2 LINGUISTIC MODELS

The structure of phonological representations
(Part I)

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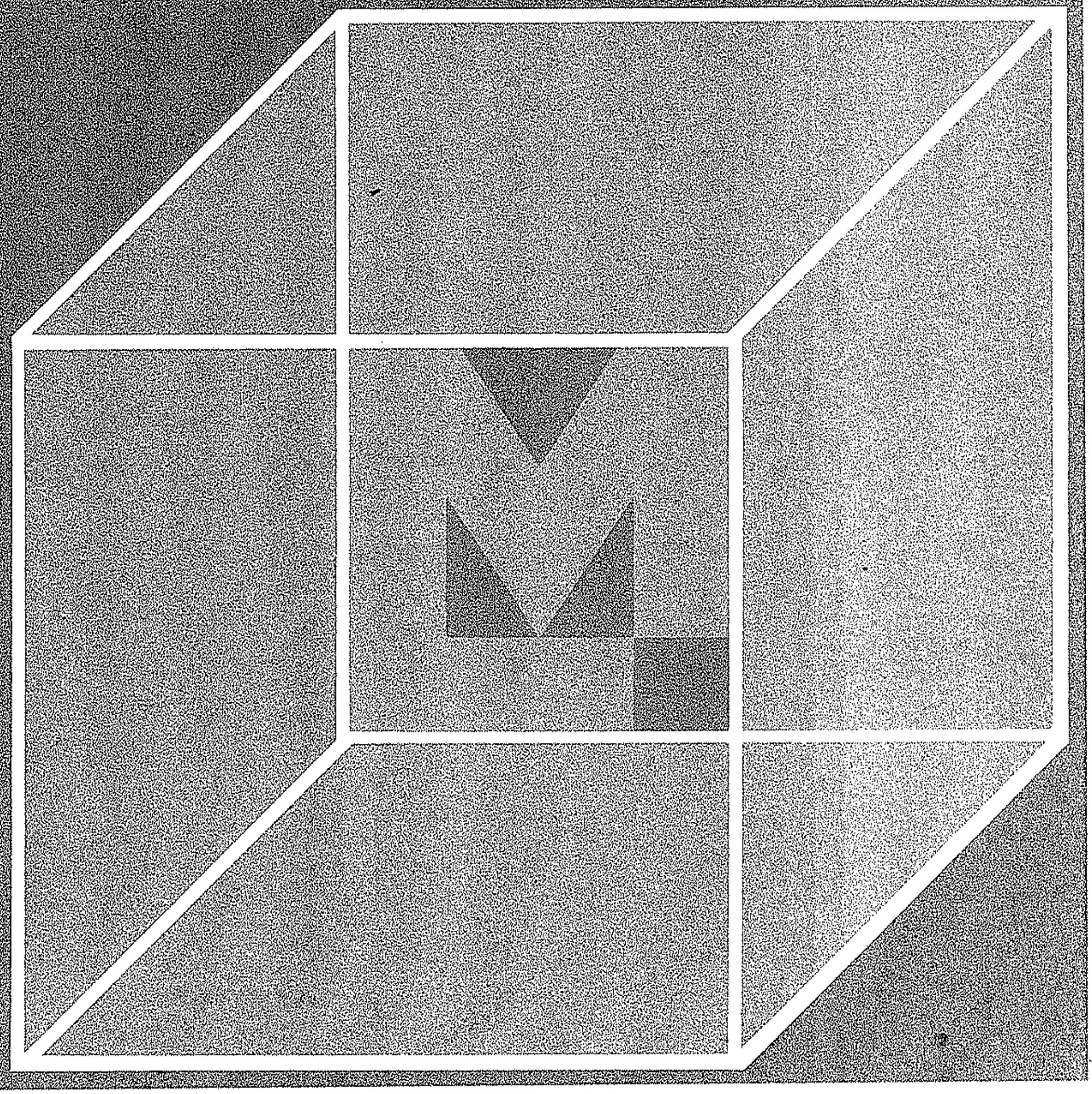

An Overview of Autosegmental and Metrical Phonology *

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"In this study, suprasegmental features (pitch, stress, juncture) have not been seriously considered. Ultimately of course, these phenomena must be incorporated into any full syntactic theory, and it may be that this extension still requires a more elaborate system of representation." (Chomsky 1955: 29)

1. INTRODUCTION

The history of generative phonology up until now can be divided into two phases. In the first phase the focus was on the rule system that related underlying phonological structures to phonetic structures. This we may call the *derivational* aspect of the theory. Central topics were questions of rule formulation, rule application, rule ordering and the degree of abstractness of underlying representations. In the second phase attention has shifted to the structure of the phonological representations themselves. The reason for this shift appears to be twofold. On the one hand discussions within the derivational paradigm had reached an unfruitful stage, in that the participants in these discussions no longer adhered to the same set of theoretical assumptions, but in fact disagreed about fundamental aspects of the theory. In particular the abstractness debate gave rise to this kind of schism. Several 'natural' or 'concrete' phonological theories were advanced in which the idea was given up that one rule type could be used to account for all distributional regularities. Although natural and concrete phonologists were apparently unable to convert the proponents of more abstract analyses it is certainly true that the spirit of some of their ideas has been incorporated in recent elaborations of the standard theory, subsumed under the name 'lexical phonology' (cf. Kiparsky, Part I), where part of the phonological rules has been transferred to the lexicon to form an integrated aspect of the morphological component.

It is interesting to note that the emergence of lexical phonology has a close parallel in syntax, where we have witnessed a similar transference of syntactic rules to the lexicon, giving rise to 'lexical syntax'. For an extensive discussion of the emergence of lexical syntax as well as an illustration of some of the striking similarities between lexical phonological rules and lexical syntactic rules we refer to the Introduction in Hoekstra, Van der Hulst and Moortgat (1980).

On the other hand, a second reason for shifting attention to representations was that generative phonologists had become seriously interested in 'suprasegmental features'. An immediate result of extending the empirical domain of the theory in this direction was the recognition of the fact that the standard view of phonological representations was oversimplified. These two factors have resulted in a large amount of energy being invested in the development of new ideas concerning the structure of phonological representations. Two lines of research have proved to be of particular interest and the goal of this volume (and its sequel: *The Structure of Phonological Representations. Part II*) is to inform the reader about these and other closely related developments.

In this introductory article we will present an outline of the two lines of research mentioned above, which have led to the development of the theories known as *Autosegmental Phonology* and *Metrical Phonology*. We will pay special attention to the kind of arguments that have been used to introduce new theoretical notions. This, we hope, will provide the uninitiated reader with the necessary background. Anticipating the more detailed discussion in the following sections we will sketch here briefly the questions that are at issue.

In the standard theory phonological representations consist, at every level, of a linear arrangement of *segments* and *boundaries*. Segments are conceived of as unordered sets of features (with a feature-specification). The boundaries interspersed between the segments are, with respect to their 'nature' and location, dependent on morphological and syntactic structure. They partition the string of segments into substrings that constitute possible domains for phonological generalizations. The *hierarchical* aspect of the morpho-syntactic structuring is only of limited importance for the application of phonological rules, with the one exception of stress rules. It is important to note that the segments are not grouped in terms of any other hierarchical structure, such as e.g. syllables. This standard view is oversimplified in several ways, two of which directly relate to the geometry of phonological representations.

First, it has been shown that the 'scope' of one feature need not be exactly one segment, or, to put it more precisely, that not all features that characterize some property of a segment are synchronized by the same temporal function (cf. Anderson, Part II). Both *sub*segmental and *supra*segmental phenomena have led to the recognition of the untenability or undesirability of the 'strict segmental theory'. In the theory of Autosegmental Phonology it is proposed that the standard *one-tiered* representation be split up into several *tiers*, each constituting a linear arrangement of segments. Segments in different tiers are linked to each other by *association lines* that indicate how they are to be coarticulated. The autosegmental theory was originally designed to handle tonal phenomena, which were problematic for the standard theory, and a number of fruitful analyses have been proposed. The ability of this theory to deal with subsegmental phenomena caused fresh attention to be paid to the treatment of complex segments in general, since these segments had been problematic for the standard theory from the beginning. The extension of the autosegmental theory to non-tonal phenomena has been most significant, however, in the area of vowel and consonant harmony. Finally, the autosegmental principles have even led to a new morphological theory that seems well equipped to deal with non-concatenative morphological operations, especially those involving various kinds of 'copying'. In section 2 the autosegmental theory will be discussed more fully.

A second major modification of the standard paradigm concerns the organization of segments into larger units. It has become clear that the partitioning of the segmental string dictated by the morpho-syntactic structure of an utterance is insufficient to allow for the expression of all phonological generalizations. In the theory of Metrical Phonology the nature of a different kind of hierarchical organization is explored, one that is based on phonological principles, though not without its relations to the morpho-syntactic (grammatical) hierarchy. In the phonological hierarchy segments are grouped together into syllables, syllables into 'feet', feet into phonological words etc. The metrical theory was originally introduced as a new theory of stress, but it soon appeared that it had a much wider scope. In this case also the new theory was capable of solving a number of 'old problems' such as the proper treatment of syllable structure and phonological boundaries in general. A slightly unexpected extension of the metrical theory involved the application of some of its principles in the analysis of vowel and consonant harmony. In section 3 we will discuss the metrical theory.

Ideally, autosegmental and metrical phonology should complement each other. In practice there are areas of disagreement, or doubt, about the treatment of a number of phenomena. One such area is vowel and consonant harmony, as we have seen above. Clearly, both theories have extended their empirical domain to a point where they now intersect. There are several ways in which this conflict can be resolved and we will discuss some of these in section 4.

It is well known that nonsegmental theories are not a novelty in phonology. Outside the framework of generative phonology, and even before this theory was proposed, we can find both theoretical and descriptive work based on ideas that are very similar to those being discussed in these volumes, although it is equally true that autosegmental and metrical phonology differ from all these other theories in a number of essential ways. To keep this introductory article within reasonable limits we have not tried to relate what is being discussed here to other approaches. This does not mean that we think that nothing could be gained from a careful study of these other theories, however.

2. AUTOSEGMENTAL PHONOLOGY

2.1. General remarks

The standard theory is characterized by what Goldsmith (1976) has called the 'absolute slicing hypothesis'. A representation of the sound flow starts with exhaustively splitting it up in 'slices'. The slices or *segments* are linearly ordered and defined as having no ordered subparts (cf. Clements 1976). Each segment then is an unordered set of specified features, which can be interpreted as characterizing functions from points in time to states of the articulatory organs (or, alternatively, to acoustic properties of sounds). In most cases the features are interpreted in terms of a constant state, but in some cases a changing state is involved. A well know example is the feature [delayed release], used for affricates as in German *Pfeife* [p͡f] or *Zeit* [t͡s]. But there have also been suggestions that features like [prenasal] for sounds like [m͡b], or [diphthong] are necessary. We refer to Ewen (Part II) for more examples and discussion. In the German dialect of Zürich affricates function like units at the underlying level, but at later levels it is necessary to refer separately to the constituent parts (i.e. the *internal structure*) of these sounds, which would be impossible if atomic features, like [delayed release], were used (Van Riemsdijk and Smith 1973). The suggestion that another characterization of complex segments is called for can be found in a number of publications, most recently in Anderson (1976, 1978). In general, what is suggested is some sort of linear arrangement of features within the segment, thus characterizing the beginning and end points of the segment (and sometimes even a point in between). This is in conflict with the conception of segments mentioned above.

The segmental theory has also been attacked from 'the other side'. Complex segments involve *sub*segmental structure. The study of tonal phenomena in particular has revealed that we also have to recognize *supra*segmental structure. Tones can 'spread' over several tone-bearing segments (i.e. several vowels in a sequence may have the same tonal specifications), and it has been suggested that such phenomena can best be dealt with by removing the tonal features from the tone-bearing units and placing them on a 'higher level' from which they can be superimposed onto several tone-bearers at a 'lower level'. But a theory incorporating this idea also comes into conflict with the standard segmental theory.

We will now discuss both attacks on the integrity of the segment in more detail, turning our attention first to tonal phenomena since problems surrounding the treatment of these were the main reason for rejecting the absolute slicing hypothesis.

2.2. The representation of tone

2.2.1. Contour tones

Tones that involve a 'changing state' are termed contour tones. Contour tones are opposed to level tones, which involve a constant pitch. Contour tones may be rising tones or falling tones or rising-falling etc. Level tones are high, mid or low.

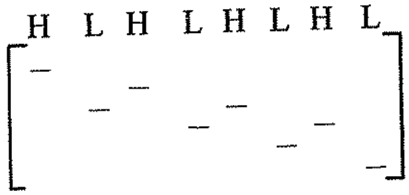
Segments that bear a contour tone are comparable to affricates and features like [rising] or [falling] are comparable to features like [delayed release] or [prenasal]. The characterization of changing states in terms of an atomic feature, formally indistinguishable from other features like [high] or [round], has certain disadvantages, that disappear if it is decided to characterize contour tones in terms of a sequence of level tone features, e.g. [+high], [-high] for a falling tone. This position has been defended by Woo (1969).

One of the crucial arguments involves the formulation of phonological rules. It appears to be the case that a falling tone will behave like a low tone when acting as a left context in a rule, and like a high tone when acting as a right context. The following example will illustrate this.

Many African tone languages exhibit a phenomenon termed *downdrift*. Downdrift involves a gradual decrease in pitch of tones that belong to a single utterance and that are, phonologically speaking, the same. The example is from Igbo:

(1) ó nà áŋwà ínyà ígwè

H L H L H L H L



(H and L stand for high tone and low tone)

From a phonological point of view both *áŋwà* and *ígwè* have the same tonal pattern (HL), but the phonetic realization of their tonal pattern differs. The distance between the H and L is the same in both cases, but the H (and L) of the first word has a higher absolute pitch than the H (and L) of the second word. The usual means of describing this is to write a rule that drops the pitch of every H tone after a L tone:

(2) $H \rightarrow {!H} \;/\; L\ \_$

(!H stands for 'lowered H')

In languages that have both downdrift and falling tones it is usually the case that H tones are dropped not only after L tones but also after falling tones. If the latter is characterized in therms of an atomic feature (e.g. Falling or F) the downdrift rule would have to be complicated:

(3) $H \rightarrow {!H} \;/\; \left\{ \begin{matrix} F \\ L \end{matrix} \right\} \_$

This is only one example of a conjunction of F and L, and it might very well be an accident that the two are associated here. However it turns out that such conjunctions show up again and again, and in fact constitute the norm under such circumstances. When the context bar is on the right L appears together with F, when it is on the left L appears together with R (rising tone). Conjunctions that turn up in several rules suggest that a generalization is being missed (cf. Chomsky and Halle's "weak clusters"). There must be something that the conjoined environments have in common. In this example the property that is shared by the conjoined environments is revealed if falling tones are characterized in terms of the two level tones H and L. Now one can see why a falling tone behaves like L when it is a left context and like H when it is a right context.

This proposal does not necessarily entail that the segmental theory is abandoned but if it is not, the theory predicts that contour tones cannot occur on short vowels. Recall that the segmental theory does not allow sequences of features within one segment. Long vowels pose no problems if they are represented as two short vowels: each short vowel can contain one part of the feature sequence that characterizes a contour tone. And there are languages that forbid contour tones on short vowels. Note that this state of affairs is difficult to account for if atomic features are used for contour tones, since in that case there is no formal difference between level tone features and contour tone features. Within the two-feature approach it is possible to say that languages that forbid contour tones on short vowels have a constraint to the effect that each vowel may be associated with only one tone feature. In fact, working within the segmental theory this constraint would follow automatically. However, there also are languages that allow contour tones on short vowels. How must this type of situation be accounted for if the two-feature approach is accepted but if, at the same time, the segmental theory is maintained? Several 'possibilities' come to mind:

(4) a. $\begin{bmatrix} \vdots \\ -\text{high} \\ +\text{high} \\ \vdots \end{bmatrix}$ b. $\begin{bmatrix} \vdots \\ -\text{high},+\text{high} \\ \vdots \end{bmatrix}$ c. $\begin{bmatrix} \vdots \\ -\text{high} \\ \vdots \end{bmatrix}\begin{bmatrix} \vdots \\ +\text{high} \\ \vdots \end{bmatrix}$

(a) is unsuited to characterize a rising tone since it could just as well represent a falling tone; after all the features are unordered. (b) tries to capture the ordering of the two features, but it violates the definition of a segment. (c) cannot be taken as characterizing a short segment, without giving up the normal assumption (cf. above) that two adjacent feature bundles represent a long segment. The conclusion seems to be that short vowels with contour tones cannot be accounted for in the segmental theory, unless the two-feature approach is rejected, but this, as has been shown, is well-founded.

2.2.2. The autosegmental solution

The autosegmental solution is a simple and a radical one. Within this theory the idea is given up that there is only one string of segments that characterizes the sound flow. Rather it is proposed that a phonological representation consist of several layers or *tiers*. Each tier constitutes an independent string of segments. This view implies that a horizontal segmentation 'precedes' the vertical segmentation. In the first segmentation the tonal part of the utterance is separated from the rest. Then both tiers are separately subject to a vertical segmentation:

(5) tonal tier $[+\text{high}]$ $[-\text{high}]$ $[+\text{high}]$ .....

segmental tier $\begin{bmatrix} +\text{cons} \\ -\text{voc} \\ \vdots \end{bmatrix}$ $\begin{bmatrix} -\text{cons} \\ -\text{voc} \\ \vdots \end{bmatrix}$ $\begin{bmatrix} +\text{cons} \\ -\text{voc} \\ \vdots \end{bmatrix}$ $\begin{bmatrix} -\text{cons} \\ +\text{voc} \\ \vdots \end{bmatrix}$ .....

The phonological representation now resembles the score of a song. The tune is on one line and the text on the other.

The autosegmental theory does not require that there should be an equal number of segments on each tier. Furthermore sequences of identical segments (e.g. two low tones) are usually avoided, in the sense that such sequences are assumed to be marked. If in the course of a derivation two identical tones come to stand next to each other they will be collapsed automatically into one 'segment', according to what is referred to as the *Obligatory Contour Principle*. The theory is called autosegmental since it regards tones as autonomous segments (autosegments).

A short vowel that bears a contour tone can be characterized as follows:

(6) [+high] [–high]

$$\begin{bmatrix} -\text{cons} \\ +\text{voc} \\ \vdots \end{bmatrix}$$

(From now on we will use H and L as abbreviatory symbols for tonal feature bundles, just as we use 'C' and 'V' for feature bundles containing non-tonal features. We will call the CV-level the 'segmental' level, though it should be kept in mind that the tonal level is really segmental too. Later in this article the symbols 'C' and 'V' will receive a different interpretation). The lines that connect the tonal segments to the non-tonal segment indicate how segments on different tiers are co-articulated. The essence of the autosegmental theory is encapsulated in this idea of association or co-articulation and it is easy to see that the theory has solved the problem of contour tones. In the next section we will discuss how the autosegmental approach, originally designed to solve the problem of contour tones, has lead to the solution of seemingly unrelated problems.

2.2.3. The 'problem-solving efficiency' of autosegmental phonology

Within a 'multi-tiered' framework the phonological representation of lexical entries may consist of two tiers:

(7) $\begin{bmatrix} \text{LHL} \\ \\ \text{CVCVCV} \end{bmatrix}$

The tonal pattern and the segmental make-up are both independent properties of a lexical entry. Imagine now a tone language that allows words of type (8a) but not of type (8b); cf. the example given in Leben (1971):

(8)	a.	i.	CV̂C	ii.	CV̀CV̂C	iii.	CV̀CV́CV̀C
	*b.	i.	CṼC	ii.	CV́CṼC	iii.	CV́CV̀CV́C

(The diacritic '´' indicates H, '`' indicates L; '^' thus means LHL). If there is a separate level for the tonal melodies it becomes apparent that all words of type (a) have the melody LHL, whereas all words of type (b) have HLH. In an autosegmental model only one statement is needed to rule out type (b). Within a segmental model it is necessary to repeat the constraint three times since the number of segments is different in the three possible word types. This problem of missing an obvious generalization does not exist in an autosegmental model.

In addition there is another problem that disappears, viz. the question why, in this example, contour tones on three-syllabled words are absent. The autosegmental model explains this fact:

(9) i. ii. iii.

The contour tones result from a situation in which the number of tones is greater than the number of syllables. Of course, it is assumed here that tones are mapped onto the vowels in one particular way: from left to right in a one-to-one fashion as far as possible. The mapping-relation will be discussed in more detail in sect. 2.2.5.

Another point in favor of the autosegmental model is that the existence of morphemes lacking either the tonal or the segmental tier is predicted given a model in which tonal and segmental properties are encoded independently. Segmentless morphemes can be found indicating for example tenses of verbs. A particular melody (say L) is associated with verbs without any change at the segmental level. For examples we refer to Goldsmith (1976). Morphemes that lack the tonal tier in their lexical representation are equally common. Usually such toneless morphemes are affixes. They receive tone at the surface from the base they are attached to.

Within a segmental model the representations of 'defective' morphemes requires the use of archisegments, i.e. in this case segments that have blanks for the tonal features or for all features except the tonal ones. Such underspecified segments were disallowed in the SPE theory and the representation of 'defective' morphemes must therefore be thought of as anomalous in this theory. Defective morphemes are easier to account for in an autosegmental model, requiring no additional theoretical notions (such as archisegments) apart from those already necessary for 'complete' morphemes.

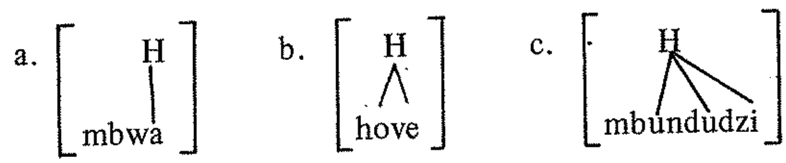
2.2.4. *The independence of autosegmental tiers*

The examples we are now about to present have been set apart since they provide the strongest support for the autosegmental model. If tones and segments are really as independent as autosegmental phonology assumes then it should be possible for rules to refer to one tier without affecting the other tier. For example, it is predicted that a rule may delete part of the tonal tier, causing some bearers to be deprived of tones.

The fact that rules may operate on one level disregarding other levels explains why tonal rules often have 'unbounded' effects. Odden (1980) describes a rule in Shona (a Bantu language) that lowers a sequence of high tones in a word possessing a high toned prefix (one out of a limited set):

(10)	mbwá	'dog'	né-mbwà	'with dog'
	hóvé	'fish'	né-hòvè	'with fish'
	mbúndúdzí	'army-worm'	né-mbùndùdzì	'with army worm'

Within a multi-tiered model all three words will have the same melody, viz. H:

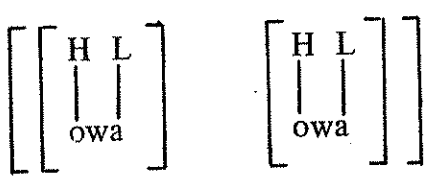
(11)


The dissimilation rule will refer to this single H and change it to L. This means that the change in all three word types is accounted for in terms of a single rule (i.e. not a rule schema) and it is also explained why the rule is unbounded in effect: the number of syllables is completely irrelevant.

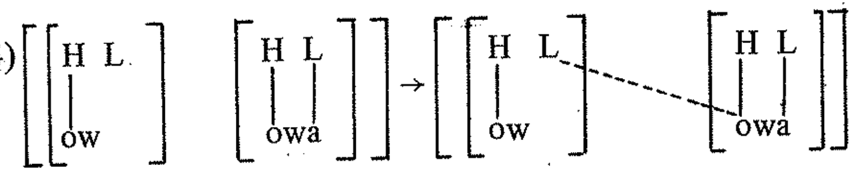
An example involving a deletion rule is taken from Elimelech (1976); cf. Clements (1979: 100). In *Etsakọ* the expression 'each N' involves the reduplication of the relevant N:

(12)	ówà	'house'	ówǒwà	'each house'

A reasonable derivation of the reduplicated form takes the following underlying form as its starting point. (In section 2.3.4. we will discuss another possible treatment of reduplication.):

(13)


The surface form is derived by deleting the first *a*. The deletion rule refers only to the segmental tier and therefore we expect that the tone that is associated with this *a* will stay. If *Etsakọ* were a language that forbade contour tones on short vowels this would be the end of the story The floating L tone would remain unassociated, which means that it would not receive a phonetic interpretation. However, *Etsakọ* permits contour tones on short vowels. In this case we need a rule that associates the 'floating' tone to the right. Clements & Ford (1979) have hypothesized that a tone that is set afloat in this way will always be associated with the segments that caused the deletion of its original bearer:

(14) 

The phenomenon that tones remain when the corresponding tone-bearing segments are deleted is called *stability*.

Stability is also evidenced in the following example. Thai has a word game in which parts of syllables constituting a word may be interchanged. The melody however stays as it was (Leben 1973, Yip 1981):

(15)	klúày hɔ̀ɔ́m	klɔ́ɔ̀m hùáy	'banana'
	téǹ rāā	táà rēn̄	'dance'

It is clear that if tonal and segmental features form an integrated whole such phenomena become hard to account for. Though we can represent defective morphemes in the segmental framework (using archisegments) it is more difficult to imagine a rule type that deletes parts of segments or moves such parts around. Note that the reverse is not true. I.e. if one needs rules that refer to tonal and segmental features simultaneously such rules can be formulated in an autosegmental model. Such rules will be more complex than rules that just refer to a single level, and, as Clements and Ford (1979) argue, it is therefore correctly predicted that they are less common. In the next section we will mention a few examples of such rules.

2.2.5. *Association principles*

The concept of multi-tiered representations was introduced in Leben (1971), where however no details can be found about the way tones are linked to tone bearers. In Williams (1971, published as Williams 1976), a 'mapping rule' is discussed that maps tones onto segments (vowels) from left to right. A similar rule is employed in Leben (1973). Both authors then develop a model in which phonological representations are multi-tiered before the mapping, but one-tiered after the mapping. This makes it possible to distinguish two types of rules in terms of the ordering relation with the mapping rule. We may have rules that apply before the mapping and rules that apply after the mapping. The former can be used for phenomena that bear witness to the independence of autosegmental levels, whereas the latter may be used when we have to refer to tonal and segmental features at the same time.

Examples of the latter kind of rule are provided in Osburne (1979) who discusses the phenomenon that vowels may be lengthened when they are associated with more than one tonal feature. Osburne's point is that such phenomena suggest a more intimate relation between tones and their bearers than is necessary for rules that refer to a single tier.

Recently Odden (1980) has provided new arguments in favor of the Leben-Williams model. He refers to a rule (again in Shona) that has a bounded effect, i.e. in a sequence of high tones only one is changed into a low tone:

(16) hóvé 'fish' hóvè húrú 'large fish'

This would be difficult to describe in terms of a dissimilation rule if there is only one tonal segment (i.e. H) to refer to. When we assume that the mapping of tones onto vowels results in a one-tiered representation in which each vowel has its own tonal specification Odden's rule may simply refer to the specification of the relevant vowel.

A major argument against this model comes from contour tones. If tones are merged with segments one cannot account for short vowels that have a contour tone. This simple fact led Goldsmith (1976) to a different interpretation of the mapping relation. Goldsmith proposed that phonological representations are multi-tiered at all levels. The result of the mapping operation is just that we indicate how segments on different tiers are co-articulated. Formally this is done by inserting association lines between the different tiers.

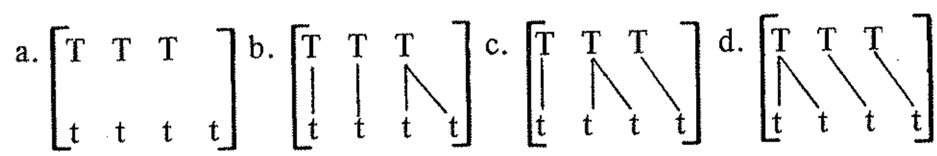
It may now be asked how the examples given in Osburne (1979) and Odden (1980) can be accounted for. It was noted earlier that it is perfectly feasible to write rules that refer to more than one level. Such rules are more complex and this will only be a problem for the autosegmental model if the relevant phenomena turn out not to be as 'marked' as for instance Clements & Ford claim they are. As for Odden's rule, the same facts can be accounted for in terms of a rule that inserts an autosegment (L) associated with the second vowel in *hóvè*.

A compromise between the Leben-Williams model and the Goldsmith model is suggested in Halle & Vergnaud (Part I). They argue that the autosegmental specification of tonal segments at a separate level does not preclude the assignation of *segmental* tone features too. For arguments in favor of this model we must refer to their article. Assuming that the decision of Halle & Vergnaud is well-founded it might be suggested that 'local' phenomena be handled in terms of rules that affect the segmental features, though we must in that case add an extra convention to their theory saying that if a rule changes a segmental value this will imply dissociation with the corresponding tonal autosegment and subsequent reassociation with or creation of another autosegment.

We will now turn to the important question how the association lines come into being and what principles govern the wellformedness of multi-tiered representations. A first approximation to these problems is laid down in the so called Wellformedness Condition (WFC), put forward in Goldsmith (1976):

(17) *Well-formedness Condition*
1. Each tone is associated with at least one segment
2. Each segment is associated with at least one tone
3. Association lines do not cross

As it stands, this convention is both too weak and too strong. It is too weak as an instruction to draw the lines, since in some cases there are several possibilities of satisfying it. Given (18a) as the starting point there are at least three possibilities:

(18)


These problems are noted in Haraguchi (1977) and Clements & Ford (1979). These authors then suggest that the Wellformedness Condition should be made more specific. They propose three conventions, the first of which resembles the mapping rule that was already proposed in Williams (1971). This rule states that tones are associated with tone bearers in a one-to-one fashion from left to right until we run out of tones or bearers. The other conventions specify what the following steps should be. According to Goldsmith's WFC we would have to associate the remaining tones with the last bearer (clause 1 in 17) or the remaining bearers with the last tone (clause 2):

(19)


Here the WFC is too strong, however. Clements & Ford (1979) as well as Halle & Vergnaud (Part I) argue that tones that remain unassociated after the left-to-right rule has applied (or that become dissociated when their original bearer is deleted) should not be (re)associated as a matter of convention. When nothing is said in a particular grammar such unassociated tones will remain unassociated, which means, as we have said before, that they will not receive a phonetic interpretation. According to Halle & Vergnaud (Part I) the association of more than one tone with a single vowel is a marked phenomenon that requires an extra language specific rule if it occurs. If such a rule is absent from the grammar only one tone per vowel will be permitted. Hence clause 1 of the WFC that requires that each tone must be associated with at least one segment must be abandoned. We refer to Halle & Vergnaud's article, where it is shown that their model may lead to simpler analyses. We have already seen that tones that are set afloat as the result of deletion rules must be reassociated by means of specific rules (cf. our example in (14)). This also implies that there cannot be a general convention governing the association of floating tones.

What is retained from the WFC are clauses (2) and (3). The fact that association lines may not cross (clause 3) is a fundamental aspect of the autosegmental theory that may never be overruled, but clause (2), as it stands, leads to indeterminacy. When an unassociated tone-bearing unit has a tone both to its left and to its right there are two possibilities for association. Clause (2) must therefore be supplemented by additional principles, such as those proposed by Goldsmith himself or replaced by a set of more specific conventions like those of Clements and Ford (1979).

So far we only have considered tone-systems in which the tonal melody is associated with the segmental string from left to right, *starting with the leftmost tone and the leftmost tone-bearing unit.* There are languages in which the association does not begin with the leftmost tone and the leftmost tone-bearing unit. In other words, there are tonal systems in which some other tonal segment than the first must be associated to a particular tone-bearing unit before any other association takes place (according to the universal conventions discussed above). Systems of this type usually have a more limited set of melodies (often just one). The normal convention is to mark with a star ('*') the tonal and the segmental elements whose association precedes all other association.

The most important difference between systems that use stars and those that do not is then in the way the first association line is introduced, connecting in the first case the *leftmost* segments, and in the second the *starred* segments. Once the first line is drawn all other association follows from the same universal conventions. This point was made very explicit in Haraguchi (1977) who proposed that learning the tonal system of a language involves choosing an initial association rule from a limited set of universally available rules. So far we have seen two such initial association rules and it may be that there are no others.

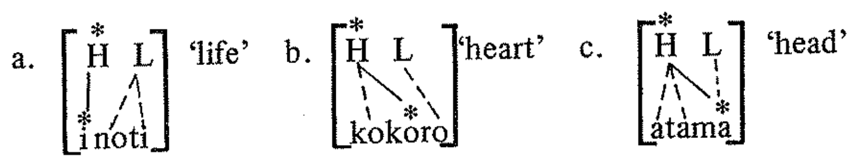
Tonal systems that employ the first choice, i.e. associate the leftmost elements, are usually called (lexical) tone systems: each lexical item is provided with a particular melody in the lexicon. Such systems are opposed to systems that use 'stars' and which are commonly referred to as pitch-accent systems.

In the case of pitch-accent systems the melody may be introduced by a phonological rule. There exists considerable disagreement about a precise definition of pitch-accent or about the question whether tone-systems are fundamentally different from pitch-accent systems. Clements & Ford (1979) suggest for example that 'lexical-tone' languages may be thought of as 'pitch-accent' languages that always have the star on the leftmost position, both on the tonal and the segmental tier.

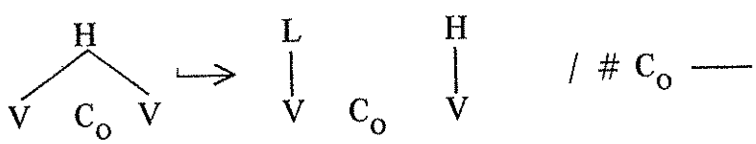
Goldsmith (1974, 1976: ch. 3, 1981a) has given an analysis of English as a 'tone-language', or, rather as a 'pitch-accent language'. The set of melodies is limited to one: MHL and the starred H tone is associated with the vowel that bears primary accent:

(20)


Other pitch-accent systems are discussed in Goldsmith (Part I). An extensive analysis of pitch-accent in Japanese can be found in Haraguchi (1977) from whom we have taken the following examples:

(21)


The first rule is to associate the starred segments. This is indicated by the closed line. The other association lines follow, in Haraguchi's account, from the WFC. The surface patterns of the present examples show an initial L tone if the first tone-bearer is non-starred. To introduce this L tone Haraguchi formulates a rule that looks like:

(22)


Finally it is necessary to remove the L tone that forms part of the basic melody if its bearer is also associated with the H tone. The final result is:

(23)


It is interesting to note that Halle & Vergnaud would not need the rule that deletes the final L. Their model would not predict association in the first place. Another difference between Haraguchi's treatment and that of Halle and Vergnaud (Part I) follows from the fact that in Halle and Vergnaud's version the universal association conventions apply only to unassociated, i.e. non-starred tones. In example (21c) the starred H cannot spread to the first two tone-bearing units. Segments that remain without a tone receive the unmarked value for tone, but this is not the high tone, at least not in Japanese. Therefore the melody they assume for Japanese is HHL rather than HL.

2.2.6. Tone-bearing segments and 'projections'

There is one important point that must be discussed. How do the tones 'know' where to go? Let us assume, to simplify matters somewhat, that tones are associated with vowels (and not with syllables, or parts of syllables). Consonants then have to be skipped somehow or other. Clements (1976) and Halle and Vergnaud (1981) assume that for each type of autosegmental association a particular set of 'P-bearing units' (tone-bearing units in this case) must be identified. Alternatively, one might make use of the so-called projections that were proposed in Halle & Vergnaud (1978) to take care of a similar problem with regard to vowel harmony. Though Halle and Vergnaud (1981) themselves have rejected to make use of the notion projection for the purpose of association we will indicate what this notion stands for, because it is used in many recent publications. In short, projections are strings of segments that result from omitting segments that do not have a certain property, e.g. the string of vowels, which results from omitting all segments that do not have the property '[+voc]'. Projections, as the notion is used in the literature, do not have to be made up of segments. They can comprise sequences of elements (however defined) of any level of the phonological hierarchy, i.e. we find reference to the rhyme-projection, syllable-projection, foot-projection. One should not think of projections as derivational levels. Different projections including the 'basic' segmental projection (which is itself the segment-projection) constitute simultaneous representations. For some discussion of the notion projection we refer to Anderson (Part II).

2.3. Extensions of the autosegmental theory

We have seen how the autosegmental theory solved a particular problem in the representation of tone. The solution that was proposed entailed certain predictions with regard to the behaviour of tones and tone-bearing units which have turned out to be correct. In this section we show how the autosegmental theory extended its empirical domain to non-tonal phenomena. These display some of the properties that were successfully dealt with in the analysis of tone. First we will look at autosegmental treatments of *sub*segmental phenomena, which remind us of the problem we had with contour tones. Then we will turn to the non-tonal counterparts of *supra*-segmental phenomena such as vowel-harmony and length. A further extension of the autosegmental theory, the treatment of syllable structure, will be discussed in the next section (sect. 4) in order to compare this treatment there with the metrical theory of the syllable.

2.3.1. Complex segments

The representation of complex segments has been discussed over the years in a fair number of articles (see Ewen, Part II for a survey and an analysis of such segments in a dependency framework). Most recently Anderson (1976, 1978) has called our attention to the representation of prenasalized and postnasalized consonants. Anderson rejects the use of features like [prenasal] or [postnasal]. His arguments are completely parallel to the arguments against contour features such as [rising]. For the purpose of rule application a postnasalized consonant behaves like a nasal consonant when it is a left context and like a non-nasal when it is a right context. The similarity to the situation with contour tones is recognized by Anderson. He proposes explaining this behaviour by giving segments sequentially ordered subparts, i.e. ordered opposite specifications for the same feature:

(24) [b͡m]

<table>
<tr><td>syll</td><td colspan="2">-</td></tr>
<tr><td>cons</td><td colspan="2">+</td></tr>
<tr><td>nas</td><td>-</td><td>+</td></tr>
<tr><td>high</td><td colspan="2">-</td></tr>
</table>

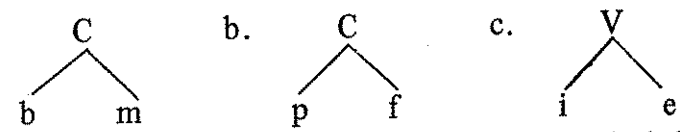
Anderson does not make any claims about tiers or association lines but he is aware of the fact that the impact of his proposal is the same as that of the autosegmental theory, although the notation differs: the definition of segments as unordered sets has been abandoned (cf. Anderson 1978: 54). The autosegmental equivalent of (24) would be (25):

(25) [-nas] [+nas]

$$\begin{bmatrix} \text{-syll} \\ \text{+cons} \\ \text{-high} \\ \vdots \end{bmatrix}$$

In more recent versions of the autosegmental model one can find a slightly different treatment of complex segments (cf. Clements and Keyser 1981). The basic idea is that a complex segment is characterized in terms of two fully specified segments that are linked to one 'segmental slot':

(26) a. b. c.



(postnasalized stop) (affricate) (short diphthong)

The notion 'segmental slot' will be discussed in sect. 2.3.3. Within this approach complex segments are referred to as *branching segments.*

2.3.2. Harmony

In this section we will discuss how the autosegmental theory has been applied to non-tonal suprasegmental phenomena. The question might be asked whether an autosegmental treatment of harmony phenomena is necessary. Several authors have tried to show that autosegmental treatments run into certain difficulties not present in segmental analyses using iterative rules (cf. Vago 1980, Anderson 1980, Part II). We will not go into their arguments here but refer to Anderson (Part II), who claims that segmental rules can still be used beside autosegmental rules and 'metrical rules' (to be discussed in sect. 4.3.). In fact, Anderson claims that using segmental rules to deal with harmony phenomena solves the overlap problem that exists between autosegmental and metrical theory. Placing vowel harmony outside the range of both theories, he argues, allows one to develop more constrained versions of both, while the power of segmental rules does not have to be increased in any significant way.

2.3.2.1. Vowel harmony. When all vowels in a particular domain (usually the word) have to agree for one or more features we speak of vowel harmony. Clements (1976a) has discussed a number of properties that most vowel harmony systems are claimed to have in common, of which 'unboundedness' and 'bidirectionality' are the essential ones. For a critical discussion of Clements' list we refer to Anderson (1980). Unboundedness refers to the fact that (within a particular domain, in this case the word) a particular feature is assigned to all vowels (regardless of their number), i.e. to the vowel-projection. This 'spreading' resembles the situation with tones, when there are more bearers than tones and tones are spread over several bearers. If harmonizing features are, like tones, autosegments and the same or comparable association principles are applicable then harmonizing features display exactly the behaviour one would expect. The same is true of bidirectionality, which refers to the fact that in most systems both prefixes and suffixes are subject to harmony, i.e. the harmonizing feature of the base spreads in two directions.

The issue of bidirectionality is not uncontroversial. It has been shown that the basic association rule for tones may be directional (i.e. left-to-right) rather than bidirectional, though in particular cases tones may be associated to the left also, e.g. if this is the only way in which a tone-bearer can be associated with a tone (cf. example (21a) in Japanese, where the H tone spreads to the left to become associated with the leftmost tone-bearer). Anderson (1980) claims that directionality statements can not be avoided in autosegmental treatments of harmony. Leaving this matter for further discussion, we will give a simple example of an autosegmental treatment of vowel harmony, taken from Clements (1977a).

In Hungarian vowels agree in their specification for the feature [back]. Lexical entries take one of the two following forms (in the case that they are stems):

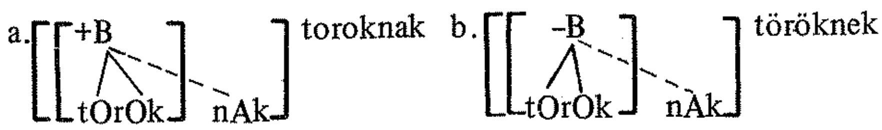
(27) a. $\begin{bmatrix} \text{+B} \\ \\ \text{tOrOk} \end{bmatrix}$ torok 'throat' b. $\begin{bmatrix} \text{–B} \\ \\ \text{tOrOk} \end{bmatrix}$ török 'turkish'

('B' stands for the feature [back]; capital letters indicate vowels that are unspecified for the harmonizing feature).

A major difference between tone and vowel harmony is that in the former case one never finds 'melodies', i.e. sequences of unassociated segments at the level of the harmonizing features. In section 2.3.4. we will discuss an extension of the autosegmental model in which tonal melodies do find a counterpart in melodies of vocalic features. It is the fact that there is only one autosegment that makes spreading bidirectional in the case of vowel harmony. Application of the universal association convention will give us:

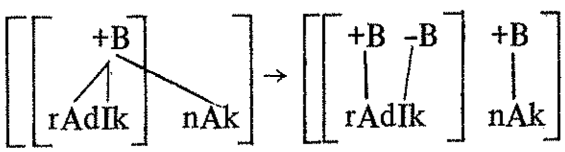
(28) a. $\begin{bmatrix} \text{+B} \\ / \backslash \\ \text{tOrOk} \end{bmatrix}$ b. $\begin{bmatrix} \text{–B} \\ / \backslash \\ \text{tOrOk} \end{bmatrix}$

One of the diagnostics for the autosegmentality of a feature that was present in the case of tones was that there may be morphemes in which one of the tiers may be missing from the lexical representation. As is well known, languages with vowel harmony usually have affixes that agree in their vowel specification with the bases they are attached to. Such morphemes can be compared to toneless morphemes in tone languages (cf. sect. 2.2.). An example is the suffix *nAk* 'to (dative)' in Hungarian:

(29) 

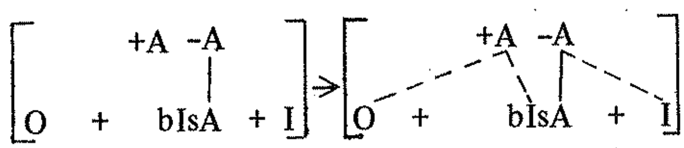
A characteristic property of vowel harmony systems is the presence of vowels that in some way interrupt the smooth flow of the spreading feature. Basically these vowels seem to be of two types.

The first type of apparent interruption concerns vowels that are not affected by the harmony process at all. Such segments are called *neutral*. In Hungarian for example the front vowel *i* is not subject to backing harmony. What is curious about neutral segments is that they are transparent for the spreading process. In Hungarian, a back vowel to the left of the neutral vowel /i/ causes backing harmony in a vowel standing to the right of the neutral vowel. Clements' original treatment of neutral vowels runs as follows. First neutral vowels are affected, i.e. associated with the harmonizing feature, then an additional rule ties them to the autosegment –B:

(30) 

This treatment is critically discussed in Anderson (1980) and Vago (1980). Another treatment would be to exclude neutral segments from the stipulated set of 'P-bearing' segments.

The second type of interruption concerns segments that, like neutral segments, are not affected by a spreading feature, but that, unlike neutral segments, are not transparent. Such segments block the spreading and they are called *opaque*. The usual treatment of opaque segments is to assume that such segments are lexically associated with 'their' autosegment. An example will be taken from Akan, as analyzed by Clements (1976). In Akan the low vowel /a/ blocks the spreading of the autosegment [Advanced Tongue Root]:

(31) 

We have assumed here that the universal association conventions apply both to the free [+A] and to the bound [–A]. This is in fact Clements' position.

Another analysis is possible, however. Halle and Vergnaud (1981, Part I) assume that the universal association conventions (both for tonal and non-tonal autosegments) apply only to free autosegments. In their theory then the result of applying the universal conventions in Akan would be (32):

```
(32)  ┌   +A  -A     ┐
      │   .^\  |     │
      │  /   \ |     │
      └O  + bIsA  + I┘
```

The final vowel surfaces as [-ATR] and this is explained by assuming that *all* vowels are segmentally specified with the unmarked value (assuming that the unmarked value is [-ATR]). When vowels are linked to an autosegment, the specification of this autosegment overrides the segmental value, but when there is no autosegment the segmental value turns up.

In some cases it is clear that the theory of Halle and Vergnaud must be preferred. One example of this concerns the blocking of rounding harmony in Mongolian by high round vowels (cf. Chinchor 1979). All vowels that follow such vowels are [-round], and this value cannot be explained in terms of spreading from the blocker (cf. Halle and Vergnaud for another example; they analyze Mongolian harmony differently).

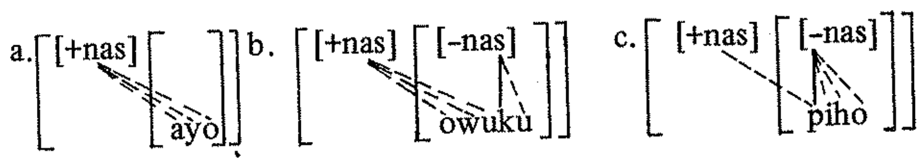
However, it is not always the case that vowels surface with the unmarked value when a blocker prevents association with a free autosegment. There are cases (e.g. in Guarani, as discussed in Van der Hulst and Smith, Part II) in which we must assume that the blocker is subject to spreading. This implies that we must distinguish two types of blockers: spreaders and non-spreaders. For the former type Halle and Vergnaud (1981) propose a metrical treatment that will be discussed in sect. 4.2.

For a more detailed account of the autosegmental framework we refer to the publications of Clements. Critical assessments of this type of analysis can be found in Anderson (1980), Vago (1980), Barratt (1981), Battistella (1979) and Halle and Vergnaud (1981).

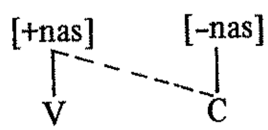
2.3.2.2. Other types of harmony. Here one example of the autosegmental behaviour of *nasality* will be given, which is interesting since it involves a morpheme that consists only of nasality. This, as the reader will recall was one of the diagnostic features for autosegmental treatment. In Terena, as described in Bendor-Samuel (1960), subjects of verbs and first person possessive pronouns are expressed in terms of a span of nasality that starts from the beginning of the word and spreads to the right as far as the first stop or fricative. This stop or fricative surfaces as a prenasalized obstruent:

(33)	eˈmoʔu	'his word'	ẽˈmõʔũ	'my word'
	ˈayo	'his brother'	ˈãỹõ	'my brother'
	ˈowoku	'his house'	ˈõw̃õŋgu	'my house'
	ˈpiho	'he went'	ˈmbiho	'I went'
	aˈhyaʔaʃo	'he desires'	ãˈnʒaˈʔaʃo	'I desire

One may treat obstruents as *opaque* segments associated with an autosegment [-nas]:

(34) 

(Note that the segments following the opaque segments would also surface as [-nas] if we assumed the theory of Halle and Vergnaud, [-nas] presumably being the unmarked value). It will be assumed here that prenasalized stops in examples like (34b) are the result of a later rule:

(35) 

In Van der Hulst and Smith (Part II) other examples of the autosegmental behaviour of nasality will be given. Hyman (Part I) presents an autosegmental analysis of nasality in Gokana, which he compares to 'traditional' segmental analysis.

2.3.3. *Three dimensional phonology*

There are several questions with regard to the autosegmental theory that have not been dealt with yet. First: what kinds of features show autosegmental behaviour? And second: if several autosegmental tiers are present within the same language (e.g. tonal tier, a harmony tier and a segmental tier) how are they related to each other?

With regard to the first question it may simply be the case that formally each feature can behave independently from all others, but that there are substantial constraints, related to matters of articulation, on the number of tiers present in languages. Interesting proposals in this regard have been made within the framework of dependency phonology (especially Ewen 1980, cf. Ewen Part II), where each segment is seen as an unordered set of 'gestures' each of which is again an unordered set of features in the usual sense:

(36)

place height rounding backness	articulatory gesture
consonantality voice continuance sonorance	categorial gesture
glottal stricture glottalicness velaric suction	initiatory gesture

It seems reasonable to assume that a proposal along these lines could account for the relatively independent behaviour of features that belong to different gestures. Something similar is proposed (within an autosegmental analysis of aspiration in Icelandic) in Thrainsson (1978), who sets apart laryngeal and supralaryngeal features.

With regard to the second question – how are different tiers related to each other – one can choose between two alternatives. All the tiers may be piled up, one on top of the other, as it were, or possibly, there is one basic tier with which all other tiers are associated. It is the latter approach (attributed to Halle by Goldsmith 1976) that one finds in recent work.

It is assumed that the basic tier consists of the major class features [consonantal] and [vocalic], with 'C' standing for [+cons, -voc] and 'V' for [-cons,+voc]. The basic tier then takes the form 'CVCVCCVCVCVV...'. In sect. 3 it will be shown that this basic tier corresponds to the terminal nodes of the phonological hierarchy. It is clear that phonological representations take the form of multi-dimensional objects, when the number of tiers that may be associated with the basic tier is only limited by the number of phonological features (or gestures).

2.3.4. Non-concatenative morphology

The possibility of representing different (clusters of) features on different tiers is used in a novel way by McCarthy (1979, 1981, Part I) to deal with certain types of so called non-concatenative morphological operations.

One of McCarthy's most extensive examples concerns the verbal morphology of classical Arabic. McCarthy's framework can be illustrated most clearly by reviewing this example in some detail.

Each verb in Classical Arabic may occur in a number of derivational classes (involving meanings such as habituality, iterativity etc.) and within each such class the verb has a number of inflected forms (indicating tense, voice, finiteness etc.). All the forms in the paradigm of each verb are characterized by a constant element i.e. three or four 'root' consonants that occur in each form. These consonants always occur in the same linear order, but forms of a verb may differ to the extent that different vowel patterns may be interspersed among the consonants in the consonantal pattern. Moreover, one of the consonants may be doubled and occasionally an 'extra' consonant is added:

(37)

	perfective Active	perfective Passive
I	katab	kutib
II	kattab	kuttib
III	kaatab	kuutib
IV	aktab	uktib
V	takattab	tukuttib
VI	takaatab	tukuutib
VII	nkatab	nkutib
VIII	ktatab	ktutib
IX	ktabab	ktubib

etc.

It can be seen that different derivational classes (numbered I, . . .) are characterized in terms of specific 'CV-skeleta':

(38)

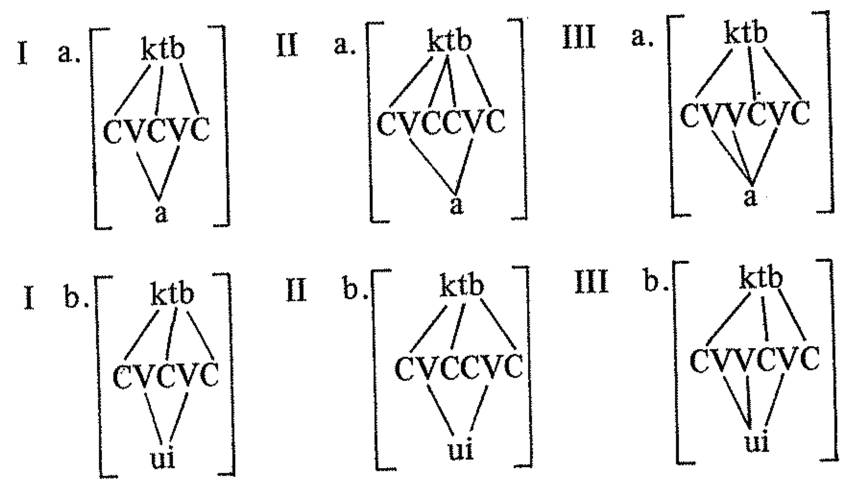
I	CVCVC
II	CVCCVC
III	CVVCVC
IV	CVCCVC
V	CVCVCCVC
VI	CVCVVCVC
VII	CCVCVC
VIII	CCVCVC
IX	CCVCVC

Furthermore one will notice that, whereas the skeleta (plus an occasional extra consonant e.g. *t* in V, VI and *n* in Vii) characterize the derivational class uniquely in most cases (with regard to VIII and IX the class is also determined by the way in which the consonantal pattern is 'spread') the vowel melodies characterize tense and voice. McCarthy suggests that the consonantal and vocalic patterns are to be considered as autosegmental levels and that the CV skeleta (familiar in descriptive grammars of Arabic) be given the theoretical status of the basic autosegmental tier we discussed in the previous section.

It has been claimed by McCarthy and others (cf. Goldsmith 1979) that the vocalic and consonantal patterns or 'melodies' form the counterpart of tonal melodies. In section 2.3.2. we noticed that autosegmental levels involving harmonizing features never showed melodies, which, comparing this with tonal phenomena leaves us with a 'gap'. McCarthy's melodies, it is claimed, fill this gap. The reader should be aware of the fact that the motivation for assigning melodies to autosegmental tiers differs crucially in McCarthy's analysis from the analyses that were discussed. McCarthy uses different tiers for different *morphemes*, as well as different (bundles of) features. This means that in McCarthy's theory the same feature may occur on a number of different autosegmental levels. This implies that there is a theoretical difference between autosegmental morphemic melodies and autosegmental harmonizing features, which are usually not independent morphemes (but cf. nasalization in Terena in sect. 2.3.2.2.).

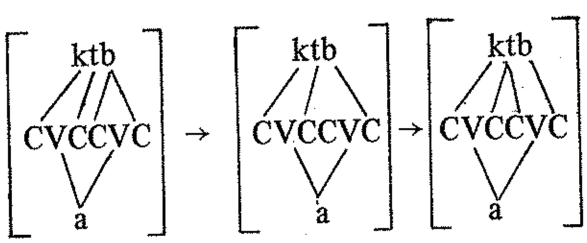
When looking at the example in (39) one will notice that both the vowel and the consonantal melody may 'spread out' in cases where there are more slots than segments:

(39)



One will also notice that in II the consonants and in IIIb the vowels are not associated as expected. It is suggested that in such cases an extra rule is needed that deletes the 'expected' line, after which reassociation takes place; e.g. for IIa:

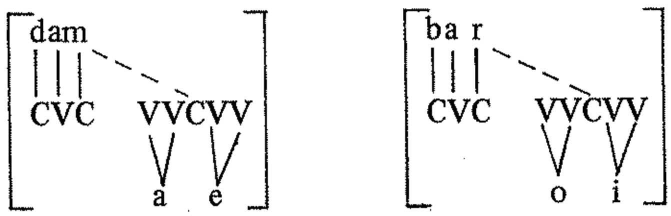
(40)



Other morphological processes that involve 'copying' of some sort can be handled in a similar way. Halle and Vergnaud (1980) analyze plural formation in Hausa, where the stem final consonant is 'copied' in the plural suffix, as follows:

(41) a. dámóo dámàamée 'land monitor'
báràa báròorí 'servant'

b.

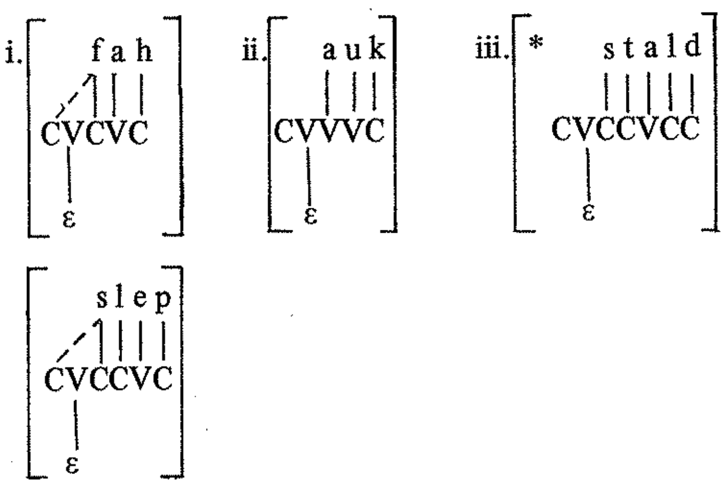


The suffix consists of a CV skeleton that is only partially supplied with a melody. In order to fill the empty C slot the last consonant of the stem melody is associated with it.

Reduplication processes are also ideal candidates for this kind of treatment. Consider reduplication in Gothic. To form the preterite an extra syllable is prefixed to the stem, consisting of a fixed vowel [ε] (written as *ai*) preceded by a copy of the first consonant of the stem:

(42) a. i. fahan faifah 'to catch'
slepan saislep 'to catch'
ii. aukan aiauk 'to augment'
iii. staldan staistald 'to stand'

b.

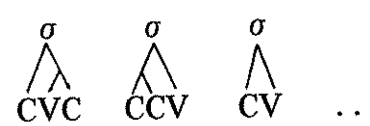


The forms in (42i) illustrate that only the first consonant spreads to the empty C slot and the form in (42ii) shows that nothing extra need to be stated in those cases where the stem begins with a vowel. Example (42iii) is problematic, however. It appears that when the stem begins with *st*, *sk* (we may assume also *sp* but an example is lacking in Gothic) both consonants are repeated. This could be accounted for by representing these clusters as single consonants ('complex segments') an idea for which independent motivation exists (cf. sect. 3.3.1. and Ewen Part II). Halle and Vergnaud (1980), quoting Marantz (to appear), mention another possible approach to reduplication that involves having a copy of the whole word melody associated from left to right (or vice versa when the reduplication affix is a suffix). Segments that are 'left over' do not surface by a convention that we are already familiar with (cf. sect. 2.2.5). McCarthy (Part I) also discusses reduplication processes (as well as the special case of echo formations). We refer to his article for further details.

2.3.5. Length

In the previous section the examples show that the autosegmental model, as developed so far accounts for *length* by associating one segment, e.g. of the vocalic melody, with more than one slot in the CV skeleton (cf. the examples in (41)). It is this treatment of length that offers us the possibility of accounting for the cases where long segments exhibit dualistic behaviour - behaving sometimes like a single consonant and sometimes like two consonants. Leben (1980) points out that Hausa long consonants pattern with "single segments in a plural class (. . .) and yet behave like clusters with respect to syllable structure constraints". The present model explains this dualism, since long consonants will be characterized, at the CV level, in terms of two C slots. This explains why such consonants are clusters with regard to syllable structure, because syllable structure is defined at the CV level. C's and V's correspond, as we said earlier (and will discuss more fully in sect. 4) to the terminal nodes of the syllabic constituent structure:

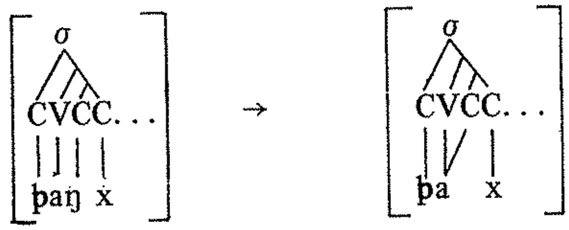
(43)



It is also explained why long consonants may behave as single segments since they are in fact represented as such at the autosegmental morphemic level.

Another possibility offered by the model is a means of handling compensatory lengthening. Consider a change that took place in Proto-Germanic where short vowels followed by a nasal consonant and a velar voiceless fricative changed to long vowels with 'simultaneous' loss of the nasal:

(44) a. þaŋxta > þāxta 'I thought'

b. 

One can account for the lengthening and loss in terms of a single operation: the deletion of the association line between the nasal and its slot. There is one problem, however. Note that the present analysis is only possible if vowels may be associated with C slots (cf. Clements and Keyser 1981). This seems rather awkward and it is perhaps better to alter our conception of the CV skeleton, i.e. we should conceive of this skeleton not as consisting of C's and V's but simply of *segmental positions*. The information which segment constitutes the peak of the syllable is not lost when this move is made, since it can be deduced from the syllable structure that organizes the segmental positions: the position that is exhaustively dominated by nodes labelled with S corresponds to the V, all other positions correspond to C's. (The labelling of nodes will be explained in sect. 3 and, with reference to syllable structure, in sect. 3.3.1.). If this is done, this analysis of compensatory lengthening is virtually identical to that of Ingria (1980), where one can find more examples of this type of analysis. A rather different account of compensatory lengthening using rules that alter the syllable structure itself is offered in De Chene and Anderson (1979).

The fact that segmental slots remain when the associated segment has been cut loose (or deleted) may be regarded as an instance of the phenomenon of *stability* referred to in sect. 2.2.4. This supports the present model in which the relation between the segmental skeleton and the morphemic melodies is indeed one of autosegmental association.

2.4. Recapitulation

In the preceding sections we have discussed how a theory originally designed to 'solve' a tonal problem (i.e. contour tones on short vowels) developed into a general theory of tone. As such the autosegmental model is accepted by most generative phonologists. Then the theory was applied to other phenomena that are traditionally, like tone, considered to belong to the area of suprasegmentals, viz. harmony and length. There also is an autosegmental treatment of syllable structure, but this will be discussed in sect. 3.3.1., where we compare it to the metrical treatment. Finally the idea of linking 'melodies' to a skeleton was used to account for all sorts of non-concatenative morphological processes.

Not all extensions have met with general approval. Some prefer segmental solutions for harmony (Anderson) others have proposed metrical solutions (to be discussed in sect. 4). Other controversial points relate to the possible inventory of autosegmental levels and to the mapping conventions that relate levels to the central skeleton.

3. METRICAL PHONOLOGY

In this section we will discuss the second important development – *metrical phonology*. The theory of metrical phonology was originally developed as a theory of stress, but (and this may sound familiar by now) the domain of this theory was extended to other phenomena exhibiting metrical diagnostic features. As is not surprising the extension of metrical theory has led to a point where it has 'invaded' the territory of autosegmental phonology, which has resulted in the availability of a number of competing theoretical proposals some of which we will discuss in sect. 3. For the moment we will temporarily set aside the idea that phonological representations are multidimensional.

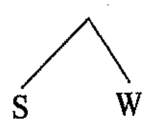
3.1. General remarks

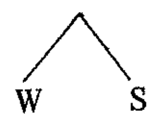
In Fudge (1969) it is argued that there are two types of hierarchical organization imposed on each linguistic expression, both taking segments (or the elements of the segmental skeleton) as their starting point. One is the morpho-syntactic hierarchy in which segments are organized into morphemes, morphemes into words, words into phrases etc. The other is the phonological hierarchy, in which segments are grouped together into syllables, syllables into 'feet', feet into (phonological) words etc. Metrical phonology (in a 'developed' stage) is a theory about the nature of this phonological hierarchy, its internal organization, its role in the application of phonological rules, and its relation to the morpho-syntactic hierarchy. As was said above, metrical theory began as a theory of stress (much as autosegmental theory began as a theory of tone). We will first discuss the metrical approach to stress, and then turn to the extensions, especially with regard to syllable structure.

3.2. The metrical theory of stress

The theory originally proposed in Liberman (1975), further elaborated in Liberman & Prince (1977), Halle & Vergnaud (1978) and Selkirk (1980) will be presented here more or less in the form that it has in Hayes (1981), though a number of details will be omitted.

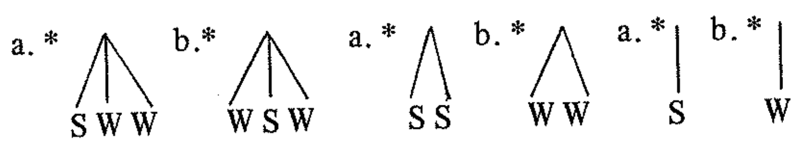
Within metrical theory the stress pattern of a word (or larger units) is represented in terms of a binary branching constituent structure where sister nodes are labelled 'S' (meaning 'stronger than' or 'dominant') and 'W' ('weaker than' or 'dependent'). The basic building blocks are thus:

(45) a.


b.


The labels S and W are not to be interpreted as phonological features with a fixed phonetic interpretation. They indicate that the node labelled S is *in some way* dominant with respect to the sister node labelled W. The 'stronger-than' relation is binary, asymmetrical and irreflexive, which means that the following structures are excluded from the theory:

(46) i. Binary ii. Asymmetrical iii. Irreflexive



Binary trees, labelled S/W, have one and only one terminal element that is exclusively dominated by nodes labelled S. It is this property which makes them so suitable to express those characteristics of the sound flow that are traditionally called culminative. Stress is one such property (being the peak of a syllable is another). Stress is, however, not only a culminative property – it is also a relative property. This is why the structure under (46 iiia,b) should receive no interpretation in the theory. It makes no sense to say of a single isolated syllable that it is dominant or dependent.

One of the first questions to be answered now is: on what grounds is the precise constituent structure determined for expressions that have more than two syllables. Here one must make a distinction between expressions that do not have a morphological and/or syntactic structure and those that have. In the former case the expression consists of a monomorphemic word. It is generally accepted that in the latter case the prosodic structure can often be built up as a function of the morpho-syntactic structure, though the function in general is not one of isomorphy. We will not discuss here the assignment of metrical structure (also often termed prosodic structure) to syntactic phrases and sentences. We refer to Nespor and Vogel (Part I) and Selkirk (1980). The important point is that the prosodic structure, being only partially determined by the syntactic structure, is not isomorphic with it. This reminds us of the 'readjustment' rules in SPE needed to account for the lack of congruence between syntactic and intonational phrases.

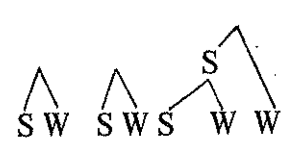
As for morphologically structured words, a major dividing line seems to exist between compounds and derived words. In languages like English or Dutch the prosodic structure of compounds is in the normal case isomorphic with the morphological structure. For some derived words the same can be said, as long as the affixes involved belong to the so-called *neutral* class. In the standard theory it is assumed that neutral affixes are associated with a strong boundary ('#'). Put in metrical terms we may say that such affixes constitute a prosodic unit on their own; they form phonological words, just like their bases. For non-neutral affixes (associated with the boundary symbol '+') the issue is more problematic. The question may be asked whether prosodic structure is built up 'cyclically' or non-cyclically in words derived with non-neutral affixes. Kiparsky (1979, Part I) argues (with regard to English) for the former option. Clearly if prosodic structure is assigned cyclically then the morphological structure determines the resulting structure.

The position defended by Selkirk (1980) is essentially the same as Kiparsky's. The difference is that Selkirk assumes that prosodic structure is a lexical property. In her analysis the cyclic effects follow from the fact that each newly derived word contains the base *with* its prosodic structure. If Selkirk is right, and cyclic effects do not follow from a particular mode in which rules are applied to words, then one is forced to say that prosodic structure will be non-cyclic (i.e. unrelated to morphological structure) in languages in which prosodic structure is not a lexical property (i.e. languages that have completely fixed stress). In these languages the prosodic structure of each derived word must be built up 'without help from the morphology'. In other words, from a prosodic point of view, such words must be treated as if they were underived words. Let us therefore turn to the question how to deal with underived words.

In their original treatment of English stress Liberman & Prince provide the following algorithm for assigning metrical structure. First the English stress rule assigns [+stress] to certain vowels working from right to left. Then every sequence of a single [+stress] vowel followed by a maximal sequence of [–stress] vowels is associated in a left-branching tree labelled S/W (i.e. left node S, right node W). They call the resulting trees *feet*. The feet are then joined into a right-branching structure labelled W/S (with an extra proviso that we will ignore here):

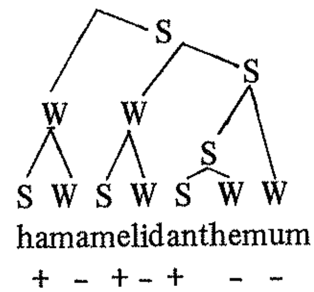
(47) i. stress-assignment: hamamelidanthemum
+ – + – + – –

ii. foot-formation:



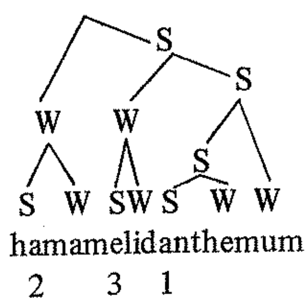
hamamelidanthemum
+ – + – + – –

iii. word-tree-formation:



A structure like (47iii) must be interpreted as follows. Main stress falls on the penultimate vowel, i.e. the vowel that is exhaustively dominated by nodes labelled S. Non-primary stresses fall on the other vowels that are assigned [+stress] by the stress rule. In the SPE notation the vowel bearing the main stress comes out as [1stress], the vowel having the strongest non-primary stress as [2stress], the next strongest as [3stress] etc. These stress values can be deduced from metrical trees by counting the number of nodes dominating the lowest node labelled W (if any) and adding 1 to the resulting integer. This last step (adding 1) is required to achieve descriptive equivalence with the SPE system. (Without this step, main stress would come out as having zero stress.) Since weak syllables in a foot must be interpreted as having no degree of stress at all we will only carry out this procedure for strong syllables (cf. Selkirk 1980):

(48)



In subsequent work (Prince 1976, Selkirk 1980) it has been pointed out that the feature [stress] and the stress assignment rule are superfluous, provided that we make foot assignment sensitive to the same segmental properties that trigger application of the English stress rule. For example: the English stress rule assigns [+stress] to each tensed vowel. Selkirk, in her analysis, forbids the occurrence of tensed vowels in a W position in a foot, which means in effect that syllables containing a tensed vowel will always be the head of a foot, and hence will always have some degree of stress.

The system outlined so far makes use of notions like 'foot' and 'word tree'. In Halle & Vergnaud (1978) an attempt is made to investigate what types of feet and word trees one needs to describe all existing stress systems. Hayes (1981) gives a further elaboration of their proposals and shows that a large variety of stress systems can be elegantly accounted for by stipulating values for a limited number of parameters. We will mention here some of the most important types.

We saw that the assignment of feet in English is sensitive to the make-up of syllables, e.g. whether or not they contain a tensed vowel. Hayes calls such feet *quantity-sensitive* (henceforth Q-sensitive). Q-sensitive feet come in two different types: *bounded* or *unbounded.*

A stress system makes use of bounded feet if there is an upper limit to the number of syllables that may be grouped into a foot. English feet are restricted to an upper limit of three syllables, at least in Selkirk's analysis. Hayes claims that bounded feet are universally limited to disyllabic feet, called binary feet, and monosyllabic feet, called degenerate feet. He has noted that ternary feet only occur at the edge of words, and he argues that in such cases we may assume that the marginal (final or initial) syllable is *extrametrical.* This means that such a syllable is (made) invisible for the foot assignment rules, which can only assign binary and degenerate feet. Afterwards a rule of 'stray syllable adjunction' joins the extrametrical syllable to the final (or initial) foot, thus creating a ternary foot. An argument in favor of the extrametricality device is that in systems using Q-sensitive feet, the quantity of the extrametrical syllable appears to play no role whatsoever. One might ask why the ternary feet are not added to the inventory of possible feet, with the proviso that these ternary feet may only occur at the margins of words. The extrametricality device must also be constrained so as to apply only at the margins of words. However, this issue must be left for future discussion.

An example of *unbounded* Q-sensitive feet is provided in Hayes' analysis of Eastern Cheremis where primary stress falls on the last full vowel of the word and, if there is no full vowel, on the first vowel. The feet are sensitive for the distinction between full and reduced vowels. Every full vowel followed by a maximal sequence of reduced vowels constitutes a separate foot. If a word consists only of reduced vowels, these form a single foot:

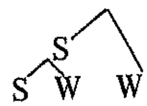
(49) a.

```
  /\
 W  S
 |  |
šiiňcáam   'I sit'
```

b.

```
    /\
   W   S
   |   /\
   |  S  W
slaapáazəm   'his hat (acc.)'
```

c.

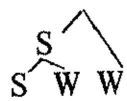


pűügəlm ə 'cone'

d.

kíid əst əz ə 'in his hand'

e.



t ə l ə z ə n 'moon's'

Languages may differ in how they interpret quantity distinctions for the purpose of foot construction. The cover terms used are 'light' vs. 'heavy':

(50)

light	heavy
open syllable	closed syllable
lax, short vowel	tensed, long vowel
reduced vowel	full vowel
etc.	

We will see in section 3.3.1. how the light-heavy distinction may be presented metrically (in most cases) as a distinction between non-branching vs. branching nodes.

We will now turn to feet that are Q-*in*sensitive. Here one finds the same distinction of bounded vs. unbounded feet. As an example of bounded Q-insensitive feet Hayes adduces the stress system of Maragungka, where primary stress falls on the initial syllable and a non-primary stress on every second syllable thereafter:

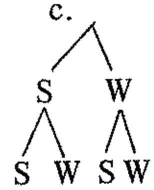
(51) a.

tíralk 'saliva'

b.

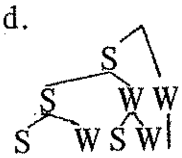
mérepèt 'beard'

c.



yángarnàta 'the Pleiades'

d.

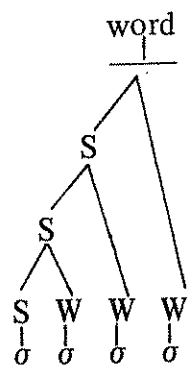


lángkaràtetì 'prawn'

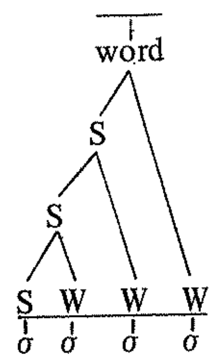
wélepènemànta 'kind of duck'

When a language has unbounded Q-insensitive feet all syllables of every word will always be grouped together in one foot, meaning that the word tree is always degenerate. Why, one might ask, is it not possible to say that in such languages there is only a word tree, i.e. no foot level. The point is that feet and word trees receive different phonetic interpretations. In a foot all syllables except the head are stressless. So if a language has only one stressed syllable in a word, all other syllables being stressless, one may say that the language has unbounded Q-insensitive feet. But if one is dealing with a language having some degree of stress on each syllable it is necessary to say that the language has only degenerate, monosyllabic feet and dominating them a word tree:

(52) a.



b.

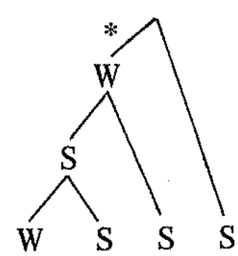


Selkirk suggests that we identify languages of type (52b) as the syllable-timed languages. She mentions French as an example. Stress-timed languages would then be those in which feet may contain sequences of a strong syllable followed by one (if the feet are bounded) or more (if they are unbounded) weak syllables.

The theory of stress as outlined so far has only made use of trees that are uniformly branching *per level.* Furthermore, in all the cases we discussed labelling is predictable on the basis of the direction of branching of the tree (Wheeler 1979 argues that this is always the case). This suggests that the following structures are illformed:

(53) a.

b.



Let us assume (simplifying the matter somewhat; cf. Hayes 1981, ch. 4) that this is indeed the case, and that a child learning his language can only choose trees that are uniformly branching at a particular level, with the labelling being determined by the direction of branching. Learning the stress system of a language now means that the child must find out whether or not there is a foot-level, whether or not feet are bounded and Q-sensitive, what the branching and labelling is at a particular level etc. Having fixed the parameters the stress system will be uniquely determined. We note here that learning the direction of branching and learning the labelling may be considered as one and the same thing if leftbranching trees are always S-W and rightbranching trees always W-S. The redundant nature of the S-W labelling is brought to the surface in recent elaborations of the metrical theory in which the labelling is omitted (Halle, Lectures in Paris, March 1982).

As stated here the metrical theory accounts for the fact that stress is relative and culminative. The success of this approach is also apparent from the fact that certain aspects of the SPE-theory that were especially introduced for the treatment of stress (such as the stress lowering convention) are no longer necessary (cf. Liberman & Prince 1979: 263 and Hayes 1981: ch. 2).

3.3. Extensions

The first extension of the metrical theory we will discuss here concerns syllable structure. In sect. 2.3. we made reference to the fact that there also is an autosegmental theory of the syllable. In the next section we will compare both extensions. After that a proposal to handle downdrift (cf. sect. 2.2.1.) in metrical terms will be looked at. Finally we will review Selkirk's interpretation of the metrical theory as a theory about phonological domains.

3.3.1. Syllable structure

The standard theory makes no use of the notion syllable. It has often been argued that this was an unfortunate attempt to reduce the number of phonological primes. One undesirable consequence was the fact that certain conjunctions had to be constantly repeated in phonological rules, which is the classic indication that a generalization is being missed. Examples are the SPE notion 'weak cluster' and (54a,b) which stand for open and closed syllable, respectively:

(54) a. $\ldots / - \begin{Bmatrix} CV \\ \# \end{Bmatrix}$ b. $\ldots / - C \begin{Bmatrix} C \\ \# \end{Bmatrix}$

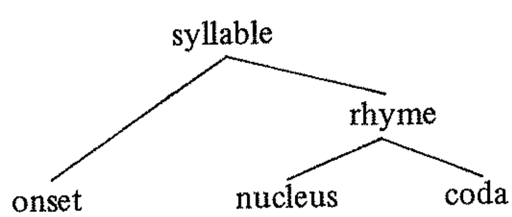
It would be better if the rule could refer to what the conjoined environments have in common. Another motivation for introducing the syllable was that so called phonotactic restrictions (i.e. phonological wellformedness conditions) are most appropriately formulated in terms of the notion wellformed syllable or rather wellformed parts of a syllable. Considerations of this type led to the introduction of *syllable boundaries* which represents the only possible means of accommodating the notion of syllable in a linear theory.

In Kahn (1976) we find the first non-linear approach to the syllable attractive to phonologists working within a generative framework. Kahn's theory is inspired by autosegmental notation. A node labelled 'syllable' is associated by a series of universal and language specific conventions to the segmental string, resulting in structures like:

(55)

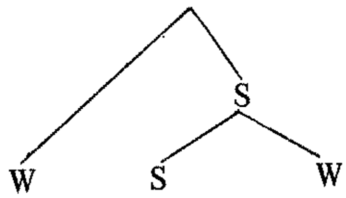

One will notice that in certain cases one segment is associated with two syllable nodes. This is allowed by the autosegmental theory. Such segments are termed *ambisyllabic* and they play an important role in Kahn's analysis of allophonic alternations in English.

It has been argued, in particular by Selkirk (Part II) that the formulation of phonotactic restrictions makes a more detailed structuring of the syllable desirable. For example, co-occurence restrictions are not usually applicable to the syllable initial consonant(s) and the following vowel, whereas restrictions between the vowel and its succeeding consonant(s) are extremely common. Such differences are inexplicable if one assumes a Kahn-type structure of the syllable. However, if one assumes that the vowel plus what follows form a constituent within the syllable this difference is given a structural basis:

(56)


A structure like (56) has been hypothesized by some phonologists for a long time (e.g. Pike & Pike 1948, Fudge 1969). The resulting structure can be given a metrical interpretation. Each syllable has a peak, i.e. the segment that possesses some phonetic feature (e.g. sonority or aperture) to the greatest degree. This is reminiscent of the fact that each word has one syllable bearing main stress. The S/W labelling provides a means of expressing this property of the syllable:

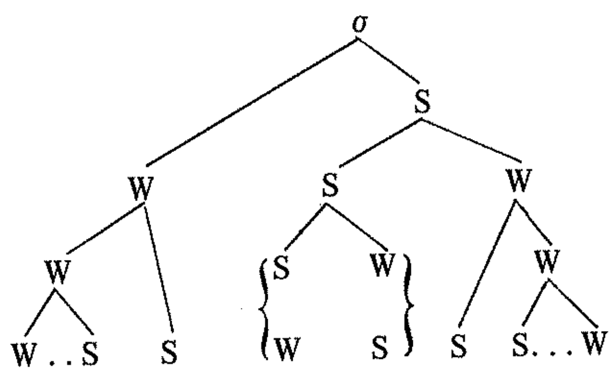
(57)



It becomes apparent now why S and W must not receive a fixed phonetic interpretation. Below the syllable level the labels correspond to sonority but above this level to accent (i.e. pitch, duration, loudness).

Kiparsky (1979) contains a proposal concerning the metrical structure of syllables with a more complex structure, i.e. complex onsets, nuclei and/or coda's:

(58)



The present structuring of the syllable accounts for the phenomenon that consonants which are nearer to the syllable margin are generally less sonorant than those that are nearer to the peak. Notoriously problematic in this respect are clusters like *sp, st* or *sk,* which, as we have seen in section 2.3.4. are also problematic in other respects. A typical 'metrical' approach is to consider the *s* as being extrametrical in such cases, but it is also possible to regard the clusters as forming one (complex) segment.

It seems clear that ambisyllabicity cannot be accounted for in the metrical theory of the syllable, assuming one interpretation of the formalism used. That is, assuming that the metrical structure forms the output of a phonological grammar that uses rewrite rules. One segment cannot belong to the expansion of two sister nodes. That metrical structure can in fact be seen as the output of a phonological grammar is an essential aspect of the framework of categorial phonology as developed in Wheeler (1981). Cf. also Prince (1980).

In section 3.2. we discussed the distinction between light and heavy syllables, which appeared to play an important role in stress systems possessing Q-sensitive feet. It was noted there that this distinction could be expressed in terms of branching in the metrical theory. It is now possible to show what this means.

When feet assignment rules are sensitive to whether syllables are open or closed one can say that such feet are built on the *rhyme-projection.* If the rhyme node branches this means that the syllable is closed, but if it does not the syllable will be open. It is also possible for feet to be built on the *nucleus projection.* This is the case when the feet are sensitive to the distinction between long and short vowels. Long vowels correspond to a branching nucleus, short vowels to a non-branching nucleus. Apparently feet are never built on the *syllable-projection,* which implies that whether or not a syllable contains an onset is completely irrelevant for stress assignment.

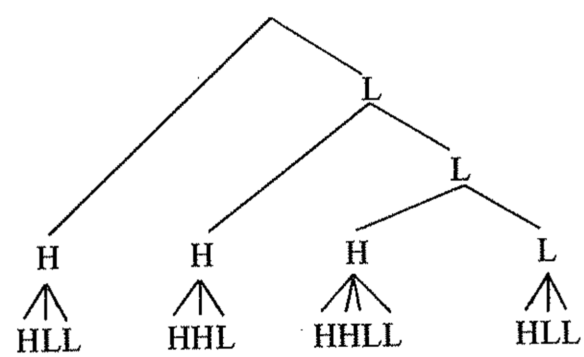
3.3.2. Downdrift

In section 2.2.1. we discussed the phenomenon that the pitch height of tones may gradually decrease toward the end of an utterance. It has been suggested by Clements (1981a) and Huang (1979) that downdrift should be interpreted metrically. They propose the following algorithm:

(59) i. Join each maximal sequence of H's followed by a maximal sequence of L's in a n-ary branching tonal foot
ii. Join tonal feet in a rightbranching structure labelled H/L

When this algorithm is applied to a sequence of H and L tones the result is as follows:

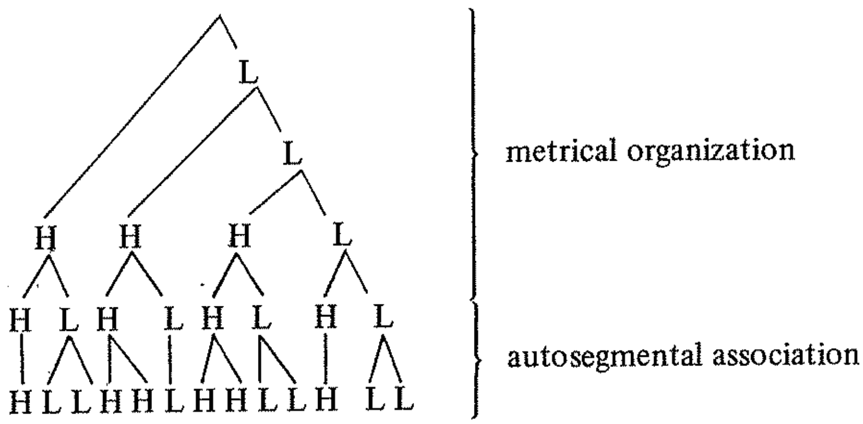
(60)



It is clear that one of the central assumptions of metrical structure is abandoned as far as the construction of tonal feet is concerned: the tonal foot is not binary branching. One could attempt to 'save' the fundamental metrical principle of binarity in the following way. In section 2.2.2. we mentioned the so called Obligatory Contour Principle. If in the course of a (morphological) derivation two identical tones come to stand next to each other they will automatically be collapsed into one 'segment'.

The tonal level thus created is then subject to (tonal) foot formation; the tonal feet are binary, containing a H tone as left daughter and a L tone as right daughter. Clause (i) of (61) can now be said to follow from metrical principles. Clause (ii) remains of course necessary:

(61)



It seems that no empirical consequences are involved, but we believe that the structure in (61) has some conceptual advantages over that in (60).

3.3.3. Phonological domains

Selkirk (1980, 1980a) has pointed out that the metrical theory is not just a theory about 'prominence' (whether in syllables, words or larger units). The constituent structure (with or without the labelling) also serves a clear purpose in the application of phonological rules. It may be the case e.g. that a rule is limited in its application to strings of segments that are dominated by a particular prosodic category, e.g. the foot. The fact that rules may be sensitive to such domains provides independent support for recognizing them as primitives in the theory. According to the domain of application Selkirk distinguishes syllable-span rules, foot-span rules etc. Another way in which phonological domains may be of relevance is that a rule may apply at the edge of a domain or to adjacent segments which stand at the edge of adjacent domains. It is evident that in rules of this latter type reference can be made to the phonological constituent structure, i.e. to the labelled phonological bracketing. This removes the need for so-called phonological boundary markers such as '$' (syllable boundary). In addition many rules that refer to a grammatical boundary can now be reformulated in terms of rules that refer to phonological constituent structure (which is itself partially determined by the grammatical boundaries) (cf. Rotenberg 1978).

4. AUTOSEGMENTAL AND METRICAL THEORY

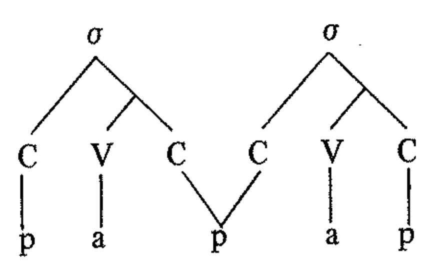
In section 3.3.1. we discussed two approaches towards syllable structure. The availability of two competing proposals is the result of the fact that both the autosegmental and the metrical theory have extended their empirical domain to this area. There are other areas where the extensions of both theories have also led to the availability of competing analyses, especially with regard to the treatment of harmony processes. In this section we will discuss in more detail this 'clash' of theories and the various ways that have been suggested of achieving a division of labour. First we will return to the treatment of syllable structure and then we will show how an extension of the notion foot has been used to deal with certain types of harmony.

4.1. Syllable structure again

Recently Clements & Keyser (1981) have argued for a return to Kahn's theory of the syllable. They question the arguments that have been put forward for a more complex structure on the general grounds of simplicity: notions like heavy and light syllable can also be expressed structurally in a n-ary tree. One of their more important arguments involves the treatment of ambisyllabicity, which, as we have seen cannot be expressed in the metrical framework.

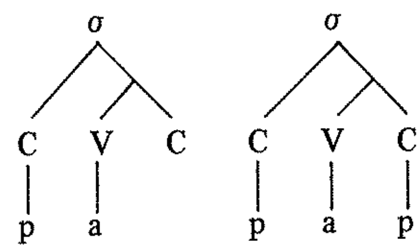
One might suggest that given the separation of the CV skeleton and the morphemic melodies, which Clements & Keyser have also adopted in their theory, the notion of ambisyllabicity could be expressed in a metrical framework in terms of one consonant that is linked to two C slots of two adjacent syllables:

(62)



A disadvantage of this approach is that ambisyllabic consonants need not necessarily be long consonants. Earlier (in sect. 2.3.5.) it was shown that segments from the morphemic melody that are associated with two slots at the CV level are interpreted as long in the autosegmental theory. This is perhaps not a real problem, however. It might be suggested (capturing the essence of a proposal advanced in Vogel 1977: 91) that segments, linked to two slots are interpreted as long, *only* if there exists a length contrast in the language in question. Another way out of this problem (suggested by Deirdre Wheeler) would be to make use of the fact that slots may remain unfilled. An ambisyllabic consonant would then be any consonant this is preceded by a 'floating C':

(63)



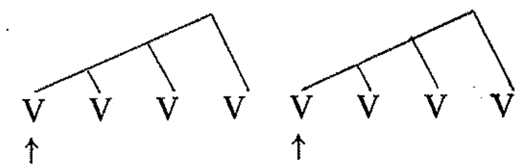
We will leave both proposals for further discussion and turn to another area of overlap.

It has been argued that when tautosyllabic adjacent segments share identical features these features can be assigned to the metrical node dominating those segments. A mechanism called *feature percolation* takes care of the fact that this feature is assigned to each segment dominated by the metrical node (Halle & Vergnaud 1978, Lowenstam 1979). However, assuming the necessity of the autosegmental framework one could also propose that a feature that has all the segments within a metrical constituent in its scope can be handled in terms of an autosegment whose association is tied to this particular domain. In the next section we will see that the *percolation of features* in metrical trees and *autosegmental association* are also competing mechanisms for handling harmony processes.

4.2. Foot structure

One of the most serious attempts to extend metrical theory, or rather the binary branching tree, to areas that were regarded as the exclusive domain of autosegmental theory is the Halle & Vergnaud (1981) treatment of certain types of harmony. They distinguish two types of harmony, viz. directional and non-directional harmony. For the latter type they recommend the autosegmental model, but for the former type they propose using binary branching trees coupled with feature percolation. Directional harmony is characterized by the fact that one can identify designated segments, which trigger the spreading either to the left or to the right up until the next designated segment. There are no opaque segments that are not also triggering segments. For this type of harmony Halle and Vergnaud propose the following treatment. Each sequence of segments terminated to the left (if the direction of the harmony is rightward) by a designated segment (indicated by the arrow in (64) is organized in a binary left-branching tree:

(64)



Subsequently the harmonizing feature of the opaque segment is copied onto the top node. The mechanism of feature percolation takes care of the fact that all vowels in a harmony foot receive the appropriate feature. To deal with directional harmony one could also allow for *directional association.* We have seen that the basic association convention for tonal systems is in fact directional, i.e. left-to-right. Anderson (1980) too has pointed out that autosegmental theory cannot escape from directional association. The crucial question is whether there is any reason to prefer binary branching feet over directional association rules. One could argue that, in the absence of arguments in favor of the metrical solution a choice for directional association rules must be made.

The position that even directional harmony must be dealt with autosegmentally does not imply that one denies the relevance of foot structure for particular types of harmony. Such domains are relevant if independently necessary foot structure (i.e. stress feet) specifies the domain within which harmony takes place. An example is reported in Hayes (1981) where it is claimed that stress feet form the domain for vowel harmony in Eastern Cheremis. In Eastern Cheremis the autosegmental association of the harmonizing feature is apparently tied to the domain of the foot. This point will be dealt with in more detail in Van der Hulst & Smith (Part II).

5. CONCLUDING REMARKS

In the preceding section we have discussed a classical problem, viz. the availability of several analyses of one phenomenon, while it is methodologically desirable that the theory be such as to exclude more than one analysis. This seems to be in line with the general state of affairs in generative phonology at present. We have not discussed in detail all the areas where one can find competing analyses. Even with respect to tonal phenomena where the autosegmental theory seems to be best motivated, very challenging metrical alternatives have been proposed, e.g. in Zubizaretta (Part II). There are, in addition, treatments of stress (e.g. in Schane 1979a,b) in which some of the insights of metrical phonology are adopted though *not* the idea that there is a *binary* branching constituent structure (for a discussion of Schane's theory we refer to Haraguchi, Part I and Hayes, Part I).

With respect to the overlap between metrical and autosegmental theory several proposals have been put forward to eliminate this. Anderson (Part II) wants to retain segmental analyses precisely in those cases where the two theories overlap. Halle and Vergnaud (1978, 1981) eliminate the overlap by arguing that there is 'metrical' harmony and 'autosegmental' harmony. Leben (Part I) proposes that the metrical and autosegmental theory can be reduced to one. He mentions a number of similarities between the two systems and proposes stress feet with an autosegmental structure and a metrical labelling. In Van der Hulst & Smith (Part II) yet another way to solve the overlap problem is suggested in which metrical theory is primarily seen as a theory of phonological domains, which set an upper bound to harmony processes. These are then handled in terms of autosegmental association.

We cannot offer the reader a unified theory in this introduction that will meet with general acceptance, but we hope that the present overview has shown that generative phonologists are attacking a variety of theoretical problems and have come up with a number of insightful answers. Not surprisingly this has led to an increase in the descriptive capacity of the theory and also to underdeterminacy. The time has come then to examine critically the devices that are presently available in order to find out which should be preferred.

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