharát
'agriculture'	kà?sì?kam	kasìkam	kasikam

Still other words can be found which do not permit tone reduction in the combinative speech style even though the glottal stop has been deleted.

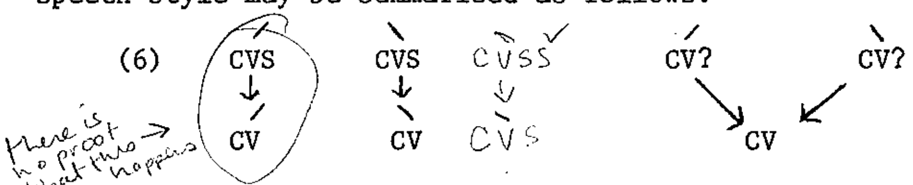
(5)	Isolative(underlying) form	combinative form (a)	(b)
'Buddha image'	phrá?phúttá?rûup	phráphúttharûup	*phraphúttharûup

The combinative forms (a) in both (4) and (5) then clearly show that it is not possible to collapse the deletion of the glottal stop and the neutralization of the underlying tonal contrast into a single phonological rule. To do so simply misrepresents the facts. Now that we have established the need for separate rules, I would next like to take up the question of how these 2 rules are to be ordered with respect to each other.

3. Ordering of TONE REDUCTION and GLOTTAL STOP DELETION

The isolative forms present no problem for ordering of TONE REDUCTION with respect to GLOTTAL STOP DELETION. These rules simply don't apply in that speech style. Although both rules apply in the combinative speech style, those forms too present no problem in rule ordering. The rules are intrinsically ordered with respect to each other since the only CV syllables that could possibly serve as input to TONE REDUCTION are those that result from the deletion of the glottal stop. In the rapid combinative speech style, however, we do encounter a problem in rule ordering because of more than one possible source for CV syllables - those that are derived from underlying CV? syllables and those that are derived from underlying CVS syllables. Somehow we must account for why those CV syllables that originate from underlying CVS syllables do not undergo TONE REDUCTION, whereas those CV syllables that originate from underlying CV? syllables do. The situation in the rapid combinative speech style may be summarized as follows:

(6)



The most obvious solution that comes to mind, within the framework of generative phonology as presented in The Sound Pattern of English (Chomsky and Halle 1968), is to extrinsically order the rules as shown informally in (7) below, the effect of which will be to prevent those CV syllables originating from underlying CVS syllables from undergoing TONE REDUCTION.

(7) 1. CV? → CV

2. CV → MID

3. CVS → CV

A formal statement of the rule that deletes the glottal stop is given below. For a detailed justification of this particular formulation, see Gandour 1974b.

(8) GLOTTAL STOP DELETION

? → ∅ / ___ C

A rough formalization of the rule (simplified a bit for purposes of this discussion) that changes CVS syllables [not] to CV is given in (9). It [CVSS → CVS not CVS→CV ! idiot] is a consonant degemination rule – deleting the first of 2 consonants sharing the same place and manner of articulation.

(9) CONSONANT DEGEMINATION

$$\begin{bmatrix} \text{C} \\ \text{place of} \\ \text{articulation} \end{bmatrix} \begin{bmatrix} \text{C} \\ \text{place of} \\ \text{articulation} \end{bmatrix}$$

1 2 → ∅ 2

Condition: rapid combinative speech style

The forms below illustrate how this rule applies.

(10)

	isolative(underlying) form	combinative form	rapid combinative form
'to emigrate'	?òpphá?yóp	?òpphayóp	?òphayóp
'Buddha image'	phrá?phútthá?rûup	phráphúttharûup	phráphútharûup
'guide'	mákkhúttheêt	mákkhútthêet	mákhúthêet

The TONE REDUCTION rule will be formulated in Section 4.

Another possible solution would be to impose a 'global condition' (see Lakoff 1970, Surintramont 1973) on TONE REDUCTION such that the rule could discriminate – that is, look back to the underlying forms –

between those CV syllables that come from an underlying CVS and those that come from an underlying CV?. This solution, however, entails the use of a mechanism that greatly strengthens the power of a generative phonology. As indicated in (7), the mechanism of extrinsic rule ordering more than adequately handles the problem. Accordingly, we must opt for solutions that make use of as little theoretical machinery as possible, and yet, at the same time, capture what appear to be the correct linguistic generalizations.

Interestingly enough, proponents of unordered rules run into an embarrassing situation here since it is not possible to collapse TONE REDUCTION and GLOTTAL STOP DELETION into a single phonological rule (cf. Section 2).

Concerning the ordering of TONE REDUCTION with respect to other relevant phonological rules, I next want to consider VOWEL SHORTENING – the rule that shortens underlying long vowels in non-final position. It has been claimed (Warotamasikkhadit 1967, Surintramont 1973) that VOWEL SHORTENING must be extrinsically ordered after TONE REDUCTION in order to prevent the CV syllables that result from the application of VOWEL SHORTENING from losing their original underlying tones. This claim is based on the following formulation of VOWEL SHORTENING.

(11) VOWEL SHORTENING

$$VV \rightarrow V$$

This rule makes the explicit claim that the length of the vowel in CV syllables that come from underlying CVV is the same as in CV syllables that come from underlying CV?. Since the tones on underlying CVV syllables are preserved in both the combinative and rapid combinative speech styles, VOWEL SHORTENING must come after TONE REDUCTION in the ordering of the rules.

Unfortunately, both Warotamasikkhadit 1967 and Surintramont 1973 misrepresent the phonetic facts when they suggest that VOWEL SHORTENING yields vowels no longer than short vowels derived from underlying short vowel syllables. As mentioned earlier in Section 1.4, all non-final syllables get reduced in some way. An underlying CVV syllable does, indeed, get its long vowel shortened in the combinative and rapid combinative speech styles but in varying degrees depending on the accompanying tone. Only when the underlying CVV syllable carries a MID tone does the long vowel become as short as those short vowels that arise from underlying CV? or CVS syllables; for example, 'food' /?aahaǎn/ [?ahaǎn], 'language' /phaasǎa/ [phasǎa], 'minute' /naathii/ [nathii]. It is expected that these observations based on auditory impression will be borne out in an instrumental phonetic investigation on the relationship between pitch and vowel length in Thai. For some preliminary discussion on the relationship between VOWEL SHORTENING and TONE REDUCTION, see Gandour 1974a.

4. TONE REDUCTION: Its Form and Manner of Application

There are numerous polysyllabic words in Thai that contain sequences of 2 or more CV? syllables. In this situation, the question arises as to which of the CV? syllables in the sequence may undergo TONE REDUCTION. How this question is answered will partly determine how the TONE REDUCTION rule is to apply - that is, from left-to-right, from right-to-left, simultaneously, etc.

Consider first the words listed in (12). For each of these words, combinative form (a) shows that in a sequence of 2 adjacent CV? syllables, it is the second CV? syllable that retains its tone. The alternate pronunciations of the combinative form represent those of my informant. Judgments of the morphological composition of these words, as with all other words in this paper, are based primarily on Gedney's (1947) analysis of Indic loanwords in Thai. The status of the parentheses enclosing the internal word boundary in the underlying forms will be taken up shortly.

(12)	isolative (underlying) form	combinative form (a)	combinative form (b)
'approval'	?à?nú?(#)mát	?anúmát	?anumát
'to permit'	?à?nú?(#)yâat	?anúyâat	?anuyâat
'to protect'	?à?nú?(#)baan	?anúbaan	?anubaan
'civilization'	?aará?yá?(#)tham	?aarayátham	?aarayatham
'humanity'	má?nútsà?yá?(#)tham	manútsayátham	manútsayatham
'culture'	wátthá?ná?(#)tham	wátthanátham	wátthanatham
'death'	mɔɔrá?ná?(#)kam	mɔɔranákam	mɔɔranakam
'agriculture'	kà?sì?(#)kam	kasìkam	kasikam
'federated state'	sà?hà?(#)rát	sahàrát	saharát
'cooperative'	sà?hà?(#)kam	sahàkam	sahakam
'federation'	sà?hà?(#)phan	sahàphan	sahaphan

Based on words in (12), Surintramont (1973:135) argues that the tone neutralization rule must apply from left-to-right - "In bisyllabic words (cf. Section 1-(1)), the Reduction rule always neutralizes the first syllable to mid tone if it neutralizes a tone at all. So it seems natural to us that a hypothesis...which effectively relates the directionality of tone neutralization to the first syllable, and, subsequently, to a left-to-right application of the rule, is basically a sound claim."

This claim, however, turns out to be observationally inadequate.

One need look no further than the words presented in (13). In these words it is the first CV? syllable, not the second, that retains its tone in a sequence of 2 adjacent CV? syllables. Surintramont simply based his analysis on too restricted a set of data, and even more significantly, totally ignored the morphological make-up of these words and its effect on the application of the TONE REDUCTION rule.

(13)

	isolative (underlying form	combinative form (a)	(b)
'poet'	cintà?(#)kà?wii	cintàkawii	cintakawii
'lecture'	paathà?(#)kà?thǎa	paathàkathǎa	paathakathǎa
'literature'	wanná?(#)khá?dii	wannákhadii	wannakhadii
'written article'	sǎará?(#)khá?dii	sǎarákhadii	sǎarakhadii
'algebra'	phítchà?(#)khá?nít	phítchàkhanít	phítchakhanít
'decimal'	thótsà?(#)ní?yom	thótsàniyom	thótsaniyom
'statesman'	rátthà?(#)bù?rùt	rátthàburùt	rátthaburùt
'coup de tat'	rátthà?(#)prà?hǎan	rátthàprahǎan	rátthaprahǎan
'congress'	rátthà?(#)sà?phaa	rátthàsaphaa	rátthasaphaa

Notice that in both (12) and (13), a non-final CV? syllable gets reduced unless it is immediately followed by a word boundary. It would appear, then, that any attempt to formulate TONE REDUCTION would have to take morphological considerations into account. Indeed, when we consider words like those in (14), which contain a sequence of 3 CV? syllables, we can further see the influence of the internal morphological composition of these polysyllabic words.

(14) isolative (underlying form combinative form

		(a)	(b)
'east'	bù?ra?(#)pà?thít	burápathít	burapathít
'Royal Academy'	râatchà?(#)bandìttà?yá(#) sà?thǎan	râatchàbandìttayásathaǎn	raâtchabandìttayasathaǎn

To account for both the morphologically simple and complex polysyllabic lexical items, I propose that TONE REDUCTION be formulated as follows:

(15) TONE REDUCTION

$$\begin{bmatrix} V \\ -MID \end{bmatrix} \rightarrow [+MID] \;/\; \_\_\_\_ \; [+segment]_2$$

This rule reduces HIGH or LOW tone on a CV syllable to MID unless it is immediately followed by a boundary unit. The CV syllable must be followed by a minimum of 2 segments in order to block the rule from applying to CV? syllables in word-final position. If the subscript were 1, the rule would incorrectly reduce the tones on these word-final CV syllables as well. The rule applies simultaneously within a word.

To account for combinative forms (a) and (b), I assume that either of 2 possible underlying forms for the morphologically complex lexical items are available to, at least, some speakers. One underlying form contains the internal word boundary, the other does not. This has been indicated by parentheses in (12), (13), and (14) above. What determines which underlying form is selected on a given occasion I leave as an open question for the sociolinguists. Nevertheless, there are clearly 2 variant pronunciations of the combinative forms that must be accounted for.

Moreover, based on my own observations and those of my informants, it appears that some speakers only have the underlying form without the internal word boundary. This is just what we might expect since the words in question are mostly learned words of Pali-Sanskrit provenience and not instances of any productive derivational morphology. Some speakers apparently have already restructured these words as morphologically simple lexical items.

Evidence from English loanwords in Thai tends to point to the latter underlying form as dominant in some sense. Open syllables in English loanwords are invariably pronounced with MID tone. In other words, TONE REDUCTION (15) applies with no regard for the internal morphological composition of the English word. There is no variation in the pronunciation of these loanwords. A few examples are given in (16). More discussion on English loanwords in Thai càn be found in Henderson (1951) and Gandour (1974d).

(16)	English	Thai (combinative form)
	Florida	flɔlidâa
	Rotary	rotərîi
	Kennedy	khenədîi
	uranium	yurenîam
	technology	théknɔlocîi
	furniture	fənicə̂ə

Positing alternate underlying forms for certain polysyllabic lexical items clearly allows us to give a reasonable account of tone neutralization. The rule applies simultaneously to all non-final CV syllables unless they are followed by an internal word boundary. Any complication with regard to TONE REDUCTION then lies not with its manner of application, but instead the underlying form to which it applies.

REFERENCES

Abramson, A.S. 1962. The Vowels and Tones of Standard Thai: Acoustic Measurements and Experiments. International Journal of American Linguistics, Publication 20.

Anthony, Edward M. and others. 1968. Foundations of Thai: Book 1. University of Michigan Press: Ann Arbor.

Chomsky, Noam and Morris Halle. 1968. The Sound Pattern of English. Harper and Row: New York .

Gandour, J. 1974a. On the Representation of Tone in Siamese. Studies in Tai Linguistics in Honor of William J. Gedney, ed. by Jimmy G. Harris and James R. Chamberlain, 170-195. Central Institute of English Language: Bangkok.

Gandour, J. 1974b. The Glottal Stop in Siamese: Predictability in Phonological Description. Phasaa 4.2:66-78.

Gandour, J. 1974c. Consonant Types and Tone in Siamese. Journal of Phonetics 2:337-350.

Gandour, J. 1974d. A Note on English Loanwords in Thai. Unpublished paper, UCLA.

Gedney, W. J. 1947. Indic Loanwords in Spoken Thai. Unpublished doctoral dissertation, Yale University.

Gedney, W. J. 1973. A Checklist for Determining Tones in Tai Dialects. Studies in Linguistics in Honor of George Trager, edited by M. Estellie Smith, 423-437. Mouton: The Hague.

Haas, Mary R. and others. 1964. Thai-English Student's Dictionary. Stanford University Press.

Henderson, Eugenie J.A. 1949. Prosodies in Siamese. A Study in Synthesis. Asia Major (New Series) 1:189-215. Reprinted in Prosodic Analysis, edited by F.R. Palmer, 27-53, Oxford University Press: London. 1970.

Henderson, Eugenie J.A. 1951. The Phonology of Loanwords in Some Southeast Asian Languages. Transactions of the Philological Society: 131-158.

Hiranburana, S. 1971. the Role of Accent in Thai Grammar. Unpublished doctoral dissertation, University of London.

Ladefoged, Peter. 1964. A Phonetic Study of West African Languages. Cambridge University Press.

Lea, W.A. 1973. Segmental and Suprasegmental Influence on Fundamental Frequency Contours. Consonant Types and Tone. Southern California Occasional Papers in Linguistics No. 1, edited by Larry N. Hyman, 15-70. Linguistics Program of University of Southern California: Los Angeles.

Lehiste, I. and G. Peterson. 1961. Some Basic Considerations in the Analysis of Intonation. Journal of the Acoustical Society of America 33:419-425.

Lehiste, I. 1970. Suprasegmentals. MIT Press: Cambridge.

Mohr, B. 1971. Intrinsic Variations in the Speech Signal. Phonetica 23: 65-93.

Noss, Richard B. 1964. Thai Reference Grammar. U.S. Government Printing Office: Washington, D.C.

Parmenter, C.E., S. N. Trevino, and C.A. Bevans. 1933. The Influence of a Change in Pitch on the Articulation of a Vowel. Language 9.1:72-81.

Pike, Euenice V. 1974. A Multiple Stress System Versus a Tone System. International Journal of American Linguistics 40.3:169-175.

Stanley, Richard. 1973. Boundaries in Phonology, A Festschrift for Morris Halle, ed. by S.R. Anderson and P. Kiparsky, 185-206. Holt, Rinehart and Winston: New York.

Surintramont, A. 1973. Some Aspects of Underlying Syllable Structure in Thai: Evidence from KHAMPHUAN--A Thai Word Game. Studies in the Linguistic Sciences 3.1:121-142.

Warotamasikkhadit, Udom. 1967. Some Phonological Rules in Thai. Journal of the American Oriental Society 87.4:541-574.

Section 6. Evidence from Lue for Contour Tone Features

EVIDENCE FROM LUE FOR CONTOUR TONE FEATURES*

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Introduction

In the study of tone in generative phonology, there has been much discussion as to whether contour tones should be represented phonologically as single indivisible units or as sequences of level tones. Some generative phonologists, including Woo (1969) Maddieson (1970) and Leben (1973), take the position that a theory of generative phonology should *not* permit contour tone features on the phonological level of representation; others, including Wang (1967) Yen (1970) and Mohr (1973), take the position that contour tone features *should* be permitted.

Much of the evidence cited in support of the former position is taken from African languages and American Indian languages, whereas much of the evidence cited in support of the latter position is taken from the languages of the Sino—Tibetan family together with many neighboring languages of Southeast Asia (see, however, Elimelech (1974) where evidence from Kru, a language

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spoken in West Africa, is given in support of underlying contour tones).

It is clearly an empirical issue as to whether a theory of generative phonology must allow for the possibility of contour tones as single units on the phonological level of representation. A phonological theory which excludes contour tone features is more highly constrained, thereby limiting the class of grammars and languages, and thus preferable. But a constraint on grammars which obscures what is "really going on," that is, which fails to reveal generalizations, cannot be empirically justified.

The psychological implications of these two different representations of contour tones were stated by Sapir (Pike 1948:8, footnote 13, excerpts from a letter dated July 14, 1938):

> It is of course true in a purely *physical* sense that 'all tone languages can be analyzed in terms of register.' All this means is that you can't have 'movement' without having an A from which you move to B. Hence one may claim necessary priority of points A and B to movement from A to B. *But* movement *from* A *to* B (a physical statement) is not really the same thing as movement *in a direction* away from A and toward B. Psychologically, one can have an experience of such movement without being able to 'geometrize' in terms of fixed points A and B . . .

Given the possibility of these two different psychological interpretations of contour tones, a theory of generative phonology must be able to provide alternative feature representations for the same physical pitch contours. That is, we would expect to find that pitch contours would function differently from language to language.

In this paper I will investigate a case of tone sandhi from Lue, a Tai dialect spoken principally in the southern part of Yunnan Province, China, that seems to require not only the contour tone feature RISING but also the tone feature CONTOUR. The latter feature has not received much attention in the literature since Wang (1967) proposed it as a phonological feature of tone. Fromkin (1972) suggests that such a feature is necessary for descriptively adequate phonetic representations but leaves open the question of whether it is also necessary for phonological representations. This paper suggests that only by postulating the feature CONTOUR in underlying phonlogical representations in Lue can we capture what appear to be the correct linguistic generalizations.

Data

According to Li (1964), Lue has 6 contrastive tones.

#1	55	˥	(high level)
#2	31	˧˩	(falling)
#3	25	˨˥	(high rising)
#4	33	˧	(mid level)
#5	13	˩˧	(low rising) or 11 ˩ (low level)
#6	22	˨	(mid-low level)

The distribution of the alternant phonetic shapes of tone # 5 is given below. Note that a pause boundary is represented as "&."

11 ˩ occurs before { 25 ˨˥, 31 ˧˩ }

13 ˩˧ occurs before { 22 ˨, 33 ˧, 55 ˥, & }

The following examples illustrate the distributional restrictions of the alternant phonetic realizations of tone # 5.

xa ^{11}	kay ^{25}	'to kill a chicken' l/R
xa ^{11}	kun ^{31}	'to kill a person' F
xa ^{13}	nok ^{33}	'to kill a bird' M level
xa ^{13}	pet ^{55}	'to kill a duck' H level
xa ^{13}	&	'to kill'

Li merely states the distributional restrictions on the allotones of tone #5; he presents no arguments for taking one or the other to be basic. In the section below, where possible alternative solutions for handling the tonal alternation will be eveluated, we will see that solution's that posit 13 as basic are to be preferred,

Alternative Solutions

It is clear that there are any number of observationally adequate ways to account for the alternations of tone #5 The question is, what is the correct solution? The following alternative solutions utilize the set of phonological features of tone proposed by Wang (1967) that include contour tone features FALLING, RISING, and CONTOUR; or the set proposed by Fromkin (1972) excluding classificatory contour tone features as given below:

Wang (1967)	Fromkin (1972)
CONTOUR	HIGH
HIGH	MID
CENTRAL	LOW
MID	
RISING	
FALLING	

Solution (a). If we assume that tone #5 is represented as 11 phonemically and that Wang's features are used, three features are needed on the systematic phonemic level, HIGH, CENTRAL, and CONTOUR, as shown in (1). Only the feature specifications closed by the solid line are distinctive; the other feature specifications are predictable by redundancy conventions or by phonolgical rule.

(1)	#1 55	#2 31	#3 35	#4 33	#5 11	#6 22	13
high	+	−	+	+	−	−	−
central	−	−	−	+	−	+	−
contour	−	+	+	−	−	−	+
rising	−	−	+	−	−	−	+

The feature RISING is added by phonological rule, as shown in (2). In this solution, as in all other solutions, tone #3 is analyzed as. 35.

(2) $\begin{bmatrix}-\text{high}\\-\text{central}\\-\text{contour}\end{bmatrix} \rightarrow \begin{bmatrix}+\text{rising}\\+\text{contour}\end{bmatrix} / \_\_ \begin{Bmatrix}[-\text{contour}]\\ \& \end{Bmatrix}$

$11 \rightarrow 13 \; / \_\_ \begin{Bmatrix}22\\33\\55\\ \& \end{Bmatrix}$

Solution (b). Assuming once more that tone #5 is represented as 11, and using the Fromkin features which require that the contour tones be represented as tone sequences, the following matrix of the phonemic and phonetic tones results, with the 13 tone derived by rule (4). Since long and short vowels do not contrast in Lue, this will require the use of a nonsegmental tone bearing unit for the contour tones.

(3)	4 #1 55	2 #2 31	1 #3 35	3 #4 33	#5 11	#6 22	13
high	++	−−	−+	−−	−−	−−	−−
mid	−−	+−	+−	++	−−	++	−+
low	−−	−+	−−	−−	++	++	+−

44

(4)
$$[+\text{low}] \rightarrow \begin{bmatrix}+\text{mid}\\ -\text{low}\end{bmatrix} \;/\; [+\text{low}] \_\_ \left\{\begin{matrix}[+\text{high}]\\ [+\text{mid}]\\ \&\end{matrix}\right\}$$

$$11 \rightarrow 13 \;/\; \_\_ \left\{\begin{matrix}22\\ 33\\ 55\\ \&\end{matrix}\right\}$$

Whatever set of features are used, a solution which posits tone #5 as underlying 11 and deriving 13 would appear to be unnatural. There is no plausible reason why a low level tone should become a rising tone (using Wang's contour features) before either a level tone *or* before a pause. Assuming contour tones as sequences of level tones does not help since a rule which would change a sequence of two low tones into a low followed by a mid before either a sequence of identical level tones or pause is equally implausible. The distributional evidence too suggests that 11 cannot be underlying since it is far more restricted in its privileges of occurrence. Furthermore, with 11 in the phonemic inventory, it is necessary to postulate 4 phonemic level tones. This would leave us with a highly marked inventory of tones in terms of statistical frequency of tonal systems among the tone languages of the world. For all of these reasons, then, it is difficult to justify 11 instead of 13 as underlying tone #5.

If we therefore posit 13 as the underlying tone, we are still faced with a decision as to which set of tone features best reveals the "naturalness" of the tone sandhi rule.

Solution (c). Assuming that tone #5 is represented as 13 and using Fromkin's set of tone features, we have the matrix of phonemic and phonetic tones as given in (5). In this solution, as in all of the remaining solutions, tone #6 is analyzed as 11.[1]

(5)	#1 55	#2 31	#3 35	#4 33	#5 13	#6 11
high	++	−−	−+	−−	−−	−−
low	−−	−+	−+	−−	+−	++

(6) $\begin{bmatrix}-\text{high}\\-\text{low}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{high}\\+\text{low}\end{bmatrix} / \begin{bmatrix}-\text{high}\\+\text{low}\end{bmatrix} \underline{\quad} \begin{bmatrix}-\text{high}\\-\text{low}\end{bmatrix} \begin{bmatrix}\alpha\ \text{high}\\-\alpha\ \text{low}\end{bmatrix}$

$$13 \rightarrow 11 \ / \ \underline{\qquad} \begin{Bmatrix}31\\35\end{Bmatrix}$$

Rule (6) says that the end point of tone #5 (13) assimilates to its beginning point (13) and, at the same time, dissimilates to the beginning point of the tone on the following syllable, (31) or (35). Technically speaking, this rule yields the correct output, but seems highly implausible.

Solution (d). Another possible analysis using the features HIGH and MID in the systematic phonemic inventory is given in (7) and (8). Although the use of the latter pair of features enables us to simplify the structural description of the tone sandhi rule, we are still left with a phonetically implausible rule.

(7)

	#1	#2	#3	#4	#5	#6
	55	31	35	33	13	11
high	++	−−	−+	−−	−−	−−
mid	−−	+−	+−	++	−+	−−

(8) $$\begin{bmatrix}+\text{mid}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{mid}\end{bmatrix} \;/\; \begin{bmatrix}-\text{mid}\end{bmatrix} \_\_\_ \begin{bmatrix}+\text{mid}\end{bmatrix}\begin{bmatrix}-\text{mid}\end{bmatrix}$$

$$13 \longrightarrow 11 \;/\; \_\_\_ \begin{Bmatrix} 31 \\ 35 \end{Bmatrix}$$

Solutions (c) and (d), in which contour tones are analyzed as sequences of tones are highly suspect. Why should a tone sandhi rule depend not only on the immediately preceding and following tones but also on a following sequence of *two* tones?

Solution (e). Again assuming that tone #5 is represented as 13 phonemically, let us now consider a solution that is formulated with the contour tone features RISING and FALLING. If we assume that the tones in Lue are represented as shown in the matrix below, then it is possible to write a rule like (10) that handles the tonal alternation correctly.

(9)	#1 55	#2 31	#3 35	#4 33	#5 13	#6 11
high	+	−	+	−	−	−
central	−	−	−	+	−	−
rising	−	−	+	−	+	−
falling	−	+	−	−	−	−

(10) $\begin{bmatrix} -\text{high} \\ +\text{rising} \end{bmatrix} \rightarrow [+\text{rising}] \; / \; \underline{\quad\quad} \begin{bmatrix} \alpha\,\text{high} \\ \alpha\,\text{rising} \\ -\alpha\,\text{falling} \end{bmatrix}$

$$13 \rightarrow 11 \; / \; \underline{\quad\quad} \begin{Bmatrix} 31 \\ 35 \end{Bmatrix}$$

Rule (10) does not present the problem inherent in an analysis which excludes contour features in that the structural description of the rule does not require a complex sequence in the environment. But it does not strike one as a natural or phonetically plausible rule. Why should a rising tone become a non-rising tone before a segment whose tonal features HIGH and RISING have the same value, and with both of these features having the opposite value specified for the feature FALLING?

Solution (f). Once more using Wang's set of tone features, but this time positing the feature CONTOUR as well as RISING in the systematic phonemic inventory, we are finally able to formulate what looks like a phonetically pausible tone sandhi rule, as shown in (12).

(11)	#1 55	#2 31	#3 35	#4 33	#5 13	#6 11
high	+	−	+	−	−	−
central	−	−	−	+	−	−
rising	−	−	+	−	+	−
contour	−	+	+	−	+	−

(12)

$$\begin{bmatrix} -\text{high} \\ +\text{rising} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{contour} \end{bmatrix} \; / \; \underline{\quad\quad} \begin{bmatrix} +\text{contour} \end{bmatrix}$$

$$13 \rightarrow 11 \; / \; \underline{\quad\quad} \begin{Bmatrix} 31 \\ 35 \end{Bmatrix}.$$

This rule says that a low-rising *contour* tone changes to a low *level* tone when immediately preceding other *contour* tones. Although no data are provided in Li's (1964) paper, this rule would apply before 13 as well as 31 and 35. This particular tonal alternation, I would like to suggest, is an instance of a more general process of tonal dissimilation whereby a certain member of a tone class (13 is a member of the class of contour tones) becomes unlike other members of the same class (31 and 35 are the other members of the class of contour tones) by changing the specification for the defining feature of that class. The result of this dissimilatory process is the simplification of a contour tone in non-final position, a well-attested tone sandhi phenomenon in the tone languages of the world (Pike 1948, Wang 1967, Hyman and Schuh 1974). In addition, from a physiological perspective, it seems reasonable to speculate that the laryngeal adjustments required for transition between two contour tones in sequence is more complex than those required for transition between a level tone and a contour tone in sequence.

Thus, in order to reveal what appears to be the correct linguistic generalization, we see that it is necessary to use not only the contour tone feature RISING but also, and more importantly, the feature CONTOUR itself. For additional evidence in support of the feature CONTOUR as a classificatory feature, see Wang (1967:99).

Conclusion

Based on the evidence from Lue we can see that a theory of phonology must permit the specification of contour tones as single indivisible units on the classificatory level of representation. In addition, it must allow for CONTOUR as a classificatory feature. Otherwise, we cannot capture what appears to be the correct generalization for the tonal alternation in tone # 5, an instance of a general process of tonal dissimilation.

In line with Sapir's remarks on contour tones, it would seem then that movement *in a direction* away from A and toward B, and *not* movement *from* A *to* B, is what is psychologically real to a native speaker of Lue. That is, only by postulating the feature CONTOUR can we give a descriptively adequate account of the behavior of the tones in Lue.

REFERENCES

Chao, Y.R. 1930. A System of Tone Letters. Le Maître Phonétique (3rd Series) 45: 24-27.

Elimelech, Baruch. 1973. On the Reality of Underlying Contour Tones. Paper presented at Winter Linguistic Society of America Meeting, San Diego, California. To appear in UCLA Working Papers In Phonetics 27, 1974.

Fromkin, Victoria A. 1972. Tone Features and Tone Rules. Studies In African Linguistics 3.1:47-76.

Hombert, Jean-Marie. 1974. Is Tone Segmental or Suprasegmental? How To Decide? Unpublished paper. Department of Linguistics, University of California at Berkeley.

Hyman, Larry M. 1974. Discussion Paper On Sino-Tibetan Tone. Remarks on tone papers presented at 6th International Conference on Sino-Tibetan Languages and Linguistics, University of California, at San Diego, October 1973. To appear in Proceedings of 6th International Conference on Sino-Tibetan Languages and Linguistics, ed. by Benjamin Tsou, University of California at San Diego.

Hyman, Larry M. and Russell G. Schuh. 1974. Universals of Tone Rules: Evidence From West Africa. Linguistic Inquiry 5.1:81-115.

Leben, William R. 1973. Suprasegmental Phonology. Unpublished Ph. D. dissertation, Massachusetts Institute of Technology.

Li, Fang-Kuei. 1964. The Phonemic Structure of the Tai Lü Language. Bulletin of the Institute of History and Philology, Academia Sinica 35:7-14.

Maddieson, Ian. 1970. The Inventory of Features. Research Notes (Department of Linguistics and Nigerian Languages, University of Ibadan) 3.2-3:3-18.

Mohr, Burckhard. 1973. Tone Rules and the Phonological Representation of Tones. Paper presented at 6th International Conference on Sino-Tibetan Languages and Linguistics, University of California at San Diego, October 1973. To appear in Proceedings of 6th International Conference on Sino-Tibetan Languages and Linguistics, ed. by Benjamin Tsou, University of California at San Diego.

Pike, Kenneth L. 1948. Tone Languages. University of Michigan Press, Ann Arbor.

Wang, William S-Y. 1967. Phonological Features of Tone. International Journal of American Linguistics. 33.2:93-104.

Woo, Nancy. 1969. Prosody and Phonology. Unpublished Ph. D. dissertation, Massachusetts Institute of Technology.

Yen, Sian L. 1970. A Note On the Theoretical Framework for Tonal Analysis. International Journal of American Linguistics 36.4:290-296.

Section 7. Counterfeit Tones in the Speech of Southern Thai Bidialectals

ABSTRACT

Evidence from tone errors produced by Southern Thai bi-dialectals reveals that the disordering mechanisms (perseveration, anticipation, transposition) that have been proposed to handle consonant and vowel errors may be extended without modification to tone errors. The tone errors further reflect or support the independence of tone features and some proposed universals regarding tone rules. Although some of the tone errors may be directly attributed to 'dialect interference', the majority of errors are better explained in terms of more general physiological and/or perceptual factors (among others) that may intrude in the production of an utterance.*

0. Introduction

In recent years there has been a growing interest in speech errors because of the evidence they provide on questions concerning internalized grammars and the production of speech. All of the earlier studies, with the exception of Fromkin (1971), have discussed errors that involve consonants and vowels--i.e. 'segmental' errors, but have not discussed errors of stress, tone, or quantity--i.e. 'suprasegmental' errors. In this paper I will mainly discuss errors that involve tonal phenomena.

The earlier studies of consonant and vowel errors show rather convincingly that the errors are not merely random substitutions but instead are contextually conditioned and constrained by the structure of the language. Since tones, like consonants and vowels, also play a distinctive phonological role, we might expect tone errors to be subject to similar processes. I will attempt to show that tone errors can be accounted for the the same kinds of explanations that have been proposed for consonant and vowel errors, and further, that they similarly provide evidence for linguistic constructs.

The 350 tone errors that were analyzed were produced by bidialectal speakers in Phuket province in southern Thailand when speaking Standard Thai (Siamese). They were collected by myself and by two native speakers of Phuket Thai and one native speaker of Standard Thai.[1]

The aim of the study was not to compare differences between tonal errors produced by bidialectal and monodialectal speakers but primarily to see if tonal errors were similar to or different from segmental errors. Since almost all speakers in the Phuket province speaking Standard Thai are bidialectal, a collection of errors in this region of necessity involved bidialectals. A comparison of types of errors must therefore await future collection of errors produced by native Standard Thai speakers. Since these unintentional errors which occurred in spontaneous speech were produced by bidialectals it was necessary to distinguish between errors due to dialect interference and those of a more general character.

The speakers of Southern Thai dialects are well aware of the mistakes they produce when speaking Standard Thai, as is shown by the fact that they characterize such errors as 'counterfeit speech'. This is an apt description since the errors constitute a deviation from the standard language; analogously, counterfeit money constitutes a deviation from a standard currency. We can thus call the tonal errors counterfeit tones.

As will become apparent, some of the errors, especially those that result from the misapplication of a tone rule of the Phuket dialect, can be accounted for in terms of dialect interference. These provide evidence for the 'psychological reality' of such phonological rules. However, the largest number of errors can be better explained by more general mechanisms causing a serial disordering of whole tones or tonal features, as suggested in Lashley's (1951) seminal paper on serial order in behavior.

Figure 1 presents a comparison of the tones of Standard Thai and Phuket Thai.

(1)

		Standard Thai	Phuket Thai
khaa	'leg'	[_/] 'rising'	[¯\] 'high-falling'
khaa	'galangal'	[_] 'low'	[¯\] 'high-falling'
paa	'forest'	[_] 'low'	[⌒] 'mid-rising-falling'
paa	'to throw'	[—] 'mid'	[⌒] 'mid-rising-falling'
naa	'rice field'	[—] 'mid'	[-\] 'low-falling'
.....			
khaa	'value'	[¯\] 'falling'	[_/] 'rising'
paa	'aunt'	[¯\] 'falling'	[—] 'high-mid-level'
chaa	'slow'	[¯] 'high'	[_] 'low-level'

mot	'used up'	[-] 'low'	[¯] 'high'
kop	'frog'	[-] 'low'	[/] 'mid'
mot	'ant'	[¯] 'high'	[-] 'low'
saat	'to splash'	[_] 'low'	[—] 'low-mid-high'
baat	'monetary unit'	[_] 'low'	[—] 'low-mid-high'
phaap	'picture'	[¯\] 'falling'	[_/] 'rising'

In non-stopped syllables Standard Thai has five contrastive tones: rising, low, mid, falling, and high; Phuket Thai has six distinctive tones: high-falling, mid-rising-falling, low-falling, rising, low-level, and high-mid-level.

If the tonal errors were simply due to dialect interference one would expect that the errors would show a substitution of the Phuket tone for the Standard Thai tone in cognate words. Sixty-five percent of the errors cannot be accounted for in this way.

Since there are only five phonetically contrastive tones in Standard Thai, one might argue that the tone substitution errors produced by the Phuket bidialectal are due to chance. A chance hypothesis would be confirmed if we found that the errors were unsystematic and not subject to explanation: that is, if we found, for example, that the substituted tones were generally insensitive to the surrounding phonological and/or phonetic context of the utterance. But, as we shall see, these tone errors are not random and can be explained by the same principles that account for segmental errors--perseveration, anticipation, and transposition.

1. Kinds of Tone Errors

1.1 Errors of Perseveration

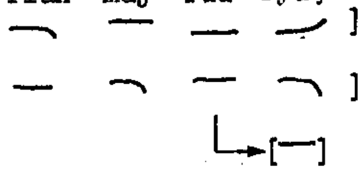
Errors of perseveration result in the substitution of one tone in perseveration of an identical or similar tone which occurs earlier in the utterance. The examples in 2 illustrate such errors.

(2)

a. rian maj ruu ryaŋ — '(I) can't seem to learn'

Phuket Thai: [ ]

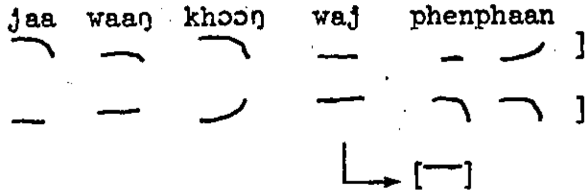
Standard Thai: [ ]



b. ɟaa waaŋ khɔɔŋ waj phenphaan — 'Don't leave things scattered around.'

Phuket Thai: [ ]

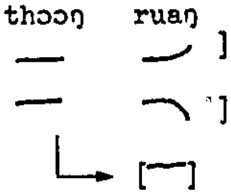
Standard Thai: [ ]



c. thɔɔŋ ruaŋ — '(I've) got diarrhea.'

Phuket Thai: [ ]

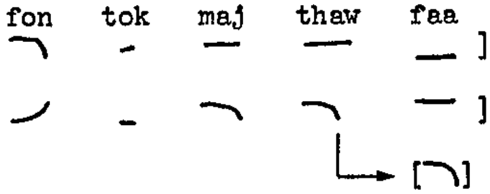
Standard Thai: [ ]



d. fon tok maj thaw faa — 'It's not raining all over.'

Phuket Thai: [ ]

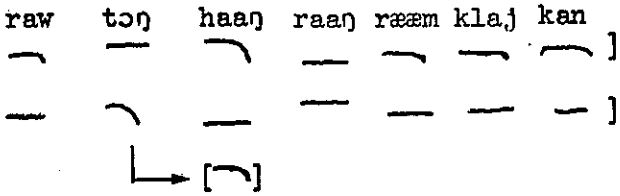
Standard Thai: [ ]



e. raw tɔŋ haaŋ raaŋ rææm klaɟ kan — 'We must spend the night away from each other.'

Phuket Thai: [ ]

Standard Thai: [ ]

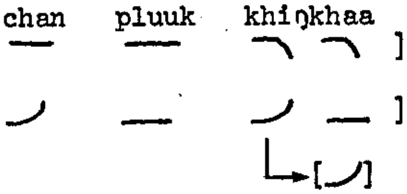


= Phuket Thai

f. chan pluuk khiŋkhaa — 'I grow ginger.'

Phuket Thai: [ ]

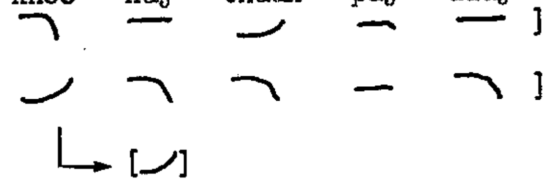
Standard Thai: [ ]



g. khɔɔ haj thaan paj duaj — 'I'd like for you to go too.'

Phuket Thai: [ ]

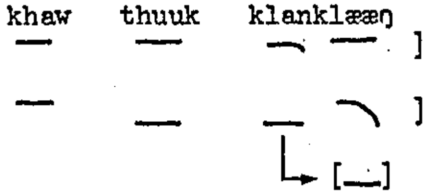
Standard Thai: [ ]



h. khaw thuuk klanklæŋ — 'He was being picked on.'

Phuket Thai: [ ]

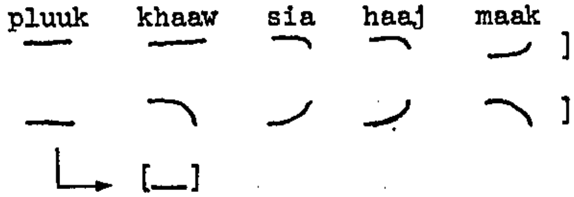
Standard Thai: [ ]



i. pluuk khaaw sia haaj maak — 'A lot of our rice was ruined.'

Phuket Thai: [ ]

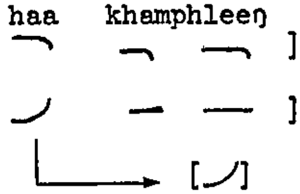
Standard Thai: [ ]



j. haa khamphleeŋ — 'Look for song lyrics.'

Phuket Thai: [ ]

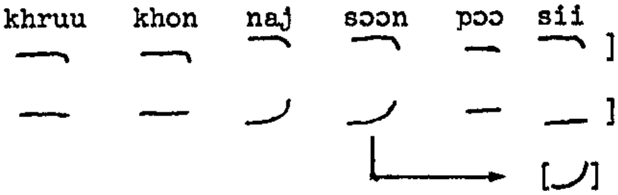
Standard Thai: [ ]



k. khruu khon naj sɔɔn pɔɔ sii — 'Which teacher teaches Grade 4?'

Phuket Thai: [ ]

Standard Thai: [ ]



2a-c show perseveration of a high tone, 2d-e a falling tone, 2f-g a rising tone, and 2h-i a low tone. No examples of perseveration of a mid tone occur in the present corpus. 2j-k further illustrate that the substituted tone need not occur on a contiguous syllable. As we shall see, this also holds true for errors of anticipation and transposition, similar to consonant and vowel errors.

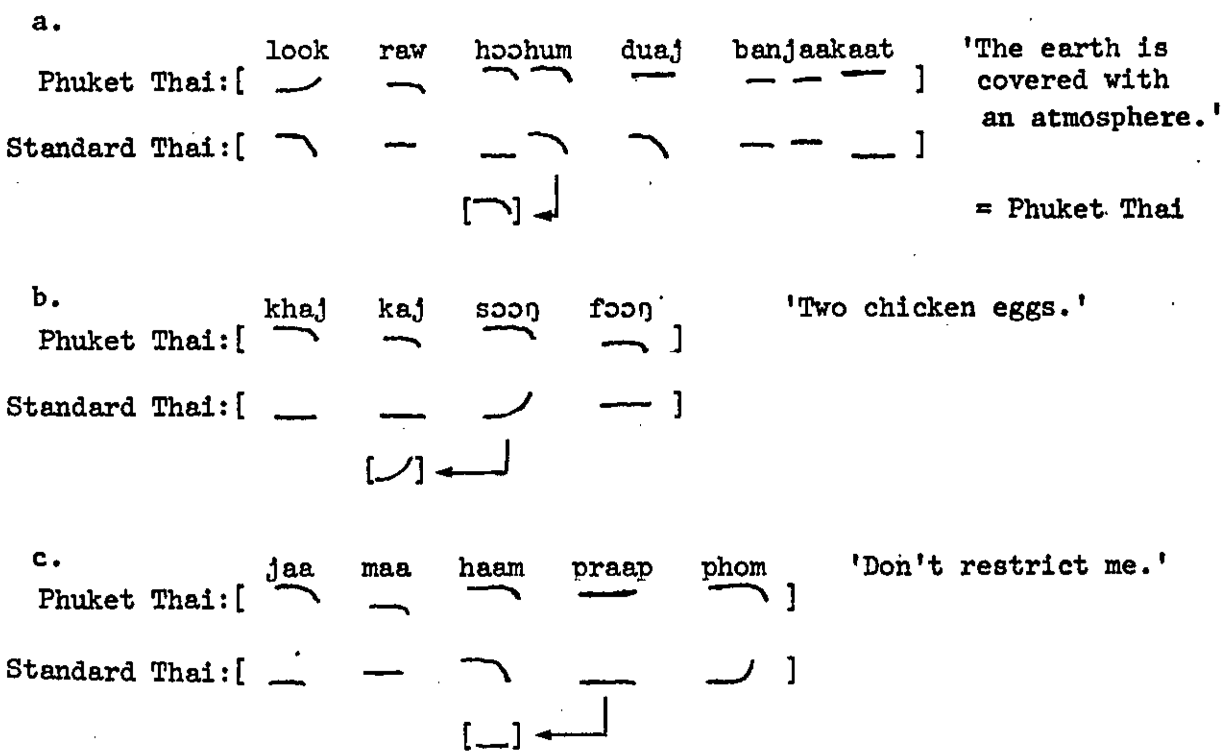
Each example contains the following: a broad phonetic transcription of the tones of the utterance in both Phuket Thai and Standard Thai; the counterfeit tone(s), which appears directly below the intended Standard Thai tone(s), together with an indication of whether the tone in error is identical to the tone for that particular lexical item in Phuket Thai (=Phuket Thai) or not (blank =Standard Thai); an arrow that points from the tone(s) that caused the disordering to the counterfeit tones produced in the error; a broad phonetic transcription of the Standard Thai segments of the utterance (the Phuket Thai consonant and vowel segments are not given where they differ from Standard Thai, since they are not immediately relevant to the issues under discussion); and finally, a rough English translation of the intended Standard Thai utterance.

These perseverative tone errors in 2 are similar to a segmental error like 'Chomsky and Challe' for the intended 'Chomsky and Halle' (Fromkin 1971).

1.2 Errors of Anticipation

Errors of anticipation result in a substitution of one tone in anticipation of an identical or similar tone which occurs later in the utterance, as shown in 3.

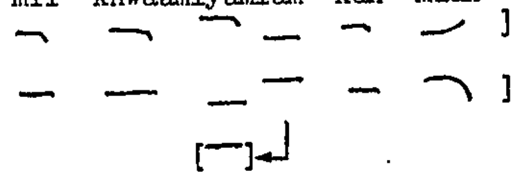
(3)



d. mii khwaamlyamlam kan maak — 'There's a lot of inequality.'

Phuket Thai:[ ]

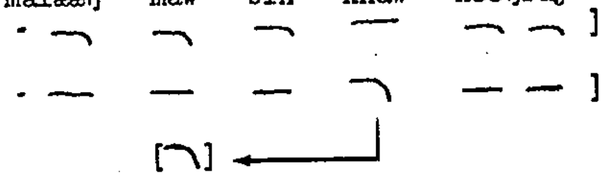
Standard Thai:[ ]



e. malææŋ maw bin khaw kɔɔŋfaj — 'The dizzy fly flew into the fire.'

Phuket Thai:[ ]

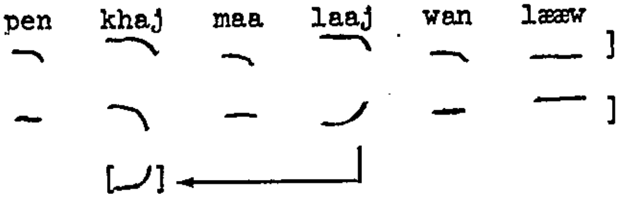
Standard Thai:[ ]



f. pen khaj maa laaj wan lææw — '(I've) had a fever for several days now.'

Phuket Thai:[ ]

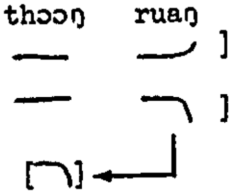
Standard Thai:[ ]



g. thɔɔŋ ruaŋ — '(I've) got diarrhea.'

Phuket Thai:[ ]

Standard Thai:[ ]



3a-d, in that order, show anticipation of a falling, rising, low, and high tone. No examples of anticipation of a mid tone are found in the present corpus. 3e-f show that the substituted tone need not occur on a contiguous syllable. As is true of segmental errors, the fact that tone errors may involve non-contiguous syllables further suggests that speech production is not based on a simple left-to-right Markov processing of successive elements, but instead involves the processing of a larger syntactic/phonological organizational unit prior to the issuing of motor commands. These tone errors then are not errors in motor control but rather errors in the linguistic message. 3g, in comparison with 2c, shows that the same sequence of words may be subject to either an error of anticipation or perseveration.

These anticipatory tone errors are also similar to segmental errors, as in the example 'alsho share' for the intended 'also share' (Fromkin 1971). However, unlike the results of investigations of segmental errors in which the majority were found to be anticipatory (Fromkin 1971:30), in the present corpus of tone errors, perseverative errors outnumber anticipatory errors by a ratio of about 2 to 1.

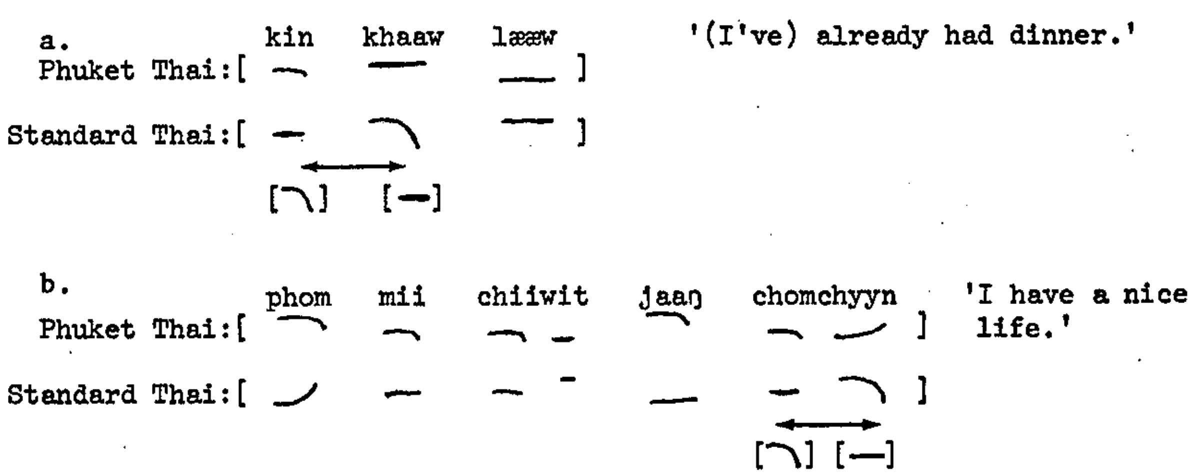
Hyman and Schuh (1974), in their discussion of universals of tone rules based on evidence from tone languages spoken in West Africa, observe that rules that spread tones from left-to-right (i.e. perseverative tone rules) are quite common in these languages whereas rules that spread tones in the opposite direction (i.e. anticipatory tone rules) rarely occur. They further observe that these perseverative tone rules are most likely to occur when the interval between the two tones is greatest.

The predominance of perseverative tone errors might reflect this tendency for tones to spread from left-to-right, possibly reflecting some built-in constraint in the speech production mechanism. The absence of mid tone in perseverative tone errors might reflect the tendency for tones to spread when the interval between the two is greater.

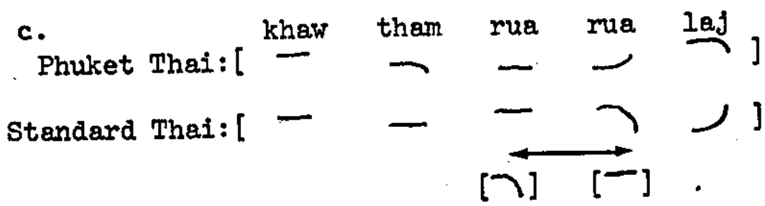
1.3 Errors of Transposition.

Errors of transposition, commonly called 'Spoonerisms' when they involve segments, result when two tones reverse or switch their original position in an utterance. Transposition errors are illustrated in 4.

(4)

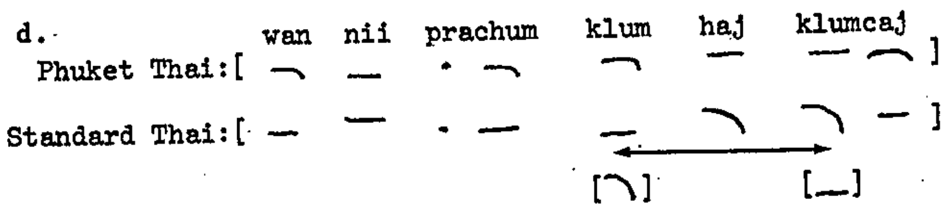


c.



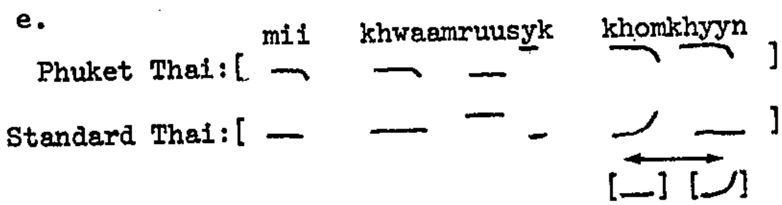
'He made a hole in the fence.'

d.



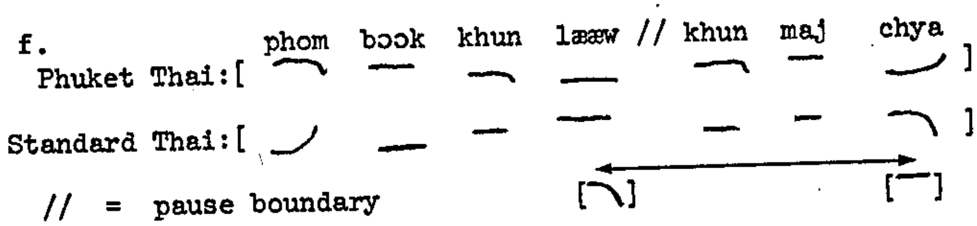
'Today's meeting depressed me.'

e.



'(I) feel bitter.'

f.



'I told you but you wouldn't believe me.'

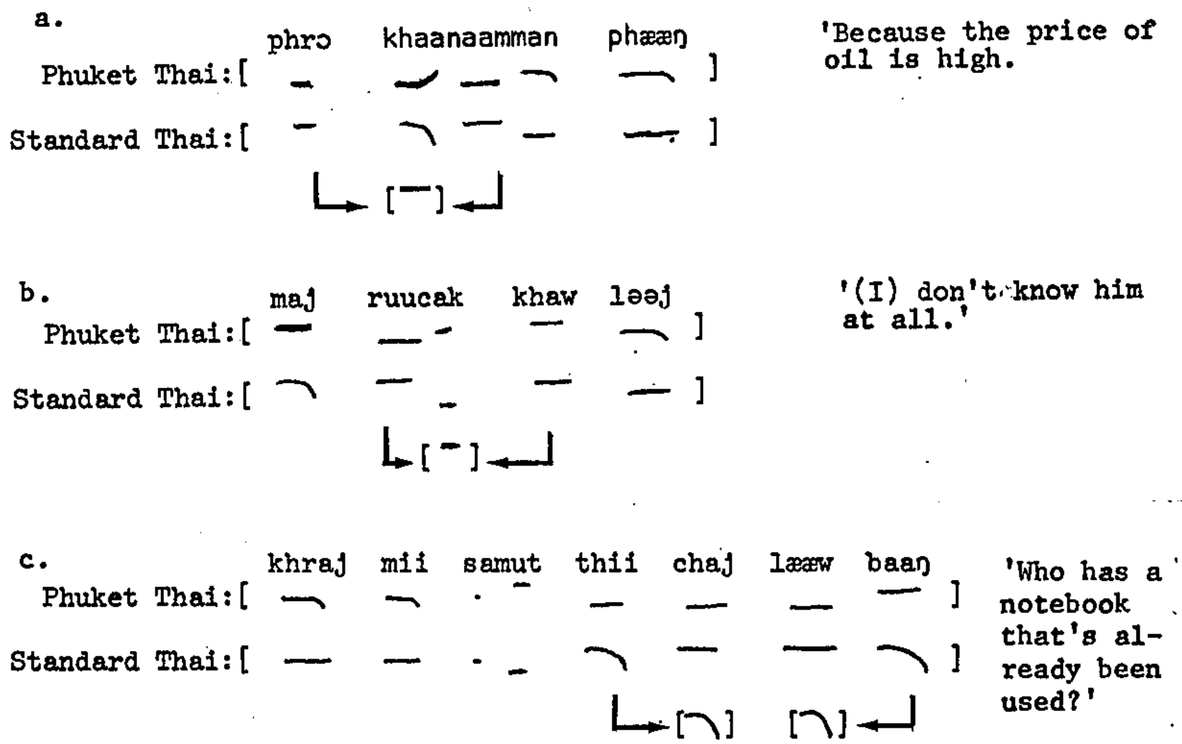
Note, too, that unlike perseverative and anticipatory tone errors, transposition errors may involve a mid tone as evidenced in 4a-b.

These errors are also similar to transposition errors involving segments, as in the example 'teep a cape' for the intended 'keep a tape' (Fromkin 1971).

1.4 Further Similarities Between Tone and Segmental Errors

As is true for consonant and vowel errors, a number of tone errors cannot be unambiguously classified.

(5)



In 5a-b we cannot tell whether the substituted high tone results from anticipation of the following high tone or perseveration of the preceding high tone. In 5c we cannot tell whether the falling tones are errors of anticipation or perseveration, or both. It appears that the probability of a tone error increases when an unlike tone intervenes between a sequence of like tones. This too is found in segmental errors.

One interesting fact about these tonal errors is that unstressed syllables are not normally involved. This is in agreement with the finding of Nooteboom (1969) who points out that 'in significantly more cases than is to be expected in a random distribution the elements involved in a speech error belong to stressed syllables'. MacKay (1969) and Boomer and Laver (1968) also found this to be true for segmental errors. We find here a further similarity between tone and segmental errors.

1.5 Implications for Linguistic Theory

1.5.1 Orthogonal Tone Features

All of the errors that we have discussed so far point to the reality of the independence of whole tones or tone features; that is, the tones may be copied or shifted while the consonants and vowels of the syllable remain in their original position. Fromkin (1971:35-38) employs a similar argument to show the reality of properties or features of consonants and vowels that are smaller than the segment, as in the example 'glear plue sky' for the intended 'clear blue sky' (Fromkin 1973). Note, however, that although tone features function similarly to segmental features in that they can be independently disordered, the evidence from these tone errors argues neither for nor against assigning tones to a suprasegmental as opposed to a segmental unit. Since segmental features are assigned to segmental units, tone features too could be assigned to segmental units on the basis of the tone errors. Clearly, other linguistic evidence must be sought to force a decision on such a theoretical issue.

1.5.2 Representation of Contour Tones

As for the phonological representation of contour tones, Want (1967) proposes a set of distinctive features of tone that includes unit contour tone features (e.g. FALLING, RISING) while Woo (1969), Maddieson (1970), and Leben (1973) among others meantain that all contour tones are to be analyzed as sequences of level tones (e.g. HL = FALLING, LH = RISING). Unfortunately, the data are inconclusive on the question of whether contour tones are to be analyzed as indivisible units or as sequences of level tones. However, the fact that the overwhelming majority of errors reveal that the tones are copied or shifted as unitary wholes, although not evidence against a sequential interpretation of contour tones on a lexical level, certainly necessitates unit contour tone features at some level of representation. Furthermore, most of the substituted tones do not appear to be sensitive to the begin-point and/or end-point of tones that are anticipated or perseverated.

We do find, however, some errors in the present corpus which lead to the conclusion that contour tones be analyzed as sequences of level tones. These errors are given in 6.

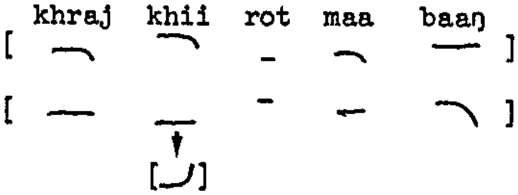
(6)

a.

khraj khii rot maa baaŋ

Phuket Thai:

Standard Thai:



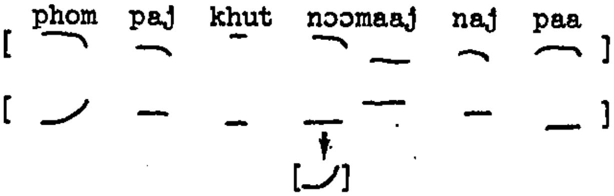
'Who all came by car?'

b.

phom paj khut nɔɔmaaj naj paa

Phuket Thai:

Standard Thai:



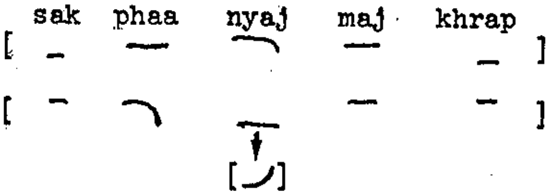
'I went to dig up bamboo shoots in the forest.'

c.

sak phaa nyaj maj khrap

Phuket Thai:

Standard Thai:



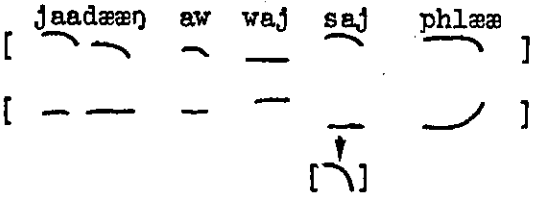
'Did washing clothes make you tired?'

d.

jaadææŋ aw waj saj phlææ

Phuket Thai:

Standard Thai:



'Keep the iodine handy for first-aid.'

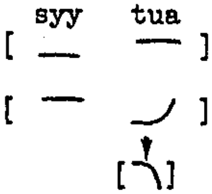
= Phuket Thai

e.

syy tua

Phuket Thai:

Standard Thai:



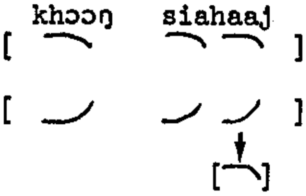
'Buy (your) ticket.'

f.

khɔɔŋ siahaaj

Phuket Thai:

Standard Thai:



'Things have disappeared.'

= Phuket Thai

6a-c suggest that the counterfeit rising tones be analyzed as a sequence of L-H level tones: the rising tones result from the preceding L tone (begin point) anticipating the transition to the following H tone (end point). Similarly, 6d-f suggest that the counterfeit falling tones be analyzed as a sequence of H-L level tones: the falling tones result from the spreading of a preceding H tone (begin point) into a following syllable that carries a L tone (end point). What seems to have happened in these tone errors is shown in 7.

(7)

a. L H → $\widehat{LH}$ H (6a-c)

b. H L → H $\widehat{HL}$ (6d-f)

It should also be pointed out that a process such as the one depicted in 7a is almost unattested in the tone languages of West Africa (Hyman and Schuh 1974). It is possible that the rare occurrence of 7a reflects a typological property of those languages, and not a universal constraint on tone spreading. The process in 7a certainly seems reasonable from a phonetic standpoint. A rising tone facilitates the transition from a lower tone to a higher tone.

The use of unit contour tone features as in 8a-b, would obscure the nature of these tone substitutions.

(8)

a. L H → R H

b. H L → H F

The evidence from tone errors in the speech of Phuket bidialectals then suggests that contour tones need to be analyzed as both indivisible units and as sequences of level tones. Segmental errors have been shown to occur at either a more abstract level or at the phonetic level.

The fact that the great majority of contour tone errors involve perseveration, anticipation, or transposition of the whole contour, suggests that even at a more abstract phonemic level contour features may be present.

1.5.3 Tone: Production and Perception

In about fifty percent of the errors the tone substituted for the target or intended tone is a high-falling tone. That is, in half the errors the contaminating tone(s) which perseveres or is anticipated, or transposed is a high-falling tone. This cannot be due to an overwhelming occurrence of high-falling tones in Phuket Thai since the mid-rising-falling and low-falling tone also occur widely in the lexicon. The fact that a high-falling tone is substituted for Standard Thai mid and high tones almost as frequently as rising and low tones also makes it difficult to explain in terms of dialect interference alone. It is not the case that the Phuket bidialectal is only substituting a high-falling tone for cognate low and rising tones. However, the distribution of tones in Phuket Thai would partially account for the unevenness in the kinds of tones substituted in these errors since the tones above the dotted line in (1) (see Section 0) occur more frequently than those below.

I would like to suggest that the preponderance of high-falling tones in these errors may be due to language-universal phonetic tendencies instead of language-specific phonological characteristics of the Phuket dialect. First, I know of no tone language that has a phonologically low-falling tone without also having a high-falling tone, whereas numerous Asian tone languages do have only a high-falling tone in their tonal inventory. Li and Thompson (1975), in their investigation of tone acquisition in Mandarin children, found also that the high-falling tone (tone 4), along with the high-level tone (tone 1), was acquired earlier than either the rising (tone 2) or low (tone 3) tones. Ohala and Ewan (1973), based on tone production data, suggest that falling tones are easier to produce than rising tones. Brown (1965, 1975), from evidence on diachronic tone changes among Thai dialects, suggests that a tone gravitates to the most natural height for its contour, tone space permitting: the most natural height for a falling tone is claimed to be mid-high as compared to mid-low for a rising contour tone. These errors thus seem to show how physiological and/or perceptual factors may influence the kind of errors that occur. Just as in other kinds of speech errors a multiplicity of factors converge. The errors cannot simply be attributed to motor control or performance factors; interaction with other factors must be taken into account in order to explain these errors on the performance level (Fromkin 1975).

Another interesting asymmetry in the distribution of the tones substituted in the errors is that contour tones, i.e. falling and rising tones, outnumber level tones by a ratio of 4 to 1. Among the level tones the high tone clearly predominates; few instances of low and mid tones occur in the errors. This distribution in frequency of occurrence of the substituted tones tentatively suggests the rank order in 9.

(9)

'Contour'	1.	FALLING
	2.	RISING
	3.	HIGH
'Level'	4.	MID
	5.	LOW

It would appear that errors are more likely to produce dynamic pitch contours than static pitch contours; among the latter, errors are more likely to result in more 'extreme' pitches. Speculatively, this hierarchy might reflect a scale of 'perceptual saliency' whereby (comparatively) dynamic tonal contours are perceptually more salient than (comparatively) static tonal contours, and whereby the 'extreme' pitches are perceptually more salient among the static tonal contours. This perceptual bias may intrude in the production of pitch as evidenced by the errors in the present corpus.

2. Dialect Interference

Let me now turn to tone errors that can be directly attributed to dialect interference to see what they tell us about phonological rules.

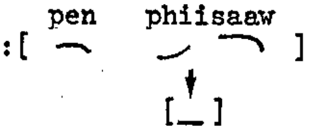
2.1 Phuket Tone Sandhi

Phuket Thai has a tone rule, not found in Standard Thai, by which the rising tone becomes a low-level tone in non phrase-final position at normal speech tempo. The application of this rule is illustrated in 10.

(10)

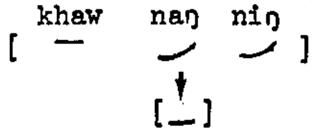
a.

Phuket Thai: [pen phiisaaw] '(She's) my older sister.'



b.

Phuket Thai: [khaw naŋ niŋ] ' He's sitting still.'



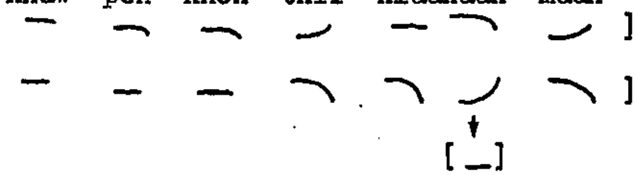
Examples of how the application of this rule may affect a Standard Thai utterance produced by a Phuket bidialectal are given in 11.

(11)

a. khaw pen khon thii klaahaan maak — 'He's a very person.'

Phuket Thai: [ ]

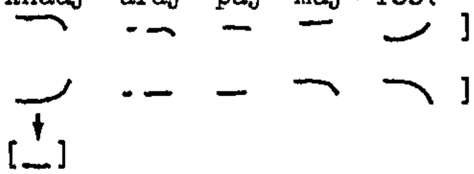
Standard Thai: [ ]



b. khaaj araj paj maj root — 'I can't seem to sell anything.'

Phuket Thai: [ ]

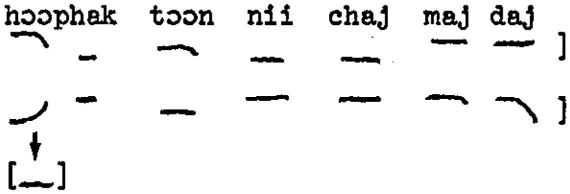
Standard Thai: [ ]



c. hɔɔphak tɔɔn nii chaj maj daj — 'These days the dormitory is a mess.'

Phuket Thai: [ ]

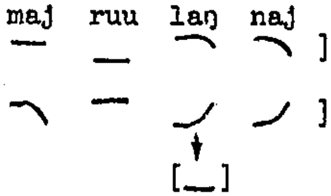
Standard Thai: [ ]



d. maj ruu laŋ naj — '(I) don't know which house it is.'

Phuket Thai: [ ]

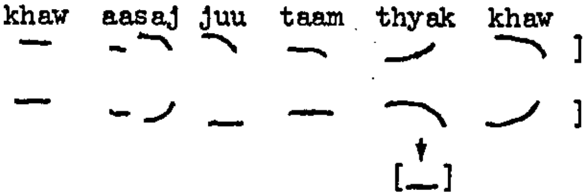
Standard Thai: [ ]



e. khaw aasaj juu taam thyak khaw — 'They live in the mountains.'

Phuket Thai: [ ]

Standard Thai: [ ]



[ ] = Phuket Thai

Although it is possible that these errors are random substitutions, a more non ad-hoc explanation is that the tone rule is not only part of the Phuket dialect grammar which linguistic evidence necessitates but is actively utilized in performance. This is demonstrated by the fact that the Phuket speaker may incorrectly apply this rule to a Standard Thai underlying form as in 11a-d, and sometimes to a Phuket Thai underlying form as in 11e. Note that in 11a-d the tone rule would not apply to the Phuket Thai underlying forms. In 11c, for example, the underlying form for hɔɔ has a rising tone in Standard Thai, a high-falling tone in Phuket Thai. The tone rule does not apply to the high-falling tone.

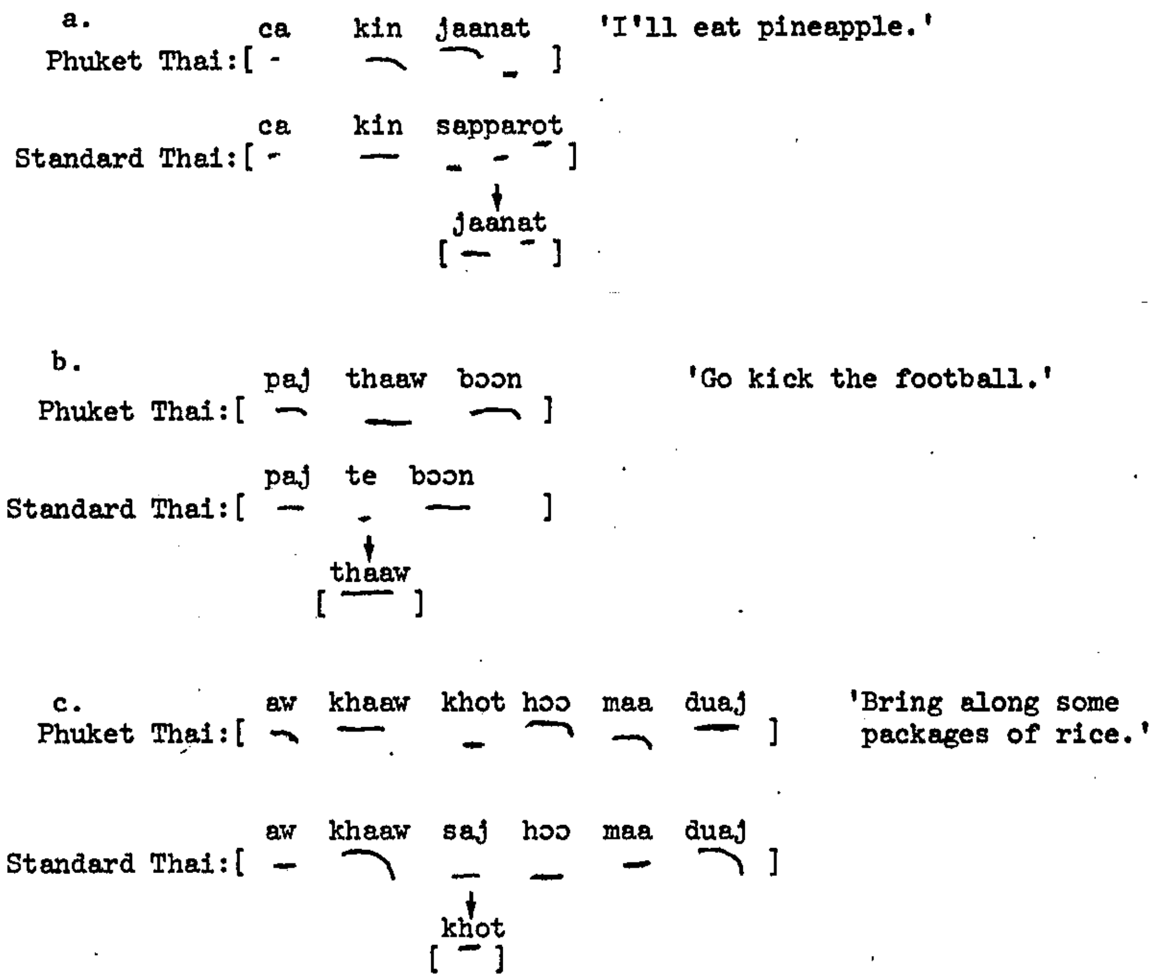
11e further shows that an error may occur in the selection of the underlying cognate form before the application of the tone rule; otherwise, the low-level tone cannot be accounted for. The corresponding Standard Thai underlying form has a high-falling tone and, as we have already seen, the tone rule applies to the rising tone only.

What is important here is that the errors show that the interference is rule-governed. A rule of one grammar is applied incorrectly at a point in another grammar at which it would otherwise apply.

2.2 Non-Cognate Lexical Items

A number of examples can be found in which the Phuket bidialectal substitutes a non-cognate Phuket Thai word in a Standard Thai utterance but pronounces the word with its Standard Thai tone. These are shown in 12.

(12)

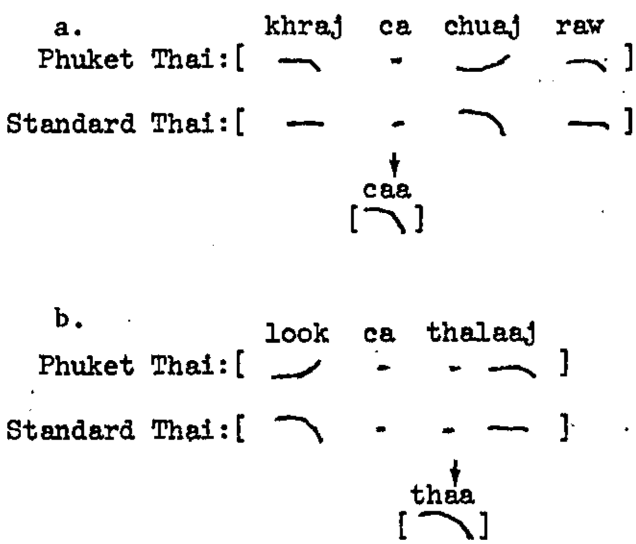


In 12b the word for 'to kick' is <u>te</u> in Standard Thai, <u>thaaw</u> in Phuket Thai. The word <u>thaaw</u> means 'foot' in Standard Thai. Here the speaker substituted the Phuket Thai word but pronounced it with its high tone of the Standard Thai word. These errors clearly result from interference of the Phuket dialect.

2.3 Language-Specific Phonological Constraints

A few errors in the corpus reveal the phonological constraint that disallows contour tones on syllables containing a single sonorant segment.

(13)



a. 'Who will help us?'

b. 'The world is going to crumble.'

In both 13a-b a normally unstressed short vowel is lengthened to accommodate the falling contour tone. 13a shows that <u>ca</u> (future auxiliary) anticipates the falling tone of <u>chuaj</u>; 13b shows that the falling tone of <u>look</u> perseveres into the first syllable of <u>thalaaj</u>, normally pronounced with a short vowel on a mid pitch level. Here we see that unstressed syllables may sometimes be involved in tone errors, as also happens in segmental errors. 13a-b also tell us something about the sequence of events in the production of an utterance. The disordering of the tone must occur before or simultaneous with the lengthening of the vowel.

That is, the substitution of the falling tone necessitates a long vowel. If the vowel is not lengthened as a result of the tonal change, a phonological constraint of both Standard Thai and Phuket Thai would be violated. As with segmental errors, tone errors provide evidence for the posited phonological rules of a language.

3. Conclusion

To sum up, the evidence from tone errors made by Phuket bidialectals shows us that (1) the disordering mechanisms that have been proposed to account for consonant and vowel errors may be extended without modification to handle tone errors (2) tones function independently of other segmental features (3) language-specific phonological rules and constraints on the distribution of tones are evidenced in the kinds of errors which occur and (4) tone errors seem to reflect or support some proposed universals regarding tone rules. Tone errors then do provide relevant data for linguistic theory--to paraphrase Fournié--giving us if not a window, at least a peep-hole, through which we can view the workings of the human mind.

FOOTNOTES

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[1]The tones in error, plus their context, were written down in Standard Thai orthography. This method of transcribing errors made it possible to unambiguously identify the substituted tones with any of the tones of either Standard Thai or Phuket Thai. It did not, however, allow for a reliable transcription of tone errors that could not be categorized in either of the two dialects. Such errors, if they do occur in any systematic way, were simply not accessible to this method of investigation.

REFERENCES

Boomer, D. S. and J. D. M. Laver. 1968. Slips of the tongue. British Journal of Disorders of Communication 3.1-12.

Brown, J. M. 1965. From Ancient Thai to modern dialects. Bangkok: Social Science Association Press.

Brown, J. M. 1975. The great tone split: did it work in two opposite ways? Studies in Tai linguistics in honor of William J. Gedney, ed. by J. G. Harris and J. R. Chamberlain, 33-48. Bangkok: Central Institute of English Language.

Fromkin, V. A. 1971. The non-anomalous nature of anomalous utterances. Language 47.27-52.

Fromkin, V. A. (ed.) 1973. Speech errors as linguistic evidence. The Hague: Mouton.

Fromkin, V. A. 1975. Wheres and whyfores of preach seduction. Paper presented at the 90th meeting of the Acoustical Society of America, San Francisco.

Hyman, L. M. and R. Schuh. 1974. Universals of tone rules: evidence from West Africa. Linguistic Inquiry 5.81-116.

Lashley, K. S. 1951. The problem of serial order in behavior. Cerebral mechanisms in behavior, ed. by L. A. Jeffress, 112-136. New York: Wiley.

Leben, W. R. 1973. Suprasegmental phonology. MIT PH.D. dissertation.

Li, C. N. and S. A. Thompson. 1975. Tone acquisition in Mandarin children. Paper presented at the 8th International Conference on Sino-Tibetan Languages and Linguistics, University of Californis at Berkeley.

MacKay, D. G. 1969. Forward and backward masking in motor systems. Kybernetik 6.57-64.

Maddieson, I. 1970. The inventory of features required for handling tone in transformational phonology. Research Notes (University of Ibadan, Nigeria) 3.2-3:3-18.

Nooteboom, S. G. 1969. The tongue slips into patterns. Nomen: Leyden studies in linguistics and phonetics, ed. by A. G. Sciarone et al., 114-132. The Hague: Mouton.

Ohala, J. and W. G. Ewan. 1973. Speed of pitch change. Journal of the Acoustical Society of America 53,345 (abstract).

Wang, W. S-Y. 1967. Phonological features of tone. International Journal of American Linguistics 33.93-105.