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ABSTRACT

This paper examines the problem of whether tonal representation should be considered segmental or suprasegmental. Woo's hypothesis that tone features are to be specified segmentally is discussed as well as Leben's statement that in some languages tone is suprasegmental. The following are criteria suggested as a basis for tonal representation: where tone is a feature of units larger than a segment, or if contour tones fall on single vowels, the representation should be suprasegmental; where phonotactic constraints refer to both tonal and nontonal constraints, the representation should be segmental. However, it is not yet clear what features are generally needed to represent tone either suprasegmentally or segmentally. Furthermore, there are indications that a viable theory of language will have to take into account varying types of tone languages which require further classification beyond that of requiring segmental or suprasegmental representation. (AM)

On the Phonological Representation of Tone

Victoria A. Fromkin

[Paper presented at the 11th Congress of West African Languages -- Yaoundé, Cameroons, April 1-5, 1974]

A major goal for linguistic theory is to define the notion 'possible human language'. No matter what our theoretical bent, we will probably all agree that a particular language is in a general sense a system which relates sounds and meanings. In a formal sense this system may be regarded as the grammar of the language. We are therefore aiming at a theory of possible grammars. Clearly such a theory must define in a formal and substantive fashion that part of the grammar which concerns the sounds and sound patterns of human language. There is no a priori way of deciding what such sound systems will be. There is, for example, no logical reason why we should find that in most of the languages of the world pitch differences can distinguish meanings. But in fact we know that this is the case. In fact, there is no language in which pitch plays no role. This led Beach to conclude that all languages are tone languages since he believed that any language which uses pitch contrastively in any manner is a tone language.

But such a definition of a tone language does not constrain the theory of grammars sufficiently -- it makes no predictions as to how pitch can function grammatically. It is similar to a definition of language which

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states that all languages utilize sounds produced by the upper respiratory tract. It fails to make explicit the extent to which the sound systems of languages may differ, and the kinds of differences which are 'permissible'.

Since all languages use pitch contrastively, one method of distinguishing between languages classified languages into tone languages and non-tone languages. But what are the criteria by which such classification can be made? One criterion suggested by Pike (1948) depends on whether the pitch on individual syllables makes for lexical contrast. Thus he states:

> "...there may exist languages which one desires to call tonal because, although they do not have contrastive pitch on each syllable, they do have lexically significant contrastive pitch spread over entire words or morphemes. In this book, however, the syllabic type of toneme must be present for a language to be labelled tonal." (p. 5)

Such languages in which lexical contrasts exist due to distinctive pitch on different syllables, or the vowels of these syllables, present no problem in anyone's classification. Many African languages, Amerindian languages, and Sino-Tibetan languages are, by this definition tone languages, as may be illustrated by the following:

(1) Igbo (Welmers 1970) (two contrastive pitches or tones)

Low-Low	[àkwà]	'bed'
Low-High	[àkwá]	'egg'
High-Low	[ákwà]	'cloth'
High-High	[ákwá]	'crying'

(2) Nupe (George 1970) (three contrastive tones)

Low	[bà]	'to count'
Mid	[bā]	'to cut'
High	[bá]	'to be sour'

(3) Fe?Fe? -Bamileke (Hyman 1972) (four contrastive tones)

Low	[pɯ̀α]	'bag'
Raised-Low	[pɯ᷅α]	'bend over'
Mid	[pɯ̄α]	'go crazy'
High	[pɯ́α]	'two'

(4) Mandarin Chinese (four contrastive tones)

High	má	'mother'
Rise	mǎ	'hemp'
Rise-fall-rise	mã	'horse'
Fall	mâ	'scold'

(5) Thai (five contrastive tones)

Mid	nāā	'rice paddy'
High	náa	'younger maternal aunt or uncle'
Low	nàa	'Naa, a nickname'
Falling	nâa	'face'
Rise	nǎa	'thick'

It is also equally clear that there are languages in which the pitch of syllables does not contrast meaning. French may be cited as an example of a language which is clearly not a tone language.

There are linguists who believe that Pike's definition would still fail to sufficiently distinguish languages in terms of the function of pitch. For example, in Etung (Edmondson and Bendor-Samuel 1966), in the Southern and Western Kyūshū dialects of Japanese (McCawley 1964), and in Mende (Leben 1973), among others, there is lexical pitch or tone but it is suggested that such tone is a feature on morphemes rather than a feature on segments or syllables. One argument suggested by Leben (1973) to support this claim is that in Mende morphemes can have a Low High Low tonal contour but may not have High Low High. He cites the following examples:

(6) mbâ LHL 'companion'

nyàhâ LHL 'woman'

nìkílì LHL 'groundnut'

Furthermore, this restriction applies to words of any number of syllables. This being the case, it appears to be 'ad hoc' to suggest that the domain of tone in this language is the segmental vowel. Rather, it appears that the 'word' is more properly the tone bearing unit.

If these languages are classified as tone languages, then Pike's criterion is clearly too narrow. But McCawley (1964, 1970) believes rather that this criterion is too broad since it would include languages like Japanese and Serbo-Croation which he calls accent or pitch-accent languages. In Serbo-Croation, he points out, once the accented syllable is determined, the pitch contour of the word is predictable. The syllable immediately before the accented one gets a rising phonetic pitch; if that accented syllable is the first one it receives a falling pitch, as shown in (7).

(7) (The asterisk under the vowel signifies accent)

godina → gôdina ; venčāvati → venčāvati

'rebel' 'lighthouse keeper'

The rules for accent assignment need not concern us here. McCawley's view is that such languages are typologically different from tone languages. He distinguishes, then, between tone languages in which each syllable must be marked in the lexicon for tone, and accent languages which he considers to be non-tonal. The latter category he divided into three classes: (a) bound accent languages in which the accent or stress (and therefore the pitch contour) is fully predictable. He classifies English as such a language, although others might disagree with him about the predictability of lexical stress; (b) partially free accent languages, like Serbo-Croation and (c) free accent languages like Japanese.

Woo (1969) also distinguishes between tone and non-tone languages but includes under her classification of tone languages those which McCawley calls pitch accent. Her criteria are as follows: tone languages are those in which distinctive tone must be marked on at least one vowel in each lexical item. In this class there is a two way division: (a) lexical tone languages in which the tone must be marked on each vowel such as Igbo, Nupe, Mandarin, Thai etc., and (b) tone harmony languages in which there is a tonal diacritic associated with each lexical form, such as Japanese, Mende, Serbo-Croation. A non-tone language is defined by Woo as one in which the lexicon contains no prosodic features associated with the lexical formatives.

Whether one calls the second category tonal or pitch accent it is clear that languages in the world do fall into one of these three classes. A mere classification of languages, however, does not help to define in specific terms how the grammars of these languages are to be constrained. Can one, for example, expect the same kinds of phonological rules to occur in all of these languages? Clearly, in French one does not expect any phonological rules to have to refer to tonal features or pitch phenomena. Nor would one expect in a language like English that a stress rule will have to include in its environment segmental feature information. That is, no language has been found in which stress is assigned, for example, on the initial syllable unless the first consonant is voiced (See Hyman 1973).

In Kpelle, where words are restricted to a sequence of high tones or low tones, or high tones followed by low tones (Welmers 1962), one would not expect to find a rule which lowers a high tone before another high. Or, in a language like Kinga (Schadeberg 1972) where tones are restricted such that only one high tone can occur in a word, one would not expect a tonal rule which violates this constraint.

Thus, while a classification for its own sake may not be important, given the correct classification we may be able to constrain our theory of phonology such that the classes of possible grammars are narrowed.

Representation of Tone: Segmental, Suprasegmental or both?

The only reason that I have presented this overly simple and well known typological summary is because it has important influence on the kinds of restrictions we place on grammars of tone languages.

Historically, tone like other 'prosodic' phenomena has been considered 'suprasegmental' but formally treated segmentally, as a feature on vowels. How tone should be represented is not merely a matter of taste; there should be different consequences dependent on the different representations.

Woo's (1969, 1970) proposal, then, that grammars should be constrained so that tone features are to be specified segmentally is a claim about the identity of all phonological features. Furthermore, the hypothesis predicts that there should be no language where such a treatment would obscure important generalizations. Leben (1973) has challenged this claim in suggesting that "tone is a suprasegmental phenomenon in some languages". At the 10th Congress of the West African Linguistic Society in Legon, I

presented a paper in support of Woo and in opposition to Leben. I am pleased to be here at this Congress so that I can make a public retraction. Leben's evidence is very convincing. One argument centers around languages such as Mende where there are morphemic restrictions on tonal contours, i.e. where distinctive tones can not occur freely. He shows that such constraints can be accounted for very awkwardly and in a non-intuitive fashion if tone is a feature assigned to either segments or syllables. Consider, for example, a language with two contrastive tones, High and Low. If tone is a segmental feature one might expect any combination of tones to occur: In monosyllables -- HIGH (H), LOW (L); in disyllables -- HH, HL, LL, LH; in trisyllables -- HHH, HHL, HLH, HLL, LHH, LHL, LLH, LLL; etc. In Mende, however, the sequences HL and HHL are prohibited. He argues that this constraint appears ad hoc if tones are features on segments in Mende. If, rather, tones are features are morphemes the possible phonological tone patterns may be restricted as follows:

(8) A.

Morpheme Features	1 syl	2 syl	3 syl
H	H	H H	H H H
L	L	L L	L L L
LH	$\widehat{LH}$	L H	L H H
HL	$\widehat{HL}$	H L	H L L
LHL	$\widehat{LHL}$	L $\widehat{HL}$	L H L

He suggests that these are the only tone contours permitted. The tonal sequences assigned to morphemes under A. would then be mapped onto segments by two mapping rules to derive the necessary phonetic representation:

(a) "If the number of level tones in the pattern is equal to or less than the number of vowels in the word...put the first tone on the first vowel, the second on the second, and so on.

(b) If the number of level tones in the pattern is greater than the number of vowels in the word...put the first tone on the first vowel, the second on the second and so on; the remaining tones are expressed on the last vowel available.

This proposal therefore predicts that in two syllable words the only contour tone which can occur is a falling tone on the second syllable, (i.e. no *$\widehat{LH}$ L for example) and that no contour tones will occur in three syllable

words. It further predicts the nonoccurrence of a LLH sequence in a three syllable word or a HLH sequence. This is a strong hypothesis, and these restricted occurrences of tones lends strong support for representing tone in Mende by a suprasegmental matrix assigned to each lexical entry.*

Notice the formal consequences of such empirical data. If tone is a non-segmental feature i.e. a feature of morphemes, then in a formal grammar there must be some way of representing it other than as part of the segmental matrix. This requires then an additional matrix for each lexical item. In addition, at some point the tones must be integrated into the phonological or phonetic representation of the formative which therefore necessitates some formal mapping rules.

If, as in Southern and Western Kyushu (McCawley 1964), one need not specify tonal contours differently for monosyllabic words or disyllabic words, this fact is also "captured automatically if all morphemes in the language are specified with a feature describing the tonal contour" (Leben 1973).

Leben also argues for suprasegmental matrices of morphemes with evidence showing that tonal phenomena behave differently from segmental phenomena. He suggests that the kinds of restrictions on tonal sequences do not pertain to segmental features. That is, a restriction like the one in Mende permitting LHL but no HLH is, he argues, a consequence of the unique characteristics of the suprasegmental nature of tone. He posits that one would not expect to find a phonotactic constraint which permitted [-nasal] [+nasal] [-nasal] but did not permit [+nasal] [-nasal] [+nasal]. This is an interesting point but is negated by examples of sequential constraints on other features such as 'rounding' or 'backness' as observed in vowel harmony languages. In Terena (Bendor-Samuel 1970) nasalization also appears to be a feature assigned to a word rather than a segment. Leben's conclusion is that there may be other features which are best assigned to morphemes rather than segments. But one cannot argue for the suprasegmental nature of tone on the grounds that tones can be restricted in ways in which segmental features can not, and then on finding other such 'segmental features' conclude that these too must therefore be possible suprasegmental features.

It might indeed be found that any 'independently controllable' phonetic (phonological) feature is a candidate for suprasegmental status. This, to some extent, is implicit in the British prosodic analysis theory.

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* Following the presentation of this paper, Jan Voorhoeve argued convincingly that Leben's constraints on tone sequences in Mende are not valid and therefore this language does not support a suprasegmental matrix for tones. This does not mean that there are no languages that support the suprasegmental theory, but the cases cited so far are not persuasive. See Voorhoeve (1974), and also Maddieson (1974).

But finding this non-unique status of tone leads us to look for additional differences between tonal phenomena and other phonetic features.

Looking beyond grammatical requirements we do find some interesting data to support this special status. It has long been observed, for example, in studies of child language acquisition that children imitate and respond to intonation patterns very early in life, even before the babbling period (Ervin-Tripp 1966). This has been shown to be true of children learning intonation (non-tonal) languages and tone languages. In one study, children learning Chinese, for example, could be distinguished by their tonal contours from other children.

Aphasic studies have also shown the separation of tonal phenomena from segmental phenomena. Tonal contours may be retained when other phonological features are lost. Lyman reports on a study conducted in Peiping that Chinese aphasics often retain tonal contours despite the loss of segmental information of words. It is also the case that loss of intonation is rare in aphasia.

Evidence from word games presented by Hombert (1973) and by Gandour (personal communication) further reveals that in many languages the tonal contour of a word remains even if syllables are moved.

In Thai, there is a language game *Khamphuan* [KP] (*kham* 'word,' *phuan* 'to switch') which provides some interesting evidence. In this game, one finds a reversal of the syllable-final vowel(s) plus consonant with either a reversal of the tone or with no reversal of tone. The following examples taken from Surintramont (1973) are given by Gandour to illustrate this game:

(9)	Regular Form	KP1 Form	KP2 Form
'banana'	klúày hòóm	klòóm húày	klóòm hùáy
'see movie'	duu nàŋ́	dàŋ́ nuu	daŋ nùú
'dance'	téǹ ram	tam réǹ	tám̀ ren

In KP1, there is a shift of the syllable vowel(s) and final consonant *plus* the tone, and in KP2, the reversal occurs *without* a tone shift.

Such 'games' do not provide evidence for representing tone suprasegmentally in a particular language but certainly lend support for the characteristics of tone which makes tone a candidate for special treatment in phonology.

Evidence from such sources makes plausible the hypothesis that in certain languages tone is a feature on units larger than a segment, i.e. should be represented suprasegmentally.

To conclude that in some languages suprasegmental representation of tone is necessary does not mean that tone should always be represented in a separate matrix. It is also clear that where there is an interaction between tonal and segmental features, tone features must have already been mapped onto the segmental matrices. This mapping must occur at some point for all languages so that the final phonetic output will contain both segmental and tonal information. When we sing we can produce melodic contours without segmental information -- but when we speak the pitch is not separated from other properties of the speech signal.

Leben correctly, I believe, points out that the mapping of suprasegmental tone onto the segmental matrix will vary from one language to another. One possible criterion which can be used to determine whether tone is to be represented suprasegmentally at all is whether the phonotactic constraints on morphemes are dependent on tonal and segmental contexts. That is, if there are contextual constraints on tonal sequences or tone features, and if these constraints must be stated in reference to segmental features we may conclude that in such a language tone is segmental grammatically.

Thai seems to be such a language. Gandour (1973) presents some data showing the tonal constraints on Thai morphemes. There are five contrastive tones in Thai: HIGH (H), LOW (L), MID (M), FALLING (F) and RISING (R). H and R do not occur when preceded by /p b t d c k ?/ except in non-Indic loanwords, onomatopoeic words, and 'particles'.

Within polysyllabic morphemes, CV syllables that begin in a sonorant segment /m n ŋ l r w y/ always carry a *high* tone, and CV syllables that begin in a voicelss unaspirated stop /p t c k ?/ always carry *low* tone. The seemingly counterintuitive restrictions will not be discussed here, but what is clear is that one cannot state these restrictions without reference to segmental features. If tone were represented as a suprasegmental matrix assigned to the morpheme there would be no way to reveal these generalizations.

Two criteria have thus been suggested, namely, (1) where tone is a feature on units larger than a segment, tone is to be represented suprasegmentally, and (2) where phonotactic constraints need to refer to both tonal and non-tonal features, tone is to be represented segmentally. We have yet to see whether these are contradictory criteria.

Another criterion is suggested by Leben, namely, that where contour tones which fall on single vowels must be analyzed as sequences of level tones, these sequences will occur suprasegmentally, thereby excluding the need for contour features, at least in these cases. There are clearly cases in which phonetic contours should be derived from underlying sequences. I will not discuss these arguments in detail since they have been presented amply in the literature but will merely cite a few examples.

Some phonetic contour tones are clearly the result of what Hyman and Schuh (1973) call tone spreading; If they are not analyzed as deriving from underlying level tones generalizations will be obscured. Thus in Yoruba one finds a sequence of LOW-HIGH realized phonetically as LOW-RISING. Spreading the low tone onto the high tone vowel reveals the assimilatory character of this process:

(10) H → LH/ L ____

A rule written using a contour tone feature obscures this:

(11) H → RISING / L ____

Similarly, there are cases where downdrift rules operate such that a High tone is lowered when preceded by a Low tone. In many languages this downstepped high also occurs after a falling tone. The rule is a simple one where a falling tone is represented as a sequence of HIGH-LOW.

Hyman (1973) presents further evidence from Mandarin to show that the use of contour features would obscure the assimilatory nature of tonal rules. He refers to two rules cited by Mohr (1973). Mohr uses the following features to designate the pertinent tones usually given by Sinologists in numerical terms:

$$35 = \begin{bmatrix} +\text{High} \\ +\text{Rising} \end{bmatrix}$$

$$55 = [+\text{High}]$$

$$53 = \begin{bmatrix} +\text{High} \\ +\text{Falling} \end{bmatrix}$$

The rules in Mandarin and Cantonese are as follows:

(12) Mandarin: $\begin{bmatrix}+\text{High}\\+\text{Rising}\end{bmatrix} \rightarrow [-\text{Rising}] \;/\; \begin{bmatrix}+\text{High}\\-\text{Falling}\end{bmatrix} \text{---} [-\text{Neutral}]$

i.e. 35 → 55 / 55, 35 __ T (where T = any tone except neutral)

(13) Cantonese: $\begin{bmatrix}+\text{High}\\+\text{Falling}\end{bmatrix} \rightarrow [-\text{Falling}] \;/\; \text{\_\_\_} \begin{bmatrix}+\text{High}\\-\text{Rising}\end{bmatrix}$

i.e. 53 → 55 / ___ 55, 53, 5

Hyman points out that although these two rules "represent the same assimilatory process, the rules do not reveal this identity".

In both rules 3 → 5/ 5 ___5.

If these tones were represented as sequences of level tones the assimilatory nature of the process would be revealed:

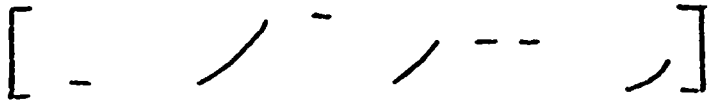
$(3 = \begin{bmatrix}-\text{High}\\-\text{Low}\end{bmatrix} \;,\; 5 = [+\text{High}])$

$\begin{bmatrix}-\text{High}\\-\text{Low}\end{bmatrix} \rightarrow [+\text{High}] \;/\; [+\text{High}] \text{\_\_\_} [+\text{High}]$

Can we then conclude that all phonetic contour tones should be represented as sequences of level tones? If one finds cases where a contour tone cannot be decomposed into level tones, if, for example, tone rules which apply after high tones do not apply after a Rising contour, or if rules which apply after low tones do not apply after a falling contour it would be apparent that such tones cannot be represented as sequences. Elimelech (1973) presents evidence that Kru is such a language. Kru is a language in which Downdrift occurs, and which has a High, a Low, a Rising, and a Falling tone. If the Rising tone is derived from a sequence of [Low] [High] one would expect the following:

(14) 'The rice is on the table'

kɔ̀	nǎ	nɛ́	ụ̌	téblé	kpǔ
L	L H	H	L H H	H	L H



Downstep L LH H LH HH LH

Gliding rule

This, however, is not what occurs. Rather as shown by Elimelech we get the following pitch contour.

(15) kɔ̀ nă né ụ́ téblé kpŭ

Furthermore, in a sequence of rising tones, each subsequent rise begins on a pitch identical to the ending pitch of the preceding tone. Such sequences may be simplified in normal tempo by a rule which changes a rising tone to a high before another rise, but in deliberate speech a sequence of rises is realized as (16a) not as (16b).

(16) jŭ nă jĕ nĭ nă

child the saw water the

'the child saw the water'

a.

b.

Elimelech presents additional evidence from the constraints on tonal contours of monosyllables and disyllabic words to show that in Kru important generalizations would be lost were these contours to be represented as level tone sequences.

There is also evidence for contour features in Lue, a Tai dialect spoken in the southern part of the Yunan province of China. Gandour (1974) discusses a problem of a tonal alternation in this dialect using data from Li (1964) showing that contour features not only provide for a simpler solution but a more insightful one. According to Li there are 6 phonemic tones, one of which has two alternate phonetic realizations: Low (11) or Low-Rising (13). The low tone occurs before the Mid-Rising tone (35) or before the Falling tone (31); the Low-Rising tone occurs elsewhere, i.e. before a High (55), a Mid (33), a Lowered-Mid (or raised low) (22) and before phrase boundary as illustrated in (17).

(17) xa^{13} ## 'to kill'

xa^{13} pet^{55} 'to kill a duck'

xa^{13} nok^{33} 'to kill a bird'

xa^{11} kun^{31} 'to kill a person'

xa^{11} kay^{35} 'to kill a chicken'

Since the Low-Rising tone occurs in more environments, no matter what feature solution is decided on, the rule will be stated more simply if it is this tone which is lexically specified with the level low tone derivative.

If the contour tones are represented as sequences of level tones, the seven phonetic tones can be specified as in (18).

(18)

	H (55)	M (33)	L-M (22)	H-Rise (35)	M-Fall (31)	L-Rise (13)	L (11)
High	+	-	-	- +	- -	- -	-
MID	-	+	-	+ -	+ -	- +	-
LOW	-	-	-	- -	- +	+ -	+

The rule to derive the Low tone from the Low-Rise can then be stated as in (19)

(19) [+Mid] → Ø / [+Low] ___ [αTone] [-αTone]

Clearly, the real complexity of this rule is obscured by using the cover symbols 'αTone' and '-αTone.'

If contour features are used, one possible specification is as given in (20):

(20)

	55	33	22	35	31	13	11
HIGH	+	-	-	+	-	-	-
MID	-	+	-	-	+	-	-
LOW	-	-	-	-	-	+	+
RISING	-	-	-	+	-	+	-
CONTOUR	-	-	-	+	+	+	-

The tone sandhi rule can then be stated as (21):

(21) $\begin{bmatrix}+\text{Low} \\ +\text{Contour}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{Rising} \\ -\text{Contour}\end{bmatrix} \; / \; \_\_\_ \; [+\text{Contour}]$

I am not claiming that these are the only features or feature specifications which one could use. I do believe, however, that whatever tonal features are used, the sandhi rule required if contour features are not used would have to be unduly complex and would obscure the simple tonal dissimilation which is revealed by rule (21). I think, therefore, that Gandour's claim is a correct one.

Clearly, then, any feature system must permit a way of representing contours in such languages as distinct from level tone sequences. We clearly need features such as [Rising] and [Falling]. These phonological features also make it possible to represent the phonetic glides required on the phonetic level for those languages that have phonetic contours derived from sequences.

It is not yet clear what features are generally needed to represent tone either suprasegmentally or segmentally. There seem to be problems with every feature set yet proposed.

To discuss the features which have been proposed, their strengths and shortcomings, would require another paper. I think that such a discussion would be premature. Research is now going on in many places concerned with the physiology and perception of tone, the historical development of tone, and synchronic tonal phenomena which will hopefully soon resolve some of the current problems. Any viable feature set must at least account for the following: (1) contrasts between at least 4 level tones (2) indissoluble contour tones (3) the relation between phonation types and tones (4) assimilatory (and also dissimilatory) tonological rules, (5) the natural tone classes required (6) tonal development and tonal change, including tonogenesis. Furthermore the physiological or perceptual correlates of whatever features are used should agree with known physiological and acoustic facts. Perhaps at the 12th Congress someone will present a paper which will provide us with such a set.

The opinions I have expressed here today are still very tentative. We have much to learn about tonal phenomena. The work reported on by many linguists however seems to show that tone languages may be of two types: those in which underlying representation of formatives require suprasegmental matrices and those which require segmental representation of tone. Furthermore, there seems to be further classification required in that in some languages tonal rules never need to refer to segmental features and in others, even in those where there is evidence for supra-segmental tone, rules must refer to segments. In addition, phonetic contours may be derived from sequences of level tones in some languages, whereas in others, the phonological and phonetic representations may both require contour features. A viable theory of language will have to include among the class of possible languages these different types.

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