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一般語言學家大多數認為「音高」為聲調的主要成分。如趙元任先生的「五點制」為傳統的中國語言學聲調研究之最具代表性者，是以比較各聲調的高低，以為分別相對音高的標準；派克先生認為聲調之主要對比在於相對的音高；其他語言學家諸如布拉茲曼先生、王士元先生等也都認為音高在聲調裡佔最重要的成分。但對音長都未作考慮。

近年來吳南施女士假設：「所有的升降調幅都應分析為由連續性平調相連所組成的。」這種假設是基於「聲調的辨音成分，即是音高成分」而來的。也因此她必須另作假設，即「所有升降調幅只能出現於長母音音節，短母音音節沒有此種升降調幅。」而抹殺了音長。且和閩南語、廣東話及豪撒語（一種非洲語言）等之升降調幅出現於短母音音節的現象相抵觸。

另有部分語音學家及語言學家，曾經建議，音高並非絕對是國語聲調裡，最主要的聲學上關連者。聲學實驗報告顯示聲乃是相當複雜的語音現象，至少包含有下列三種成分：

- 音高——指音形成時，由聲帶顫動的頻率而得音的高低。
- 音強——指音形成時，用力的輕重。
- 音長——指某音所佔時間久暫。

本篇目的在討論聲調的辨音成分，不只音高，亦應包括音長在內。同時併討論如果音長亦為聲調的辨音成分之一，則吳南施第二項「限制升降調幅，只能出現於長母音音節」的假設不能成立。

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- and Tung (1957, 1959).
7. The examples are taken from Cheng (1968), "Tone sandhi in Taiwanese", p. 23. However, our classification is slightly different from his.
  8. It seems to me that the traditional Chinese bipartite division of syllables into initials and finals instead of the Western partition into consonants and vowels may offer insights into the formulation of the modern phonological theory. However, nothing can be said at this stage until we investigate the area more closely hopefully with the help of modern instruments.
  9. It seems to me that the analysis of the neutral tone might be more complicated than that proposed by Cheng and others if we consider the Mandarin as it is now spoken in Taiwan, where the second item of *dung syi* 'thing' can be either pronounced as neutral tone or first tone. It has also been reported that even in Peiping-dialect, the second morpheme of the following expressions can be either pronounced as neutral tone or one of the underlying four tones without changing the meaning.
 

1a. <i>jì lù</i> 記錄 'record'	3a. <i>syōū lí</i> 修理 'repair'
b. <i>jì lu</i>	b. <i>syōū li</i>
2a. <i>jiyè shaù</i> 介紹 'introduce'	
b. <i>jiyèshau</i>	
  10. Cheng 1973, p. 53.
  11. Kratochvil (1964) and Woo (1969), cp. esp. Woo pp. 62-69.
  12. A detailed study of the syntactic environments in which similar sandhi takes place in Taiwanese is available in R.L. Cheng (1968).
  13. In terms of marking convention, an alternate feature short might be considered, because there are more long tone syllables than short ones. It is normal for an unmarked tone feature to become minus tone feature (Wang 1967). Thus an unmarked short feature becomes a minus short.
  14. This example was pointed out to me by Dr. Julia Falk.
  15. For a detailed formulation of discussion of quasi-matrix and quasi-step matrix, see Lockwood (1973).

quasi-matrix retains Woo's hypothesis that contour tones are represented as sequences of level tones.

In the above discussion, we have reinterpreted Chao's tone-letter notation in order to show that contour tones can be represented as sequences of level tones. We have also attempted to show that length is both a tone feature and a function of tone change. We have therefore proposed that the feature length be added to the distinctive features of tone so as to permit the representation of short contour tones as sequences of level tones.

#### Notes:

1. The data in Table I are taken from Woo (1969) pp. 57-58. The syllables are retranscribed in the Yale system instead of the system used in Woo's work for some practical reasons. It is not clear why Woo did not give duration measurements for the initial consonant j- and final nasals for the examples illustrating the falling-tone. For the initial j-, I suspect it might be because j- behaves differently from other consonants in that it can function as a syllabic consonant. As to the omission of the duration measurements for the final nasals, I have no explanation for it now. If Woo had used the same initial consonant for all the four tonal groups in the experiment, the results might have been better. However, this is the best data available to me at present.
2. It has been pointed out by Egerod in the discussion of Kratochvil's (1970) paper that the finding of the features of tone other than pitch is important because these features can be used for historical reconstruction.
3. E.g., Welmers, Pike, Wang, Longacre, Leben, Dwyer, etc.
4. Karlgren 1963, p. 213.
5. It has been pointed out that a large number of dialects reveal the fact that after voiceless initials the tone was in a comparatively high pitch, after voiced initials in a lower pitch, e.g., tân:-d'ân (Karlgren 1963:271).
6. Taiwanese, a southern Min Chinese dialect, is spoken by approximately seventy percent of the population of Taiwan. Despite the name, it does not differ in any significant way from Amoy as described by Bodman (1955)

instead of singular component, we couldn't analogously use the quasi-matrix formalism which is illustrated but not adopted in that paper.<sup>15</sup>

In this proposal, level and contour tones can be represented as follows:

Level tone

+segment
$\mathcal{L}$ length
$\pm$ high

Contour tone

+segment	
$\mathcal{L}$ length	
$\pm$ high	$\pm$ high

Where [length] has n-ary values at both phonetic and phonemic levels.  $\mathcal{L}$  is a variable stating the degrees of length which are indicated by integers 1, 2, and 3, etc. If a language has two degrees of length, then the integers 1 and 2 are used, where 1 = short and 2 = long. If a language has three degrees of length, then the integers 1, 2, and 3 are used, where 1 = short, 2 = long, 3 = extra long. The use of integers at the phonetic level has long been justified in the phonological literature. At the systematic phonemic level a feature normally has binary values, such as [+voice] or [-voice]. There is no language known as yet that has manifested three degrees of voicing. However, there have been cases where the human ear can perceive more than two degrees of length. Since it is perceptually possible for length to have more than two degrees, we might just as well use the phonetically justified integers at the phonemic level. Thus, if a language distinguishes two degrees of the duration of tone, then long and short level and contour tones are represented phonetically as follows:

Short level

+segment
1 length
+high

Long level

+segment	
2 length	
+high	+high

Short falling

+segment	
1 length	
+high	-high

Long falling

+segment	
2 length	
+high	-high

The use of length in this way enables the phonetic and phonemic representation of both level and contour tones to be represented naturally. The use of the

(1) Short falling

$$\begin{bmatrix} +\text{segment} \\ -\text{length} \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ -\text{length} \\ -\text{high} \end{bmatrix}$$

(2) Short level

$$\begin{bmatrix} +\text{segment} \\ +\text{length} \\ +\text{high} \end{bmatrix}$$

(3) Long level

$$\begin{bmatrix} +\text{segment} \\ +\text{length} \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ +\text{length} \\ +\text{high} \end{bmatrix}$$

(4b) Long falling

$$\begin{bmatrix} +\text{segment} \\ +\text{length} \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ +\text{length} \\ -\text{high} \end{bmatrix}$$

(Where [-length] corresponds phonetically to [length +1]

[+length] corresponds phonetically to [length +2] )

In this representation, a sequence [-length] [-length] equals to [+length]. We feel that this use of [+length] for short level tone is misleading. Moreover, if (4a) or (4c) is to be represented phonemically, how to represent it? It would be something like

$$\begin{bmatrix} +\text{segment} \\ -\text{length} \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ +\text{length} \\ -\text{high} \end{bmatrix} \quad \text{or} \quad \begin{bmatrix} +\text{segment} \\ +\text{length} \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ -\text{length} \\ -\text{high} \end{bmatrix}$$

Then, how is a sequence [-length] [+length] or [+length] [-length] to be interpreted? It is also a use of - in a sense (i.e., mathematically multiplicative) entirely different from the normal use of binary values. Note, for example, the fact that a word final consonant cluster that is . . . [  $\begin{smallmatrix} C \\ -\text{voice} \end{smallmatrix}$  ] [  $\begin{smallmatrix} C \\ -\text{voice} \end{smallmatrix}$  ] # is not and should not be considered as a voiced sequence.<sup>14</sup> Thus the mathematical use of -- = + must be restricted to the feature [length].

As mentioned above, we agree to the proposal using [length] to specify tonal duration. But we feel that the representation of contour tones as a sequence of two tone-bearing *segments* complicates the phonological theory. We feel the representation might be simpler if we use quasi-matrix configurations. The term quasi-matrix is suggested by Lockwood (1973) for configurations not requiring the strict maintenance of segment boundaries. Lockwood uses a singular component rather than binary features and claims that a quasi-step matrix can be used at both the phonetic and phonemic levels. If we use binary or n-ary features

tones as a sequence of two tone-bearing segments.

At present, we are in basic agreement with this proposal using the feature [length] to specify the duration of a segment.<sup>13</sup> According to Dwyer, [length] appears phonetically with n-ary values which correspond to the passage of time, the larger the integral value, the longer duration of the segment. Phonologically, length has binary values [+length] 'longer' and [-length] 'shorter'. According to this proposal, long and short level and contour tones are represented phonetically as follows:

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(1) Short falling

$$\begin{bmatrix} +\text{segment} \\ \text{length} +1 \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ \text{length} +1 \\ -\text{high} \end{bmatrix}$$

(2) Short level

$$\begin{bmatrix} +\text{segment} \\ \text{length} +2 \\ +\text{high} \end{bmatrix}$$

(3) Long level

(a)  $\begin{bmatrix} +\text{segment} \\ \text{length} +4 \\ +\text{high} \end{bmatrix}$

or

(b)  $\begin{bmatrix} +\text{segment} \\ \text{length} +2 \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ \text{length} +2 \\ +\text{high} \end{bmatrix}$

(4) Long falling

(a)  $\begin{bmatrix} +\text{segment} \\ \text{length} +1 \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ \text{length} +3 \\ -\text{high} \end{bmatrix}$  or (b)  $\begin{bmatrix} +\text{segment} \\ \text{length} +2 \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ \text{length} +2 \\ -\text{high} \end{bmatrix}$

or (c)  $\begin{bmatrix} +\text{segment} \\ \text{length} +3 \\ +\text{high} \end{bmatrix} \begin{bmatrix} +\text{segment} \\ \text{length} +1 \\ -\text{high} \end{bmatrix}$

In Dwyer's definition of the distinctiveness principle, i.e. "any sequence of identical segment is non-distinct from any other sequence of the same segments as long as the duration of each sequence is the same" (Dwyer 1973: 19), the representations of (3a) and (3b) are identical.

To show how length operates on the phonemic level, Dwyer gives the following phonemic representations for the above examples (omitting 4a and 4c):



Thai. More recently, he has pointed out that the suprasegmental framework has a number of deficiencies and fails to account for some tonal phenomena, such as downstep in Tiv and downdrift in Hausa (Leben 1975:5). Therefore, he seems to support the autosegmental system suggested by Goldsmith (1974 & 1975). The autosegmental theory, roughly stated, is a suprasegmental theory. Both share the same fundamental idea that the underlying tone melody is treated as a separate linguistic level independent of the segments or the syllable structure. But in the autosegmental system, the association of segments with tones never results in a single representation in which tones have been converted into segmental features. Rather, the phonology simply keeps track of which tones and which segments have been associated with one another. Goldsmith's theory originally arose from work in African languages, English and Sanskrit as well as in Japanese. It is not clear at present whether its principles apply to tone languages such as Chinese.

Fromkin also criticizes the complication of the suprasegmental proposal and suggests a similar representation utilizing tone-bearing non-segments. She claims that "it would create fewer problems than the proposal to include two matrices." (Fromkin 1972: 68). According to this proposal, long and short level and contour tones are represented phonemically as follows:

Short level		Short rising		Long level		Long rising	
v	v	φ	v̇	v̇	v	v̇	
[+seg +high]	[+seg -high]	[-seg +high]	[+seg +high]	[+seg +high]	[+seg -high]	[+seg +high]	

(From Dwyer 1973: 16)

Dwyer (1973) criticizes the non-segmental proposal because the use of unnatural feature configurations is impossible at the phonetic level, though possible at the phonemic level. Another criticism raised by Larson says "what sort of process deletes segments with no phonetic properties?" (Larson 1971, quoted in Dwyer 1973: 17). Dwyer (1973: 17) raises a question of distinctness. "Is  $V\phi$  distinct from  $\phi V$ ? Is  $V\phi$  distinct from  $V\phi\phi$ ? Although answers to these questions can be provided, they complicate the existing theory. There he suggests a modified use of the feature [length] to allow the representation of short contour

speech tempo, on the other (Wang 1967). Bodman (1955) reports a very interesting phenomenon of sandhi for Amoy Hokkien (quoted in Wang 1967). As mentioned in Note 6, despite the name, Amoy and Taiwanese do not differ from each other in any significant way. The seven lexical tones of Taiwanese indicated on page 7 also apply to Amoy. In a large class of syntactic environments,<sup>12</sup> the tones undergo sandhi in a way that can be illustrated by a tone circle and linearized in the following formula:

$$\begin{pmatrix} \text{Ia} \\ \text{Ib} \end{pmatrix} \longrightarrow \text{IIIb} \longrightarrow \text{IIIa} \longrightarrow \text{IIa} \longrightarrow \text{Ia}$$

Tone IV does not participate in the sandhi circle; in other words the sandhi changes occur only in the environment having long tone syllable. In African languages, length functioning in tone change has also been reported for Mende (Dwyer 1973).

Dwyer (1973:15) points out that "according to current phonological theory, any sequence of two segments differing only by tonal features has a longer duration than either of the single segment." If a set of distinctive features of tone as proposed by various linguists over the years is claimed to be universal, then a feature of length or duration has to be added in order to distinguish long and short phonemic tones. Then, what is this feature and how are the long and short tones to be specified? Various proposals have been made for the representation of tones. Leben (1971, 1973a, b) proposes that phonemic tones must be represented suprasegmentally if we want to maintain Woo's hypothesis that there are no underlying contour tones. Later these suprasegmental tones would be mapped onto tone-bearing segments; after this mapping, tones would be expected to behave like any other segmental feature. Leben's suprasegmental representation of underlying tone might work for African languages, such as Mende, Maninka, Hausa, but it would require two separate matrices, "one segmental and one suprasegmental" and an additional mapping rule. We feel that this treatment not only complicates the phonological system, but also violate naturalness in the sense that the second matrix is not pronounceable. Furthermore, in languages such as Chinese and Thai, tone is probably not a suprasegmental phenomenon. Leben himself also points out the difficulty of representing tone suprasegmentally in Mandarin and Standard

(d) dāde 'big one'

Many acoustic studies, as reported by Kratochvil (1964), Zadoenko (1958) and Dreher and Lee (1966), and as shown in some spectrograms in Wang and Li (1967), have revealed that the neutral tone does have different pitch contours, conditioned by the preceding full tones. The shapes of the neutral tone, measured on the five-point scale, are reported as follows: (Dreher and Lee, quoted in Cheng 1973: 56)

- (a) after first tone: 41
- (b) after second tone: 31
- (c) after third tone: 23
- (d) after fourth tone: 21

Based on this acoustic finding and the intuition of the native speaker, we agree with the following generalizations made by Cheng: (1) the neutral tone is contoured; (2) after first, second and fourth tones the neutral tone is falling, but after third tone it is rising. As mentioned in the preceding discussion the duration of the neutral-tone syllable is about one half shorter than that of a full tone syllable. We therefore conclude that the neutral tone is phonetically a short contour tone.

As evident from the above examples, we are convinced that there are phonemic short contour tones at least in Taiwanese. And we are also convinced that the neutral tone in Mandarin is phonetically a short contour tone. Whether it is crucially contrastive is a matter of experimentation to find evidence of contrast. Therefore, we suggest that Woo's hypothesis constraining contour tones to long vowels be abandoned.

In the preceding sections, we have shown that at least in Taiwanese Chinese the distinctive features of tone are not just features of pitch height, but also features of duration. By showing that they are contrastive, we have demonstrated short contour tones as well as long contour tones. The Taiwanese examples given on page 7 also reveal that there are long high level tones as well as short high level tones. Length is also a function of tone change. In Chinese, tone sandhi seems to be conditioned by syntactic and morphological grounds on the one hand, and

of duration of the neutral tone. For example, Zadoenko gives the following report on the duration of the bisyllabic word pairs (quoted in Cheng 1973: 55):

	Whole word	1st syl.	2nd syl.
1a. dǔng syī 'east & west'	44	20	24
b. dǔng syi 'thing'	25	15	10
2a. shēng hwó 'life'	50	23	27
b. shēng hwò 'livelihood'	25	15	10
3a. dwō shǎu 'many & few'	52	17	35
b. dwō shau 'how many'	24	14	10
4a. syūng dì 'brothers'	44	25	19
b. syūng di 'younger brother'	23.5	16	7.5

The items in *b* have the neutral tone on the second syllable and are shorter in duration than those in *a*. The length of a neutral-tone syllable is about one half that of a full-tone syllable, and all neutral-tone syllables have about the same length, whether they are monophthongal or otherwise.

The duration of the neutral-tone syllables noted in Zadoenko's experiment corresponds in large part to the measurements which are made in similar experiments by others.<sup>11</sup>

The pitch of the neutral tone is determined by the tone of the preceding syllable. Chao (1933: 129) states that to the Peking ear, the values of the neutral tone following first, second and fourth tones sound like fourth tone, and that the neutral tone following third tone sounds like first tone. But later (1948: 27) he considers the neutral tone as a point at a certain pitch height, and describes this point more precisely as follows:

- (a) half-low after first tone
- (b) middle after second tone
- (c) half-high after third tone
- (d) low after fourth tone

He gives the following examples:

- (a) tāde 'his'
- (b) shéide 'whose'
- (c) nǐde 'your'

the shortness in duration in Category IV is due to the occurrence of the final voiceless stops is another question.<sup>8</sup> Tones in this sense are probably not suprasegmental phenomena. Leben (1971: 199) also points out the difficulty of treating tone in Mandarin and Thai as a suprasegmental feature. However, a discussion of whether to express tone as a segmental feature or as a suprasegmental feature is out of place here. The difference between tones IIIa and IVa gives sufficient evidence that contour tones do occur on short vowels as well as on long vowels. Short contour tones are also reported for other Chinese dialects, such as Cantonese, Suchow, etc.

Another piece of evidence showing the existence of contour tones on short vowels concerns the neutral tone in Mandarin. There has been a controversy concerning the nature of the neutral tone among Chinese linguists. Cheng (1973), in his monograph, devotes a lengthy chapter to discussion of the nature of the neutral tone and its interaction with the tone sandhi rule. Cheng rejects the idea that the neutral tone is a fifth underlying phonological tone as proposed by Hockett (1947) and Martin (1957). He proposes that a neutral tone can be derived from the underlying four basic tones with the aid of syntactic information or a certain marking in the lexicon. That is, many occurrences of the neutral tone can be predicted on syntactic or morphological grounds. Those which cannot be so predicted require a diacritic feature NEUTRAL in their lexical representation. On the other hand, Woo (1969: 226–232), in her thesis, gives a lengthy argument against Cheng's (1968) treatment of the neutral tone which is largely followed in his 1973 monograph. She concludes that the lexical neutral tone should be specified with a fifth pitch contour  $\left[ \begin{array}{l} -\text{high T} \\ -\text{low T} \end{array} \right]$   $\left[ \begin{array}{l} -\text{high T} \\ -\text{low T} \end{array} \right]$  as it was traditionally analyzed by Hockett and others. Whether the neutral tone should be analyzed as derived from the four underlying tones or should be specified with a fifth pitch contour is not our main concern here.<sup>9</sup> What interests us is whether the neutral tone is phonetically a short contour tone.

The neutral tone syllable is generally perceived as short and lax.<sup>10</sup> Zadoenko (1958) and Dreher and Lee (1966) have reported detailed acoustic measurements

*lung` , luk ; lan̄ , lan´ , lan` lat; lam̄ lam´ , lam` ; lap.*<sup>4</sup> Each tone category can be subdivided into two classes according to whether the initials are voiceless or voiced<sup>5</sup>. So theoretically speaking, each tone could have split into two tones in a modern dialect to result in as many as eight tones. However, due to variations of merger and split, the number of tones varies from dialect to dialect. For example, the development of the four Mandarin tones mentioned above can be shown in the following chart:

Ancient Chinese		Mandarin		
Ping shēng	Vls initial ----- Vd. initial -----	First tone	⌈	55
		Second tone	∧	35
Shǎng shēng	-----	Third tone	∨	214
Chyù shēng	-----	Fourth tone	∇	51
Rù shēng	-----		⌈ 55, ∨ 35, ∨ 214, ∇ 51	

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In terms of the four categories of Ancient Chinese, Taiwanese<sup>6</sup> syllables can be classified into seven lexical tone classes as presented in the following table.<sup>7</sup>

Tone	Graph	Pitch	Examples
Ia	⌈	55	[si ŋ <sup>55</sup> ] 'rise'
Ib	∧	35	[si ŋ <sup>35</sup> ] 'succeed'
II	∨	53	[si ŋ <sup>53</sup> ] 'save'
IIIa	∇	21	[si ŋ <sup>21</sup> ] 'holy'
IIIb	⌈	33	[si ŋ <sup>33</sup> ] 'prosperous'
IVa	∇	2	[sik <sup>2</sup> ] 'clever'
IVb	∧	5	[sik <sup>5</sup> ] 'cocked'

The numbers assigned to the tones correspond etymologically to the four tone categories of Ancient Chinese; the letters *a* and *b* indicate a historical split that corresponds, respectively, to voiceless and voiced initial consonants. From this classification, we can say that tones here mean not just syllabic pitch, but syllabic duration as well. For a syllable belonging to category IV may differ from one of another category in nothing but syllabic duration, the former being shorter than the latter. For example, Ia and IVb differ only in duration; both are high level, Ia being longer than IVb. The same difference holds for IIIa and IVa. Whether

七

contour feature [fall] or [rise]. And this is not the case as reported by Dywer and Leben. Woo's proposal, in which a falling tone is represented as a sequence of [+high] followed by [-high], makes the operation of tone-copying rules work naturally and without difficulty. Fromkin (1972: 67) points out a general case "that in progressive 'tone copy' [rules] the final feature value is copied, whereas in regressive 'tone copy' rules the initial tonal feature is copied."

As evident from the preceding discussion, we argue that Woo's (1969: 141) hypothesis "that the distinctive features of tone are features of pitch height, and that contour tones are represented as sequences of these features," is a valid claim.

Woo's other hypothesis restricting contour tones to long vowels has been regarded by various African tonologists, such as Leben, Dwyer, etc., as unnecessary. This claim is primarily based on evidence from some African languages. In these languages, dynamic tones are limited to syllables containing sonorant clusters of some type, and long vowels are usually represented as geminate clusters. Thus, a syllable whose nucleus is a long vowel may have a dynamic pitch contour. Therefore, Woo argues that no dynamic tone can occur on a short vowel distinctively. Yet, it has been reported by many linguists over the years that contour tones do occur on short vowels.<sup>3</sup> For example, Leben (1971) shows that at least in Hausa and Mende short vowels must be represented phonologically as a High-Low sequence. In the following passages, we will try to show that in Chinese there are short contour tones as well as long contour tones.

Since the tones of a modern Chinese dialect develop from the four tonal categories of Ancient Chinese (ca. 600 A.D.), it is necessary to briefly mention the tonal classification of Ancient Chinese here. The Ancient Chinese linguists classified tones into four categories: *píngshēng* 'even tone', *shǎng shēng* 'rising tone', *chū shēng* 'falling tone' or 'departing tone', and *rù shēng* 'entering tone'. The entering tone occurs only with syllables with final /p,t,k,ʔ/. The ancient linguists then considered the abrupt cutting off of the voice in the vocal cords in words of type *lak*, *lat* as a "tone", as opposed to the slow dying out of voice in words of types *la* and *lan*; thus they obtained four-tone groups like: *lung-* , *lung'* ,

usually graphically represented by a vertical reference line, extending from points 1 to 5 for pitch range, and a simplified tone graph which represents the shape of the tone. The four Mandarin tones can be specified as follows:

TABLE II

Tone	Pitch	Graph	(Length)
First Tone	: 55	└	(37)
Second Tone	: 35	┘	(47)
Third Tone	: 214	∨	(55)
Fourth Tone	: 51	∩	(27)

That is, in this notation, a tone is represented as sequences of pitch heights. First tone is realized as a sequence of two high pitches (55), Second tone rises from a Mid level (3) to High (5), Third tone falls slightly (from a 2 level to a 1 level) and then rises almost to High (4 level), and Fourth tone falls from High (5) to Low (1). Chao's number notation offers an important insight into the workings of tonal assimilations in Chinese. However, a discussion of the tonal rules is beyond the scope of this paper.

It has been customary for the tonologists of African languages to describe the dynamic tones as sequences of pitch heights, each of which is associated with some sonorant segment, usually a vowel, but not necessarily a syllabic one. The need for such representation is evident from the operation of tone-copying rules in some African languages. For example, rightward tone-copying rules in Southwestern Mande copy only the tone features [high] and possibly [low]. As Dwyer, attributing the observation to Fromkin, pointed out:

Nowhere is there any evidence of the copying of a contour feature. When a kinetic tone is in a position to be copied, only its final component, high for rising and non-high or low for falling, is copied.

(Dwyer 1973: 15)

Leben (1971) also reported the same phenomenon for the compound Rule in Mende Compounds. Rules such as tone-copying, which apply only to the L of a HL sequence, would be impossible in a language which employs contour features. A copying rule, if applied to a contour tone, would copy the entire



has to be added to the distinctive features of tone. We will return to this point later.

Now let us take a look at Woo's proposal that all phonetic contour tones should be analyzed as underlying sequences of level tones. Her hypothesis was based on the analogy of the phonetic interpretation of a diphthong such as /ai/ as a VV sequence. Thus a rising tone might be defined as a sequence [-high tone] [+high tone]. Woo states :

In other words, the dynamic tones can be viewed as the "diphthongs" of the tone sets, with the contour being the natural result of the transition from one level to another. As with real vowel diphthongs, the transition is not a well defined point, but an interval. (Woo 1969: 78)

Woo further cited Kratochvil's acoustic findings for Mandarin tones to support her "diphthong" concept of the dynamic tones:

... none of the contours of the tones are strictly rising or strictly falling, but rather are what he terms "S-curves". The rising S-curve of the rising tones is a "rising contour with the curve level or with a slight 'dip' at the end of the vowel ...", and the falling S-curve for the falling tone is a falling contour with the curve level or with a slight 'hump' at the beginning and level or with a slight 'dip' at the end of the vowel." (Kratochvil 1964, in Woo 1969: 78-79)

Thus Woo proposed that for Mandarin the dynamic contour tones can be described as sequences of pitch height features instead of the features [rise] and [fall] as proposed by Wang (1967). She further argues that the segmental analysis of Mandarin tone also holds for other Oriental languages, such as Cantonese and Standard Thai. Therefore, she claims that all those languages whose tones have traditionally been described in terms of the features [rise] and [fall], may also be tonally described as having dynamic tones which are sequences of pitch heights, each of which is a feature of some sonorant segment.

四 Chao's (1930) tone-letter notation, in a sense, can also be viewed as representing contour tones as sequences of level tones although he did not explicitly state so. He divides the total pitch range into five levels numbered 1,2,3,4, and 5, corresponding to low, half-low, middle, half-high, and high respectively. A tone is

III. Falling				
( √ Fourth)				
jà	31	—	31	
jài	29	—	29	
jàn	27	—	27 (V+N)	
jàng	23	—	23 (V+N)	
jàu	25	—	25	
IV. Falling—Rising				
( √ Third)				
dǎ	53	2	51	
dǎi	52	2	50	
dǎng	52	2	35	15
dǎu	59	2	57	
děi	52	2	50	
děng	53	2	37	14
dǐ	57	2	55	
dǐng	53	2	36	15
dǔ	55	2	53	
dwǎn	61	2 (+4)	40	15

This experiment shows that third tone, i.e., the falling—rising tone, has an average duration of 1.5 times the duration of the other tones, and hence the longest among the four tones. And Fourth tone, i.e., falling tone, is the shortest of the four tones. The average length of the four tones can be summarized as follows:

Longest	√	(third tone)	55
Middle	∧	(second tone)	47
		(first tone)	37
Shortest	∨	(fourth tone)	27

The relative duration of the tones noted in this experiment corresponds to the measurements made by others, such as Brotzman (1964) and Kratochvil (1970). Cheng (1973) also pointed out that the acoustic measurements reported by Zadoenko (1958) and Dreher and Lee (1966) indicate that the third and second tones are longer than the first and fourth tones.

From the above observation and acoustic findings, we come to the tentative conclusion that length plays some important role in tonal realization.<sup>2</sup> Each tone is associated with some degree of duration. If a theory of phonology aims at achieving observational and descriptive adequacies, a feature of length or duration

been considered as distinctive features of tone, the length of tone has long been observed as part of tonal realization, though it has seldom been incorporated into the theory of phonology. Hockett (1947:219) states that "the tones [of Peiping] are contrasting contours of pitch, volume, glottalization, and length." But he did not go on to elaborate this complex phenomenon. In terms of Mandarin tones, there is general agreement that third tone is phonetically the longest among the four tones. As for the other tones, there is disagreement. Hartman (1944) states that syllables with the high level or the high rising tone are shorter than syllables having one of the other two tones. Hockett (1947) perceives that third tone is longest, fourth tone is half-long, and the others are relatively short. Woo (1969) has reported detailed acoustic measurements of the duration of the citation tones of Mandarin syllables as shown in the following table:<sup>1</sup>

TABLE I.

Tone	Total duration	Initial cons. (+glide)	Vowel	Final nasal
I. High level ( ˉ First)				
bā	36	2	34	
bān	38	2	21	15
bāng	38	2	21	15
bēi	35	2	33	
II. Rising ( ˊ Second)				
má	42	6	36	
mái	44	8	36	
mán	48	6	23	19
máng	44	6	23	15
máu	40	8	32	
méi	38	4	34	
mén	42	4	17	21
méng	42	6	19	17
mì	38	4	34	
mían	48	6(+8)	20	14
mín	36	2	20	14
míau	42	4	32	
míng	42	6	16	20
móu	44	8	36	

# LENGTH AS A COMPONENT OF TONE

Hsiu Ying Chen

聲調成分中音長的問題

Most linguists in both Chinese and general linguistics assume that pitch is the primary dimension of tone. Chao's (1930) tone-letter notation is the most representative of the traditional Chinese linguistic approach. Pike (1948:3) defines tone as "having significant, contrastive, but relative pitch on each syllable." Other linguists, such as Brotzman (1964), and Wang (1967), also assume that tone is predominantly a pitch feature in their tonal analysis. More recently Woo's hypothesis that all phonetic contour tones should be analyzed as underlying sequences of level tones was also based on the assumption that "the distinctive features of tone are features of pitch height." (Woo 1969:141) As a consequence, it forces her to make a concomitant hypothesis that all contour tones occur only when there are long vowels in the underlying forms. That is, no dynamic tone can occur on a short vowel distinctively. Nevertheless, some phoneticians and linguists have suggested that pitch is not necessarily the predominant acoustic correlate of Mandarin tone, and that the tone appears rather as a complex acoustic phenomenon with at least three dimensions: fundamental frequency (pitch), overall amplitude (loudness), and time (duration). It is the purpose of this paper to show that the acoustical manifestation of tone is not just a feature of pitch, but a feature of duration as well. If a feature of duration is incorporated into the distinctive features of tone, then it is not necessary for Woo to constrain contour tones to long vowels. In the following pages, we will first try to show the acoustic correlate of duration of Mandarin tones. Then we will argue that Woo's hypothesis, that contour tones must be represented as sequences of level tones, is a valid claim, but at the same time we will suggest that Woo's other claim constraining contour tones to long vowels be abandoned so as to accommodate short contour tones in languages such as Taiwanese, Cantonese, Hausa, etc. Finally we will suggest that a feature [length] be added to the distinctive features of tone in order to permit the representation of short contour tones as a sequence of level tones.

While in most phonological studies the features of pitch height have primarily