Theoretical Issues in Phonology in the 1970's

Morris Halle 1972

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The topic that is central to my paper is the role that theory plays in the study of speech sounds. I take it that a study of the speech sounds of a given language must account for, among others, the following three sets of facts: it must yield insights into the articulatory aspects of the sounds; it must concern itself with the acoustic and psychoacoustic character of the sounds, and, finally, it must allow us to make sense of various regularities that can be observed in the behavior of different speech sounds and sets of speech sounds, regularities that have traditionally been referred to as phonological or morphophonological. The task of the student of speech sounds then is to discover a theory that will do justice to these different aspects of speech.

The question whether a single coherent theoretical framework can account for these disparate aspects of speech is an empirical one that can be argued only by a detailed examination of particular cases. On the basis of my own experience, I am inclined to believe that it is perfectly possible to discover such a single coherent theory. I know of no instance where, upon *mature reflection* (and I emphasize the phrase "mature reflection"), it turned out that e.g., articulatory facts had to be explained by one type of theory, whereas the psychoacoustic and phonological facts required a theory that was inconsistent with the former. On the contrary, I can cite many instances where the attempt to account for the different aspects of speech with the help of a single theory has had a significant improvement in our understanding of the matters under discussion.

These assertions are, of course, purely subjective, and that is not only perfectly proper but also unavoidable, for in the last analysis, it is a purely subjective question that each scholar must decide for himself, of whether to approach a topic in one way or another. Each of us is, to a certain extent, attempting to find her or his way through an uncharted wilderness and, therefore, can only make guesses as to the direction in which he or she should turn next. And it is quite inevitable that our

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guesses will often be wrong and that we shall thus be called upon to pay the standard penalty for guessing wrong, which is to have wasted days or months or even years.

While the choice of a particular method of solving a problem must by its very nature be a subjective matter, the failure or success of this method is anything but subjective. There are ways of finding out in science whether you are right or wrong. Although it must be said at once that these are quite unlike the marks we got in elementary school for knowing or not knowing the right answer, for a considerable effort is often required before one can be sure that a proposed solution to a problem is indeed correct, or more correct than any known alternative.

In what follows I have attempted to illustrate the points just made about theory in general, and about the role that a particular theory plays in the study of the sounds of speech. I am especially concerned here with exhibiting the interaction between theory and fact, in showing how a specific theory leads us to view facts in a specific light, how it leads us to discover new facts, and finally how it leads us to raise questions about the theory itself, about the direction in which it is to be developed further.

I begin with a simple example. There are numerous languages in which tonal contrasts play a crucial role. The simplest of these are the languages that exhibit what Trubetzkoy has termed "register correlation"; i.e., "where every syllable ... is marked by a definite relative pitch level or register". Languages of this type often distinguish systematically two or three pitch levels. As examples of languages with two pitch levels one may cite Japanese and Otomí (Bernard 1966); whereas Igbirra (Ladefoged 1964) and Mixtec (Pike and Wistrand 1971) show three distinct levels of pitch. In view of this, it is clearly necessary that the universal phonetic framework provide for a distinction of at least three pitch levels: high, mid, and low. It has long been known that the articulatory mechanism of pitch distinction must involve the stiffness of the vocal cords. If one assumes that in the neutral position for speech (see Chomsky and Halle 1968:300) the vocal cords have the stiffness appropriate for the mid pitch level, then it follows that to produce a sound with high pitch, the vocal cords must be stiffened beyond that of the neutral position; whereas to produce a sound with low pitch they must be slackened below the neutral stiffness. Accordingly, *Halle and Stevens (1971)* have proposed that the universal set of phonetic features include the two features *stiff vocal cords* and *slack vocal cords*.

Since language is a system *où tout se tient*, the introduction of these two features immediately raises the question of what happens when they are combined with supraglottal articulatory configurations other than those found in the vowels. In particular, one immediately must ask how an obstruent produced with stiff vocal cords differs from one produced with neutral stiffness or with slack vocal cords. It turns out that the primary effects of different degrees of vocal cord stiffness under those conditions are not differences in the rate of vocal cord vibration that are perceived as differences in the pitch level, but instead the primary effects in obstruents are the inhibition *vs.* facilitation of vocal cord vibration: stiff vocal cords tend to make voicing impossible; whereas slack vocal cords facilitate it. In other words, obstruents with the feature [+stiff vocal cords] are voiceless, while obstruents with the feature [+slack vocal cords] are voiced. It follows from the nature of these features that there are no sounds which are produced with vocal cords that are [+stiff, +slack], but there can exist sounds which are produced with neutral vocal cord stiffness; i.e., which are [−stiff, −slack]. Given the framework that has been proposed here we should expect, therefore, three types of obstruent: voiceless, voiced and intermediate; the first corresponding to the low pitch vowels, the second to the high pitch vowels, and the third, to vowels with mid pitch.

This consequence may on first sight appear somewhat surprising, since voicing in obstruents has often been cited as the example of a binary feature *par excellence*. It must, however, be recognized that in the papers in which this claim was made, little attention was paid to the phonetic realization of the different sounds. When the phonetic facts are studied in detail—as they have been, for example, in a series of papers by Lisker and Abramson, or by the Danish phonetician Fischer-Jørgensen and her associates—it emerges that there is considerable evidence for the tri-partite classification of obstruents that the framework proposed here appears to suggest. Thus, in terms of the onset time of vocal cord vibrations relative to the stop release, which was studied in considerable detail by Lisker and Abramson (1964) and by Fischer-Jørgensen (1968), the stops fall into three distinct categories. There is one class of stops where the onset of vocal cord vibrations precedes the stop release; a second, where they lag behind the release, and a third, where vocal cord vibrations begin almost simultaneously with the stop release. Although no language appears to make use of all three types, the universal framework must make allowance for all three, since otherwise it will be unable to account for the different choices made by different languages shown in Table 1.

Among the aspirated stops there are three distinct categories with respect to voice onset time. In addition to the familiar voiced and voice-

Table 1. Tables of Ranges of Voice Onset Times (in msecs) Relative to Stop Release in Stops from Different Languages (Data from Lisker-Abramson 1964, except for French data from Fischer-Jørgensen 1968:132. Negative values indicate that voicing precedes stop release.)

Aspirated stops

	+slack −stiff		−slack −stiff	−slack +stiff		
	Marathi	Hindi	Korean	Marathi	Hindi	Korean
labials	−100/−65	−105/0	10/35	40/110	60/80	65/115
dentals	−110/−40	−150/−60	15/40	40/85	35/100	75/105
velars	−120/−45	−160/−40	30/65	60/105	10/35	82/200

Unaspirated stops

	+slack −stiff		−slack −stiff			−slack +stiff
	Marathi	Hindi	Marathi	Hindi	Korean	French
labials	−160/−85	−120/−40	0/25	0/25	0/15	12/51
dentals	−175/−65	−140/−60	0/20	5/25	0/25	18/67
velars	−160/−75	−95/−30	10/40	10/35	0/35	26/61

less aspirates where the onset of vocal cord vibration precedes, respectively lags behind, the stop release by a very considerable amount (50 msecs or more), there exists a third type of aspirated stop, found, e.g., in Korean, where the voicing onset lags only very moderately behind the stop release. A similar picture emerges in the plain stops. Here again there are three distinct categories even though the total range of values found is somewhat smaller than in the aspirated stops. As in the case of the aspirated stops we find, in addition to prevoiced stops, two other types of stops where the onset of vocal cord vibrations lags behind the stop release. In one type the lag varies between 0 and 35 msecs, whereas in the other type, exemplified by the voiceless stops of French studied by Fischer-Jørgensen (1968), the lag varies between 12 and 67 msecs. As noted in *Halle and Stevens (1971)*, an analogous tri-partite categorization appears to be required for the various types of glottalized stops.

In sum, there is some evidence in favor of the suggestion made above that in addition to stops that are [+slack −stiff] and those that are [−slack +stiff], there are also stops that are [−slack −stiff].

This does not exhaust by any means the evidence in favor of the proposition that pitch level distinctions in vowels and voicing distinctions in obstruents are controlled by the same pair of features. For instance, it has long been known that the development of the tonal system of the Far Eastern languages exhibits a direct correlation between voicing and pitch level. In a paper originally written more than forty years ago, Roman Jakobson observed (1962:216):

> Dans certains dialectes chinois les consonnes sonores et les consonnes sourdes sont confondues. La corrélation vocale des consonnes est remplacée par la corrélation de registre des voyelles suivantes: le ton bas de la voyelle se substitue au caractère sonore de la consonne précédente, le ton élevé correspond au contraire au caractère sourd de la consonne en question. La différence de registre, d'abord variation combinatoire, est devenue une propriété de corrélation.

What is of special importance to us here is that the historical development sketched by Jakobson proceeded along lines that are essentially implicit in the feature framework developed here: a low pitch is the reflex of a voiced consonant, whereas a high pitch is the reflex of a voiceless consonant. In other words, the vocal cord configuration—stiff or slack—in the consonant is assimilated by the following vowel subsequent to which the contrast in the consonants is lost.

Much additional evidence bearing on this point can be found in the only partially published work of Dr. LaRaw Maran of Indiana University (Maran forthcoming) and in the numerous studies that we owe to Professor A. G. Haudricourt of Paris. Among the latter I have found especially instructive his 1961 paper, "Bipartition et tripartition des systèmes de tons dans quelques langues d'Extrême-Orient" (Haudricourt 1961). I would also draw attention to his contribution to this congress, in which he discusses two examples—one from Punjabi, and the other from an Austronesian language—where the loss of voicing distinction eventuates in the development of pitch contrasts in the vowels.

Given the traditional phonetic systems where voicing and pitch features are totally distinct, the correlations between voicing in consonants and tonal contrasts in the vowels are nothing but curious coincidences. On the other hand, given a framework such as the one under discussion here, where voicing and pitch levels are controlled by the same set of features, the observed correlations are no more puzzling than is the appearance of nasality in vowels next to nasal consonants, or the common occurrence of lip rounding in consonants next to rounded vowels. All are instances of assimilation; i.e., of a process to which languages are known to be susceptible. To the extent that this is an adequate explanation of the development of the tones that have been discussed here, these developments themselves must be taken as support for the proposed feature framework, where the same set of features govern both pitch levels in vowels and voicing in consonants.

2

It has frequently been pointed out that the feature system provides us with a means not only for designating individual speech sounds, but also for designating particular classes of speech sounds. Thus, for instance, given the feature system developed by Chomsky and Halle (1968), the feature complex [+syllabic, −consonantal] designates the class of vowels, whereas the feature complex [−syllabic, −sonorant] designates the class of obstruents. It is also obvious that there are many logically conceivable classes of speech sounds which can be designated only by very involved and elaborate feature complexes. For instance, a class consisting of the sounds [p, r, y, a] can be designated only with considerable difficulty in the feature system of Chomsky and Halle (1968). It goes almost without saying that one could define a different system of features, where it would be simple to designate the class [p, r, y, a], and difficult to designate a class containing all and only the vowels of the language. Rules of language do not normally affect single speech sounds; they apply rather to whole classes of speech sounds, such as the vowels, the obstruents, etc. It is an important bit of evidence in favor of a proposed system of features that it allows for the convenient designation of classes of speech sounds that figure in the rules of various languages and that it does not make the same provision for classes of speech sounds that do not function in this fashion. Thus, for example, a reasonable feature system must provide for the convenient designation of classes such as vowels and obstruents, but must not do the same for the class consisting of [p, r, y, a].

In this section I intend to examine a rule which appears to involve a class that can be designated only with difficulty in the now current feature system. I believe that I can show that it is the rule, rather than the feature system, which is in need of modification. The data reviewed in this section thus contrast with those discussed above. Whereas above I attempted to justify a change in the theoretical framework by showing that this change allows for a more satisfactory description of the facts, in this section I shall try to show that it is not the theoretical framework but the proposed description of the facts that is inadequate. I shall argue here that a better understanding of the facts requires a rule where the objectionable class of speech sounds is replaced by a more conveniently designated set, thereby implicitly vindicating the proposed feature system as correct, at least with regard to the relevant features.

The rule of interest appears in the phonology of modern Russian as well as in that of most, if not all, Slavic languages. The rule accounts for alternations such as those in (1).

(1)	(a)	*znaj-u*	*zna-l-a*	*zna-t,*
		žiw-u	*ži-l-a*	*ži-t,*
	(b)	*do-stan-u*	*do-sta-l-a*	*do-sta-t,*
		raz-d,en-u	*raz-d,e-l-a*	*raz-d,e-t,*
		za-styn-u	*za-sty-l-a*	*za-sty-t,*
	(c)	*žm-u*	*ža-l-a*	*ža-t,*
		mn-u	*m,a-l-a*	*m,a-t,*

With the exception of the set of forms in (1c), where in addition to the deletion of the nasal, the vowel [a] appears in the stem, (and about which we shall have something to say below), the facts in (1) appear to be adequately captured by a rule which requires that in position before consonants, stem final glides and nasals are truncated. (This rule was first formally proposed in Jakobson 1948). The difficulty with the truncation rule just proposed is that a class consisting of glides and nasals, but not including the liquids can be designated only with difficulty, given the present feature system. To designate such a class we should have to specify that all sounds which are nonsyllabic, sonorant, and either nonconsonantal and nonnasal, or consonantal and nasal. As I have already indicated, I shall now attempt to show that this unnatural class appears in the rule not because of any shortcoming in the feature system, but rather because of a failure to capture certain deeper regularities of the language.

As illustrated in (2), where cognate pairs of perfective and imperfective verbs are given, the differences in verbal aspect for certain classes of verbs are signalled by adding the suffix -áj- to the stem. Moreover, as shown in (2b), when the stem ends in the glide /j/, the suffixation is accompanied by a replacement of this glide by /w/.[1]

(2)	(a)	*spas-u*	*spas-aj-u;*	*vy-pad-u*	*vy-pad-aj-u;*	
		po-mog-u	*po-mog-aj-u;*	*p,er,e-žiw-u*	*p,er,e-žiw-aj-u*	(see n. 1)
	(b)	*u-spej-u*	*u-spew-aj-u;*	*raz-duj-u*	*raz-duw-aj-u*	(see n. 1)

The facts of (2b) have led Flier (1972) to propose that Russian grammar must include a rule which turns /j/ into /w/ before certain suffixes including the imperfectivizing suffix -áj-.

Consider, in the light of this, the behavior of the verbs ending with a nasal cited in (lb):

(3) *ot-den-u* *ot-dew-aj-u* (see n. 1);
za-styn-u *za-styw-aj-u* (see n. 1)

It is immediately obvious that the addition of the suffix -áj- is in this case accompanied by a replacement of the stem final nasal by /w/. It would appear, therefore, that in these cases, not only the glide /j/ is replaced by /w/, but also the nasal /n/. This is a most difficult rule to state given any reasonable feature framework. If our framework is to do any work for us at all we must take this as a hint that there is something not quite in order with the rule and look for a different, less cumbersome solution.

Such a solution is not hard to find. In fact almost all of the pieces that we require are already at hand. All that we need to note is that in addition to unsuffixed perfective verbs, Russian contains numerous verbs which take the suffix -nu- in the perfective and, like the unsuffixed verbs in (2), form the imperfective by adding the suffix -áj- to the root.

(4) *pri-vyk-n-u* *pri-vyk-aj-u*; *is-čez-n-u* *is-čez-aj-u*;
u-gas-n-u *u-gas-aj-u*

In parallel with (4) we can therefore account for the forms in (3) by postulating underlying representations like those in (5):

(5) *raz-dej-n-u* *raz-dew-aj-u* (see fn. 1);
za-styj-n-u *za-styw-aj-u* (see fn. 1)

We have already noted that glides delete before consonants, hence there is nothing new in the fact that in the present tense the /j/ fails to appear in the output. The only thing that remains to be explained is the disappearance of the -nu- suffix in the preconsonantal forms of (lb). The disappearance before the -*l*- suffix of the past tense is quite general. Thus, for the verbs cited in (4) we have the past tense forms in (6):

(6) *pri-vyk-l-a* *is-čez-l-a* *u-gas-l-a*

The disappearance of the suffix -nu- before the infinitive suffix -t, is then the only unusual fact about the verbs in (lb). This fact will be captured by adding a special subcase to the rule that deletes the suffix -nu- in certain forms.

We have thus shown that the verbs in (lb) do not require that the truncation rule should apply to nasal consonants as well as to glides.

We turn now to the verbs illustrated in (1c) and we note that in these verbs the nasal is not truncated in preconsonantal position, but rather replaced by the vowel /a/. We should, therefore, need a rule of the form (7). (See (9) below).

(7) $[+\text{nasal}] \rightarrow /a/ \ / \ \#X \text{——} [-\text{syl}] \ Y\#$

If rule (7) is to be added to the grammar, there is no longer any reason whatever for extending the truncation rule so that it applies to nasal consonants. There are a number of problems connected with rule (7), which shall be discussed directly. The results of this discussion will, however, not require us to change rule (7) substantially. The conclusion that the truncation rule must not affect nasal consonants can, therefore, be allowed to stand. In sum, the unnatural class of speech sounds that appeared in the earlier formulation of the truncation rule is not a fact of Russian, but rather a consequence of our failure to appreciate fully the nature of the phenomenon we were describing.

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In addition to the verbs cited in (1c), Russian includes a small number of nouns which exhibit quite similar alternations between nasals and /a/. A few illustrative examples (the gen. sing. and nom. sing. forms) are given in (8).

(8) *vr,em,-en,-i* *vr,em,-a*; *im,-en,-i* *im,-a*; *znam,-en,-i* *znam,-a*

What we observe here is an alternation between /en/ in prevocalic position and /a/ in word final position. We could capture these facts quite readily if we extended rule (7) in two ways. First we must let the rule apply also in word final position. Secondly, we must let it apply not only to nasal consonants, but also to sequences of vowel + nasal consonant. In fact, the latter extension is almost mandatory since it has been shown by Lightner (1965) that it is necessary in any case to postulate a vowel in the stem of each of the verbs in (1c). Rule (7) must, therefore, be generalized as in (9).

(9) $[+\text{syllabic}]\,[+\text{nas}] \rightarrow /a/ \;/\; \#X \underline{\quad\quad} ([-\text{syl}]\; Y)\#$

There are several aspects of (9) that require clarification. The first of these concerns the manner in which (7) was generalized to apply also in word final position. This was done, quite simply, by enclosing the sequence [−syl] *Y* in parentheses. In order that this actually be possible it is necessary to justify the appearance of the symbols *X* and *Y* which in line with standard convention stand for a sequence of zero or more segments and boundaries, not including, however, the word boundary #. By writing the rules in the form (7) we are making explicit the fact that a rule such as (7) applies to words, but does not apply either to word sequences or to strings that are not contained within words. As shown in (9) rules that have the form (7) can readily be generalized to apply also in word final position; whereas rules of the form of (10) can be generalized equally easily to apply also in word initial position.

(10) $$\begin{bmatrix} +\text{syl} \\ -\text{hi} \\ -\text{stress} \end{bmatrix} \rightarrow /a/ \;/\; \#X \begin{bmatrix} -\text{syl} \\ +\text{back} \end{bmatrix} \underline{\quad\quad} Y\#$$

In fact, rule (10) is found in a wide variety of Southern Russian dialects and expresses the phenomenon known as akan'e which consists in the replacement of a nonhigh unstressed vowel by /a/ after a hard (i.e., [+back]) consonant. Significantly, in the overwhelming majority of dialects where (10) applies, it extends also to word initial position. This is precisely what the formalism that has been adopted here would make us expect, for it is this formalism which allows us to extend a rule such as (10) to word initial position merely by placing parentheses around the subsequence

$$X \begin{bmatrix} -\text{syl} \\ +\text{back} \end{bmatrix}.$$

The intuition that is implicit in the formalism discussed here is that a left-hand environment of a rule can readily be generalized to include word initial position, whereas a right-hand environment can equally readily be extended to word final position. If this is correct, then this sheds some light on the question as to why processes that take place in pre-obstruent position often also take place in word final position. The answer that has frequently been offered (most recently by R. Lass in a paper significantly titled "Boundaries as Obstruents: Old English Voicing Assimilation and Universal Strength Hierarchies" (Lass 1971) is that the word boundary possesses the relevant phonetic features of the obstruents. This seems rather an extreme departure from phonetic realism, for, if one thing has been clearly established by the phonetic research of the last twenty-five years, it is that word boundaries have no phonetic properties in common. Thus, in normal English speech, *a name* and *an aim* are phonetically indistinguishable. They may, of course, be distinguished by inserting a glottal stop at the beginning of the word *aim*, or by interposing pauses in the appropriate places, but these are not normal pronunciations. The same is true of such Russian doublets as *vypolz tarakanom* 'he crawled out like/as a cockroach' *vs. vypal s tarakanom* 'he fell out with a cockroach', both of which are normally pronounced as [vɨ́pəlstərakánəm]).

Moreover, it is not correct that word boundaries always function like obstruent type environments. In fact, there are a number of cases where word boundaries function on a par with vowel type environments. For example, in Latvian morpheme final vowels delete if the next morpheme begins with a vowel, or if they are word final. (See Halle and Zeps 1966). This fact is captured quite naturally by the proposed notational conventions as in (11).

(11) $[+\text{syl}] \rightarrow \emptyset \; / \; \#X \text{———} (+[+\text{syl}]\; Y)\#$

In Southern Paiute (see Chomsky and Halle 1968:346) under precisely the same conditions, consonants (rather than vowels) are deleted. A comparison of rule (9) with (11) shows immediately that what is common in the environments of both rules is that the right hand environment and word final position go hand in hand (as do left hand environments and word initial position), and not that word boundaries share phonetic properties with any class of speech sounds.

4

The second aspect of rule (9) that requires comment is that the rule affects at once two segments and merges them into a single one. This is rather unusual in that phonological rules normally affect only single segments. Exceptions to this, such as rules of metathesis, have long been known, but relatively little has hitherto been said about their character.

It was noted in Chomsky and Halle (1968) that rules such as (9) really require part of the power of syntactic transformations and should, therefore, be written in the form (12).

$$(12)\quad \underbrace{\#X}_{1}\ \underset{2}{[+\text{syl}]}\ \underset{3}{[+\text{nasal}]}\ \underbrace{([-\text{syl}]\ Y)\#}_{4} \Rightarrow$$
$$1,\ 2 \rightarrow /\text{a}/,\ 3 \rightarrow \emptyset,\ 4$$

The first thing to remark about rules of the form (12) is that the effects that they produce can be captured also by separating them into several distinct rules. Thus, for instance, rule (12) could be replaced by the pair of rules in (13).

$$(13)\quad \left.\begin{array}{l}\text{(a) } [+\text{syl}] \rightarrow \text{a} \,/\, \#X\text{—}[+\text{nas}] \\ \text{(b) } [+\text{nas}] \rightarrow \emptyset \,/\, \#X\text{———}\end{array}\right\}\ ([-\text{syl}]\ Y)\#$$

There is, however, no particularly strong argument for doing this, and one can adduce at least one fact against the proposal, namely, that words which are exceptions to (13a) are also exceptions to (13b), which suggests that we are dealing here with a single process and not two separate processes, and that (12) is a more appropriate description than (13).

It is well known that French nasalization is a process quite similar to that captured in rule (12). We shall examine the relevant French facts here because it has been suggested that in French, arguments can be adduced to show that nasalization consists of two distinct parts which must be captured by two rules between which it is necessary to interpose a third rule.

As shown in (14), before consonants and in word final position, vowels are nasalized, if followed by a nasal consonant, and the nasal consonant is then deleted.

(14) *bɔnør* 'bonheur' *bɔ̃te* 'bonté' *bɔ̃* 'bon'

In certain syntactic environments we encounter what has traditionally been known as *liaison*; i.e., a situation where word boundaries don't appear to count. Thus, we have (15a) but (15b).

(15) (a) [bɔnami] *bon ami*
(b) *le* [bɔ̃] *est difficile à atteindre* [bɔ̃ amãže] *bon à manger*

In (15b) nasalization takes place before word boundary, but in (15a) nasalization does not take place. We shall assume that nasalization is blocked in (15a) because prior to the nasalization rule(s), the phrase was subject to the *liaison* rule which eliminated the word boundary at the end of the word *bon*.

It is crucial to observe that in (15a) both parts of the nasalization process are blocked; in the output the vowel is not nasalized and the nasal consonant is preserved. Hence, examples such as (15a) fail to provide any argument for treating nasalization as a process consisting of two rules, one of which provides for the nasalization of the vowel and the other for the deletion of the nasal consonant (cf. [13]). As was noted by Dell (1970), there is a small number of words in French where the appearance of nasality in the vowel is not completely correlated with the disappearance of the nasal consonant. As shown in (16), in these words nasality in the vowel appears even when the nasal consonant is not deleted.

(16) (a) [mɔ̃nami] *mon ami*
(b) [rjẽnafer] *rien à faire*

Dell proposed that cases such as (16) be accounted for by letting the *liaison* rule apply after vowel nasalization (13a), but before the rule deleting nasal consonants (13b). The more common cases illustrated in (14) and (15) would then be handled by derivations in which the *liaison* rule preceded both vowel nasalization and the rule deleting nasal consonants. We have, therefore, derivations with different orders of rules as shown in (17).

(17)

	(a) bɔ̃n#ami		(b) mɔ̃n#ami
liaison	+	(13a) *vnas*	ɔ̃
(13a) *vnas*	---------	*liaison*	+
(13b) *ndel*	---------	(13b) *ndel*	---------

The argument just presented hinges crucially on the fact that the description must include a special statement that the rules of *liaison* and *vowel nasalization* apply in that order in Adj + Noun sequences, whereas elsewhere they apply in the inverse order.

As an alternative to this solution we could postulate that nasalization is a single process embodied in a rule such as (18).

$$(18)\quad \#X\ [+\text{syl}]\ [+\text{nas}]\ \underbrace{([-\text{syl}]\ Y)\#}$$
$$\quad 1 \quad 2 \quad 3 \qquad 4 \quad \Rightarrow$$
$$1,\ 2 \Rightarrow [+\text{nas}],\ 3 \Rightarrow \emptyset,\ 4$$

We should then account for the nasality in words such as *mon*, *rien*, etc. by supplying it in their lexical entries. Thus, in place of a statement establishing different orders of application for a pair of rules, the alternative account would contain an extra *phonetic* specification in the lexical representation of words such as *mon*, *rien*, etc. These entries would be exceptional only in the sense that in the lexical entries of French there are, otherwise, no nasal vowels. It seems to me that as a general principle, solutions requiring special statements determining the order of application of phonological rules should be less highly valued than solutions that require an additional phonetic specification in the lexical representations of a handful of items. I conclude, therefore, that the preferred solution for French is the one incorporating rule (18) where nasalization is a single rather than a two-step process.[2]

5

The nasalization rule just discussed illustrates an interesting effect of some rules which consists in fusing the phonetic properties of two adjoining segments into a single segment. In addition to nasalization we might mention the monophthongization rules, of which the Sanskrit sandhi is perhaps the most famous example, where the sequences /ai/ and /au/ are replaced by /e/ and /o/; i.e., where the result of the fusion preserves the high feature of the first segment, and rounding and backness of the second segment. Fusion rules of this type represent a somewhat aberrant form of behavior, for in the overwhelming majority of phonological processes that have been studied, the domain of a phonological feature is a single segment. There has, of course, been one notable exception to this. In numerous works the so-called 'prosodic' features of tone, pitch and stress have been specifically treated as 'suprasegmental'; i.e., as features whose domain is some unit other than the segment. Until recently such attempts have to my mind, at least, failed to be fully convincing—primarily because they have not excluded alternative solutions in which all features are purely 'segmental'. In this final section of my paper I want to review some data which seem to me to place the issue of suprasegmental features in a new light.

In an attempt to extend the distinctive feature framework to the prosodic features of tone and pitch, Woo (1969) proceeded on the basis of the following two hypotheses:

(19) (a) prosodic features are segmental rather than suprasegmental
(b) on the systematic level all tones are stationary. (Nonstationary 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).

These twin hypotheses constrain severely the manner in which tonal phenomena can be treated in phonological descriptions. In particular, they require that phonetic properties such as 'rising' or 'falling' should play no direct role either in underlying representations or in phonological rules. It is, therefore, of some significance that in a number of languages it could be shown not only that these constraints can readily be satisfied, but also that they lead to descriptions that are clearly superior to the alternatives which make use of non-stationary features.

Among the facts that the constraints (19a) and (19b) readily explain is the following. In many languages nonstationary tones appear freely on diphthongs and long vowels, whereas on short vowels contrasts between nonstationary tones are systematically excluded. This is the case in Lithuanian, in classical Greek, in the American Indian languages Otomí (see Bernard 1966) and Northern Tepehuan, and a number of African languages (Maddieson 1971). Observe that, if the theoretical framework requires us to represent non-stationary tones by features such as 'rising', 'falling' etc., then the restriction on the appearance of these tones is just another curious fact. If on the other hand the framework does not contain features such as 'rising', 'falling' etc., then the only way to characterize non-stationary tones is as sequences of stationary tones; i.e., 'rising' would then be characterizable as a sequence of low pitch + high pitch, 'falling' as high pitch + low pitch, etc. If, furthermore, the assumption is made that the domain of the feature is the segment, then the absence of non-stationary tones on short vowels is not just a curious fact, but is rather a logical consequence of the theory; for since the only way to represent non-stationary tones is as sequences of stationary tones, a short vowel which can only be represented by a single segment cannot have a non-stationary tone.

The constraints (19a) and (19b) make it possible to handle a whole series of additional facts as well. Details can be found in the studies cited in the preceding parapraph. In certain language areas the facts are so persuasively handled by the proposed constraints that at a recent conference at the University of Ibadan the conferers agreed on the propositions "that the introduction of features like (Rise) and (Fall) is not an acceptable method of handling gliding [i.e., non-stationary] tones" and "that a better method of handling gliding tones is to deal with them as sequences of level pitches" (Maddieson 1971:80).

Non-stationary tones arise, however, not only in conditions where it is natural to regard them as the surface manifestation of segment sequences. There are well-attested instances of phonetically rising and falling tones on short vowels where the solution just discussed is not available. In Halle (1971) I showed that at least in two such cases (Serbo-Croatian and Slovenian) this did not require abandonment of the hypotheses in (19). In Serbo-Croatian, phonetically 'rising' tone is found only on an accented syllable followed by a syllable that has 'high' pitch, whereas the 'falling' pitch is found on all other accented syllables. In Slovene, on the other hand, the 'rising' and 'falling' tones, which phonetically are *not* the same as the identically named tones in Serbo-Croatian, are surface manifestations respectively of 'low' and 'high' level pitches. In both Serbo-Croatian and Slovene I believe that I was able to show that this treatment accounted not only for certain curious distributions of the tones, but that it was also in very close agreement with the phonetic facts themselves.

Since the twin hypotheses (19) constrain quite narrowly the kind of things that can be said about tonal phenomena in linguistic descriptions and are, therefore, readily falsifiable, at least, in principle, the fact that they were not falsified in the case of the languages noted in the preceding paragraphs must be regarded as strong evidence in favor of the hypotheses. It appears, however, that the two hypotheses cannot be maintained, in general; in particular, certain facts from African languages which have recently been reviewed by Leben (1971) lead to the conclusion that the theory must be modified so as to allow prosodic phenomena to be treated also as 'suprasegmental' phenomena. The hypothesis about the exclusively stationary character of prosodic features, on the other hand, appears to be confirmed by Leben's data.

Leben points out that in Mende there are at least five distinct tonal qualities in vowels:

(20)	*high level*	*pɛ́lɛ́*	'house';	*low level*	*bɛ̀lɛ̀*	'pant-leg';
	falling	*mbû*	'owl';	*rising*	*mbǎ*	'rice';
	rising falling	*mbã*	'companion'			

The important thing to observe here is that the vowels with non-stationary tones are short and can under no circumstances be regarded as segment sequences, rather than single segments. In view of this fact it is clear that both hypotheses of (19) cannot be true. We have the choice of either adding the non-stationary features 'rising', 'falling' and 'rising-falling' to our list and thereby giving up (19b); or we can give up (19a) and treat prosodic features as suprasegmental.

Leben shows conclusively that the first alternative is undesirable. Among other things, he points out that in Mende the tonal contour of compound nouns is determined by a special rule which copies on to the first syllable of the second member of the compound, the last tone of the first member; moreover, the rule assigns 'low' pitch to all other vowels in the second compound. The way the rule operates is illustrated in (21a).

(21) (a) *pɛ́lɛ́ hánì* *bɛ̀lɛ̀ hànlì*
(b) *mbû hànì* *mbǎ hánì*

In (21b) we see that if the last tone of the first member of the compound is non-stationary—i.e., 'rising' or 'falling'—then it is not copied in its entirety; instead, what is copied is the terminal portion of the tone: 'high' in case of 'rising' tone, 'low' in case of a 'falling' tone. In other words, the non-stationary tones behave as if they consisted of a sequence of two level pitches, of which the second gets copied onto the next syllable in accordance with the rule stated above. (I disregard here the effects of a subsidiary process which deletes the second part of the non-stationary tone under certain conditions. As Leben points out, this subsidiary process serves further to support the view that non-stationary tones must be represented by sequences).

If hypothesis (19b) is, therefore, to be maintained, we must give up (19a) and regard the prosodic features as suprasegmental, rather than segmental. In effect this would mean that in addition to a matrix specifying the segmental features of a given formative, there would have to be a second matrix which specified the suprasegmental features. Thus, the Mende examples cited in (20) might be represented by prosodic matrices such as (22).

(22)

	pɛlɛ			*bɛlɛ*			*mbu*			*mba*	
high	+	+	high	−	−	high	+	−	high	−	+
low	−	−	low	+	+	low	−	+	low	+	−

The grammar would then have also to include two sets of rules. The first set would treat the suprasegmental feature matrix of a word in isolation from its segmental feature matrix. A rule like the compound Noun rule of Mende illustrated in (21) requires this sort of separate treatment of the suprasegmental feature matrices. In addition, there must also be a second set of rules whose primary function is to map the sequential units of the suprasegmental matrix on to the sequential units of the segmental matrix. The result of this mapping is then a representation much like the traditional phonetic transcription with pitches and tones assigned to vowels and other sonorants in the familiar manner.

Although much remains to be learned about this mapping, two observations of some interest can be made here. First, the mapping of suprasegmental units on to segmental units need not be one-to-one. Thus, in the examples from Mende in (20) we find several instances where more than one suprasegmental unit was mapped on to a single segmental unit. Instances where a single suprasegmental unit is mapped on to two consecutive segmental units have been noted by Leben and others. Even more intriguing are the cases discussed by McCawley (1970) in his note on tone in Tiv, where a sequence of two segmental units is mapped on to three segmental units. In this connection attention must also be paid to the interesting attempt by Sven Öhmann (1967) to account for dialectal differences in the implementation of the Swedish tones by postulating differences in the correspondences between suprasegmental and segmental units. (Thus, in one dialect a suprasegmental sequence of low-high would be mapped on to consecutive vowels in a one-to-one manner, whereas in another dialect the onset of the high pitch would be delayed until the last part of the second vowel). It is obvious that we need a detailed investigation of these phenomena in order to discover the limitations to which the mapping of suprasegmental on to segmental units is subject.

Secondly, as Leben notes in his paper (1971), the point in a grammar at which the suprasegmental units are mapped on to segmental units may differ from language to language. Languages, such as Otomí or Serbo-Croatian, where the mapping occurs at a very early point in the grammar and where, moreover, the mapping has essentially a one:one character, will give the appearance of obeying the constraint (19a) that all features are segmental, for in these language all prosodic features will function on a par with segmental features. It is only languages such as Mende where the mapping must occur late in the grammar and where it deviates from a simple one:one correspondence that can provide the evidence against constraint (19a).

Finally, it will be recalled that in the first section of this paper I argued that the features controlling 'high' and 'low' pitch were the same as those responsible for voicing and voicelessness in consonants. This suggests that it will not be easy to draw a sharp dividing line between segmental and suprasegmental features; at least some features can apparently function both segmentally and suprasegmentally. Whether this is more than an appearance and what it tells us about the nature of language are questions that at present we cannot even properly formulate, let alone answer.

Notes

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1. A late rule turns the glide /w/ into /v/. (See Flier 1972).
2. The essential facts in this section were brought to my attention by E. O. Selkirk, who expects to treat them within the framework of a larger work on French phonology, now in progress.

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