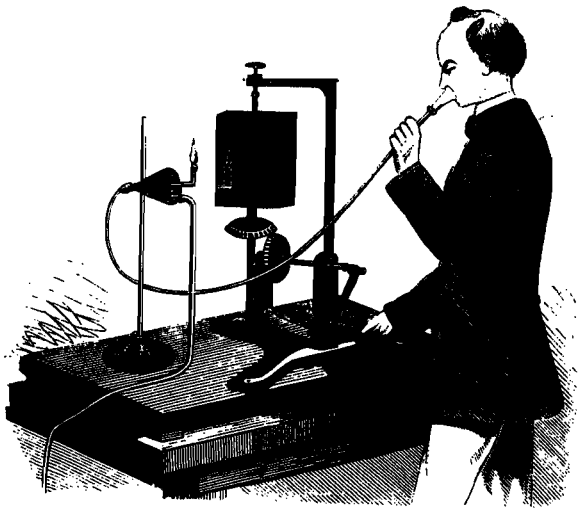
Working Papers in Phonetics 21



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Phonological Features and their Phonetic Correlates

Peter Ladefoged

There is nothing very new about the idea that speech sounds can be classified in terms of a limited number of features. Phonetic taxonomies have existed from the times of the earliest grammarian: and traditional consonant charts can be viewed as attempts to classify sounds in terms of features of place and manner of production. But with the development of the Prague school of phonology (Trubetzkoy, 1939) and the subsequent work of Jakobson and his collaborators (Jakobson, 1962; Jakobson, Fant and Halle, 1951; Jakobson and Halle, 1955) the discussion of the distinctive features of speech came to have more importance. As a result of the more recent work of Chomsky and Halle (1968), the role of distinctive features within phonological theory has become even more crucial. This paper will review the nature of phonological features in general, and will suggest a particular set of features which it might be appropriate to use in phonological descriptions of languages.

There is no sense proposing a set of phonological features without first stating clearly why one needs a feature set. The view taken here is to a great extent that prevalent in standard generative phonology. My view diverges from that of a standard generative phonology mainly in that I do not consider phonological rules expressed in terms of features to be necessarily part of the competence or the performance of a speaker. I have argued elsewhere (Ladefoged, 1971a) that the proper goal of a phonology is to attempt to describe the sound patterns that occur in a language, or in the terminology of Saussure (1916) 'la langue.' This goal is only partially the same as trying to describe the linguistic competence of a speaker, or what Saussure would call 'la faculté de langage.' But as this point is not particularly relevant to the remainder of this paper, I will not discuss it further here.

From my point of view, or from that of the standard theory, one needs features in order to describe the sound patterns of languages. A phonology is a system for showing the patterns that can occur in a language by describing the relationship between the output of a set of syntactic rules and the sounds of actual utterances. This relationship can be expressed by means of explanatory statements formalized as rules. Features are needed to denote classes of sounds and show how they act together in phonological rules. For instance, the formation of the plural or the possessive in English is most appropriately described by stating what happens to words that end in the class of sounds which are sibilant, as opposed to those which end in the class of sounds which are voiceless and non-sibilant and to those which end in the class of sounds which are voiced and non-sibilant. As is well known, the plural suffix is /ɪz/ for the first class of words (e.g. horse, horses; dish, dishes), /s/ for the second class (e.g. cat, cats; cough, coughs), and /z/ for the third class (dog, dogs; bee, bees). It is quite clear that the rules need to refer to features such as Voicing and Sibilance. Similarly, in describing the placement of the accent in English words, one wants to be able to differentiate between two classes of vowels, tense vowels and lax vowels. Rules for word accents

using these and other classes have been given by Vanderslice and Ladefoged (1971), on the basis of the rules for so-called levels of stress originally worked out by Chomsky and Halle (1968) in The Sound Pattern of English (henceforth SPE). From these and many other examples it is clear that when sounds have been described in terms of features, it is easy to divide them into natural classes of the kind that are required in phonological rules.

There are two reasons why at least some of the features in rules must be interpretable in real terms. Firstly, if phonological rules are going to be explanatory, they must themselves show why some phonological processes are more natural than others (cf. Venneman 1971). As we shall see, this can be done in a formal way if the rules are expressed in terms of features which have some physical or physiological meaning. Secondly, if a phonology is to be testable, the final rules must specify a phonetic output which is measurable. This is a stronger constraint on phonological descriptions than that proposed by Chomsky and Halle (1968), who suggest that the systematic phonetic level can be taken to be equivalent to a phonetic notation which accounts for the perceptual facts. Unfortunately perceptually based phonetic notations of this kind cannot be falsified; one cannot prove whether they do or whether they do not account for the perceptual facts. Accordingly, in order to make a phonological description falsifiable, the systematic phonetic level must be completly observable. But it does not follow that all features have to have a direct physical definition. As we shall see, it is quite possible for some features to be defined in terms of other features.

In standard generative phonology the set of features required in phonological rules is the same as the set of features used at the systematic phonetic level. But there are a number of cases where we need phonological features which have no direct phonetic correlates. For example, nearly all phonological descriptions will at some point refer to a consonantal class of sounds. It is very difficult to define this class in terms of a single property which is shared by all consonants; plainly Consonantal is not a feature which has simple phonetic correlates. But it is quite easy to define in terms of particular combinations of values of other features which do have phonetic correlates. Similarly, in describing the pitch variations which occur in sentences there is evidence (surveyed in Stockwell, 1971) which suggests that one set of rules will be required for describing the place of occurence of the major intonation change, and a different set of rules will describe what that change is. Accordingly, there will be one set of rules that specify that a certain syllable is the nucleus of the intonation contour and is marked [+ intonation], and another set of rules that later give a more precise specification by rewriting [+ intonation] in terms of other features which describe whether the pitch is rising or falling. As a final example, we may note that we often have to consider sounds as having something in common, if they are made either with a closure of the lips as in a bilabial stop, or with a rounding of the lips as in the vowel [u]. The easiest way to do this is by setting up a feature which we might call Labiality. Both vowels and consonants can be specified in terms of this feature, with a convention that [+ labiality] implies a particular subset of possible degrees of lip rounding when talking about vowels, and a particular subset of places of articulation when talking about consonants. Rounded consonants such as [b^w] would be specified as both [+labiality] and [+round]. If we have a feature such as Labiality then our phonological rules can be more explanatory. For example,

the phonological rules themselves will show that there is an assimilation involved when an unrounded vowel becomes rounded due to the influence of a bilabial consonant (as occurs in Turkish). since the rule will simply say that vowels which are [- labiality] become [+ labiality] in the environment of consonants which are [+ labiality].

All these examples strongly suggest that phonological feature systems are hierarchical. Features fall into one or other of two groups. The one group may be considered to be primes, in that they are defined in terms of non-linguistic entities; their definitions are in terms of physical phenomena. The other group may be called cover features in the sense that they are cover terms for disjunctive sets of values of the prime features; they are defined within the theory of linguistics. Both kinds of features can be used at the input to a phonology, where they act simply as classificatory devices. Phonological redundancy rules will ensure that the cover features will be rewritten so that they do not appear in the systematic phonetic output. A more elaborate discussion of the role of the two kinds of features may be found in Vennemann and Ladefoged (1971).

Another constraint on feature systems should be made more explicit at this point. The prime features are each definable in terms of a single measurable property of a kind such that sounds can be said to have this property to a greater or lesser degree. This point has been discussed at length elsewhere (Ladefoged, forthcoming). Chomsky and Halle (1968) purport to have a similar notion in that they say: 'each feature is a physical scale defined by two points.' But they do not in fact define all of their features in terms of possible physical scales. Thus they say 'vocalic sounds are produced with an oral cavity in which the most radical constriction does not exceed that found in the high vowels [i] and [u] and with vocal cords that are positioned so as to allow spontaneous voicing; in producing nonvocalic sounds <u>one or both</u> of these conditions are not satisfied.' (SPE 302, my italics). This is in no sense a physical scale defined by two points. It does not allow us to state 'the extent to which a given segment possesses the corresponding feature' (SPE 164), since it obviously does not define an algorithm which would enable us to determine the relative degree of vocalicness of, for example [e,e̞,w].

Nevertheless it seems a correct notion that phonological theory should be constrained so that the prime features should be specifiable in terms of a single measurable property. A principle of this kind is necessary to allow us to determine whether two sounds can be defined in terms of the same feature or not. Thus no language contrasts a series of clicks of the kind found in the Nguni and Khoisan languages with a series of creaky voiced stops of the kind found in Chadic languages. But it does not follow that click sounds can be described in the terms of the same feature as creaky voiced stops. There is no physical scale which would include the click mechanism and the creaky voice mechanism. Similarly no language which has contrasts between velars and uvulars (such as Eskimo or Quechua) also has contrasts between labiodentals and bilabials (of the kind that are found in Ewe). But it does not follow that these two contrasts are manifestations of the same feature, (even though Chomsky and Halle, 1968, might specify them all in terms of a feature which they label Distributed).

We might at this stage consider in what sense possible places of

articulation can be described in terms of physical scales. Chomsky and Halle (1968) follow Jakobson, Fant and Halle (1951) in using a number of binary oppositions. Thus they divide the possible places of articulation into two groups by means of a feature which they call Anterior, all the sounds made with an articulatory gesture in the front of the mouth being [+ anterior], and those made further back being [- anterior]. They also posit a feature Coronal which they use to describe sounds made generally in the dental or alveolar region. But a feature such as Coronal cannot really be a single physical scale since its opposite (noncoronal) can mean two quite different things. It refers to labial sounds if it is in the context [- anterior], and to velar or uvular sounds if it is in the context [- anterior]. It would seem that we could think of the different places of articulation in terms of a physical scale only if we consider articulatory place as a single multi-valued feature, specified perhaps in terms of the distance of the point of articulation from the glottis.

There is another way in which the notion of a physical scale has been used confusingly. Some things have been described in terms of a single scale when there are really two or three quite separate measurable properties involved. For example, Chomsky and Halle have some very elegant rules for describing the differences in "stress" which occur in English. It is possible that stress may be a cover feature. But it has been shown by Vanderslice and Ladefoged (1971) that the so-called levels of stress really involve several different phonetic primitives. Roughly speaking, stress level 1 usually involves the feature Intonation; stress levels 2 and 3 are more appropriately specified in terms of the presence or absence of the feature Accent; and stress level 4 is a matter of vowel reduction.

As a further general point concerning the nature of feature systems we must note that we cannot presume that all the prime features will have simple articulatory correlates, nor that they will all have simple acoustic correlates. Some features will be more easily interpretable in the one way, and others in the other. The original Jakobsonian features were all given acoustic definitions, on the grounds that acoustic specifications are the best descriptions of what will be heard, and 'We speak to be heard in order to be understood' (Jakobson, Fant and Halle 1951 p. 13). More recently, the Chomsky-Halle features have been defined almost entirely in articulatory terms, perhaps in accordance with the notion that they represent the sound producing capabilities of man. But it would seem that there are strong reasons for expecting some features to be more interpretable in the one way, and others in the other way. To see why this is so we must return to considering the reasons for setting up a feature set. We saw earlier that we were concerned with features that were appropriate for use in phonological rules. These rules describe the sound patterns which occur in languages; and most of these sound patterns are due to sound changes which have arisen for one or other of two causes. Some changes are the result of simplification of the articulations in an utterance, and there are other changes which are due to the auditory similarity of different sounds. Thus, as an example of the simplification of articulations, we could consider the way in which nasals become homorganic with the following stop in words such as <u>improper</u>, <u>intolerable</u>, and <u>incomplete</u>. Similarly, ease of articulation accounts for the change from a velar stop to a palatal stop (or palatoalveolar affricate) in the environment of a front vowel (as shown by pairs of words such <u>regal</u>, <u>regent</u>; <u>analog</u>, <u>analogy</u>). Assimilation of Labiality by unrounded vowels in the presence of

labial consonants (as discussed above), and voicing of intervocalic consonants (compare /s/ in semblance and resemblance) are also examples of the simplification of utterances.

But some sound patterns have arisen for reasons that have little to do with the articulations of the sounds. Thus alternations between voiceless bilabials and velars occur in many languages (e.g. in Rukonjo, a Bantu language spoken in Uganda, the first consonant of the stem in the word for 'pig' is /p/ in the form [mpunu], alternating with /k/ later becoming [x] in the diminutive form [akaxunu].) Alternations of this kind are due to the fact that [k] and [p] have the same value of the feature Gravity (the auditory property of having lower pitch spectral energy as in [p,k], as opposed to higher pitch spectral energy of this kind found in [t]). No amount of searching for neurophysiological explanations is likely to uncover an articulatory property which is common to all sounds which share this auditory property. Similarly the traditional term vowel height actually refers to an acoustic property (frequency of the first formant) rather than to any single articulatory scale. Despite some of the traditional IPA statements, the height of the tongue is not simply related to vowel height. As an additional example, the feature Sibilance (which we mentioned when we discussed the rules for English plurals) is also definable in terms of an acoustic scale which has no single valued articulatory correlates. The facts of languages continually lead us to set up some features which are definable in terms of simple measurable physiological properties, and others which are definable in terms of their acoustic properties.

It has been suggested by Vennemann (personal communication) that there is an interesting parallel between some of the auditory/acoustic features and the features which are cover terms. It would be possible to define some of the auditory/acoustic features in terms of particular values of articulatory features, in the same way as we suggested that cover features should be defined in terms of prime features. Thus [+ gravity] is, in some senses, a cover term for labial and velar voiceless obstruents, just as [+ labiality] is a cover term for labial consonants and rounded vowels. Similarly [+ sibilance] is a cover term for a certain subset of fricative consonants. I doubt, however, that all the auditory/acoustic features could be handled in this way. Vowel height, for example, does not seem to be definable in terms of any particular combination of values of other features. Furthermore, definitions of this kind do not provide explanations of why certain sound patterns occur in languages. But statements relating the auditory features to their acoustic properties indicate that the phonological patterns in question have arisen because of these acoustic properties.

The feature set which is being proposed here is obviously not the smallest set with which it is possible to make a complete description of the sounds of language. As we have seen at least some of the auditory/acoustic features are redefinable in terms of articulatory features, and all the phonological features are redefinable in terms of basic features. Consequently the proposed feature set will be highly redundant in comparison with the earlier set proposed by Jakobson, Fant, and Halle (1951). But there is really no reason to believe that we would be able to make adequate explanations of linguistic phenomena if we were to use a minimal set of distinctive features. From an acoustic point of view speech sounds can be completely specified in terms of a very small set of properties, such

Table 1. A possible set of segmental features. (Ladefoged 1971a)

Feature	Phonetic terms	Example Symbols	Language	Words	
Voice onset	voiced	b	Thai	bà:	'shoulder'
	voiceless unaspirated	p	Thai	pà:	'forest'
	aspirated	p^h	Thai	p^hà:	'split'
Glottal stricture	creaky voice	b̰	Bura	bá↓à	'dance'
	stiff voice	e̬	Kumam	l̃è:	'axe'
	voice	b	Bura	bàrá	'want'
	slack voice	a̤	Kumam	là̤	'animal'
	breathy voice	b̤	Gujerati	b̤ar	'burden'
	voiceless	p	Bura	pàká	'search'
Glottalicness	ejective	t'	Uduk	t'è	'lick'
	plosive	t	Uduk	tèr	'collect'
	implosive	ɗ	Uduk	ɗek'	'lift'
Velaric suction	no click	t	Zulu	tátù	'third'
	click	ǂ	Zulu	ǂàǂá	'climb'
Nasality	oral	d u	Yoruba	sú	'sow'
	nasal	n ũ	Yoruba	sṹ	'push'
Prenasality	not prenasalized	d	Margi	dàlmá	'axe'
	prenasalized	ⁿd	Margi	ⁿdàl	'throw'
Articulatory place	bilabial	β	Ewe	èβè	'Ewe'
	labiodental	v	Ewe	èvè	'two'
	dental	t̪	Malayalam	kut̪t̪l	'stabbed'
	alveolar	t	Malayalam	kuttl	'peg'
	post-alveolar	t̠	Malayalam	kut̠t̠l	'child'
	palatal	c	Quechua	caka	'bridge'
	velar	k	Quechua	kara	'expensive'
	uvular	q	Quechua	qara	'skin'
	glottal	ʔ	Tagalog	kaʔo:n	'fetch'
	labial-velar	p͡k	Igbo	àp͡kà	'bag'
	labial-alveolar	p͡t	Margi	p͡tʃəl	'chief'
Apicality	apical	ɹ̩	English	dɹ̩æm	'dram'
	laminal	ʒ	(South African)	dʒæm	'jam'
Stop	no closure	h	English	hæt	'hat'
	closure	t	English	tæp	'tap'
Fricative	no turbulence	l	Zulu	lòndá	'preserve'
	turbulent airstream	ɮ	Zulu	ɮùɮá	'roam loose'
Vibration	no vibration	ɹ	English	ɹɛd	'red'
	trill	r	Spanish	pero	'dog'

Feature	Phonetic terms	Example Symbols	Language	Words	
Rate	ballistic	ɾ	Spanish	peɾo	'but'
	normal	d a	Kamba	koʃa	'start'
	long	d: a:	Kamba	koʃa:	'giving birth
	extra long	a::	Kamba	koʃa::	'giving birth frequently'
Laterality	central	h	English	hæt	'hat'
	lateral	ɬ	Zulu	ɬòɬá	'prod'
Height	high	ɪ	Danish	vɪ:ðə	'know'
	mid-high	e	Danish	ve:ðə	'wheat'
	mid-low	ɛ	Danish	vɛ:ðə	'wet'
	low	æ	Danish	væ:ðə	'wade'
Backness	front	ɪ	Ngwe	mbɪ	'cowries'
	central	ɨ	Ngwe	mbɨ	'dog'
	back	ɤ	Ngwe	mbɤ	'ivory'
Width	pharyngealized	ʕ	Arabic	ʕamm	'uncle'
	neutral	ɩ	Twi	dɩ̀	'hold'
	advanced tongue root	ɪ	Twi	dɪ̀	'eat'
Rounding	spread lips	i	French	li	'bed'
	neutral lips	a	French	la	'there'
	rounded lips	y	French	ly	'read'
Sibilance	no sibilance	θ	English	θɪn	'thin'
	high pitch turbulence	s	English	sɪn	'sin'
Gravity	high frequency energy	t	Shona	túta	'carry'
	low frequency energy	k	Shona	kúka	'cook'

as the formant frequencies and the source characteristics. Work with speech synthesiers has shown that it is possible to produce excellent speech by specifying the values of only nine or ten parameters. But these parameters are obviously not the optimal set of phonological features.

Finally, before considering the individual features, we must consider whether features are necessarily binary. As Minnow (1970) has said, 'When one examines the literature on distinctive features, it is difficult to avoid the conclusion that distinctive features are binary because distinctive features are binary.' It is a trivial fact that any multivalued scale can be expressed in terms of a number of binary oppositions; and nowadays there seems to be no theoretical reason why phonological theories should be constrained so that only binary features are permitted. It used to be said (Halle, 1962) that only binary features would permit an adequate evaluation procedure. But, in the first place this is not true, as Minnow (1970) has shown. Secondly, if it were true it would mean that nearly one third of the rules in the Sound Pattern of English (all the stress rules) could not be evaluated, since they involve multi-valued feature specifications. Thirdly it is not clear why a phonology should need an evaluation procedure. I would prefer to try to judge a phonology by the adequacy of its explanations of linguistic phenomena, rather than by some form of point count (cf. Fromkin, 1971). If we are looking for explanatory rules it would seem obvious that we must permit descriptions in terms of multivalued features. A large number of phonological processes such as vowel shift and lenition clearly involve changes on one multi-valued continuum or another.

The principle purpose of this present paper is to discuss the general form of a set of features which would be appropriate for use in a generative phonology. Definitions of specific features which are in accord with these general principles have been given elsewhere (Ladefoged, 1971b). As an example of a major part of a feature set, we may conclude with a simple listing (in Table 1) of a possible set of the prime features which are needed for specifying segments. This table should obviously be regarded as indicating a plausible hypothesis rather than a definitive theory.

Each feature in Table 1 is given a name, and, in the second column, a specification in terms of a number of phonetic labels. The third column illustrates these labels by means of IPA symbols; in a few cases where there is no official IPA symbol or diacritic I have had to suggest an innovation. The fourth and fifth columns give languages, and examples in these languages, a very rough English gloss being given in parentheses. All the examples are based on my own observation of the languages in question, often in collaboration with other linguists; further details and acknowledgements are given elsewhere (Ladefoged 1971b).

Most of the features in Table 1 are specified in terms of traditional phonetic labels, and need no further comment here. But it should be noted that, for some of the features, more phonetic terms are given than are used as contrastive possibilities in any one language. Thus the feature Glottal Stricture designates a continuum of phonation types, going from the most narrowed position of the arytenoids which will allow for the generation of sound (as in what Catford (1964) calls 'creak', or Hollien et al (1966) call 'vocal fry') to the furthest apart position which occurs in voiceless

sounds. As far as I am aware, no language contrasts more than three possibilities within this continuum; no language for example, has a set of sounds which differ only by virtue of the fact that one has creaky voice, another has ordinary voicing, a third has breathy voice, and a fourth is voiceless. So the set of terms listed here contains some redundancies at the phonological level. It might have contained many more. I have already included stiff voice and slack voice following a suggestion by Halle and Stevens (1971); these terms correspond to what I have previously (Ladefoged 1971b) called tense and lax voice. We might also have differentiated (as Catford 1964) between creak and creaky voice, and between murmur and breathy voice.

Similarly, the feature Articulatory Place might have been further differentiated, despite the fact that no language contrasts more than six possibilities (Malayalam has bilabials, palatals, and velars in addition to the dentals, alveolars, and post-alveolars illustrated in Table 1). More than three degrees of the feature Rounding might also have been listed, although even the claim that Swedish contrasts this many (Malmberg 1956) has been disputed (Chomsky and Halle 1968). I am also not certain whether three degrees of Backness are needed phonologically; in the examples from Ngwe, there are variations in Height as well as in Backness.

One of the most interesting points about Table 1 is that it shows how easily many traditional IPA notions can be adapted for use in current generative phonologies. I have no doubt that the list of features given in Table 1 will have to be modified as more data becomes available. But I strongly suspect that most of the terms, many of which have been in use for hundreds of years, will always be appropriate in descriptions of languages.

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Phonetic Features and Phonological Features

Theo Vennemann and Peter Ladefoged

One of the points agreed upon by nearly all schools of linguistics is that a description of a language links meanings with sounds (Chomsky 1964) and hence must impinge on reality at two points (Joos 1950), in its semantic and in its phonetic specifications. It is also generally agreed that the phonetic specification should be in terms of some set of phonetic properties or features, disagreement arising only over the particular form of the set. In the standard theory of generative phonology (Chomsky and Halle 1968) it is further assumed that the whole of the phonological component of the description of a language is most appropriately expressed in terms of the same features which are used to specify the phonetic output. We believe this latter assumption to be false.

It seems clear to us that an adequate phonological description of a language must be expressed in terms of two kinds of features. Any empirical theory has to have a number of primitives which are definable in terms of concepts which belong outside the theory. In the case of a phonological theory, these are the prime features which are definable in terms of the acoustic or physiological properties of sounds. Each of these features consists of a single measurable property of a kind such that sounds can be said to have this property to a greater or lesser degree. In addition there are phonological features that are not themselves prime features but are disjunctions of values of prime features; we will call these features cover features to express the fact that they are cover terms for certain values of related prime features. Both kinds of features play a role in phonology in that they serve to describe the phonological contrasts made in the lexicon as well as the natural classes playing a role in phonological rules. Possible sets of prime features are given in Ladefoged (1971a and 1971b). They include features such as Nasality, which is a single measurable property which sounds can have to a greater or lesser degree. It is thus a prime feature. It is also a phonological feature, because it plays a role in forming lexical contrasts and in defining natural classes in many languages. For example, French contrasts /m/ and /b/, and /n/ and /d/, and also has a rule nasalizing vowels before nasal consonants in closed syllables. As a further example consider Backness, which is a single measurable property which a sound can have to a greater or lesser degree. It is thus a phonetic feature. It is also a phonological feature. Turkish uses Backness to distinguish two sets of vowels, non-back ones: / i y e ø/, and back ones: / ɨ u a o/. It also uses the two natural classes based on this feature in a phonological rule, its well-known vowel-harmony rule: Disregarding certain exceptions, and a restriction on low vowels

in noninitial syllables, all vowels in a word must belong to the same natural class (either /ɨ y e ø/ or /ɨ u a o/), where the class membership is determined by the first vowel of the word.

As an example of a cover feature, consider the feature Consonantal. No single measurable property has ever been discovered which would set aside all consonantal segments from all non-consonantal segments. Yet consonantality plays a role in the phonological descriptions of numerous if not all languages; and it is simple to define in terms of particular combinations of values of prime features.

Other examples of cover features are not hard to find. The first which we will examine in some detail is a feature we will call Labiality. The lack of a feature Labiality has been recognized by several authors (e.g. Cambell 1969, Vennemann 1971a) as perhaps the most obvious deficiency of the feature system proposed in Chomsky and Halle (1968). This feature system does not provide the means for expressing the fact that the segments traditionally called labial form a natural class: Bilabial and labiodental consonants such as [p b pᶠ Φ β f v m], doubly articulated labiovelars such as [k͡p g͡b ŋ͡m], consonants with a secondary labial articulation such as [pʷ mʷ tʷ tsʷ sʷ nʷ kʷ xʷ ŋʷ], and round vowels and glides such as [u o ɔ y ø œ w ɥ].* The class of bilabials and labiodentals is characterized in this framework by the feature combination [+anterior, -coronal]. The class of doubly artriculated labiovelars is represented either as one of "labials with extreme velarization", i.e. [+anterior, -coronal, +back, +high], or as one of "velars with extreme rounding," i.e. [-anterior, -coronal, +back, +high, +round], depending on "the facts of the language" (Chomsky and Halle 1968: 311). It strikes us as peculiar that phonetically identical segments should be represented with so vastly different feature matrices. Finally, consonants with secondary labial articulation as well as round vowels and glides are characterized by the feature specification [+round] occurring in their matrices. In short, this feature system does not permit us formally to express the fact that lip-based sounds, [+anterior, -coronal], and round sounds, [+round], form a natural class. We will now show with a few typical examples that they do.

Many languages show alternations between [v], i.e. a [+anterior, -coronal] spirant, and [u,w], i.e. a [+round] vowel or glide. For example, in several Germanic languages, [w] became [v]: English <u>water</u> [wɔtɾ], but German <u>Wasser</u> [vasər], Icelandic <u>vatn</u> [vaʰt̪ˑn̥], Norwegian <u>vann</u> [van ː]. The common change (1)

(1) w → v/ . . .

is represented in Chomsky and Halle's feature system as (2).

(2)
$$\begin{bmatrix} -\text{vocalic} \\ +\text{high} \\ +\text{back} \\ +\text{round} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{consonantal} \\ +\text{anterior} \\ -\text{high} \\ -\text{back} \\ -\text{round} \\ +\text{strident} \end{bmatrix} / \ldots$$

*Note that IPA symbols are used throughout this paper. Thus [y ø œ] are used where others might have had [ü ö ɔ̈].

Perhaps some features can be spared here by applying the proposed linking mechanism (Chomsky and Halle 1968: 419-435). Yet there remains the fundamental deficiency that the two segments occurring in (1) are not characterized in any representation based on (2) as belonging to the same natural class. Formulations like (2) thus obscure rather than reveal the obvious naturalness of the change (1) (Campbell 1969, Vennemann 1971a: fn.17).

The converse change likewise occurs. For example, in Faroese, /m/ and /v/ change into a diphthong-glide [w] or [u] between a vowel and /n/. The change is a fully productive rule of this language: lamin [lɛamɪn]: lamnan [launan] 'lame (masc. sg., nom. vs. acc.)', vovin [vo:vɪn]: vovnan [vɔunan] 'woven (masc. sg., nom. vs. acc.)'. The change (3)

(3) $\left\{ \begin{matrix} m \\ v \end{matrix} \right\} \rightarrow u / V \_\_\_\_ n$

is one of the numerous consonant cluster simplification rules of this language, namely a change in the direction of optimal syllable structure, and thus a natural rule. Again this fact is obscured by a formulation based on matrices with the feature specifications [+anterior, -coronal] and [+round], respectively (Vennemann 1971a:fn.17).

Assimilatory interactions between lipbased consonants and round vowels are also common. Labialization of consonants by round vowels, such as in Nupe (Hyman 1970), presents no problem, because it can be based squarely on the feature Round.

(4) [+consonantal] → [+round] / . . . $\left[\begin{matrix} V \\ +round \end{matrix} \right]$ . . .

But the complete change of a non-labial consonant into a lip-based one under the influence of round vowels does present problems. For example, Finnish changes /ɣ/ (from / k/ through two steps of weakening medially at the beginning of a consonantally closed syllable) into [v] between high round vowels (i.e., /u__u/ and /y__y/).

(5) $\gamma \rightarrow v / \left\{ \begin{matrix} u \\ y \end{matrix} \right\} \_\_ \left\{ \begin{matrix} u \\ y \end{matrix} \right\}$

E.g., luku : luvun 'chapter (sg., nom. vs. gen.)', kyky : kyvylla 'skill (sg., nom. vs. adessive)' (cf. Harms 1964: 43 for the data). In the current Chomsky-Halle system this rule cannot be represented as an assimilation--which it clearly is.

The complementary change, the rounding of vowels by lip-based consonants, is very common. We present only two examples. In several German dialects, front vowels are rounded by both lip-based and redundantly round consonants, most regularly by /p b pf f v m ʃ l/. Compare the following pairs of forms from Low German and Standard German, respectively: [frœmbd]: fremd 'strange(r)', [vœpʂ]: Wespe 'wasp', [fœŋ]: fing 'caught', [tʏmən]: zimmern 'timber', [krʏf]: Krippe 'cradle', [sʏlvəl]: Silber 'silver'. Some forms with vowels rounded in this way also occur in Standard German, e.g. Hölle 'hell', zwölf 'twelve' (but elf 'eleven'), löschen 'extinguish' (Schirmunsky 1962: 207-208). This change,

(6) $\begin{bmatrix} V \\ -back \end{bmatrix} \rightarrow$ [+round] / . . . $\left\{ \begin{matrix} \text{lip-based consonant} \\ \text{round consonant} \end{matrix} \right\}$ . . .

is inadequately represented by a notation which represents lip-based consonants as [+anterior, -coronal] and round consonants as [+round], with no feature to reflect the fact that they form a natural class.

The Mangalore Christian dialect of Konkani, an Aryan language spoken in and around Goa, shows rounding of mid-central vowels by both round vowels (regressive) and lip-based and round consonants (regressive and progressive).[1] The vowel-to-vowel roundness assimilation can be demonstrated dialect-internally with pairs such as in (7), because it is a productive phonological rule, (8).

(7)

	gloss		gloss
Jhər	fountain (sg.)	Jhoro	fountain (pl.)
kər	do (imp. sg.)	korũk	do (inf.)
kʌ!ɛ	bud (pl.)	kɔ!ɔ	bud (sg.)
rʌḍ	weep (imp. sg.)	roḍõk	weep (inf.)

(8) $\begin{bmatrix} V \\ +mid \\ -front \end{bmatrix} \rightarrow$ [+round] / ——— $C_1 \begin{bmatrix} V \\ +round \end{bmatrix}$

Our notation [V, +mid, -front, -round] is ad hoc to the task of separating /ə/ and /ʌ/ from an inventory which Dr. Miranda charts as in (9). No systematic status of these vowel features is implied.

(9) Vowel inventory of the Mangalore Christian dialect of Konkani.

	front	central	back
high, non-mid	ɪ	(ɨ)	u
non-low, mid	e	ə	o
non-high, mid	ɛ	ʌ	ɔ
low, non-mid		a	

The vowel-consonant roundness assimilation can be demonstrated internally only in as much as [ə] and [ʌ] never occur in contact with lip-based or round consonants.

[1] We owe these data to Rocky V. Miranda (University of Minnesota), a native speaker of this dialect.

(10) A morpheme structure condition of the Mangalore Christian dialect of Konkani.

$$\begin{bmatrix} V \\ +mid \\ -front \end{bmatrix} \rightarrow [+round] \; / \; \left\{ \begin{array}{l} \text{lip-based consonant} \\ \text{round consonant} \end{array} \right\}$$

However, the original phonological rule from which this morpheme structure condition resulted can be reconstructed through a comparison of the Mangalore Christian dialect with the Mangalore Hindu dialect of Konkani, cf. (11).

(11)

Mangalore Christian	Mangalore Hindu	gloss
(a) Regressive assimilation.		
tɔpl$\tilde{\varepsilon}$	tʌpl$\tilde{\varepsilon}$	cooking pot
khɔbar	khʌbʌrǎ	news
khobre-	khəbre-	news (oblique)
jɔm-	(Hindi) jəm-	condense
tɔwš$\tilde{\varepsilon}$	tʌwš$\tilde{\varepsilon}$	cucumber(sg.)
towšṬ	təwšṬ	cucumber(pl.)
(b) Progressive assimilation.		
pɔr	pʌr	fall
bhor	bhər	fill (imp.)
fɔl	(Hindi) phəl	fruit
wɔl$\tilde{\varepsilon}$	wʌl$\tilde{\varepsilon}$	half of a coconut (sg.)
wol̥Ṭ	wəl̥Ṭ	half of a coconut (pl.)

(Note that the contrast between /ə/ and /ʌ/ is neutralized in non-final syllables due to a height-harmony rule. It is this other harmony rule which, together with an apocopation rule, brought this contrast into the language. Hindi, like Sanskrit, has only /ə/.)

Additional examples from other languages could be multiplied without any difficulty, but we feel we have already demonstrated unambiguously the need for a phonological feature which comprises both lip-based and round segments.

We will not consider other examples of cover features in such detail; but there is no doubt that they are needed in phonological rules. For example the feature Intonation, which was mentioned by Ladefoged (1971a) has been used in phonological rules by Vanderslice and Ladefoged (1971). These authors show that descriptions of intonation in English clearly need to be able to specify that a certain syllable carries the nuclear intonation change (i.e. is [+intonation]) without having to specify what the intonation pattern is (i.e. whether it is [+ cadence] or [+ endglide] or both). A similar point has also been made by Stockwell (1971), in his discussion of the role of intonation in a generative grammar.

Other authors have also proposed features which would be cover features in our framework. Thus Foley (1970) has shown that there is often a need for a multivalued feature which we might call Strength, in order to describe group changes, known as consonant gradation or lenition, in which geminate

stops become single stops and single stops become voiced (Finnish), or voiceless stops become voiced and voiced stops become fricative (Danish), or stops become fricatives and fricatives become approximants. If this is so, then the possible values of the Strength feature can be defined in terms of particular values of the Stop, Fricative, etc, features. All feature theories known to us include the equivalent of a prime feature Stop, and it is shown in Ladefoged (1971a) that we need a prime feature Fricative as well, in order to describe the correct relations between stops, affricates, fricatives and approximants.

This leads us to the second goal of our paper, a proposal for the incorporation of derived phonological features, or cover features, into a generative phonological theory. Two possibilities offer themselves. One is to treat both the prime and cover features indiscriminately as "distinctive features" by cross-classifying all segments containing prime features which enter into the definition of specific cover features. This seems to be the position consciously or unconsciously advocated by such authors as Campbell (1969), Vennemann (1971a), and, with respect to the features Palatal vs. High and Back, Schachter and Fromkin (1968). Assuming for the moment that Bilabial, Labiodental, and Round are prime features, and Labial a cover feature, this proposal would classify [p] as [+bilabial, -round, +labial], [fw] as [+labiodental, +round, +labial], [u] as [V, +round, +labial], [sw] as [-bilabial, -labiodental, +round, +labial], etc.

While this proposal provides the means for establishing the natural classes required for the proper description of the language data discussed in this paper, it would imply two consequences which we consider undesirable: (1) By erasing the distinction between prime and cover phonological features, it would obscure a differentiation based on a well-defined phonetic criterion, namely the presence vs. absence of a uniform measurable phonetic property. (2) By treating prime and cover phonological features as primitive concepts of phonological theory, it would increase the number of primes of this theory, which is undesirable on general methodological grounds.

The second proposal, and the one we would like to submit in this paper, avoids both of these undesireable consequences. We suggest that the theory should define cover phonological features in terms of prime phonological features. In this way we (1) express the difference in phonetic status of these two classes of phonological features, and (2) keep the number of primes low, namely, as far as the set of feature primes is concerned, down to exactly the number of phonological features that have to be defined in terms of non-linguistic entities.

The obvious way to define phonological cover features formally is by means of redundancy rules in the form of logical equivalencies, e.g. (12)

(12) $\forall$ x. ((x is segment) $\rightarrow$ ((x is [+labial]) $\leftrightarrow$
(x is [+bilabial])
or (x is [+labiodental])
or (x is [+round])))

where $\forall$ reads "for all objects", $\rightarrow$ reads "implies", $\leftrightarrow$ reads "is equivalent to." In short:

(13) [+labial] $\leftrightarrow$ [+bilabial] or [+labiodental] or [+round]

Similarly we have (14)

(14) [+intonation] ↔ [+endglide] or [+cadence] . . . .

(Here the dots indicate that there may exist other prime features qualifying as [+intonation], e.g. [+scoop] or [+dip] if we find that a description of intonation has to include these features, which we at present consider to be simply indexical rather than phonological.)

The situation with respect to a cover feature such as Strength is slightly more complicated, both because this is a multi-valued cover feature, and because different languages employ different strength hierarchies. As an example, we would base a gradation rule which reduces Strength by one degree in a consonant system of stops, fricatives, and approximants, on a strenght hierarchy defined by the following redundancy rules:

(15) [3 strength] ↔ $\begin{bmatrix}+\text{stop}\\-\text{fricative}\end{bmatrix}$

[2 strength] ↔ $\begin{bmatrix}-\text{stop}\\+\text{fricative}\end{bmatrix}$

[1 strength] ↔ $\begin{bmatrix}-\text{stop}\\-\text{fricative}\end{bmatrix}$

The occurrence of a feature on the left-hand side of such a universal redundancy rule---we call them feature redundancy rules---thus indicates both its derived status in general and its specific definition in terms of prime features.

This representation of the concept of phonological cover features formalizes a convention which grammarians of all ages have used on an intuitive basis. Lexical inventories (or phoneme systems) are usually described in the broadest terms available. For example, stops are never labiodental and fricatives are never bilabial in English. (The same is not true for all languages. For example, Ewe, a West African language, has contrast between labiodental and bilabial fricatives, cf. Ladefoged 1968: 25.) English /p b f v m/ are, therefore, usually classified as labial, with the details given in the fine print of the description. We suggest that this be made a general convention:

(16) Convention for phonological description of segment inventories (i.e., the classification of segments in lexical representations): Segments are classified in terms of the broadest (cover) features sufficient to establish all the contrasts of the language described.

The "fine-print" is expressed by means of language-specific segment redundancy rules, which interact with the universal feature redundancy rules to produce the proper phonetic representation which must, of course, be given entirely in terms of (partly numerically specified) prime features. For example, the English segment redundancy rule

(17) $\begin{bmatrix}+\text{consonantal}\\+\text{labial}\\\alpha\text{fricative}\end{bmatrix}$ → [αlabiodental]

is recognized by the universal theory as a possible specification of the universal feature redundancy rule (13), further interpreted as implying

(18) $\begin{bmatrix} +\text{consonantal} \\ +\text{labial} \\ \alpha\text{fricative} \end{bmatrix} \rightarrow [-\alpha\text{bilabial}]$

because of the way in which universal feature redundancy rules interact with universal cooccurrence restrictions, such as that which precludes the cooccurrence of [+bilabial] and [+labiodental] in stops and fricatives.

We hasten to add that an explanatorily adequate phonological theory should make rules such as (17) superfluous, because of a further universal convention which states that the most natural labial stop is bilabial, and the most natural labial fricative, labiodental (a marking convention in the sense of Chomsky and Halle 1968: Chapter 9). Thus, English, having the most natural set of bilabial (oral and nasal) stops /p b m/ and labiodental fricatives /f v/, requires no language-specific segment redundancy rule for labial obstruents whatsoever. (It would, however, require a rule

(19) $\begin{bmatrix} +\text{consonantal} \\ +\text{labial} \\ +\text{fricative} \end{bmatrix} \rightarrow [+\text{bilabial}]$

if instead of /p b m f v/ it had the set /p b Φ β m/.)

Note that the arrow between the two sides of a feature redundancy rule has two points, i.e., expresses an equivalency rather than a unidirectional redundancy. This provides for: (1) the decoding of phonetic representations into phonological (and lexical) representations; and (2) the redundant introduction of cover features in languages which are rich enough in contrasts to require the use of prime features in the lexicon. To exemplify the second point, we only have to remind the reader of Ewe with its contrastive bilabial and labiodental fricatives. They all become [+labial] by a right-to-left application of rule (13). We note, finally, that round vowels will never be classified as [+round] in the lexicon, because of a universal cooccurrence restriction prohibiting [+bilabial] and [+labiodental] in vowels, leaving [+round] as the only possible interpretation of [+labial] in vowels under (13).

Now that cover features such as Labiality are properly introduced into the theory, the language-specific properties described earlier in the paper can be expressed as follows.

For the change of /w/ into [v], we write (20).

(20), cf. (1). $\begin{bmatrix} -\text{syllabic} \\ +\text{labial} \end{bmatrix} \rightarrow [+\text{consonantal}] \; / \; . \; . \; .$

The language-specific output of this rule, such as [v] rather than [β], is expressed by a further redundancy rule determining the interpretation of [+labial] in obstruents. We note in passing that where /w/ becomes [γ], we write (21),

(21) $\begin{bmatrix} -\text{syllabic} \\ +\text{velar} \end{bmatrix} \rightarrow [+\text{consonantal}] \; / \; . \; . \; .$

and where it becomes [γ^w], as syllable-initially in certain styles of Spanish (Hooper 1971), we write (22):

(22) $\begin{bmatrix} -\text{syllabic} \\ +\text{velar} \\ +\text{labial} \end{bmatrix} \rightarrow$ [+consonantal]/ . . .

For the Faroese change of /m/ and /v/ into [w] we write, conversely (cf. Venneman 1971a: fn. 17 for (21)-(23)):

(23), cf. (3). $\begin{bmatrix} +\text{voice} \\ +\text{labial} \end{bmatrix} \rightarrow$ [-consonantal] / V__n

For the Finnish change[2] of /γ/ into [v] we write:

(24), cf. (5). $\begin{bmatrix} +\text{fricative} \\ +\text{voice} \\ +\text{grave} \end{bmatrix} \rightarrow$ [+labial] / $\begin{bmatrix} V \\ +\text{high} \\ +\text{labial} \end{bmatrix}$ — $\begin{bmatrix} V \\ +\text{high} \\ +\text{labial} \end{bmatrix}$

For the German dialect rounding of vowels near labial consonants we write (25):

(25), cf. (6). $\begin{bmatrix} V \\ -\text{back} \end{bmatrix} \rightarrow$ [+labial]/ $\begin{bmatrix} C \\ +\text{labial} \end{bmatrix}$

For the Konkani morpheme structure rule we write:

(26), cf. (10). $\begin{bmatrix} V \\ +\text{mid} \\ -\text{front} \end{bmatrix} \rightarrow$ [+labial] / $\begin{bmatrix} C \\ +\text{labial} \end{bmatrix}$

Note that we would also reformulate the vowel harmony rule:

(27), cf. (8). $\begin{bmatrix} V \\ +\text{mid} \\ -\text{front} \end{bmatrix} \rightarrow$ [+labial] /__ $C_1 \begin{bmatrix} V \\ +\text{labial} \end{bmatrix}$

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[2]Note that we can omit the specification [+strident] in (24) because Finnish has a rule specifying labial fricatives as labiodental independently of this particualr change. We would also like to point out that we consider (24) as only an approximation of the real generalization which we view as follows. In Finnish, as in many other languages, there exists a correlation between degree of roundness and vowel height such that the higher the vowel the greater the degree of roundness. These can be numbered as in (a).

(a)
u — 2
o — 1
a — 0

These degrees of roundness are not lexically contrastive; but in the present case they clearly play a role in a morphophonological process. Rather than expressing this process as in (24), in which the feature [+high] is used as a conditioning factor, the linguistically significant generalization to be captured should be based directly on degrees of labiality. We thus write:

However, we would not insist that this rule be combined with (26), firstly because (27) is unidirectional while (26) is bidirectional, and secondly (27) occurs without (28) in the Goa Hindu dialect of Konkani. (In the Goa Christian dialect, the change ə→o, ʌ→ɔ has become context-free.) Perhaps the partial independence, yet obvious relatedness of the two rules can be expressed by a partial combination such as in (28).

(28) $\begin{bmatrix} V \\ +mid \\ -front \end{bmatrix} \rightarrow [+labial] \; / \; \left\{ \begin{array}{l} \_\_\_\_ \; C_1 \begin{bmatrix} V \\ +labial \end{bmatrix} \\ \begin{bmatrix} C \\ +labial \end{bmatrix} \end{array} \right\}$

Before we end this paper, we would like to point out a possibly desirable extension of the formalism proposed here. Ladefoged (1971a) has pointed out that there are two kinds of prime features, those which are defined in terms of articulatory concepts such as place of articulation, and those which are defined in terms of acoustic concepts, such as the features Sibilance and Gravity. There is no doubt that we need to posit a feature such as Gravity because of its well-known role in phonological rules, e.g. f→x/___t in Dutch (cf. German Luft, Dutch lucht 'air'); x→f in English (cf. the pronunciation and the spelling of enough, and German genug); x→p in a Bantu language such as Rukonjo (cf. the stem -xunu, in [mpunu] 'a pig' and [akaxunu] 'piglet'); and in the Finnish ɣ→v change (24). There is also no doubt that it is possible to define Gravity in a way that explains why [p, k, f, x] fall into one class by specifying the acoustic property that these sounds all share, namely, lower as opposed to higher non-periodic spectral energy.

Yet, Gravity is also definable as a disjunction of some of the prime features which are needed for specifying certain places and manners of articulation. Similarly Sibilance, another acoustically defined feature which plays a well-known phonological role, for example in the English plural allomorphy, could also be defined as a disjuction of certain articulatorily definable features in that it may be a subset of a class defined by the feature Fricative and other articulatory prime features. This leads us to hypothesize that feature redundancy rules may not only define phonological cover features such as in (13), but may also establish the necessary link between prime features based on acoustic properties, and those based on articulatory properties. We thus write (29) on the analogy, and with the content, of (13).

(29) [+grave] ↔ [+labial] or [+back]

This notation may prove useful in the case of some acoustic prime features,

(24a) $\begin{bmatrix} +fricative \\ +voice \\ +grave \end{bmatrix} \rightarrow [+labial] \; / \; \begin{bmatrix} V \\ n \; labial \end{bmatrix} \_\_ \begin{bmatrix} V \\ n \; labial \end{bmatrix}$

condition: n>l.

Similar examples of redundant feature specifications functioning in phonological rules are discussed in Vennemann 1971b. The concept of directly explanatory formulations of phonological processes in natural generative phonology is further explicated in Vennemann 1971c.

but we are not sure if it can be applied to all of them. Future research may lead us to consider that acoustic-articulatory relationship rules like (29) cannot be equated with true feature redundancy rules defining cover features like (13).

In summary, there seems to be no doubt that we need two kinds of phonological features, and that the relationship between them is of the form indicated in our feature redundancy rules. The number of prime features must, as in any theory, be minimal; but the number of derived features constructed from them must be sufficient so that we can give explanatory formulations of linguistic phenomena. Only by the use of both kinds of feature will we be able to fully develop a truly natural generative phonology.

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The Role of Intonation: Reconsiderations and Other Considerations

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In my article on this subject (Stockwell 1960) (written just weeks after my first exposure to transformational theory at the 1958 conference on English grammar at Austin, Texas [1]), two claims were made about intonation in grammar that I very soon came to believe were wrong:

(1) (i) That the number of surface phonological phrases tends to correspond one-for-one to the number of deep sentences.

(ii) That choice among alternative intonation contours is on a par with choice among alternative category realizations within the base component: i.e. that one "chooses" contours as he "chooses" lexical elements.

There are several kinds of correlation between deep structure and intonation, but nothing as simple as (1.i). On the other hand, neither is intonation a simple function of surface structure, as was assumed by Chomsky and Halle 1968. A good deal of work of recent vintage -- in particular Bresnan 1971, Downing 1970, Pope 1971, and Lakoff 1971 -- has borne on the question of predicting the location and form of intonation contours from levels of deep or shallow structure (and to some extent surface). It is possible that the only aspect of intonation that is predictable from surface structure alone is the range of "optional phrasing" possibilities (Bierwisch 1966, Downing 1970). The other matter on which I believe I was wrong, the choice of meaning differences between contours (i. e. where the difference is not a function of the location of the center of the contour, or of the presence vs. absence of a contour, but in the actual form of the contour itself), has not received much subsequent clarification.

There were also claims in that early work which I see no reason to retract, though some of them need considerable elaboration:

(2) (i) That there is such a thing as a "neutral" or "normal" or "colorless" intonation contour for any sentence, serving as a baseline against which all other possible contours are contrastable, and thereby meaningful. [2]

(ii) That it is an intrinsic property of certain transformational rules that they assign to their output an intonation contour (i. e. that not all contours are predictable from inspection of phrase-markers at the surface or any deeper level: that some contours are consequent upon the derivation itself). [3]

(iii) That what is relocated to form "contrastive stress" is the center of the intonation contour: that the notion "center of the contour" is a distinct notion within a correct theory of intonation. It should not be collapsed with the notion "stress" that relates to levels of prominence lower than the major one of each phonological phrase.

(iv) That Prepositions and Personal Pronouns (and, I should have added, several other "grammatical" or "functional" classes, like Articles, some Auxiliaries, Modals, Conjunctions, certain classes of Particles and Adverbs -- in general, all classes which can enter into satellite "clitic" relationships with Nouns, Verbs, and Adjectives [though the matter is not simple: see Kingdon 1958: 170-207]) are obligatorily destressed (or never receive stress) and do not "count", as it were, in computation of the center of the NEUTRAL contour.

I would like to consider these various claims in relation to subsequent research to see to what degree a coherent theory of intonation has been achieved and to what extent there remain areas largely unilluminated. To discuss them I will distinguish four kinds of questions:

A. The REPRESENTATION question: What is the most economical and realistic system of linguistic representation of the intonational facts (i.e. the total set of linguistically negotiable perturbations of pitch and rhythm)?

B. The NUCLEAR STRESS question: On what basis, and to what extent, is the location of the contour CENTER to be predicted?[4] (A corollary of this question concerns the prediction of which items can be DE-stressed. Destressing, and contour center marking, are two sides of the same coin).

C. The BOUNDARY question: On what basis, and to what extent are the intonational "pauses" to be predicted? (By "pause" I mean the boundaries between intonation contours, which do not correspond with silence, or absence of phonation, or "breath groups"). "Pauses", in the sense here intended, are uniform perceptual realities, but they may not have uniform correlates either acoustically or articulatorily: perhaps timing.

D. The MEANING question: What is the range of meaning that can be differentiated directly or indirectly by intonational facts? (I shall not deal with this question here. I include within it and the previous one the matter of segregating out the endless variety of "tone of voice" information that is not negotiated on a strictly linguistic basis. See Stockwell, Bowen, and Silva-Fuenzalida 1956).

A. The REPRESENTATION question.

The greatest part of the literature on intonation prior to Pike 1945, as well as most of the literature produced in Europe to this date, has focused on the MEANING question, and of course much of Pike's own work provided lively and insightful analysis of subtle contrasts in meaning that he believed intonation could differentiate. With Pike, Trager and Smith 1951, and Chomsky and Halle 1968, the REPRESENTATION question received enormously more attention than it had before. This question naturally entails decisions about the relative weights of various acoustic parameters, in order to minimize the set of prosodic features required and arrive at an optimal phonemic representation. The most recent exemplars of this debate are Vanderslice and Ladefoged (1970). Lieberman 1967 was crucially devoted to this problem (as well as some of Lieberman's earlier research, including his brilliant demolition [Lieberman 1965] of the Trager-Smith analysis with respect to its claims of syntactic independence).

The REPRESENTATION question can be viewed formally or informally. Informally -- that is, how can one unambiguously and efficiently write sentences down so that they can be read back as intended -- the question is not important. I am content to represent intonation with squiggly lines, or with lines of type following the contour as Bolinger does, or in the manner of Kingdon 1958. But formally -- that is, trying to determine the set of features that most persuasively account for the phonetic capacities of man, in respect to the role of intonation in natural languages -- the question remains one of some interest. Throughout the '50's when this question was of burning interest, the most brilliant contributions were made by Bolinger (esp. 1957, 1958a, 1958b), who demonstrated beyond all doubt that what everyone really meant by "main stress" or "primary stress" or "heaviest accent" was PITCH OBTRUSION (the famous accents A, B, and C); and that what the Trager-Smith "superfixes" came down to (the famous *light house keeper* examples) could be unambiguously rendered only by appropriate devices of TIMING ("disjuncture").

For reasons which remain mysterious to me, Chomsky and Halle persisted through their major opus in providing ingenious rules that are capable of assigning levels of stress far more finely differentiated than the four that Trager and Smith claimed. The impossibility of

finding consistent perceptual correlates for putative contrasts between two (non-nuclear stress) versions of the *black board eraser, light house keeper, British history teacher* types of examples has given Vanderslice 1970 rich ammunition for his amusing if sometimes pompous annihilation of the superfixes and their generative-transformational reflexes. Chomsky and Halle took the Trager-Smith data as given, and they undertook originally to show how these complex stress patterns were syntax-dependent.

The Trager-Smith four stresses still remain superficially intact in the latest foray (revised ms January 1971) of the Vanderslice-Ladefoged campaign. PRIMARY is identified by them as the simultaneous features [+heavy], [+accent], [+intonation] -- i.e., it is that accentable syllable which falls at the center of the intonation contour, which is what it always was in Trager and Smith 1951, in Hockett's 1958 modification of their notation, and in the various other treatments the analysis was given (Hill 1958, Gleason 1955, Stockwell, Bowen, and Silva-Fuenzalida 1956, Stockwell 1962, Stockwell and Bowen 1965). SECONDARY is [+heavy] [+accent] [-intonation] -- i.e. "full articulation with increased respiratory energy causing a pitch obtrusion", which is the same as primary except not at the contour center. TERTIARY is [+heavy] [-accent] [-intonation] -- i.e. everything that's left except the reduced vowels. WEAK is the reduced vowels (or "reduced timing", since there is not actual centralization in all instances). One of the Vanderslice-Ladefoged contributions is to point out that there are no viable stress contrasts between secondary and tertiary after the nuclear syllable ("nuclear syllable" is another of the many paraphrases for "center of the intonation contour"): e.g. (3.i) = (3.ii) unless an optional disjuncture is inserted in (3.i) for just this purpose:

(3) (i) He saw a BLACK bird, not a GREEN one. [Contrastive]

(ii) He saw a BLACKbird, not a CROW. [Compound]

But although they claim (correctly, in my judgment) that the four stresses cannot be used to resolve such ambiguities, they still require four levels of prominence, in all, for English: they transcribe the phrase *elevator operator* as (4.i) (= in Trager-Smith notation (4.ii), = in Chomsky-Halle notation (4.iii)):

(4) (i) elevator operator
+a -+h - +h -+h -

(ii) élevàtor òperàtor (TS would write *élevàtor ôperàtor)*

(iii) 1 4 3 4 3 4 3 4 1 4 3 4 2 4 3 4
elevator operator (CH would write *elevator operator)*

If we move the contour center to the left (as in *They MURDERED the elevator operator)*, so that the 1-stress on the first syllable is downgraded to secondary, then there are still two levels of prominence on this phrase, or any similar one. This is because English allows either full vowels or reduced vowels at the lowest stress level, as in pairs like *typhoon ≠ saloon, buffoon; citation ≠ legation*. The distinction can be made as a function of the "heaviness" of the vowel -- i.e., unaccented syllables can be heavy (have unreduced vowels) or light (have reduced vowels). This solution to the much debated 4-stress vs. 3-stress question of the '50's was adopted some years ago by Householder (1957) and by me in practical work (Stockwell and Bowen 1965), though until Chomsky and Halle 1968 no one had stated the crucial rule which determines which vowels are reducible and which ones must remain unreduced -- and it is THAT insight which is crucial to the Vanderslice and Ladefoged kind of solution.

The levels of prominence that we need to represent are, then, the following, given that vowel qualities are also represented (or predictable by rule):

(5) ACCENTED (= CENTER OF CONTOUR = NUCLEAR STRESS = Bolinger's PITCH ACCENT = Trager and Smith PRIMARY = Chomsky and Halle 1-STRESS = IPA STRONG = SENTENCE STRESS = Vanderslice and Ladefoged [+intonation, +accent, +heavy])

STRESSED (= NON-NUCLEAR ACCENTABLE SYLLABLE = Vanderslice and Ladefoged [-intonation, +accent, +heavy] = Trager and Smith SECONDARY = Chomsky and Halle 2- and sometimes 3-STRESS = WORD STRESS = IPA MEDIAL = Bolinger's (1958b) "morphological stress")

UNSTRESSED (= everybody's weakest stress, universally acknowledged when the vowel is reduced, sometimes debated in examples like *refugee, canteen, portray, asbestos, typhoon, austere, effigy* where the relevant vowels are not reduced: these are the Vanderslice and Ladefoged [-intonation, -accent, +heavy] syllables, corresponding to Trager-Smith tertiary stress)

For the moment I take as established some version (the details are not important to the remainder of this discussion) of the Vanderslice-Ladefoged 1970 modification of the Chomsky-Halle 1968 rules for word-stress assignment. I think there are not many issues of great moment left under the REPRESENTATION question, because so much convincing work was accomplished between Pike 1945 and Vanderslice 1970.

B. The NUCLEAR STRESS question.

In a recent paper by Joan Bresnan (1971) we have an insight which, if it is correct, is one of the most persuasive and explanatory insights into obvious and familiar data that the M.I.T. school has come up with yet.[5] Whatever the difficulties that she still faces in making her proposal stick in detail (and there are several such, both ones that she is aware of and ones that have been, or shortly will be, pointed out to her by colleagues), the basic insight is so appealing that like some of Chomsky's first ideas about the role of transformations in grammar one feels it just HAS to be right. The relevant data has been around for so long that it's interesting to speculate on the way that scientific insights come about. Clearly, in this case at least it is not a matter of new data, nor even of a new observation about the grammatical relations to be found in the data. Stanley Newman (1946) cited such minimal pairs as

(6) (i) I have INSTRUCTIONS to leave

(ii) I have instructions to LEAVE

and pointed out that *BREAD to eat* "indicates a syntactic relation in which the noun is the logical object of the verb: that is, *bread to eat* has a relationship with 'to eat bread', whereas in *a desire to EAT*, "the verb stands in the relation of complement to the noun" (p. 179). One need not translate the preceding into the equivalent transformational jargon to come up with Bresnan's insight: namely, that the accentuation of *INSTRUCTIONS* in (6.i) and the de-accentuation of *to leave* occurs in the deep structure by the regular Nuclear Stress Rule at a stage prior to the transformation that lifts *INSTRUCTIONS* out of the lower sentence and drops it into the object slot of the upper one, into which position it carries along its accentuation; whereas in (6.ii) *LEAVE* is never moved away from its naturally accentuated position. [6]

Bresnan presents three classes of examples:

(7) RELATIVE CLAUSE (vs. Noun complement)

(i) Mary liked the PROPOSAL that George left. [7]

vs.

(ii) Mary liked the proposal that George LEAVE. [8]

(8) DIRECT AND INDIRECT QUESTIONS (fronting of stressed noun vs. fronting of unstressed pronoun) [9]

(i) John asked what BOOKS Helen had written.

vs.

(ii) John asked what Helen had WRITTEN.

(iii) Helen has WRITTEN something? [Contained in 8.ii]

(iv) What has Helen WRITTEN? [Interrogative of 8.iii]

(v) Helen has written some BOOKS. [Contained in 8.i]

(vi) What BOOKS has Helen written? [Interrogative of 8.v]

(vii) The parable shows what SUFFERING men can create.
vs.
(viii) The parable shows what suffering-men can CREATE.

(9) REDUCED RELATIVE CLAUSE (vs. Noun complement)

(i) Helen left DIRECTIONS for George to follow.
[i.e. "directions such that George could follow them"]
vs.
(ii) Helen left directions for George to FOLLOW.
[i.e. "directions to the effect that George should follow her"]

Bresnan's claim is simply that relative clause formation and question formation are cyclical rules, [10] and that the Nuclear Stress Rule follows them IN THE CYCLE (not necessarily immediately -- at the end of the cycle, before last cyclic and post-cyclic rules and of course before the next cycle up.) This device produces the right results by virture of the peculiar way in which the NSR was formulated originally (as far back as Chomsky-Halle-Lukoff 1956, where it first appeared). The rule doesn't do what one might intuitively think a contour-center-marking rule OUGHT to do, namely ADD a pitch-accent to the item that is singled out for the one-to-the-customer privilege (where the customer is a "phonemic phrase" -- i.e. everything between the two nearest boundaries of sufficient status to become intonationally-marked "pauses"). Rather, the rule SUBTRACTS stress from the other items in the same phrase, and renders them thenceforth frigid and unresponsive to the possibility of becoming contour centers themselves. They can be weakened further, by subsequent applications of the NSR in higher (i.e. later) cycles -- a weakening which is vacuous in terms of its effect on the prosodic qualities of the phonetic output, as already discussed under the representation question -- but since the NSR is set up in such a way that it will only operate on items that already HAVE maximum stress, they can't be strengthened and they therefore end up as destressed remnants to the RIGHT of the contour center (as in 7.i, 8.i, 8.vi, 8.vii, and 9.i above).

There are a number of aspects of the Chomsky-Halle formulation of the NSR that deserve comment: but if we ignore details of the rule itself and focus only on the Bresnan claim that the rule applies cyclically, the substantive content of her claim is that in normal, neutral intonation patterns the center of the contour is determined BY THE SEQUENTIAL ORDER OF ITEMS IN THE DEEP STRUCTURE, such that if a stressable item is the right-most one subject to the NSR, then the stress that it receives is carried with it if it is moved to the left by subsequent transformations: by placing the NSR after the cyclic syntactic transformations, Bresnan guarantees that rules within the cycle

can move an item without changing the location of the contour center, but movement rules of the next cycle up, or post-cyclic or last-cyclic rules, WILL change the location of the contour center if they move that item to which the contour center has been assigned in the cycle.

Bierwisch (1968) has argued that constituents which are contour centers in the surface structure "must be specially marked for that property in a very early stage in the syntactic derivation" (177). His arguments had to do with anaphoric elements (with reduced stress consequent upon their anaphoric status within the context) and contrastive stress of various types. His arguments are therefore of a very different type from Bresnan's, even though he anticipates her conclusion, in this respect. It is remarkable how little has been accomplished subsequently in the study of the formal properties of contrastive stress. There is nothing comparable in detail or in conviction to the Chomsky-Halle kinds of proposals about the rules that govern the placement of neutral stress.

Bierwisch does not converge with Bresnan to argue for stress determination prior to surface structure in the case of neutral (non-contrastive) intonation patterns, but only for contrastive ones -- or perhaps something more subtle, such as topic/comment marking. Emily Pope (1971), however, does converge by arguing that some syntactic rules that bring about deletions must FOLLOW rules which assign intonation contours: and the assignment of intonation contours, as she sees it, in turn depends on stress assignment. Her argument depends on contrasts like the following:

(10) (i) Yes, happily. [= "Yes, they are married happily."]

(ii) Yes, happily. [= "Yes, they are married, I'm happy to say."]

She claims that "the process of intonation assignment is a mapping from surface structure syntactic information to phonetic "interpretations" (72), and that it is a phonological phenomenon. I find some of her arguments less than persuasive, specifically (a) that intonation assignment depends on prior stress assignment, and (b) that intonation assignment rules "take into account brackets but not labels" (73), in that respect resembling the NSR, which she assumes to be a phonological rule *par excellence*. In respect to (a), I merely note that the only way in which intonation depends on prior stress assignment is for determination of the center of the contour: but WHAT contour turns up (e.g. rising vs. falling) in no way depends on the location of the center. It is quite likely that the contour, and its center, are altogether independent phenomena; the center perhaps depends on such factors as the NSR, emphatic stress marking, contrastive stress, or topic/comment marking; and the contour itself depends on factors sometimes very remote from the surface, such as degree of conviction

with which an asserted belief is held ("He $^{m}a_{y}$ b_{e} nic^{e}"), and at other times fairly close to the surface and obvious within the derivation, such as the yes/no interrogative rising intonation (which can be argued to depend either on the presence of some sort of trigger in the deep structure, or a deletable performative, or some special configuration such as WH-*either/or*, roughly "WH-either he is going, or he is not going" as source of "Is he going?"). The point is that Pope does not establish anything, in respect to the relation of intonation to the rules of stress assignment, beyond the claim that there is a one-to-one correlation between main stress and the center of an intonation contour: a fact which was not in dispute. There is ample evidence (e.g. Bolinger 1958a) that the only way main stress is perceived is by virtue of the pitch perturbation that defines the center of the contour. In respect to (b), that intonation assignment rules operate only on brackets, ignoring labels,I follow Bierwisch 1966 in large part, though I believe but cannot demonstrate here in detail that the rules of optional phrasing -- those rules which specify the location and form of intonational pauses that are not absolutely obligatory -- require category labels to bring about correct downgrading to the status of "clitic". It will not be an absolute downgrading, but a relative and hierarchical one. For instance:

(11) (i) I want to know how she BUILT it.

(ii) [Slower] I WANT to know HOW she BUILT it.

(12) (i) I saw how quickly she BUILT it.

(ii) [Slower] I SAW how QUICKLY she BUILT it.

I take it that *how* in both (11) and (12) has the same node label above it: for (11) there is a deep structure containing "She built it in some manner", and in (12) there is a deep structure containing "She built it in a quick manner". In both cases, WH-attachment to the manner adverbial results in the form *how*. In both, a slowing down of the sentence introduces optional pauses and thereby two more intonation contours than appear in the corresponding faster version. Optional phrasing of this sort, as Bierwisch 1966 has demonstrated, is a highly regular phenomenon. It operates on the general principle that pauses must be introduced between higher ranking constituents before they are introduced between lower ranking ones. The principle has the important qualification that you ignore the ranking of any constituent that has been attached as a clitic, intonationally, to some other constituent. Thus in (11) and (12), the subject pronoun is attached as a clitic to the following verb. Therefore the slower version of the sentences does not introduce pause between the two

highest constituents. Pronouns always look for a prop to support them. They are stressable only when the prop has been removed, or when they are contiguous with even less able-bodied categories (like prepositions or conjunctions),as in the phrase *between you and me.*

Returning now to (11.ii) and (12.ii), and considering examples like *between you and me* at the same time, it would appear to be impossible to state the conditions of optional phrasing without reference to category labels. Bierwisch has no examples of this type, and I am unable to make his rules (which make no reference to category labels) serve for these examples.

Pope's paper, then, sets out to show that there are phonological processes, namely intonation assignment, which must precede some syntactic transformations. If correct, this would provide another case like Bresnan's. Pope's claim that intonation assignment precedes some syntactic rules seems to be correct up to a point. There is no conceivable way in which the intonational contrast between (10.i) and (10.ii) could be assigned on the basis of surface syntactic information alone. The surface syntactic information is presumably identical. It follows either that intonation assignment is not a purely phonological process, or that in the course of the derivation of (10.i) and (10.ii) some tag is left behind (when the deletion occurs) to identify the contrast, or that intonation assignment is a phonological rule that applies before some syntactic rules (Pope's view). I think Pope has chosen the least persuasive of the three possible consequences of her evidence. I myself think the first alternative is correct. Some of the current leading M.I.T. linguists like Postal, Ross, and Lakoff are more likely to go along with the second alternative (of which a variant would be a so-called global or trans-derivational constraint). But I have no evidence to provide, yet, that would choose between the alternatives.

Even if Pope's arguments do not establish the position that phonological rules can be interspersed with syntactic ones, Bresnan's case, if solid, WOULD do so. But her case is in fact a rather spongy one. Her evidence turns out to be either wrong, or internally so inconsistent that one has to reject any conclusion based on it.

In Kingdon (1958:205) there are pairs like these:

(13) (i) Introduce me to the man you were TALKING to.

(ii) I'll lend you that BOOK I was talking about.

One can dream up indefinitely many examples like (13.i) in which the noncontrastive contour center location is on the last accentable item of the relative clause. [11] All of them should be instances of

CONTRASTIVE stress, under Bresnan's hypothesis (cf. (7) above). George Lakoff (1971) has noted comparable examples (MS p. 3):

(14) (i) Teddy is the only capitalist I would ever VOTE for.

(ii) Teddy is the only CAPITALIST I would ever vote for.

(14.i) is an especially persuasive counterexample because *capitalist* is not an obvious candidate for anaphora (and therefore unlikely to be destressed). Yet it is clear that (14.ii), not (14.i) is contrastive: it implies that the speaker would vote for any NON-capitalist.

Counterexamples like (13) and (14), where Bresnan's hypothesis wrongly predicts that the last NP in the relative clause will remain the contour center after it is fronted, are reinforced by counterexamples to her second class of cases, the direct and indirect questions (8):

(15) (i) He works for a chain of GROCERY stores.

What chain of grocery stores does he WORK for?

I asked what chain of grocery stores he WORKED for.

(ii) He established a new TRADITION.

What new tradition did he ESTABLISH?

or

What new TRADITION did he establish?

(iii) He bought a new dress for someone's WIFE.

Whose wife did he buy a new DRESS for?

It appears, in fact, that only a direct object allows a non-contrastive reading when it carries the contour center forward -- and even that is not always obligatory, as in (15.ii). In (15.i) and (15.iii), the object of the preposition, even though at contour center when final, clearly cannot carry the contour center to the left, except contrastively. Lakoff 1971 has many examples like (15), and he has devised a particularly clever example which demonstrates that if an NP can be read ambiguously as direct object or prepositional object (within, e.g., a benefactive adverb), the direct object reading is preferred if the NP is fronted along with its stress, whereas the other reading is preferred if the contour center is retained on the final accentable item:

(16) (i) The men are competing for some countries.

[AMBIGUOUS: the countries may be their potential awards, or merely their sponsors]

(ii) What countries are the men COMPETING for?
[= Who is sponsoring the men?]

(iii) What COUNTRIES are the men competing for?
[= What countries make up the list of prizes?]

A similar, but less natural, example had occurred to us:

(17) (i) The Professor looked over a book.
[AMBIGUOUS: he glanced through it, or it was interrupting his direct line of vision]

(ii) What book did the professor look OVER?

(iii) What BOOK did the professor look over?

Such examples establish beyond any doubt that Bresnan's claim is too broad: it is not the case that final contour-center nouns carry the contour center to the left with them when they get fronted. They do so only if they are direct objects -- and even then not always. Lakoff points to such examples as (18):

(18) (i) Whose UMBRELLA have I taken?
[Predicted correctly by Bresnan's hypothesis]

(ii) Whose book did the reviewer CRITICIZE?
[Not correctly predicted; somehow the heavier verb affects the decision.]

(iii) Which CAR did he buy?
[Predicted correctly if we ignore Bresnan's own statement that NP's with *which* are not supposed to follow her prediction.]

(iv) Which car did the timid little clerk who works in our office BUY?
[I think that the neutral contour would have its center on *office*, which is what Bresnan would predict if you ignore her qualification about *which;* but Lakoff marks it on *buy*.]

Lakoff does not have any new light to cast on Bresnan's third class of examples (9). He notes that J. R. Ross in a class at M.I.T. in 1967 made the correct observation about (19),

(19) (i) John has PLANS to leave

(ii) John has plans to LEAVE

that in (19.i) *plans* is underlying direct object of *leave*, and that this fact somehow accounts for its stress. But this observation goes back at least to Newman 1946, as Ross was no doubt well aware even though it is not mentioned by Lakoff.

Lakoff's own solution (Lakoff 1971) is apparently adequate to the evidence, though unsatisfying because it merely lists a set of curious facts within a global constraint [12] and provides no explanatory account of them. The constraint does, however, block a class of counterexamples to Bresnan's hypothesis which we have not dealt with so far, and which Lakoff was the first to observe:

(20) (i) It is likely that he'll solve those PROBLEMS.

(ii) *Which PROBLEMS is it likely that he'll solve?

(iii) Which problems is it likely that he'll SOLVE?

[Bresnan introduces an irrelevancy here: she excludes examples with *which* from her predictions. But the example is just as damaging with *what:* "What problems is it likely that he'll SOLVE?"]

The Lakoff global constraint sets up three conditions under which an NP will be allowed to carry its contour-center-hood forward with it:

(21) (i) In logical structure it is a direct object; [13]

(ii) In shallow structure it has no clause-mates following it; [14] and

(iii) In surface structure it is a clause-mate of its logical predicate.

It is condition (21.iii) which blocks (20.ii). Condition (21.ii) merely guarantees that it is final (and therefore subject to the NSR). And condition (21.i) is the fundamental condition that distinguishes those examples of Bresnan's which are valid from the classes of counterexamples cited in (13)-(18) above. It is also the condition that seems quite *ad hoc* and non-explanatory to me, though I have nothing better to offer.

Before leaving the nuclear stress question, we should look again at examples like (6), (9), and (19):

(6) (i) I have INSTRUCTIONS to leave.

(ii) I have instructions to LEAVE.

(9) (i) Helen left DIRECTIONS for George to follow.

(ii) Helen left directions for George to FOLLOW.

(19) (i) John has PLANS to leave.

(ii) John has plans to LEAVE.

Unlike the other classes of examples, there is no quibbling about these. Futhermore, the Lakoff constraint (21.ii) does not hold for this class:

(22) (i) I have INSTRUCTIONS to leave with Mary.

(ii) I have INSTRUCTIONS to leave on the airplane.

(iii) John has PLANS to leave here this afternoon.

And of course, since Lakoff's constraint (21.ii) merely formalizes the distributional fact which would allow Bresnan to apply the NSR to it, it follows that these examples are somewhat mysterious under either the Bresnan hypothesis or the Lakoff global constraint. Lakoff's constraint (21.i), that the contour center must be a direct object in logical structure, would appear to relate these examples to the ordinary relative clause and interrogative examples. But why does this class, alone, ignore clause-mates following it, any of which can be contour centers in other forms of the sentences:

(23) (i) He left the instructions with MARY.

(cf. 22.i)

(ii) He left the instructions on the AIRPLANE.

(cf. 22.ii)

(iii) He left the plans here this AFTERNOON.

I can offer some weak evidence that the contour center of (6.i), (9.i), and (19.i) has nothing at all to do with having been an object of the lower verb in logical structure (and therefore nothing to do with cyclical application of the NSR). Consider sentences closely related to (9):

(24) (i) Helen left DIRECTIONS, and George is to FOLLOW them.

(ii) Helen left DIRECTIONS, George can FOLLOW them (if he wants to).

(iii) Helen left DIRECTIONS (which George can follow if he wants to).

I think (24.iii) is closest to exemplifying my proposal: the low-pitch tag in (9) is the remnant of a fuller parenthesis: the entire parenthesis in (24.iii) would normally receive low pitch throughout -- I think it is a separate contour with *follow* at the center, marked not necessarily by pitch obtrusion but by timing. If there are necessarily TWO contours in such sentences, *directions* would form the center of the first one (by the ordinary NSR), and the pitch drop would be a consequence of a parenthesis rule that is needed anyway -- which may then, when truncated sufficiently, as in ... *PLANS to leave,* appear to be a destressed final segment of a single contour.

C. The BOUNDARY question.

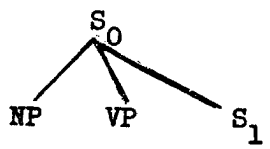
Without pretending to do justice to a long and excellent dissertation (Downing 1970), I can outline a hypothesis that has a great deal of generality going for it. The interest it has in relation to Bresnan and Pope is apparent from the following quotation (p. 204):

> Although phonological phrase boundaries have only phonological effects, they must be assigned prior to the application of certain late transformational rules of the syntactic component. Therefore it must be concluded that independently motivated aspects of syntactic surface structure are not sufficient for the operation of phonological rules: some aspects at least of surface structure are determined exclusively by the necessity of providing input to the phonological rules that specify prosodic features ...

Thus Downing adds to the clamor of Bresnan and Pope that intonation cannot be assigned from surface structure alone. He takes as the basis for his own position a claim of Emonds 1969 that "a characteristic of root sentences is to be set off by commas" (8). Emonds' notion "root sentence" is somewhat redefined by Downing, because Emonds's definition would include extraposed clauses, as in (25):

(25) (i) It bothered him that she was intelligent.

(ii)



If root sentences are to be set off by commas (i.e. are to receive a separate intonation contour), (25) must be excluded. Downing's definition, then, is that a root sentence is not commanded by a VP node. [15] Given this definition, he inserts phrase boundaries, which indicate where the intonation contour will start and stop, at both ends of every root sentence. The rule that inserts these boundaries applies AFTER the cyclic rules and BEFORE certain post-cyclic rules. It works without any *ad hoc* quality to explain the intonational pauses in conjoined sentences:

(26) (i) John bought the candy / and Mary ate it.

(ii) I told you that John bought the candy and Mary ate it.

In (26.i) the comma pause is (pretty much) obligatory -- a fact which is explained by Downing's hypothesis, since the conjunction joins two root sentences. In (26.ii) no comma pause occurs, because the conjoined sentences embedded as object of *tell* are not root sentences. This is Downing's crucial observation: he then looks at other instances of obligatory pause, and tries to make them all fit the same hypothesis -- a reasonable scientific procedure. One always wants to be absolutely forced by his data to add any more machinery to the shop full that he already has. In Downing's case, the procedure leads down an increasingly rocky and hazardous trail, however, and as he gets further away from basic conjunction, he becomes less and less persuasive.

The case beyond conjunction that looks best is adverb preposing, as in (27) (from Downing 1970:83):

(27) (i) When John phones, the girls talk to him.

(ii) When John phones the girls, talk to him.

(iii) When John phones the girls talk to him.

(27.iii) is thrown in only to show that the comma pause, either way, truly IS obligatory. But the natural order of these adverbs is final, and a pause is not obligatory:

(28) (i) The girls talk to him when John phones.
The girls talk to John when he phones.

(ii) Talk to John when he phones the girls.

(?) Talk to him_i when $John_i$ phones the girls.

But hold a moment: IS it the case that any of the sentences of (28) can be spoken naturally with only one intonation contour? Downing thinks so: I think it is possible that the sentences are all two-contour sentences, with the second contour being a low-level one:

(29) (i) The girls $^{\text{TALK}}$ to John / when he PHONES.

(ii) $^{\text{T}_{\text{A}_{\text{L}_{\text{K}}}}}$ to John / when he phones the GIRLS.

If this is a correct observation -- we will examine more data below -- notice what would follow: there would be no need for insertion of phrase boundaries when the adverbial sentence is fronted. Each intonation pattern HAS a boundary in (29); what happens is that the intonation pattern ITSELF is changed by the fronting rule, and Downing has interpreted this as boundary insertion:

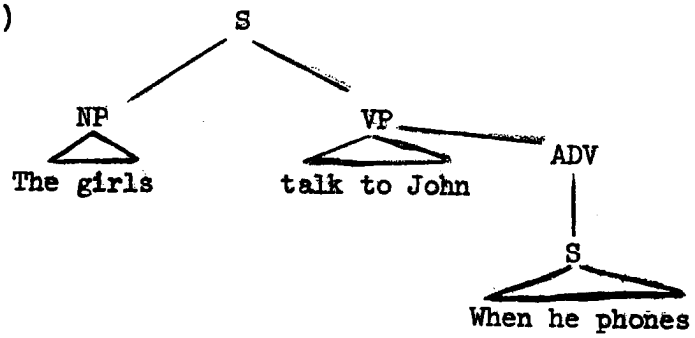
(30) (i) When he $^{\text{P}_{\text{H}_{\text{O}}\text{N}^{\text{E}^{\text{S}}}}}$ / the girls $^{\text{TALK}}$ to John.

(ii) When he phones the $^{\text{G}_{\text{I}_{\text{R}_{\text{L}}}}\text{S}}$ / $^{\text{T}_{\text{A}_{\text{L}_{\text{K}}}}}$ to John.

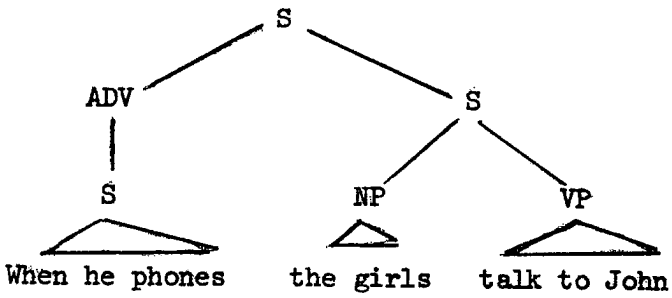
We now have two questions: (a) by what device does Downing insert phrase boundaries when adverbial sentences are fronted (assuming that they do NOT have separate intonation patterns when they are not fronted)? (b) what kind of evidence will decide whether such adverbs have separate intonation patterns in their pristine (unfronted) state?

Downing's device is to formulate all the relevant transformations as attaching the fronted element by means of Chomsky adjunction rather than sister adjunction. [16] Thus:

(31) (i)



(ii)



Quite simply, by Chomsky adjunction he turns a non-root sentence into a root sentence. He is of course honest about the *ad hoc* character of this device (p. 205): "It is not possible to predict which particular transformations will employ Chomsky adjunction; rather it is necessary to specify Chomsky adjunction, sister adjunction, etc., as part of the structural change of each particular movement transformation. It appears in fact that individuals may employ different types of adjunction (as revealed in phrasing) in what is essentially the same transformation, e.g. in adverb preposing." It appears to me that the device is then circular as well as *ad hoc:* if you know from the surface output that you need a separate intonation pattern, set up the relevant rules with Chomsky adjunction. This is equivalent to ASSIGNING the separate intonation pattern in the relevant transformation itself. Chomsky adjunction is the least well-motivated of the several types of elementary transformations, anyway. If intonational facts are used to decide when it is needed, and if it is employed to explain intonational facts, the circle is complete and unconvincing.

Let us look at some unfronted adverbial sentences:

(32) (i) When he had finished this ^{TASK} / he locked up and went $^{HO}{}_{ME}$.

(Downing 1970:53 -- intonation supplied)

(ii) He locked up and went $^{HO}{}_{ME}$ / when he had finished this TASK.

(33) (i) Since you are an old friend of the $^{F}A_{M_{ILY}}$ you have a right to $^{K}N_{O_{W}}$. (p. 53, intonation supplied)

(ii) You have a right to $^{K}N_{OW}$ since you are an old friend of the FAMILY.

(34) (i) Just as she fired the $^{P}I_{S_{T}OL}$ Bill came into the $^{R}O_{O_{M}}$.

(ii) Bill came into the $^{R}O_{OM}$ just as she fired the $^{P}I_{S_{T_{O_{L}}}}$.

(35) (i) "AM I" Hilda SAID "$PREG^{NA^{NT}}$?"

(ii) Hilda SAID, "Am I $PREG^{NA^{NT}}$?"

These have been chosen to illustrate the following claims of mine: (a) that it is utter nonsense to suppose (with Chomsky-Halle 1968) that the NSR can go right on applying cyclically and reducing the non-main-stressed items further and further -- the limit of phrase length is rather narrow (the same point is made by Bierwisch 1968, though he apparently would go much further down the road of 1-2-3-4-5-6-7 stress reduction than I would, and he says nothing about the boundary limitation problem that is inextricably tied to the NSR-repetition problem); (b) that pitch-lowering (of the whole embedded contour) is obligatory with parenthetical items like (35.i), and this fact is not expressible as a function of phrase-boundary-insertion conventions; 17 (c) that the number of intonation contours, if you grant me level contours in (32) and (33), corresponds, in this class of examples, to the number of un-deformed deep sentences.

Of course, if (c) is correct, and can be extended (e.g. by rules which erase intonation patterns only under specified conditions with the transformations themselves, so that transformational rules do much the same thing in respect to intonation that they do in respect to other aspects of structure, namely reduce depth and eliminate structure in various ways -- but not build or add structure), then one of my first hypotheses would be partially regnerated (see Stockwell 1960). But a much wider range of cases has to be examined before such a claim can be supported, and I shall not do so here: I seek only to cast doubt on the kind of approach that Downing espouses, and encourage research in a less *ad hoc* direction.

It should be clear by now that we have not achieved a coherent theory of intonation in relation to syntax yet. But a great deal of

interesting progress has been made, and intonation is, after several years of neglect, suddenly quite central again in syntactic discussions.

Footnotes

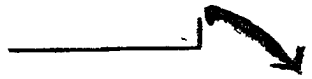
[1]At which Noam Chomsky presented the "Transformational Approach to Syntax" that was immediately available in mimeographed form, subsequently published in Hill 1962 and reprinted in Fodor and Katz 1964.

[2]It is true that coreferential noun phrases in a sentence require destressing of the second NP, in general, even if the second NP is not an ordinary pronoun: *I voted for Eisenhower even though I didn't much CARE for the general.* The phenomenon of anaphora is closely linked with those of stress reduction and contour-center location. In all such cases, I believe it can still be maintained that there is a "normal" (non-emphatic) reading which includes, as part of the specification of "normal", this kind of anaphoric destressing, and that further juggling of the contour center produces a reading which must single out for emphasis, by virtue of its contrast with the normal reading, some otherwise unpredictable item for stress/pitch highlighting (= emphasis).

[3]By this I mean, for example, that the rules which perform such operations as inversion of subject and auxiliary to form questions must themselves ASSIGN the appropriate rising contour to their output. The rising contour cannot depend on deep structure, since the underlying form of yes-no questions and of information questions is identical: the difference depends only on where the WH- morpheme is attached (to an NP, either within an adverb such that *at what time* $\Rightarrow$ *when, at what place* $\Rightarrow$ *where,* etc., or to the conjunction *either/or* such that WH-*either* $\Rightarrow$ *whether* in indirect questions, and is zeroed out of direct questions). Nor can the rising contour depend on surface inversion of subject and auxiliary, since the inversion also occurs with initial negatives: *Never have I met such a fool.* Besides the rising contour of certain interrogatives, it appears to me that part of the function of any rules that deal with coreference is, at the very least, to mark repeated coreferential items as [-Contour Center], or some such specification, so that the basic rule of normal contour-center placement, roughly "Place the main stress (= contour center) on the last stressable item to the right", can apply correctly in the presence of non-pronominal anaphoric elements. There is at least one type of example, observed first (so far as I know) by George Lakoff and called to my attention in this connection by Mona Lindau, where the usual destressing of pronouns and other anaphoric elements is reversed: *Bill kicked JOHN, and then HE kicked HIM.* This is necessary because of the use of contrastive stress twice in the same sentence: *HE* referring to John in contrast to Bill, and *HIM* referring to Bill in contrast to John. Note that these can BE contrastive only by virtue of the "normal" reading (for the same string in another context) *He KICKED him,* where *he* is Bill and *him* is John. The notion "contrastive stress" entails, as I see it, a prior notion of "non-contrastive" or "normal" or "neutral" contours.

[4]By contour center I mean the point at which the pitch contour sharply changes: the pitch skips up, or down. The center need not be the highest pitch level, nor the lowest, but only the point of (relatively) abrupt transition.

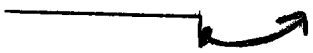
He did very nicely.



Simple assertion.

Assertion with minor reservations.

Echo question.



Assertion with major reservations.

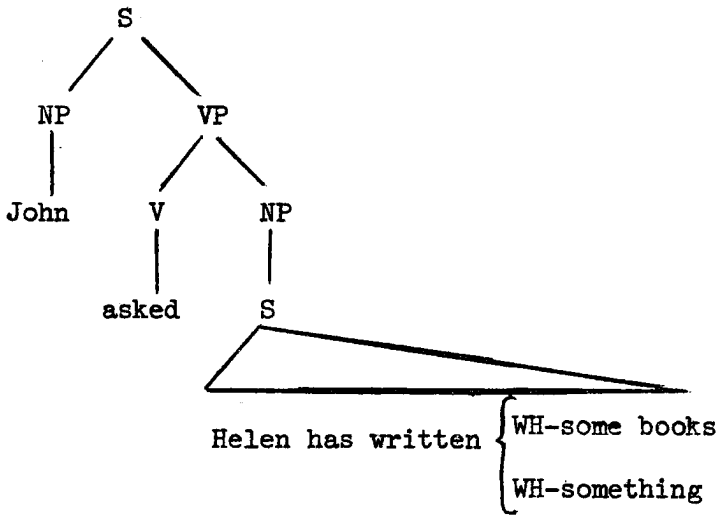
[5]There will be some difficulty, for readers not closely acquainted with recent transformationalist literature, in following all details of the ensuing discussion. I have tried to state the arguments in such a way that a precise understanding of particular rules or terms is not necessary for the purpose of grasping their general import for the theory of grammar. Since this paper was conceived as an updating of my earlier views on the role of intonation in grammar (Stockwell 1960), and since most of that updating depends on very recent work that has not yet filtered out into the generally available literature, part of what follows here has the flavor of a "house paper". For occupants of the house, so to speak, it may appear that I have oversimplified some arguments and even ignored crucial details; and for occupants of houses across the street, it may appear that I have forgotten how to talk any but the in-house language. I can only protest that my simplifications do not deliberately ignore substantive distinctions or consequences, and that I believed them useful and even necessary in order to communicate with the world outside.

[6]The NUCLEAR STRESS RULE (NSR) is a rule of Chomsky and Halle's (1968) that assigns heightened stress to the right-most stressable item in a specified domain -- e.g. a phrase or sentence.

[7]The phrase *the PROPOSAL that George left* is a Noun Phrase containing a restrictive relative clause: roughly "a certain proposal which was left somewhere by George".

[8]The phrase *the proposal that George LEAVE* is the nominal equivalent of the sentence *Someone proposed that George (should) leave.*

[9]It is assumed that (8.i) and (8.ii) have, as their underlying abstract form, something like



In order to derive the surface sentences from this structure, the object of *has written*, marked with WH-, must be moved to the front of the clause.

[10]Cyclical rules are, for the present purpose, transformational rules which apply in sequence to the lowest (most deeply embedded) sentence in a phrase-marker, and then reapply to the next higher phrase-marker, and so on. Some rules can be shown to be applicable only in the last or top-most cycle (such as Auxiliary Inversion, which derives *What is he doing?* from *(I don't know)what he is doing)*, whereas others such as Passive Formation must be ordered among the cyclical rules.

[11]Bresnan's paper was the central subject of my seminar on English intonation in the winter quarter of 1970-71. During that seminar, my students -- in particular Carol Lord -- and I discovered these and other counterexamples. At the same time, and independently, George Lakoff in Michigan was writing the paper to which some of the following discussion is devoted. The degree of our convergence is apparent below. I am most grateful to him for his willingness to make the paper available to me prior to publication.

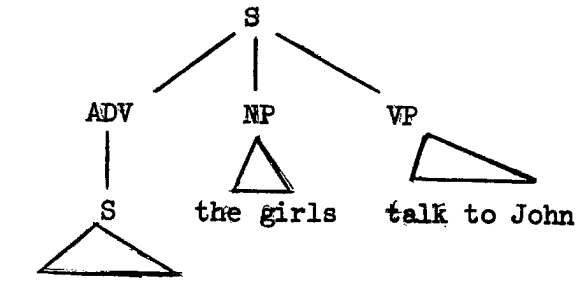
[12]A global constraint is one which applies across two or more stages of a derivation: i.e., one which is not stateable as a constraint on the operation of a particular transformational rule, but must hold across several stages, even across intervening rules to which it is irrelevant. Since a constraint of this form enormously enriches the power of a grammatical theory (and thereby weakens the claims the theory can make), one allows it only in the face of compelling evidence.

[13]By "logical structure" what is meant is "deepest, most abstract representation -- hopefully corresponding to the logical semantic structure".

[14]"Shallow structure" is that level of abstract representation that exists after all but last-cyclic and post-cyclic rules have applied. "Clause-mate" has the apparent sense, namely "constituent in the same clause".

[15]The notion "command" in this context means only that the given sentence is not dominated by a VP node nor a sister of a VP node.

[16]One of the central problems of "classical" transformational theory is that of assigning a correct structure to the output of a transformational rule. In "sister adjunction", a node is attached to the left or right of some daughter node (hence the term "sister"). Thus in (31.i), sister adjunction would yield



with the proposed adverb adjoined as left sister of NP. Chomsky adjunction, on the other hand, creates an additional node by COPYING the node which already dominates the node to which the moved item would be adjoined by sister adjunction, as shown in (31.ii), thus yielding an extra "layer" of structure.

[17]This observation has been made in the traditional literature on intonation repeatedly -- I am not sure where I got it, though I owe it most recently to Peter Ladefoged in the seminar noted earlier.

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Tone Features and Tone Rules

Victoria A. Fromkin

I. Linguists, working within the Generative Phonology paradigm, are attempting to establish a theory which defines formally and substantively the phonological components of grammars which will specify all and only the set of possible sound systems of human languages. Such a theory must provide a set of features for characterizing tone and other prosodic phenomena of language. It must also include constraints on tonal representation, the formal properties of tonal rules, and conventions which govern the interactions of tone rules with other rules of the grammar. This paper attempts to deal with some of these important questions. In particular it will discuss the distinctive features of tones (level and contour tones), tonal representation, and rules in a generative grammar.

II. The Distinctive Features of Level Tones

In one of the earliest proposals concerning "The distinctive features of tone" (Gruber, 1964) two tonal features, High and High 2 were proposed, which features provided the means for distinguishing between two, three, or four level tones. Implicit in this proposal is the claim that the basic distinction in any tone language is between high tones and non-high tones, with all other tonal contrasts being made within these two disjunctive sets. Thus, a language with two contrastive tones, would utilize only the feature High, a language with three or four contrastive tones would, in addition, specify tones using the feature High 2 as shown under (1).

(1) a. Two tone contrast: [+high] and [-high]

b. Three tone contrast: $\begin{bmatrix}+\text{high}\\+\text{high 2}\end{bmatrix}\begin{bmatrix}+\text{high}\\-\text{high 2}\end{bmatrix}$ [-high]

or [+high] $\begin{bmatrix}-\text{high}\\+\text{high 2}\end{bmatrix}\begin{bmatrix}-\text{high}\\-\text{high 2}\end{bmatrix}$

c. Four tone contrast: $\begin{bmatrix}+\text{high}\\+\text{high 2}\end{bmatrix}\begin{bmatrix}+\text{high}\\-\text{high 2}\end{bmatrix}\begin{bmatrix}-\text{high}\\+\text{high 2}\end{bmatrix}\begin{bmatrix}-\text{high}\\-\text{high 2}\end{bmatrix}$

Wang (1967) accepts Gruber's primary division between + and - High, but proposes two additional tonal features to replace High 2: Central and Mid. (In addition, he adds four 'contour' tone features, which will be discussed below.) Assuming a number of universal redundancies which he proposes, by this system, 5 level tones can be distinguished, as shown in (2).

(2)

High	+	-	+	-	-
Central	-	-	+	+	+
Mid	-	-	-	-	+

Wang's features seem immediately superior to Gruber's in that the ad hoc feature High 2 is replaced by features with greater phonetic plausibility, and, in addition, five rather than four tones may be contrasted.

Sampson (1969) finds certain difficulties with Wang's system, and proposes a hierarchy of features such that the basic division (like Gruber's and Wang's) will be between [+high] and [-high], the next contrast between [+low] and [-low], and for four or five tone systems, the feature Mid will be utilized providing the contrasts shown in (3).

(3)

High	+	+	-	-	-
Low	-	-	-	+	+
Mid	-	+	+	+	-

Although in this proposal, the feature Mid is used only when there are more than three contrastive tones, it is of course possible that the particular tone system of a language could (unless constrained by the theory) utilize the features High and Mid rather than High and Low. This position is argued for below.

The features suggested by Sampson are those also adopted by Woo (1967, 1969).

At a conference on 'Tone in Generative Phonology', held in Ibadan in 1970, following a suggestion by Maddieson (1971), the participants concluded that the features Raised and Lowered should be substituted for High and Low respectively 'to avoid possible confusion with 'High' and 'Low'

as features of tongue height.' (p 76) They further concluded that for a four or five level system a feature Extreme be utilized. Two, three, four, or five tone systems would thus be represented as given in (4).

(4)

a. two-tone system

i.

	High	Mid
Raised	+	-

or ii.

	Low	Mid
Lowered	+	-

b. three tone system

	High	Mid	Low
Raised	+	-	-
Lowered	-	-	+

c. four tone system or five tone system
(in a four tone system, the fourth tone is either 'extra high' or 'extra low')

	Mid	High	Low	Extra high	Extra low
Raised	-	+	-	+	-
Lowered	-	-	+	-	+
Extreme	-	-	-	+	+

(Cf. Maddieson (1971)

Maddieson attempts to present both phonetic and phonological reasons for the four level tone features exemplified in (4). The discussion does not seem to be over as yet. In a paper presented to the Seventh International Congress of Phonetics, Halle (1971) continues the debate. He agrees that 'it is clearly necessary that the universal phonetic framework provide for a distinction of at least three pitch levels: high, mid, and low.' Relating these pitch distinctions to vocal cord stiffness, he proposes two binary features which can distinguish these three tones: [stiff vocal cords] and [slack vocal cords]. (This proposal is earlier made in Halle and Stevens, 1971). The earlier discussions on tonal features do not attempt to provide physiological correlates for them but relate them more specifically to auditory

correlates. Thus Maddieson notes that 'The phonetic correlate of [+ Raised] is "higher than a notional median pitch" and of [- Raised] "not higher than a notional median pitch".' (p 8) The phonetic correlates of Lowered are described similarly. Halle's proposal on the other hand ties the pitch levels directly to glottal states as is shown in (5).

(5)

	Mid - V	Low - V̀	High - V́
Stiff	-	-	+
Slack	-	+	-

(The following symbols will be used throughout:

V = Mid tone; V̄ = Lower Mid Tone; V́ = High Tone;

V̀ = Low Tone; V̌ = Rising Tone; V̂ = Falling Tone; V̗ = Down Step)

In a language with three contrastive tones, such as Yoruba or Nupe, these two features are needed to specify the phonological vowels as to tone. For languages in which there are only contrasts between two tones, such as Akan, Igbo or Hausa, it would seem, then, that either the feature Slack or the feature Stiff would be redundant. In languages such as English with no lexical tonal contrast, vowels would all be [-stiff, -slack], neither feature being distinctive. This follows the suggestion that the vowel specified as [-stiff, -slack] is the 'neutral' vowel. (Halle, 1971; Halle and Stevens, 1971) Marking conventions can then specify a 'mid tone' vowel as the unmarked vowel as shown in (6).

(6) a. u Stiff vocal cords → - / $\left[\begin{array}{l}\overline{\qquad\qquad}\\ \text{+ syllabic}\\ \text{- consonantal}\end{array}\right]$

b. u Slack vocal cords → - / $\left[\begin{array}{l}\overline{\qquad\qquad}\\ \text{+syllabic}\\ \text{-consonantal}\end{array}\right]$

(But see below for marking conventions concerning these features when specified for consonants.)

For languages with two contrasting tones only one vowel would be marked. For Akan or Igbo (following the suggestion of Maddieson, 1971) the high tone vowel would be marked in contrast with the neutral vowel, while in Hausa, the low tone would be marked. A non-tone language such as English would then have all unmarked vowels for these features.

One problem is immediately apparent using the Halle/Stevens tonal features. Halle states that the theory must distinguish 'at least three pitch levels.' 'At least' is not 'only'. There is no way given the features Slack and Stiff to distinguish more than three level tones,

since, as they themselves point out, [+stiff, +slack] is physiologically impossible and must therefore be disallowed by marking conventions. Yet, 'Systems with four contrasting levels...are clearly established for several languages' as shown by Welmers (1952; forthcoming) in the following examples:

				Tones	
(7)	Tigong:	a.	efíkpí	mid-high-high	'axes'
		b.	esya	mid-mid	'holes'
		c.	enwā	mid-lowered mid	'men'
		d.	ekì	mid-low	'canoes'
	Ndoro:	e.	símá	high-high	'adze'
		f.	čarɩ	mid-mid	'axe'
		g.	čēlā	low mid-low mid	'stone'
		h.	šòrà	low-low	'chicken'

Longacre (1952) has presented evidence for five distinctive pitch levels in the Mixtecan language Trique, and Fang Kusi Li reported that Black Miso has five level tones and two rising and falling tones (as reported by Voegelin 1965).

It is of course true that phonetically many more levels of pitch must be distinguished. There are a number of ways to specify these, the easiest probably being to rewrite tonal features into relative pitch levels using integers. But the question as to whether we need more than three phonological tone contrasts is, to quote a linguistic cliche, 'an empirical one'. If Welmers and Longacre and Fang Kusi Li are correct, the Halle tonal features would be descriptively inadequate.

There are additional problems which arise even if it is shown that all the four and five level systems are lexically or basically three tone systems.

One of the main motivations for using Stiff and Slack as features for tonal specification was because 'the same set of features governs both pitch levels in vowels and voicing in obstruents.' (Halle, 1971) This proposal then is based on the claim that one finds 'three types of obstruents: 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.' It is further argued that 'the appearance of high pitch in a vowel adjacent to a voiceless consonant, and of low pitch in a vowel adjacent to a voiced consonant is not fortuitous

but rather a case of assimilation (supporting)...the claim...that the same set of features governs both pitch levels in vowels and voicing in obstruents.' Halle therefore proposes to substitute the two features discussed above for the feature Voiced. (Two additional features, Spread Glottis and Constricted Glottis are also substituted for the earlier features Tensity, Glottal Constriction, and Heightened Subglottal Pressure. (Halle and Stevens, 1971) A criticism of the phonetic adequacy of these features for consonants is beyond the scope of this paper but cf. Lisker and Abramson, 1971; Ladefoged, 1971a)

Given these two features, the contrast between voiced and voiceless stops in languages with a two-way distinction would then be represented as:

(8)

	Voiceless	Voiced
Stiff	+	-
Slack	-	+

Since the unmarked obstruent is presumbably voiceless, we can reveal this by changing the Marking conventions given under (6) above to:

(9) a. u Stiff → α Stiff / $\left[\begin{array}{l}\overline{\quad} \\ -\ \alpha\text{syl} \\ \ \ \alpha\text{cons}\end{array}\right]$

b. u Slack → - Slack / [——]

In other words, the unmarked value for Stiff for vowels is minus, but plus for consonants; and the unmarked value for Slack is minus for true vowels and true consonants, and glides. (Glides are also specified as [-stiff, -slack]. No mention is made of liquids. (Halle and Stevens 1971)

The highly marked nature of 'slackness' and the asymmetry of these two features is not the basic difficulty. Using the former feature Voiced, a phonological rule which voices obstruents intervocalically reveals this assimilation as a change from an unmarked feature value to a marked. (Schachter, 1969) Using the new features the same process occurs.

(10) [+stiff] → [-stiff] / [-stiff] --- [-stiff]

But this assimilatory rule also occurs in tone languages. For the assimilatory nature of the process to be revealed, the intervocalic voicing would have to be restricted to occurring between non-high vowels, since high tone vowels, like voiceless obstruents are [+stiff, -slack]. Where intervocalic voicing occurs before *all* vowels, regardless of the tones, the rule will have to be written as in (11).

(11) [+stiff] → [-stiff] / [+syl] ___ [+syl].

But (11) makes it appear that this 'unstiffening' process is non-assimilatory, or ad hoc. Furthermore, in languages where vowels are devoiced after certain voiceless obstruents (such as in Japanese) the rule must be stated as in (12).

(12) $[+\text{syl}] \rightarrow [+\text{spread glottis}] / \begin{bmatrix} -\text{ syl} \\ +\text{ stiff} \end{bmatrix} \_\_$

(12) must be stated in this ad hoc fashion because according to Halle and Stevens (1971) the feature specification of the relevant segments is as shown in (13).

(13)

	VOWELS				OBSTRUENTS	
	V	V̀	V́	Voiceless V	Voiced	Voiceless
spread glottis	-	-	-	+	-	-
constricted gl.	-	-	-	-	-	-
stiff v. c'ds	-	-	+	-	-	+
slack v. c'ds	-	+	-	-	+	-

Using these features we are forced to abandon our traditional collective linguistic intuition that the voicing and devoicing of consonants and vowels is a natural process, i.e. that the voicing of intervocalic consonants occurs because vowels are voiced, irrespective of the pitch of the vowels. This is not to say that there is no relationship between tension of the vocal cords and pitch. But 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, 1964, 1967, 1971a; Ohala 1970) In fact, in tone languages, 'there is often an increase in subglottal pressure during high tones' Ladefoged 1971b). The attempt, then, on the part of Halle to explain the relationship between voicing and tones, obscures the relationship between identical glottal strictures for consonants and vowels. Ladefoged suggests instead that a feature *glottal stricture* be posited to account for just such phenomena, and for other phonological oppositions Halle and Stevens specify by their features. This feature would have a number of possible values (although, according to Ladefoged, any one language will not utilize more than three contrasting values.) He states that the feature defines a continuum and that it is impossible

(even meaningless) to state how many possible values there are. He further suggests that on the classificatory level we might specify this feature by binary values for languages using only two states of the glottis, and by the integers /0 1 2/ in the classificatory matrices for languages contrasting three states of the glottis. Then, by either universal 'interpretive rules' or by context-restricted phonological rules, these items would be given appropriate values.

While I am in basic agreement with this proposal, the need for language specific mapping rules would create an unnecessary problem. If, however, the continuum is divided into a given set of discrete values and if, for example, [5 glottal stricture] means *voiced* for all languages, one can easily write a natural rule of voicing assimilation as in (14).

(14) [+segment] → [5 GS] / [5 GS] --- [5 GS]

One may recall that Chomsky and Halle (1968) argued for the substitution of the features High, Back and Low for the earlier features Diffuse, Compact and Grave because 'The former framework...did not bring out the fact that palatalization and velarization characteristically occur before front and back vowels, respectively; the connection between palatalization and front vowels and between velarization and back vowels was no more motivated than a connection between glottalization or voicing and front vowels.' (p 308) If we accept this reasoning, and I think we should, one cannot at the same time accept the new features proposed, since the intervocalic voicing of obstruents between high tone vowels or the unvoicing of vowels after voiceless consonants would then be 'no more motivated than a connection between ...voicing and front vowels.'

The desire to select features in the universal set which will explain diachronic changes as well as synchronic phonology is admirable. Until we can find a more 'explanatory' set of features, it would be better to include in the universal theory a set of statements relating glottal strictures and vowel tones than to substitute, for features such as Voiced, features which obscure natural processes in synchronic grammars.

One more question must be considered prior to deciding on the most adequate set of tonal features. In both Halle's system and Maddieson's, the 'neutral' or 'unmarked' tone is the mid tone -- [-stiff, -slack] and [-raised, -lowered], respectively. This presents certain difficulties for 'terraced level' (Welmers, 1959) tone languages. In these languages, one finds three 'phonetic' tones -- high, lowered high ('downstep' or 'drop' represented as V̗), and low, in which the 'downstep' tone occurs only after a high tone. This 'downstep' is illustrated in the examples from Akan, shown in (15):

(15) a. mɛ́hɔ́[1] [¯ ¯] 'I will strike'

b. mé bɔ́ [¯ -] 'my stone'

c. mé bɔ̀ [¯ _] 'my chest'

Following a proposal by Stewart (1964), Schachter and Fromkin (1968) derive all 'downstep' tones by a pitch assignment downdrift rule and vowel deletion rules. In such a case, one need not be concerned about the feature specification for the 'downstep' tone, since it would be specified as a high tone (i.e. [+stiff] or [+raised]) and its differentiation from other high tones would be solely based on a pitch value assigned to it. In (15b) and (15c) the underlying forms for 'stone' and 'chest' are ɔ̀bɔ́ and ɔ̀bɔ̀ respectively. The ɔ̀ represents a nominal prefix which is deleted in certain contexts. The following rules will take care of the 'drop' tone which appears on the surface.

(16) Pitch assignment (PA): a. [+ high] → p 1

b. [- high] → p 3

(p = relative pitch value. [± high] is used here arbitrarily, i.e. for these rules one could also use [± stiff] or [± raised]. I am following the suggestion of Johnson, 1970, and Williams, 1971, in their comments on Schachter and Fromkin (1968) to designate the highest relative pitch by '1' and all lower pitches by larger integer values.)

(17) Downdrift (DD)

RL: $[\alpha H] \rightarrow [\alpha H\ p\ \langle +\ 1\rangle\ ] / [\alpha H\ p] \langle\ [-\alpha H]_1 \rangle$ ——

(where H = high tone)

The 'RL' at the beginning of the rule specifies it as a Right Linear Rule (Johnson, 1970) which applies to the left most segment which meets the rule specification first, then moves to the next segment from left to right, applying in each case when the structural description is met. The formulation with slight changes was provided by Grover Hudson. It abbreviates the following four rules:

(17) a. $[+H] \rightarrow [+H\ p+1] / [+H\ p]\ [-H]_1$ ——

b. $[+H] \rightarrow [+H\ p] / [+H\ p]$ ---

c. $[-H] \rightarrow [-H\ p+1] / [-H\ p]\ [+H]_1$ ——

d. $[-H] \rightarrow [-H\ p] / [-H\ p]$ ---

---

1. In (15) and in subsequent examples the Akan utterances are given in orthographic representation except for the tones.

(18) Vowel Deletion (VD) V → Ø in certain contexts.

The following derivations illustrate how these rules apply.

(19) / mé ɔ̀bó / 'my stone' / mé ɔ̀bò/ 'my chest'

PA	1 3 1	1 3 3
DD	2	———
VD	Ø	Ø
	[mé bó̩	[mé bò]
	1 2	1 3

While the above may solve the problem for terraced level languages in which all downstep tones are derived from underlying high tones, it seems that this is not true in all synchronic grammars. One finds that at a certain stage in the history of such languages, the derived 'downstep' may become 'phonemic'. That is, even in Akan, where most 'downstep' tones are still derived from high tones, as in the examples above, there are formatives which now have 'downstep' tones which cannot be derived from high tones after the deletion of low tones without a great deal of ad-hoc-ery, as shown in (20).

(20) a. àbèrántá'ɛ́ [˗ ˗ ˉ ˗ ˗] 'young man'

b. àkúá [˗ ˉ ˗] 'Akua' (name of a girl born on Wednesday)

c. á'áné [ˉ ˗] 'yes'

One can, of course, set up an underlying low tone which never appears on the surface and which is later deleted. The 'absolute neutralization' (Kiparsky, 1968) solution only obscures what has really occurred historically in the language, i.e. the derived mid or downstep tone has become phonemic. As Vennemann (personal communication) points out, a solution which does not posit an underlying 'downstep' tone fails to reveal a complexity in the language which has arisen by historical processes, and such a solution should therefore be considered unacceptable, even if by such a method we appear to arrive at a 'simpler' two-tone language solution.

Assuming the correctness of this position, how would one use either the Halle or Maddieson features to specify the three way underlying tonal contrast? If the 'downstep' tone is considered a 'mid' tone

(and in their systems it would have to be), then it is just this mid, neutral, unmarked tone which is highly restricted and very infrequent. This is certainly a counter-intuitive specification. In addition, using their features, the 'downstep' tone would be equally distant from the high and low tones. This of course is not the case, since all derived 'downsteps' emerge from underlying high tones. Neither Halle's nor Maddieson's tone features capture the relationship between High and Downstep. Wang's and Sampson's features do. Thus, given a 'terraced level' language with both underlying 'downstep' tones and derived ones, we can rewrite the tone rules given above. One must also include the Morpheme Structure Condition (21) which constrains the 'Downstep' to positions after high tones.

(21) MSC: If:[ ] [+ Mid]

⇓

Then:[+ High]

The features specifications of the three tones would be:

	High	Downstep	Low
(22) High	+	+	-
Mid	-	+	-

To derive the correct relative pitches in a language with three underlying tones, high, downstep, and low, the pitch assignment rule (16) need not be changed, but the Downdrift Rules must be changed as given in (23):

(23) $[\alpha\ H] \rightarrow [\alpha\ H\ p\langle +1\rangle_{1,2}] / \begin{bmatrix} \alpha\ H\ p \\ \langle -\ M\rangle_1 \end{bmatrix} \langle [-\alpha H]_1 \rangle\ 2 \begin{bmatrix} \overline{\quad} \\ \langle +\ M\rangle_1 \end{bmatrix}$

which expands to:

a. $[+\ H] \rightarrow [+\ H\ p+1] / \begin{bmatrix} +H\ p \\ -M \end{bmatrix} \begin{bmatrix} \overline{\quad} \\ +\ M \end{bmatrix}$

b. $[+\ H] \rightarrow [+\ H\ p\ +1] / [+H\ p]\ [-H]_1$ ——

c. $[+\ H] \rightarrow [+\ H\ p] / [+H\ p]$ ——

d. $[-\ H] \rightarrow [-\ H\ p+1] / \begin{bmatrix} -H\ p \\ -M \end{bmatrix} \begin{bmatrix} \overline{\quad} \\ +\ M \end{bmatrix}$

e. $[-\ H] \rightarrow [-\ H\ p+1] / [-H\ p]\ [+H]_1$ ——

f. $[-\ H] \rightarrow [-\ H\ p] / [-\ H\ p]$ ——

(24) provides a derivation which illustrates how the rules work:

(24) / àbèrántɛ́ɛ́ bɛ́kɔ́ ɛ̀hɔ́ / [àbèrántɛ́ɛ́ bɛ́kɔ́ hɔ́]

'The young man will go there'

PA	3	3	1	11		1	1	3	1		
DD				22		2	2	4	3		
VD							ø				
	3	3	1	22		2	2		3	[	]

By the Pitch Assignment rule all tones designated as [+H] (including the Downstep Tones which are also [+M]) are assigned a pitch value of '1', and all [-H] tones are assigned a pitch, of '3'.

We start applying the Downdrift Rule to the left most tone. None of the rules collapsed by the schema (23) applies since it is the initial tone. Moving to the next tone, a , b, and c are inapplicable since the tone is [-H]; d does not apply since the tone is not [-H, +M] (in fact, it can never apply since no tone will be so specified); e cannot apply since the tone is not preceded by a [+H]; f applies vacuously since the assigned p = 3 already matches the assigned value to the preceding Low tone. None of the rules apply to the first high tone so the pitch value is left at '1'. a applies to the next tone, since it is specified as [+H, +M] and is preceded by a [+H, -M] tone. We therefore add '1' to the value assigned to the previous High Tone pitch value, deriving a pitch value of '2'. Only c applies to the next three [+H, -M] tones, assigning the same pitch value, '2', as has been specified for the previous [+High, +Mid] tone. Note that the value for the feature Mid does not influence this pitch assignment. The ɛ̀ in ɛ̀hɔ́ is assigned a pitch value of '4' by e , and the final tone is assigned a value of '3' by b. After the Vowel Deletion Rule has applied, the final output has two downstep tones, one underlying and the other derived.

By specifying the 'downstep' tone as [+high] we are able to show the relationship between the High tone pitch values and the 'downstep' tone, and use the same rules to assign pitch values for underlying 'drop' tones as well as derived 'drop' tones. This, I believe, argues strongly against either the Halle features or the Maddieson features. One can of course write a complicated set of rules deriving the correct pitch values using features which specify the 'downstep' as 'equally related' to both the high and the low tones. The effort does not seem warranted however, since the Halle features have been shown to be deficient on other accounts, and the Maddieson features do not seem to add anything or explain any more than do Sampson's or Wang's features.

Rather, less is explained, since using a *mid* feature the historical development of three-tone languages from two-tone languages is more easily revealed.

For the reasons given above, I propose that the Universal Set of Distinctive Features include three tone features: High, Mid, Low. In addition, I suggest that it is impossible to specify which tone is the 'unmarked' tone for all languages, since each particular tone system evolves historically in different ways. While the mid tone may be the least marked tone in a language such as Yoruba, in Twi where we find a three tone system developing from a two tone system, it is the low tone which is 'unmarked'. One may, however, suggest that the historical changes which occur will move toward a more stable three tone system in which the 'downstep' will become the 'neutral' tone, or it may become a contour tone as in Gwari. (Larry Hyman, personal communication). More research is needed on the historical developments of tone languages before we can reach this conclusion. Finally, I suggest that there is a hierarchy for tonal features, i.e. that in tone languages the basic division, following Gruber and Wang, is between high and nonhigh tones, but that the features Low and Mid are equally placed in this hierarchy. That is, for a three tone language, either Low or Mid will be the second tone utilized, depending upon the particular phonological system of rules in the synchronic grammar. Similarly, for a four or five tone system, the feature specifications for the mid tones should depend on the particular tonal rules present, i.e. a four tone system may include High, High-Mid, Mid, and Low tones, or, High, Mid, Low-Mid, Low, etc.

We may, of course, find, upon further investigation,that there are universal constraints governing the interaction of tones in a multi-tone system. Before such empirical evidence is presented, however, our theory must at the minimum be descriptively adequate. Placing constraints at this time may force us into Procrustean solutions which will obscure the intricacies of tonal phenomena.

III. The need for 'contour' features

In Section II, the features for the specification of level or 'register' tones were discussed. Phonetically, all linguists have observed the occurrence of 'contour' or 'non stationary' tones. To provide for such occurrences, Wang (1967) proposed that a feature Contour be used to distinguish stationary from non stationary tones. He further suggests that for tones specified as [+ contour], three additional features be available: Rising, Falling, and Convex. All [+ contour] tones would be redundantly [- central, - mid]. Using this set of features, one could then distinguish eight contour tones as shown in (25).

(25)

Contour	+	+	+	+	+	+	+	+
High	+	-	+	-	+	-	+	-
Rising	+	+	-	-	+	+	+	+
Falling	-	-	+	+	+	+	+	+
Convex					-	-	+	+

(Note that Convex is redundantly - for contour tones which have opposite values for Rising and Falling.)

There are two main questions which concern contour tones: (1) whether Contour tonal features are needed at all, and (2) if they are needed are Wang's features the set which should be included in the theory.

As to the first question, a suggestion by Woo (1967, 1968, 1969, 1970) that contour tones should be represented in the lexicon in all cases as sequences of level tones was adopted by the Ibadan Conference (1971), by Leben (1971) and by Halle (1971). Halle extends the proposal to the phonetic level as well as the classificatory level. '...on the systematic level all tones are stationary. Non-stationary tones, such as "rising", "falling", or "convex" are more or less surface phenomena; they have much the same status as the different formant transitions that are found in a given vowel when it is adjacent to different stop consonants.' In other words, according to Halle, the universal set of features will not include contour features for tone.

The evidence for restricting underlying, phonological tones to stationary tones is based to a great extent on the existence of 'tone copy' rules. It is shown, for example, that there are no cases reported where a contour tone is copied; in the case of rising tones, a high tone is copied, and in the case of a falling tone, a low tone is copied, when it is the following tone which is changed. (Leben, 1971) Leben provides numerous examples from Hausa, Yala, and Mende in support of this position; Woo (1970) shows this to be the case in North Tepehuan; Halle (1971) presents further evidence from Serbo-Croatian and Slovenian.

In Nupe, George (1970) has shown that all rising and falling phonetic tones can be derived from underlying level tones. Rising tones are the result of a 'tone copy' rule which George writes as in (26).

(26) [+H] → [+G] / [+L] [+Cons, +Vcd] ——

([+H] = High Tone; [+L] = Low Tone; [+G] = Gliding Tone)

This rule can also be written as (27) if it is stated that a sequence of two immediately following tones are realized phonetically as a glide.

(27) [+H] → [+L] [+H] / [+L] [+ Vcd] ---

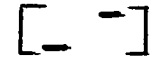
In fact, unless one posits the rising tone (i.e. Low to High Tone Glide) as a sequence of two tones, the first being a copy of the tone which immediately preceded it, the rule seems very ad hoc.

Since no evidence has been put forth showing the need to consider underlying contour tones as intrinsic, can we then dispense with any contour tone features? Do contour tones indeed 'have the same status as the different formant transitions'?

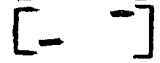
To exclude from the universal set of features any contour tonal feature would violate the very goals Halle accepts: 'all grammatically determined facts about the production and perception...are embodied in the "phonetic transcription." '(Chomsky and Halle, 1968) Furthermore, as Chomsky (1967) points out: 'it is important to note that the distinctive features postulated in universal phonetic theory are absolute in several senses but relative in others. They are absolute in the sense that they are fixed for all languages. If phonetic representation is to provide sufficient information for identification of a physical signal, the specification of feature values must also be absolute.' (p 404)

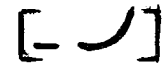
If we find that in every language, a succession of two tones is always realized as a contour or gliding tone, the absolute nature of the phonetic signal is fixed and one can, as Halle suggests, dispense with any contour tonal feature.

Unfortunately, the facts seem to contradict this assumption. In Nupe, as rule (27) shows, the sequence of a low tone followed by a high tone is realized as a low tone followed by a rising tone only if the two syllabic segments are separated by a voiced consonant. Thus one finds the following phonetic contrasts: (all examples from George, 1970)

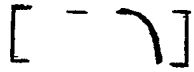
(28) a. ètú [ètú]  'parasite'

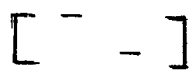
b. èdú [èdŭ]  'taxes'

(29) a. èkpá [èkpá]  'length'

b. ègbá [ègbă  'a garment border'

Leben (1971) provides other examples from Yala where *phonetically* one must differentiate between a high tone followed by a low tone, and a high tone followed by a falling tone:

(30) a. ó kà  'he said'

b. kó kà  'let him speak'

According to Leben, 30.b. does not have the glide because of the deletion of an intervening low tone, which rule follows the glide formation rule. If the phonetic representation is to represent the grammatically determined facts of Yala, and 'sufficient information for the identification of a physical signal', then the difference between a contour tone and a sequence of level tones must somehow be represented in the systematic phonetic output of the grammar.

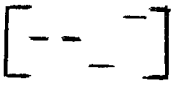
Another example of the need for a contour/non-contour contrast is given by Stewart (1962). He points out that in some dialects of Fante, depending on the syntactic and lexical features of a string, a pre-pause high tone may be realized as a high-rising gliding tone rather than a high level pitch, as illustrated in (31).

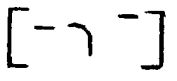
(31) a. ɔ̀bɛ́ká  'he will remain'

b. ɔ̀bɛ́ká  'he will bite it'

Furthermore, in Nupe, there is a phonetic falling tone which derives from a sequence of either high-low or mid-low in rapid speech, which is realized as step tones in slow deliberate speech as shown in (32). (George (1970)).

(32) ebe ètí 'monkey howling'

a. slow speech: [ebeètí] 

b. rapid speech: [ebētí] 

Before discussing the implications of these facts for phonological theory, it is of interest to relate the question of these contour tones to the previous question of tonal features. The Nupe examples in which the contour tone occurs if and only if the intervening consonant is voiced may seem to support the use of [-stiff, +slack] specification for both voiced consonants and low tone vowels. The copy rule would be as given in (33).

(33) $\begin{bmatrix}+\text{stiff}\\-\text{slack}\end{bmatrix} \rightarrow \begin{bmatrix}-\text{stiff}\\+\text{slack}\end{bmatrix}\begin{bmatrix}+\text{stiff}\\-\text{slack}\end{bmatrix} / \begin{bmatrix}-\text{stiff}\\+\text{slack}\end{bmatrix}\begin{bmatrix}-\text{stiff}\\+\text{slack}\end{bmatrix}\_\_$

The 'tone copy' would not occur after a [+stiff, -slack] (e.g. voiceless)consonant. But since according to Halle's new features a voiced consonant has the same 'tonal' specifications as a low tone vowel, one might expect that a high tone vowel followed by a voiced consonant would phonetically be realized as a high-low fall on the preceding vowel, or a low to high or mid tone glide on the following vowel, no matter what the tone of the preceding vowel is. This, of course is not what occurs. Furthermore, in Yoruba, Fresco (1970) and Courtenay (1968) show that the gliding rule occurs when the intervening consonant is voiceless as well as voiced, as shown in (34).

(34) Yoruba:

a.	ɔ̀tá	[_ ˇ]	'enemy'
b.	àwé	[_ ˇ]	'friend'
c.	ègbã́	[_ ˇ]	'senior sibling'
d.	èsɔ̃́	[_ ˇ]	'nine'

On the systematic phonetic level, without a contour tonal feature, how is <u>ètú</u> [_ ¯] in Nupe to be distinguished from <u>ɔ̀tá</u> [_ ˇ] in Yoruba?

It seems quite obvious that the gliding pitch which occurs on some tonal sequences but not others is not predictable in the way that formant transitions are. The example given in (32) shows that even when two different tones occur on adjacent vowels level step tones are possible. Furthermore, even if some gliding occurs between two tones on adjacent vowels, on the phonetic level we must be able to distinguish between a contour tone on a single short vowel and a level tone.

If we do require some contour tonal feature for phonetic specification one may then question the hypothesis which would constrain all phonemic representations of contour tones to sequences of level tones. It seems highly unlikely that a phonetic contrast will never occur as a phonological contrast. As pointed out by Margaret Langdon (personal communication) given a phonetic contrast one can assume that historically such a contrast will or can become restructured as an Underlying phonemic contrast. This is not too different from the suggestion that historically all nasal vowels derive from a sequence of vowel + nasal. To suggest that nasal vowels never occur at the systematic phonemic level contradicts synchronic facts. (Cf. Hyman, forthcoming)

What is being suggested here is that the universal set of features must include a feature or feature combination which will distinguish between contour tones and level tones. The particular feature(s) are discussed below, as is the question of deriving all contour tones from sequences of level tones, since the answer to the first question is dependent on the latter.

IV. Segmental vs. Suprasegmental Representation of Tone

Woo's proposal (1970) that 'prosodic features are segmental rather than suprasegmental' was based on the claim that all contour tones occur only when there are long vowels in the underlying forms. Maddieson (1971) points out that 'both Longacre (1952) and Spears (1968) talk of syllables on which three tone phonemes or pitches appear without any mention of lengthening of the vowel. These cases include syllables of the structure CV in which C is voiceless.' (p 15) The Ibadan conference concluded 'that a contrast must be made between a sequence of two (or more) "tones" and a sequence of two (or more) pitches which form a single "tone". This may be done by marking one or more of the segments bearing pitch as [-syllabic].' (p 81) They further support this conclusion by stating that this 'implies that one expands the class of "glides" and forgets the myth that non-syllabic vowels necessarily have closer tongue positions than syllabic ones.' At the conference Williamson pointed out that 'in Igbo, in a sequence, close vowel + open vowel which are on different tones, both remain syllabic,whereas in the same sequence on identical tones the close vowel becomes non-syllabic.' (p 81)

Leben (1971) also shows that at least in Hausa and Mende *short* vowels must be specified phonologically as a High-Low sequence. The existence of 'contour' tones on short vowels (revealed by many linguists over the years, cf. e.g. Welmers, Pike, Wang, Longacre etc.) convinced Leben that Woo's hypothesis constraining contour tones to long vowels must be abandoned. Because he and Halle (1971) wish to maintain Woo's other hypothesis, i.e. that there are no underlying contour tones, they propose that 'the theory be modifed so as to allow prosodic phenomena to be treated also as 'suprasegmental phenomena.' In an attempt to justify this position Leben criticizes the hypothetical feature [+ [+High] followed by [-High]] (to represent a sequence realized as a falling tone) suggesting that 'this would render Woo's hypothesis vacuous: it would permit the representation on a single segment of any sequence of level tones, regardless of whether its syllable contained a short vowel, a long vowel, or whatever. In this case the claim that contour tones are underlying sequences of level tones would become nearly empty, since the representation [+ [+high] followed by [-high]] on a segment is empirically equivalent to the representation [+falling].' ((p 14-15) If in the suprasegmental matrix posited by Leben and Halle, a sequence of [+high] [-high] is later to be mapped onto a single segment (how, is never made clear), it seems to me that this is also

'empirically equivalent to the representation [+falling].' Leben further suggests that 'it is not clear how the rule of tone copying could be prevented from incorrectly copying the feature [+[+high] followed by [-high] instead of copying the feature [-high]' (p 15) It seems to be the case that in progressive 'tone copy' the final feature value is copied, whereas in regressive 'tone copy' rules the initial tonal feature is copied. By a universal convention this can certainly be specified. The rule itself can make this clear. Leben cites some examples from Mende compounds in which the following Compound Rule is posited:

(35) (Leben, 1971,p 188)

(a) Copy the last tone of the first member of the compound onto the first syllable of the second member.

(b) Assign a low tone to the remaining syllables of the second member.

This rule accounts for the following examples:

(36) a. pɛ́lɛ́ + hani = pɛ́lɛ́ -hánì

b. bɛ̀lɛ̀ + hani = bɛ̀lɛ̀ -hànì

c. mbû + hani = mbû -hànì → mbú-hànì

Using the feature he rejects, one can write (35a) as:

(37) [tone] → [αtone] / [(β tone followed by) αtone] ——

He states further that "The falling tone on mbû is converted into a high tone by *tone deletion*. 'This can be accomplished by a 'tone simplification rule as well as a tone deletion rule as in (38).

(38) [[+high] followed by [-high]] → [+high]

There seems to be no formal reason why a feature such as [[+high] followed by [-high]] cannot be utilized to specify contour tones in underlying representation. It would create fewer problems than the proposal to include two matrices, one segmental and the other supra-segmental, for each surface structure, as I will attempt to show below.

One can however utilize a [-segmental] but tone bearing unit which could accomplish the same thing, (as was proposed by Schachter and Fromkin, 1968) or adopt the Ibadan Conference proposal utilizing tone-bearing non-syllabic vowels. Thus, in Mende, the segmental

matrices given under (39i) and (39ii) are equivalent to the supra-segmental matrices given under (39iii).

(39)

			i	ii.	iii.
a.	mbû	'owl'	/mbúØ /	/ mbúù'/	/[+h] [-h]/
b.	mbǎ	'rice'	/mbàØ /	/ mbàá'/	/[-h] [+h]/
c.	mbǎ̀	'companion'	/mbàØØ/	/ mbàá'à'/	/[-h] [+h] [-h]/

(The V' represents a non-syllabic vowel).

The number of tonal units, without segmental features, or the number of possible syllabic vowels in a string, can be restricted by morpheme structure conditions, and universally, there can be a convention which transfers the tones of the non-segmental units or non-syllabic vowels to the preceding segment. Once this is done of course, the Contour feature will also have to be added.

Leben, in keeping with the basic goals of generative phonology, is desirous of including the strongest possible constraints in the theory, thereby limiting the class of possible grammars. If, then, one solution restricts the kind of rules which can be utilized in a grammar, and if this constraint is supported by empirical evidence, this constraint should be incorporated in the general theory. He suggests that this is the case if tone is represented suprasegmentally rather than in segmental matrices, and attributes his argument to Wang (1967). Leben states: 'If tone is a feature on some entity more abstract than the segment -- such as the syllable or the morpheme -- then it is impossible to state a rule which changes the tone in an environment determined by the segments below it. This shows that the assumption that tone is expressible phonologically can serve to limit the class of phonological grammars defined by the theory in a way which cannot be done with underlying segmental features of tone.' (p 198) But this is a specious argument since Leben himself points out that 'the status which the theory must give to Mandarin and Thai is that the point in the derivation at which tone is initially expressed as a segmental feature is the beginning of the derivation -- i.e. that for such languages there is no stage in the derivation at which tone is a suprasegmental feature.' (p 199) Thus, tone both is and is not a suprasegmental feature. And nowhere does either he or Halle explain how the sequence of tones which phonetically are realized as contour tones are to be specified once such sequences are mapped onto single segments. He is correct of course in stating that this would limit the class of languages given that he is correct in stating that 'If a language does not meet the narrow constraints imposed by Woo's framework, then it is subject to the constraint imposed by suprasegmental representation: rules like (a low-tone raising rule) must be ordered

after all those rules in which tone is expressed as a suprasegmental feature.' (p 199) But in the Nupe examples given above, it is clear that the tone-copying rule must depend on segmental feature specification. Thus, according to Leben, it should occur after a suprasegmental information is translated into segmental information. This requires a rule assigning two tones to a single segment early in the derivation. How can this be done without a 'contour' feature or without the use of [-segmental] or [-vocalic] tone bearing units? If such a feature or such a method of representation is needed at some point in the derivation why not use it for the lexical representation? The example Leben cites from Hausa similarly involves a tone change depending on vowel length (i.e. segmental information). He does not consider the Hausa case a counter example because in this case he says that the suprasegmentals must have already been applied to the segments.

If every such counter example involves a similar early mapping, then I fail to see how the class of languages is constrained. And to repeat myself (ad nauseum) if two tones must be applied to one segment there must be some way of doing this which can conceivably be done from the start.

Not only are there tone rules which must include segmental feature information but tone rules must also include syntactic information present in the surface structures of the string feeding into the phonological component.

In the Akan examples given above, the Vowel Deletion rule deletes all the segmental features as well as tonal features. By Leben's proposal, then, the mapping of suprasegmental matrices onto segmental matrices must occur before the Vowel Deletion rule. The Vowel Deletion rule must also occur after the Pitch Assignment and Down Drift Rule. One may conclude that the mapping of suprasegmental onto segmental matrices occurs at the beginning of the derivation. The problem is complicated, however, because there are certain cases where tone is the only realization of grammatical morphemes.

In (40a) Ø represents the Habitual Low tone morpheme

(40) ɔ̀ bé Ø Ghánà [ɔ̀bá Ghánà] 'He comes to Ghana (habitually)'

[– ¯ – _]

The 'drop' tone on the first syllable of Ghana may be compared to the tone on this syllable in other contexts, as shown in (41)

(41) a. Òdwàá wɔ̀Ghánà [ɔ̀dwàá wɔ̀ Ghánà] 'Odwaa is (located in) Ghana'

b. ŋ̀kraŋ̀ né Ghánà àhèŋkùró. [ŋ̀kràŋ né Ghánà àhèŋkùró] 'Accra is the capital of Ghana'

To derive the 'downstep' in (40), the pitch assignment and down-drift rules must apply prior to the deletion of the 'non-segmental' low tone morpheme, as shown in (42).

(42)

	ɔ̀bá	Ø	Ghánà
PA	3 1 3		1 3
DD	3 1 4		2 5
Tone Del	3 1		2 5

Since the tone is deleted in Vowel Deletion rules or when a tone occurs *without any segmental features* it is necessary to map (if one wishes to take this road) the suprasegmental matrices onto the segmental prior to these deletion rules, which rules must occur after the other tonal rules (e.g. PA and DD). This being the case there must be some way to represent a non-segmental tone in the segmental matrices. If we utilize the proposal of Schachter and Fromkin, that is, represent such units as [-segmental, +tone], there is no difficulty. Contour tones on short vowels may be similarly represented. All units may then be specified as [± segmental], with [-segmental] further divided into [± boundary]. [-segmental, -boundary] units will be tone bearing units with no segmental features specified. I believe this is a better solution than the proposal by the Ibadan Conference which would represent such units as [-syllabic, +tone] vowels, since in the case of grammatical morphemes such as the above, it would be stretching a point to specify this vowel as the least marked vowel /a/ which, as in the case of the Akan Habitual, is never realized on the surface. If it was possible to avoid the mapping of the suprasegmental matrices onto the segmental matrices then there might be some point in including two distinct matrices. But since the examples from Hausa, Nupe, Akan etc. force us to treat the tonal features segmentally, interacting with segmental features, and requiring syntactic information for the correct application of tone rules, I cannot see that the new proposal has any merit. In fact, since the motivation for the new Halle/Stevens features was

to use identical features for vowel tone and consonantal glottal strictures, the proposal to then separate these features into two matrices seems rather unwarranted.

A contour tone in an underlying matrix may then be represented

= 'falling tone';

(43) a. $\begin{bmatrix}+h\\+seg\end{bmatrix}\begin{bmatrix}-h\\-seg\end{bmatrix}$ = falling tone ^

b. $\begin{bmatrix}-h\\+seg\end{bmatrix}\begin{bmatrix}+h\\-seg\end{bmatrix}$ = rising tone v

c. $\begin{bmatrix}-h\\+seg\end{bmatrix}\begin{bmatrix}+h\\-seg\end{bmatrix}\begin{bmatrix}-h\\-seg\end{bmatrix}$ = convex tone. ^

By a universal convention any sequence of two or more tone bearing units, in which the first is [+segmental] and the second (and third) is [-segmental] will be further specified by adding the feature [+contour] to all such units. In other words this kind of representation can be the formal way of specifying contour tones. In a language such as Yoruba, the 'gliding' rule can be stated as (44)

(44) [tone] → [αtone] $\begin{bmatrix}-\alpha tone\\-seg\end{bmatrix}$ / [αtone]___

where, if α = [+H], - α = [+L]

and, if α = [+L], - α = [+H]

Once, the feature Contour is available, it will also be possible to utilize this feature in languages where tone copy rules do not occur. Schane(personal communication) has observed that since there are tone languages in which only register, level tones occur, but no tone languages in which only contour tones occur, register tones take precedence in the hierarchy; that is, the Contour feature can only be used if there are tones without the contour feature. Furthermore, that a tone represented as [+high, +contour] will then specify a 'rising' tone, one represented as [-high, +contour] or [+low, +contour] will specify a 'falling' tone, and one represented as [+high, -high, +contour] will specify a 'convex' tone. By a universal convention, a progressive tone copy rule will copy the specified [+high] of a preceding contour tone, whereas a regressive tone copy rule will copy the opposite value of the following contour tone. The convention can be stated as in (45).

(45) Tone → $\begin{bmatrix} [\alpha H] \ / \begin{bmatrix} \alpha H \\ +\text{contour} \end{bmatrix} \ \_\_ \\ [-\alpha H] \ / \ \_\_ \begin{bmatrix} \alpha H \\ +\text{contour} \end{bmatrix} \end{bmatrix}$

Using these conventions it is possible to represent all contour tones in the lexicon without resorting to the [-segmental] units. For non-segmental tonal units which represent grammatical morphemes in the surface structure however, the [-segmental, +tone] units may still be necessary.

V. The above discussion on tonal features and tonal rules has attempted to show that (a) the features Stiff Vocal cords and Slack Vocal Cords for both vowel tones and glottal states are inadequate and should not be adopted; (b) that three features for tones High Mid Low prove to be the best yet proposed (whether High and Low are called Raised and Lowered is immaterial) since the use of the feature Mid permits specification of a mid tone either as 'closer' to High, or to Low or 'intermediate'; (c) that a contour tonal feature is necessary for descriptively adequate phonetic representations; and (d) that the inclusion of suprasegmental matrices for tonal specification in surface structures does not resolve the problem of poly-tones (or contour tones) on one segment -- it merely places the problem in a different part of the grammar.

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