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## Differences in Rule Type and their Structural Basis

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Much of the recent history of phonological theory has consisted in the development of richer notions of phonetic (and by implication, phonological) structure. The development of "Autosegmental" theory and related notions (see, e.g., Goldsmith 1976a, 1979, as well as Anderson 1976) has made it clear that feature specifications should not be regarded as uniformly synchronized by a single temporal function, as required by a uniformly segmental model. On the other hand, the development of "Metrical" theory has shown that units larger than (but hierarchically related to) the segment are relevant both as the domain of specification of some properties and as the environment of some phonological processes.

Along with richer notions of structure, of course, has come an enrichment of our notion of the character of phonological rules themselves: new types of structure require new devices to create and manipulate them. Autosegmental representations require that there be rules inserting, deleting or changing elements on one autosegmental "tier" without necessarily affecting the elements on other tiers. While this is fundamentally similar to the operation of classical phonological rules, autosegmental theory also requires us to posit rules which manipulate not the features themselves, but rather the associations between one tier and another. Such an alteration in the internal organization of a representation is of course unimaginable in a theory (such as that of classical generative phonology) in which such organization is completely uniform.

Similarly, the recognition of hierarchically organized units with significant internal structure (syllables with their internal onsets, rhymes, etc.; feet, and perhaps larger elements as well) only becomes significant when we also admit rules which alter such structure, or which refer to it in ways that cannot be simulated by reference simply to its segmental com-

\* This paper has benefited considerably from discussions with Will Leben, whose own work is obviously the primary stimulus which has led to its being written. For other assistance with this work, the contribution of our mutual friend George Dickel is gratefully acknowledged.

position. Rules of resyllabification make little sense in a framework with no overt recognition of syllables, and of course the suggestion that some features (typically, stress) can only be coherently defined as relations between elements of higher order than the segment necessarily entails a different view of the rules affecting these features than that prevailing under the picture of all features as properties of segments.

As these new formalisms in phonology have been explored, it has been noted that a great many traditional rules can be reformulated in such terms, often with considerable increase in insight and in the perspicuity of the rule's expression. A particularly clear case of this sort is the range of processes that are sensitive to position in syllable structure. A rule such as "shorten vowels in closed syllables" or "lengthen them in open syllables" can usually be given a formulation in terms of strings of segments alone (depending on the complexity of the language's principles of syllabification), and it can be regarded as part of the theoretical program of Chomsky and Halle (1968) to see whether such formulations are always available (without significant loss of generalisation, of course). Once we admit the metrical structure of syllables into representations, however, a great many unenlightening (and frequently baroque) disjunctions such as "\_\_\_\_ C {C,#}" can be replaced with more meaningful expressions. The point here is that the replacement of segmental by metrical (or autosegmental) formalisms may lead to a gain in insight even in cases where it is not, strictly speaking, necessitated by the surface form of the facts themselves.

Naturally, the observation that autosegmental and metrical formalisms can be profitably extended to some examples in the traditional domain of "segmental" phenomena raises the question of whether or not all "segmental" rules can be so replaced. Allowing three distinct formalisms for phonological processes (segmental, autosegmental, and metrical), where these have significantly different properties, would have the effect of loosening and consequently weakening our notion of phonological structure insofar as all three possibilities are simultaneously available. If we could completely subsume one of these types (e.g., segmental rules) under the others, we could mitigate this consequence without abandoning the gains achieved by the new formalisms.

A recent paper by Halle & Vergnaud (1981) dealing with the typology of vowel harmony processes typifies this research strategy. Halle & Vergnaud argue that among the harmony processes traditionally formulated in segmental terms, some (which they call "dominant" harmony) are suitably described by the formalism of autosegmental phonology; while others (called "directional" harmony) are better described by metrical formalisms. If their conclusions extend to all "harmony processes" in all languages<sup>1</sup> (including, on their account, such things as obstruent voicing assimilation

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in Russian), they would thus succeed in reducing the scope of segmental rules considerably, and one might hope to pursue the same program into other areas of phonology as well. In fact, the recent rash of activity in extending metrical and autosegmental description to a variety of areas beyond those of tone, nasality, and stress where they were first motivated (cf., for example, the papers in *MIT Working Papers in Linguistics*, Vol. 1, or many of the papers in the present volume and its predecessor) can be seen in just this light.

In a paper in Part I of the present collection, Leben raises an important additional question. He notes that, in their extensions into traditionally segmental domains, autosegmental and metrical formalisms actually share a number of properties, and that the ways in which they (potentially) differ from one another are not in fact relevant to such descriptions. On this basis, he suggests that instead of allowing both metrical and autosegmental descriptions of "segmental" phenomena, a single unified formalization can be provided which expresses the relevant properties of both, but which is more restrictive than either taken alone. If this is indeed possible, the result would be a further gain in explanatory power: instead of three possible forms for any given process, we would now be back to the condition of a narrower and more explanatory theory which allowed only one.

The present paper is intended to further extend Leben's crucial observation that the full power of metrical and autosegmental formalisms can be replaced in the relevant domains by a single, more limited rule type. We will suggest, however, that instead of being a sort of hybrid of autosegmental and metrical formalisms, the relevant rule type is essentially the traditional segmental one. It will be argued that the ways in which the two formalisms fall together are such as to exclude just those properties which originally motivated them; and that the modifications which are necessary to extend them to properly "segmental" domains are such as to rob them of their original explanatory power. We will thus contend that the proper way to constrain the possibilities of formalization in phonology is to seek a more careful delimitation of the domains studied in phonology so that, while all three possibilities remain, only one is available (in principle) for the formulation of any given rule.

The arguments presented by Leben make a substantial case for a high degree of homomorphism between autosegmental and metrical solutions in the traditional segmental domain. As we will detail below, however, the same homomorphism extends also to the solutions available within classical segmental formalisms. The nonsegmental descriptions, though, typically require modifications of the relevant theoretical principles. Insofar as these involve a weakening of the theory in question with respect to its original empirical support, one must require strong justification for

such a change. The literature is not, however, replete with such justification: indeed, it can be argued that much of the current enthusiasm for non-segmental solutions in traditionally segmental domains is based more on their novelty than on their appositeness with respect to individual problems.

An example of the sort of reasoning involved is found in Leben's discussion of various analyses of vowel harmony in Khalkha Mongolian. An analysis involving standard segmental rules, applied iteratively, was presented by Anderson (1980); a metrical analysis is provided by Halle & Vergnaud (1981). Disregarding for the moment the comparison of these analyses on internal grounds, Leben contends that their empirical coverage is substantially the same. Leben feels, however, that there is a basis for preferring the metrical account, "because the constraints it posits are needed independently for the description of stress systems" (emphasis mine: sra).

This appears, however, to mis-state the issue. The origins of metrical phonology, which are to be found in the work of Liberman (cf. Liberman & Prince 1977), were based on the argument that stress could only be defined in a rational way if it were treated as a relational notion within hierarchically organized structures not limited to concatenated strings of segments. As this notion was explored (by e.g. Hayes 1980, where a typology of stress systems is proposed and defended in detail), it became clear that manipulations of stress were thus *ipso facto* manipulations of metrical structure. The same conclusion can hardly be drawn, however, for manipulations of such properties as vowel quality, for which a strictly segmental definition seems at least coherent, if not self-evidently correct.

There is an interesting historical parallel to be drawn here between the development of metrical theory and the notion of the transformational cycle in phonology. Like metrical theory, the cycle was initially motivated by a consideration of the facts of (English) stress. Given its apparent success in accounting for complex patterns and alternations of stress, attempts were then made to extend the cycle to handle strictly segmental alternations (in particular, to deal with recalcitrant ordering problems in segmental systems). Most of these attempts must be judged in retrospect, however, to have been misguided, and the cycle remained a mechanism with its only essential support in the area of stress. It was exactly by considering why there should be this specific dependence between stress in particular and a structure-dependent principle such as the cycle that the basic insights of metrical phonology were achieved: an insistence on the universality of cyclic application would only have obscured them. The empirical content of a linguistic theory is often to be evaluated by the specificity of its principles, rather than by their generality (a point made in a syntactic context by Chomsky 1972).

Furthermore, as we will attempt to show below, the level of generality

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Of course, the question that in general segmental henceforth refer to metrical or autosegmental soever in which GV to account for area would seem, however segments (whose inclusion is irrelevant) is fair to consider the rule that is intrusive, from the transfer of a phoneme involved in autosegmental archical structure involved is a voiced consonant formative *-ive*. The relation of metrical metrical structure remain to be stated

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at which the "same" constraints are motivated for (canonical) metrical and segmental phenomena is one which is perfectly accessible to "garden-variety" segmental rules. Rather than extending metrical (and autosegmental) formalisms to new domains, the most interesting move available to phonological theory would appear to be an attempt to restrict (and thereby enrich) the three available ways of formulating phonological descriptions so that they no longer overlap in empirical coverage. It would appear that the level of generality at which the three fall together is so abstract that we have little if any motivation for abandoning strictly segmental accounts, at least in a number of domains.

Of course, the question would not be moot if we had reason to believe that in general segmental mechanisms of the classical sort (which we will henceforth refer to as "GV" or "Garden Variety" rules) were inferior to metrical or autosegmental formulations. If there were no domain whatsoever in which GV rules appeared to be motivated, the question of how to account for areas of potential overlap would hardly even be at issue. It would seem, however, that the status of rules manipulating only strings of segments (whose internal structure, if any, beyond a collection of features is irrelevant) is fairly well assured. For a somewhat trivial example, consider the rule that devoices obstruents in English before the ending *-ive* (as in *intrusive*, from *intrude*). It is quite clear that this rule does not involve the transfer of a phonological property from one segment to another, as is involved in autosegmental re-associations. It is also fairly clear that hierarchical structure is essentially irrelevant to its operation: all that is involved is a voiced obstruent, followed in linear sequence by the particular formative *-ive*. There is thus no motivation for calling this a manipulation of metrical structure, and even if one were to impose a (trivial) metrical structure on the form, the essential content of the rule would remain to be stated segmentally.

A great many morphologically conditioned processes are like the English rule just noted, but the domain of GV rules is not limited to this area. Consider processes of dissimilation, for example. The rule of Woleaian (cf. Sohn 1975) by which /a/ is replaced by /e/ when the next vowel is low, producing alternations such as [merameŋ] "moon" vs. [maraməŋ] "moon-of" from the stem /marama/² provides an instance. Again, the change involved cannot apparently be treated as a reassociation of some autosegmental property. While one can, of course, construct a metrical "tree" consisting of exactly the vowels of the word, and then perform the operation of dissimilation on the elements of this tree, the fact remains that the rule in question in no way involves a manipulation of metrical structure *per se*: the change still remains to be stated after the tree is constructed, and it is not obvious that one gains very much by saying first "disregard the consonants" (i.e., construct a tree containing

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only the vowel-projection<sup>3</sup>) and then "/a/ → [e] /\_\_\_/a/" rather than simply saying "/a/ → [e] /\_\_\_C<sub>0</sub>/a/".

Even some processes that would appear to be natural candidates for metrical or autosegmental formulation turn out, on further examination, to be based directly on segmental structure. In Icelandic, for example, there is a comparatively "low-level" phonetic rule by which vowels are specified as long before, roughly, at most one consonant; but short before two or more. Thus we have *súpa* "to sip" ([su:pa]), with a long vowel, but *síptu* "sip!" ([suftu]) with a short vowel. If this were the whole story, it would of course simply illustrate the rather common state of affairs in which "vowels are long in open syllables, but short in closed syllables". Since such a rule makes essential reference to syllabic structure, it might be assumed to be uncontroversially "metrical" in character.

This impression of the relevance of metrical (specifically, syllabic) structure to the Icelandic length rule is reinforced when we note that some clusters of two consonants are preceded by long, rather than short vowels: specifically, clusters of /p/, /t/, /k/, or /s/ followed by /j/, /r/, or /v/. Thus, one has *völlur* "field" ([vödlur]) "field" with a short vowel before [dl] (phonologically /ll/), but *uppgötva* "discover" ([üpgö:tva]) with a long vowel before [tv]. Of course, the clusters involved are just those which one might plausibly claim are syllabified together into the following syllable, thus yielding open (rather than closed) syllables and strengthening the apparent relevance of syllabic organization to the rule.

Unfortunately, the appearance of such a neat open/closed syllable basis for the Icelandic length rule is illusory. This is shown rather directly by the fact that monosyllables in which a vowel is followed by a single consonant nonetheless show long vowels; and the long vowel of e.g. *bak* "back" ([ba:k]) cannot reasonably be claimed to be produced in an open syllable. One might attempt to argue that in fact, Icelandic has a different principle of syllabification than many other languages, and syllabifies consonants with a preceding (stressed) vowel. The length rule might then be stated as something like "vowels are long before at most one consonant in the same syllable".

In this case, however, the set of obstruent plus semivowel or /r/ clusters noted above becomes an embarrassment to the analysis. There is a (somewhat unusual) class of Icelandic monosyllables ending in clusters of obstruent plus /r/, typified by *sótr*, *pukr*, *snupr*, etc. (which are semi-productively derived by deleting the -a ending of infinitives, as observed by Orešnik and Pétursson 1977). In these words, we still find long vowels: [sö:tr], [pü:kr], [snü:pr]. We must conclude that the vowel length rule in Icelandic yields long vowels when followed by at most one consonant, or by a cluster of voiceless obstruent plus /j/, /v/, or /r/, followed either by another vowel or by the end of the word. For whatever reason, the me-

metrical structure of the (indeed, must) be strictly internal composition

## SIMILARITIES AMONG

We begin, then, from what is to be necessary in phonological rules (as motivated by metrical rules) and syllabic and foot structure. We review Leben's arguments for the formulations, insofar as they concern metrical processes.

## 1. Projection type

Leben notes first that the rules operate on "the same variables" to make clear what the variables are. The notion of a "projective work by Vergnaud & variables employed in place of some more employing expression (sonants), "[+seg]<sub>0</sub>" (direct variables such as etc., phonological device. They suggest an expression such as "[+ of that form consisting expression. Thus, the (exactly) of a string order. If rules are the (rather than directly formulation can dispense

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trical structure of the word is not relevant, and the rule in question can (indeed, must) be stated in terms of a string of segments rather than the internal composition of syllables.

#### SIMILARITIES AMONG TYPES OF RULES

We begin, then, from the premise that three types of rules can be shown to be necessary in phonology: Classical segmental (or GV) rules; autosegmental rules (as motivated by the facts of tone and nasality, at a minimum); and metrical rules (as motivated by facts of stress on the one hand, and of syllable and foot structure, on the other). In the ensuing sections we will review Leben's arguments for identifying autosegmental with metrical formulations, insofar as these fall within the traditional domain of segmental processes.

##### 1. Projection type

Leben notes first that autosegmental and metrical processes in these areas operate on "the same sorts of projections of phonological units". In order to make clear what the issue is here, we must first briefly summarize the notion of a "projection". This construct comes from (so far unpublished) work by Vergnaud & Halle (1978), who suggest that the usual sort of variables employed in segmental rules are too powerful and need to be replaced by some more constrained device. They propose that instead of employing expressions such as " $C_0$ " (representing any number of consonants), " $[+seg]_0$ " (representing any number of segments), etc., or direct variables such as "Q (where Q contains no [+syllabic] segment)", etc., phonological representations should rather make use of a different device. They suggest that, corresponding to a well-formed phonological expression such as "[+syllabic]" there is, for any given form, a *projection* of that form consisting of exactly the elements within it which satisfy the expression. Thus, the "[+syllabic] projection" of a word will consist (exactly) of a string containing all of the vowels in the word, in the same order. If rules are then stated as applying to such projections of forms (rather than directly to the forms themselves), it may be that their formulation can dispense entirely with (explicit) variable terms.

Some further discussion is necessary to clarify the ways in which this view could be taken to impose an empirical limitation on possible rules. For example, if only one expression is allowed to define the projection which a given rule operates on, this would correspond to the claim that at most one type of variable can appear in a single (traditionally formulated) rule. Furthermore, this variable must be interpreted as implicitly appearing

between any two terms of the rule. In this respect, the idea is quite similar to Wilkins' (1980) "Variable Interpretation Convention" in syntax, though Wilkins goes further and contends that not only the place of the variable, but also the form of the expression defining it is derivable from the form of the nonvariable terms in the rule.

In fact, such a stronger proposal has also been made in phonology, in the work of Palacas (1971), Howard (1972), and Jensen (1974), as well as other references. This work was devoted to defining a notion of "adjacency" in phonology, which can be characterized approximately as follows. Let us identify the element of a form which may undergo a given rule as the *focus* of the rule, and the element of the rule which is the primary "trigger" of its operation (e.g., the stop to which a nasal assimilates, the vowel with which other vowels harmonize, etc.) as its *determinant* (employing terminology first introduced by Howard). We might then be able to say that the focus and the determinant of a given rule must be strictly adjacent, except for the optional presence of material whose type is predictable from the expressions which define them.

The goal of the works referred to above was largely to formulate this relation between the definition of the focus and determinant of a rule and the implicit variable separating its terms. While Vergnaud & Halle's notion of a projection corresponds to the claim that for any given rule, a single expression defines (the only) material which can appear freely between the specified terms of the rule, the proposals of Palacas, Howard, and Jensen can be seen as bearing on the stronger claim that the relevant projection for any given rule can be predicted from the form of its specified terms.

For the concept of a projection to have empirical content beyond the claim that only one (type of) variable can appear in a given rule, it is clearly important to specify what is and what is not a possible projection for a particular rule. If a claim along the lines of those made by earlier writers could be sustained, this would be a highly useful result. In general, however, that literature must be regarded as inconclusive: various proposals concerning the relation between (what we here interpret as) the relevant projection and the definitions of the focus and the determinant have been shown to be inadequate, and none can be regarded as sufficient to cover all known cases.

For example, in the Takelma Umlaut rule (cf. Sapir 1922), (suffixal) /a/ becomes /i/ before a following /i/, provided no voiceless consonant intervenes (a condition not stated by Sapir, but inferrable from the range of forms given in his grammar that do and do not undergo umlaut). There is no obvious sense in which voiceless consonants are a function of either the focus (/a/) or the determinant (/i/) of the rule, and it seems unlikely that this condition can be predicted from any other factor in its formulation.

Even if it is impossible to predict the remainder of the limited number of exceptions we need to be able to handle, such as Sanskrit retroflex "syllable rhymes" (ty onsets), etc., but perhaps what material is available to anticipate a rule which final voiced non-coronal and velar consonants)

Leben's observation of the class of possible classes relevant to metric (or at least non-distinct) that the projections of this class. There is a basic notion of a "projection constraint", the issue (rules). Furthermore, extended into the domain of assimilation, and the available to the correct class of projections would certainly appear in literature thus far. It is that, whatever the conditions of this class. Once an adequate set of projection relative to a given it cannot be directly as others), and thus reason to believe) (others).

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Even if it is impossible to predict the form of the relevant projection from the remainder of a rule, however, it may well be the case that only a limited number of expressions are available to define projections. Clearly we need to be able to project "vowels", "coronal consonants" (for rules such as Sanskrit retroflexion), "sibilants" (for Navajo sibilant harmony), "syllable rhymes" (typically relevant to stress rules, to the exclusion of onsets), etc., but perhaps there are some fairly narrow limitations on just what material is available to define a projection. There is little reason to anticipate a rule which operates on the projection of a form's syllable-final voiced non-coronals, for example (including vowels as well as labial and velar consonants).

Leben's observation thus reduces to the claim that, once we specify the class of possible projections relevant to autosegmental rules, and the class relevant to metrical rules, these classes will turn out to be the same (or at least non-distinct). Notice, however, that it still remains to be shown that the projections relevant to GV rules are in some way distinct from this class. There is clearly no incompatibility between GV rules and the basic notion of a projection (indeed, in the strong form of an "adjacency constraint", the issue was first raised exactly in connection with such rules). Furthermore, when metrical and autosegmental formalisms are extended into the domain of such processes as vowel harmony, voicing assimilation, and the like, it stands to reason that whatever projections are available to the corresponding segmental rules will also have to be in the class of projections available to metrical and autosegmental rules. This would certainly appear to be the case from the examples treated in the literature thus far. It would seem, then, that we arrive at the conclusion that, whatever the class of projections available to rules, the defining conditions of this class do not distinguish among our three rule types. Once an adequate set of criteria for defining the notion of "possible projection relative to a given rule" is found, there is no reason to believe that it cannot be directly incorporated into the theory of GV rules (as well as others), and thus this theoretical issue does not (so far as we have reason to believe) distinguish metrical and autosegmental facts from others.

When we examine this conclusion, we may feel that it is an unfortunate one. Indeed, the rules that manipulate "canonically metrical" facts such as stress and syllable structure typically refer to a rather limited range of properties as their "characteristic class". Stress rules refer to syllable structure (including syllable "weight", vowel length, etc.), but not to properties that do not have a metrical representation. That is, we do not find stress rules which require us to assign, e.g., alternating stress before a [-Back] vowel. Rules adjusting syllable structure may well require access to the composition of individual segments, and also to stress (represented as a

relation between syllable nodes), but not (arguably) to structure above this level. Similarly, strictly segmental rules may hinge on facts of syllable structure (e.g., in French the vowels schwa and /e/ are replaced by [ɛ] in closed syllables). There appear to be limits, however, on the extent to which rules manipulating one kind of structure (intra-segmental, intra-syllabic, inter-syllabic, intra-foot, etc.) can "see into" other types of structure. Some concrete suggestions for such a constraint of "metrical locality" are made in work of Hammond (1982).

Once the issues in this domain, concerning the sorts of structure which may be accessible to rules of a given type, are clarified sufficiently we may find that it is possible to assimilate the relevant constraints into a uniform notion of a "projection", applicable to rules of all types. On the other hand, we may not, and it may turn out that different constraints apply to the projections on which metrical, autosegmental, and GV rules are based. The point to be made here is that, at minimum, the class of relevant projections in the traditionally segmental domain does not appear in any way to raise issues which would exclude "GV rule" accounts of such facts, and indeed the only way such issues could bear on the problem would be if we found it necessary to *exclude* certain strictly segmental projection types from the class of those available to metrical or autosegmental rules.

## 2. *Well-formedness constraints*

Another similarity noted by Leben between autosegmental and metrical accounts is that both "obey identical well-formedness constraints": specifically, the constraints suggested by Goldsmith (*op. cit.*). Leben argues, for example, that metrical structures do not skip over and thus ignore elements of their projection, just as co-ordinate autosegmental tiers are associated in a mutually exhaustive fashion. This is potentially a very significant similarity between the two domains, and one which does not appear to have any substantial analog in the theory of GV rules; but we must note that, in order to maintain it, it is apparently necessary to exclude the analysis of phenomena such as vowel harmony from the scope of metrical or autosegmental treatments.

Leben observes, indeed, that the analysis provided by Halle and Vergnaud (1981) for Khalkha Mongolian rounding harmony constitutes a *prima facie* counter-example to the claim that metrical structures exhaust their projections. Their rule constructs a metrical structure starting with a vowel, and incorporating subsequent vowels so long as these are not both [+high] and [+round]<sup>4</sup>. After this tree is constructed, however, it is necessary to "prune" it, by removing all nodes dominating [+high] vowels<sup>5</sup>. The result is a metrical structure which is defined on the vowel-projection of a word, but which does not incorporate all vowels (specifically, it omits [+high] vowels)<sup>6</sup>.

On Leben's view, Khalkha (and certain metrical and autosegmental structures) are related since they involve a "pruning". Alternative accounts appear to arise precisely where the structure is extended into areas where it is not necessitated, we might say.

Vowel harmony in one non-high vowel is not blocked by other high vowels are distinctively specified by the rule; it is thus a constraint would require the rule are (the exclusive feature. It is quite clear that it undergoes the rule in a way which is excluded by its projection (or the structure).

The Khalkha rounding harmony is an example to such a claim about an associated claim about the structure. Examples of this sort are principled basis, of course, accounts to the matter. Autosegmental structures are continuous (even in the case of Khalkha rounding harmony) metrical (or non-autosegmental) structures are not such a radical weaker account by Halle & Vergnaud. The result is a vast increase in the number of structures between such structures and autosegmental structures. It is possible empirical structures to ignore the structure limited as narrowly as possible. The rule analyses is at the level of phonological description.

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On Leben's view, this difference between Halle & Vergnaud's account of Khalkha (and certain other processes discussed in their paper) and other metrical and autosegmental rules is simply a matter of mechanics: the projections that are relevant are merely harder to specify here than usual, since they involve a complex, two step algorithm with a notion of "tree-pruning". Alternatively, however, since this sort of additional complexity appears to arise precisely when metrical and autosegmental accounts are extended into areas other than those in which they are structurally necessitated, we might take it as an argument against such extensions.

Vowel harmony in a language like Khalkha Mongolian propagates from one non-high vowel to another; it ignores intervening /i/'s, but is stopped by other high vowels (/u/ or /ü/). We must note that all of /i/, /u/ and /ü/ are distinctively specified for the feature [ $\pm$ Round], which is manipulated by the rule; it is thus impossible to claim (as various proposed adjacency constraints would require) that both the foci and the determinants of the rule are (the exclusive) parts of a single unit specified by the harmonizing feature. It is quite clear, indeed, that material which neither conditons nor undergoes the rule is nonetheless relevant, and it is precisely this possibility which is excluded by the requirement that a metrical tree exhaust its projection (or that autosegmental tiers be exhaustively co-associated).

The Khalkha rounding harmony rule appears to furnish a counter-example to such a requirement, but we can nonetheless preserve the associated claim about metrical and autosegmental analysis if we exclude examples of this sort from their scope. This is easy enough to do on a principled basis, of course, if we simply limit metrical and autosegmental accounts to the manipulation of (independently motivated) metrical and autosegmental structure. GV rules are quite adept at describing such discontinuous (even in terms of a projection) dependencies as that arising in Khalkha rounding harmony: it is only if we insist that there are no non-metrical (or non-autosegmental) facts at all that this example forces us to such a radical weakening of the notion of metrical structure as that entailed by Halle & Vergnaud's two step tree-pruning analysis. Such algorithms vastly increase the range of possible metrical structures and relations between such structures and the projections of rules, since there is no possible *empirical* difference between allowing them and allowing metrical structures to ignore part of a relevant projection. They should thus be limited as narrowly as possible, and confining them to the domain of GV rule analyses is at least a step in the direction of limiting the power of phonological descriptions.

In addition to the requirement of exhaustive association, autosegmental representations are also subject to a constraint that association lines do not "cross" (in a geometrically obvious sense). Leben suggests that the same constraint, in essence, extends to metrical structures in the requirement that metrical trees do not overlap.

We must note first of all that if this is true, it must be relativized to the structure associated with a particular rule. Metrical trees that appear in segmental analyses, at least as far as these have been presented in the literature, are constructed *ad hoc* for each particular rule; after the rule has applied, they are not relevant (or accessible) to other rules. For example, the trees constructed for describing rounding harmony in a language like Turkish are not the same as those necessary for describing backness harmony in the same language. Trees constructed for distinct rules, thus, can and must overlap.

It might be proposed that this sort of overlap does indeed have an analog in the autosegmental domain: the associations between one pair of tiers are constructed independently of those between other pairs of tiers (e.g., associations between the "segmental core" of a form and its tonal representation are in principle independent of those between this core and its associated nasality tier). As a result, one set of associations may in fact "cross" or overlap with another set.

This apparent parallel, however, is so severely limited as to suggest that it is illusory. In fact, the relativization of the non-crossing requirement for autosegmental structures is to *tiers*, or structurally motivated aspects of forms, and not to *rules*. All of the rules manipulating tone-segment associations, that is, must respect the same set of non-crossing associations, while there is no such requirement that could apparently be imposed on metrical analyses of segmental phenomena that trees for different rules do not overlap insofar as they are defined by the same features.

We would, nonetheless, like to maintain the important constraint indicated by Leben, and prohibit overlap between metrical structures insofar as possible. In this regard, there is an important difference between the metrical trees constructed by rules designed to account for fundamentally segmental phenomena, and those constructed for essentially metrical facts (stress, syllabification, etc.). In the former case, there is in fact no way (even in principle) to verify the nature of the metrical structure assigned, since that assigned for one rule is by its very nature irrelevant to that assigned for another. Such structures, as we have noted, tend to show a significant degree of overlap from rule to rule.

By contrast, metrical structure which is motivated by the structural nature of the facts (rather than by the necessities of rule formulation) does not have such a character at all. The stress tree which is relevant for one rule, that is, is not allowed to be arbitrarily different from the stress tree which another rule requires for the same form. If the stress trees assigned to a given form must differ from one rule to another, this can only be by virtue of the existence of an independently motivated rule specifying the difference (a stress shifting rule, or the like). Similarly, the syllabification which is relevant to one rule can only differ from that

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### *3. Prominence*

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relevant to another insofar as the grammar contains a rule of resyllabification.

It would seem, then, that an assimilation of segmental phenomena to metrical facts, through the attribution of rule-particular metrical trees to processes of the former sort, involves a conceptual confusion which would prevent the imposition of a useful constraint on the notion "metrical tree". The notion of "non-overlapping structure" which is relevant for (metrical formulations of) segmental processes would appear to be distinct in character from that which is relevant for genuinely metrical phenomena.

We might ask, however, just what analog of a "non-overlap" constraint there is in the segmental domain. If it is indeed true (as it appears to be) that the ad hoc metrical structures assigned by an individual segmental rule do not overlap with one another, we can nonetheless formulate this constraint purely in terms of the properties of GV rules. What this constraint involves, that is, is roughly the following: when a given form contains multiple "determinants" (in the terminology used above) that could each influence the same "focus", only the determinant nearest to a given focus is allowed to be taken into account. Similarly, perhaps, when multiple foci are potentially subject to the influence of a single determinant, only the nearest is allowed to be affected<sup>7</sup>, though this is somewhat more controversial.

This constraint, requiring that the action of phonological rules be essentially local in character, is one which it could be argued has generally been taken for granted, though it has only been explicitly addressed in the literature referred to above on possible "adjacency conditions" and the like. Indeed, Leben also makes use of a similar constraint later in his paper, in a rather revealing way. In discussing the rule of *t*-flapping in English, he notes that, in cases where more than one *t* is found in a given foot, one which is distant from the conditioning factor (here, the location of main stress within the foot) can only be flapped if those closer to the determinant are also flapped. Given the rest of the analysis<sup>8</sup>, this appears to be a constraint which does not follow directly from the metrical formalism itself, and which must be stated separately in some way. Of course, we may hope that such constraints can, when fully understood, be formulated in a general fashion rather than on a language-particular basis. Since they appear to be applicable precisely to GV rules (or the pseudo-trees involved in metrical re-formulations of these), this would seem to furnish another potential argument for separating GV rules from metrical (and autosegmental) processes.

### 3. Prominence

Leben next notes that metrical and autosegmental formalisms are similar

in that both contrast "prominent vs. less prominent elements". That is, in an autosegmental representation some elements on one tier may be directly associated with designated (or "starred") elements on another, while other elements are not so associated. General principles of re-association may reorganize the lines connecting previously unassociated elements, but designated and pre-associated elements are not altered by convention. In metrical phonology, similarly, trees are constructed on the basis of some designated terminal element, and the device by which e.g. assimilation is performed is by the assignment of some feature from the designated terminal element of a (sub-)tree to a higher level node, from which it "percolates down" to other, less prominent nodes.

It is probably accurate to suggest that the designated elements of metrical and autosegmental structures are analogous, since both serve as the locus from which derived properties are spread. This similarity hardly excludes the class of GV rules, however. Its content seems precisely the same as that of the contrast between an element that conditions a rule (the determinant, in the terminology employed above) and that which undergoes it (the focus). The focus is "non-prominent" with respect to the determinant. Insofar as this distinction is an appropriate one to make, then, it can be made in the segmental realm independently of the utilization of metrical or autosegmental formalisms.

#### *4. Preservation of ancillary structure*

Another similarity noted by Leben between metrical and autosegmental formalisms is that both leave unchanged the structure to which rules do not explicitly refer. An autosegmental rule affecting the tonal tier, for example, does not alter the segments associated with the tones unless explicitly formulated so as to do so, and vice versa. The result is the well-known phenomenon of tone preservation (when a segment, but not its tone, is deleted), as well as the spreading of (remaining) tones when a tone, but not its associated segment, is deleted. In the metrical domain, this corresponds to the fact that a rule only operates on the tree built on its projection: unprojected elements are not affected.

A natural interpretation of the preservation of unprojected elements in metrical processes leads to an interesting account of vowel reduction. In a language like English, vowels are reduced to schwa under lack of stress (with certain additional conditions); and it has always been somewhat problematic to formulate this process in a way which reveals its real effect on vowel quality. This is because a positive specification of the quality of schwa is rather complex, and there is no evident reason why such a vowel (often described as a higher-mid back unrounded quality) should be produced as the result of what is, evidently, a simplificatory

#### *Differences in Rule*

process. An attempt to solve the problem that this presents is more than others.

These difficulties arise from the fact that the position which is not filled (we thus regard schwa as occupying a following consonantal auditory) position is a segmental slot occupied with no segmental form (an "unfilled node") at some length for a number of advantages.

If we apply this to the vowel reduction rule of the segmental quality. This description proceeds from the fact that, when we delete the segmental form of the metrical structure, the quality features, and the structure is preserved.

As the other side of the coin, the deletion of a segmental form of its associated feature in a language like Capanahuá is based on the fact that the quality features found basically on adjacent (arbitrarily located) segments are the facts cited by the principles involved in the formation of a word, it is the segments to its left that determine the rule of regressive nasalization.

(1) [-Cons] —

Alternatively, the process of association:

process. An attempt to specify the quality of schwa directly also runs into the problem that this vowel shows substantially more contextual variation than others.

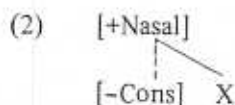
These difficulties are resolvable if we treat schwa not as some particular (partly context dependent) set of quality features, but rather as a vowel position which is not specified at all for (at least some) quality features. If we thus regard schwa as simply a "vocalic transition" from a preceding to a following consonant, rather than as a determinate set of articulatory (or auditory) position features, this naturally suggests treating it formally as a segmental slot occupying the position of nucleus within a syllable, but with no segmental features assigned to that slot (a phonological analog of an "unfilled node" in syntax). Such an analysis is proposed and defended at some length for French by Anderson (1982), where it appears to have a number of advantages.

If we apply this treatment to English schwa, we can then formulate the vowel reduction rule not as a change in quality, but rather as the deletion of the segmental quality features associated with certain unstressed nuclei. This description properly captures the fact that we are dealing with a rule of vowel reduction, but it is crucially dependent on the assumption that, when we delete the quality features, this change does not by itself entail the deletion of the vowel's segmental slot. The latter, as an aspect of the metrical structure of the syllable, is of quite a distinct type from the quality features, and it seems natural to apply the principle (that ancillary structure is preserved unchanged) in such a way that it is not affected.

As the other side of this coin, there are also some instances in which the deletion of a segmental position does not result in the complete loss of its associated features. A fascinating example is found in the Panoan language Capanahua, discussed by Halle & Vergnaud (1981 - ultimately on the basis of the description by Loos 1969). In this language, nasality is found basically on consonants only, but spreads in regular ways to adjacent (arbitrarily long) sequences of vowels and glides. We will not repeat the facts cited by previous authors in detail here, but simply summarize the principles involved. When a nasal consonant appears in (the surface form of) a word, its nasality spreads to a sequence of non-consonantal segments to its left only. We assume this can be adequately described by a rule of regressive nasalization, applying iteratively:

- (1) [-Cons]  $\longrightarrow$  [+Nasal] / \_\_\_\_\_ [+Nasal]

Alternatively, the process could be formulated as one of autosegmental re-association:



Under certain circumstances<sup>9</sup>, however, nasal consonants may be deleted. When this happens, their nasality is nonetheless preserved, and spreads not only to the left of their original position, but rightward as well.

We could accommodate these facts by the assumptions that a) all and only [+consonantal] segments are associated with a value of nasality in underlying structure; and b) the deletion rule deletes the segmental position of the nasal, and its other features, but not the associated nasality value. As a result, when the segment is deleted, the remaining [+nasal] autosegment will be re-associated by convention with those non-consonants which are accessible to it (i.e., not separated from it by a segment linked to a nasality value). Such re-association is by its nature non-directional, accounting for its spread both to the right and to the left.

It thus appears that the proper perspective to adopt with regard to deletion rules is an autosegmental one. Assuming that a segmental position (in the metrical structure of a syllable) can be associated with autosegmental material on several tiers (i.e., nasality, tone, oral articulation, etc.) we can allow rules to delete any or all of these associated elements, potentially independent of one another. If we recognize that, from an autosegmental perspective, rules must thus specify<sup>10</sup> the parts of a "segment" to which they apply, we can thus maintain the generalization that material unreferenced by a rule is not changed by it.

In any event, this property of "structure conservation" which is shared (in some form) by metrical and autosegmental formalisms is also a characteristic of GV rules. It has always been assumed, of course, that features not mentioned in a given rule are conserved unchanged<sup>11</sup>. The principal exception to this (disregarding the observations of footnote 11) is found in the domain of deletion rules: when a rule deletes a segment (to simplify a consonant cluster, for example), we normally assume that the segment's features are lost as well, whether they are explicitly mentioned in the rule or not. As we have just seen above, however, such deletions are probably to be regarded as based on the autosegmental structure of the form, and thus do not form a real exception. There is no reason, therefore, to suggest that the property of conserving unreferenced structure separates GV rules from autosegmental and metrical ones.

### 5. *Idiosyncratic specification*

Leben next observes that both autosegmental and metrical structure, while generally assigned by rule, may also be specified exceptionally. Thus, some

### *Differences in Re*

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Indeed, we can metrical structure ment of comparison is, are not subjecte ness condition; a pattern or syllab language's general mental specifica harmony, for exam pattern does not applying to non- mits only cluster rowings and othe non-anomalous c or past tense fon etc. Again, GV r segmental and me

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autosegments are lexically associated with elements on other tiers; and some metrical structure may have to be assumed present in underlying representations. It is of course hardly remarkable that this similarity also carries over to the GV rules: it has often been noted that a property which is generally assigned by rule may (exceptionally) be lexically listed instead.

Indeed, we can make the parallel more precise. Both autosegmental and metrical structure, when specified idiosyncratically, preclude the assignment of comparable structure by a general rule. Lexical associations, that is, are not subject to reorganization by the principles of the well-formedness condition; and a form which has been given an idiosyncratic stress pattern or syllabic structure does not have this annihilated by the language's general principles. Similarly, we can note that exceptional segmental specification overrides a general rule. In the domain of vowel harmony, for example, a word with an exceptional internally non-harmonic pattern does not have this replaced with regular harmony by the rules applying to non-exceptional forms. Similarly, if a language normally admits only clusters of a certain form, exceptional clusters found in borrowings and other unusual words are not thereby converted into regular, non-anomalous clusters. Morphological exceptions (e.g., irregular plurals or past tense forms in English) are not also supplied with regular endings, etc. Again, GV rules appear to share all of the relevant properties of autosegmental and metrical formulations in the segmental domain.

#### 6. *Scope of Application*

Finally, Leben notes that both metrical and autosegmental analyses distinguish between two sorts of structure. One of these is strictly local and bounded: in metrical terms, this is the type of a binary tree, while in autosegmental terms, it is the notion of a limited, language-particular re-association. The other sort of structure is a global, unlimited one: metrically, an unbounded tree, and autosegmentally the kind of unbounded association identified with the operation of the well-formedness conditions.

This is, in a way, the area in which we can find the most substantive parallel between metrical/autosegmental analyses and those provided by GV rules. Anderson (1974), among others, argues for a distinction in phonological rules between those that do and those that do not re-apply to their own output (i.e., between iterative and non-iterative rules). For instance, some languages have rules which delete a final short vowel, but reduce a final long vowel to short. This can be formulated as a simple rule which deletes a final vowel position, and which does not re-apply to its own output. Other languages, however, have rules which delete a final

consonant if this is preceded by another consonant; and such a rule often re-applies until an original final cluster of arbitrary length is reduced to a single consonant. The distinction between iterative and non-iterative rules is well motivated for GV rules, and corresponds quite directly to the difference between local and unbounded structure in autosegmental and metrical analyses.

#### DIFFERENCES BETWEEN AUTOSEGMENTAL AND METRICAL ACCOUNTS

After arguing that there are important similarities between autosegmental and metrical analyses, Leben then goes on to consider the areas in which the two theories appear to make rather different claims. He argues that the differences are actually illusory, and that a single formalism can accurately represent the essential properties of both.

##### 1. Internal structure

The first area in which the formalisms of autosegmental and metrical theory differ concerns the internal structure of units. Metrical trees, that is, contain a considerable amount of internal structure (based on the fact that they organize potentially arbitrary amounts of material by an operation of binary branching), while autosegmental structures are essentially "flat". Leben suggests that the structure imposed by metrical analyses, however, is unnecessary and unmotivated by anything other than the requirements of the theory. If true, this would suggest that flat structures such as those characteristic of autosegmental analyses would suffice in both cases.

A consideration of instances in which metrical formalisms have been employed to handle essentially segmental phenomena (such as those discussed in Halle & Vergnaud 1981) confirms the claim that, where such internal structure is assigned, it plays no subsequent role in the analysis. Leben also argues at length that structure internal to the foot is never necessary. On the other hand, there are some areas in which the internal structure of metrical trees clearly *does* play a role. For instance, it is only in terms of the internal organization of word trees that the complex array of stress distinctions in a language like English can be represented adequately. Similarly, the internal constituent structure of syllables provides us with a representation of crucial differences between syllable onsets and rhymes, nuclei and margins (or codas). Arguably, it is the internal structure of the syllable which represents the property treated in somewhat *ad hoc* fashion by Chomsky & Halle (1968) as the feature [ $\pm$ Syllabic] (cf. Anderson 1982 for some discussion).

#### Differences in Rule Type

We must thus conclude that the conclusions cannot in general be equally true that there are equally motivated. The answer to the theory in such a way that it seems clear that it is straightforwardly segmental problem. We leave the general development well understood of the theory. With this possible exception of internal structure, the important central point of the theory is to abandon this, as well as, ever, by confining metrical analysis to describing segmental changes.

##### 2. Directionality

Another apparent difference between metrical phonology and autosegmental phonology is the fact that the constraints are directional, while the constraints are directionless. Indeed, the difference in their characteristics they suggest, are bidirectional, and they provide the distinction between the two theories.

Leben suggests that the distinction between the two theories, is largely illusory. We need to make use of the concept of "anchoring" of foot structures. We have bidirectional aspects to the formalisms; his suggestion is that trees are constructed in such a way as to whether binary processes are, on this point, symmetric directional.

Without questioning Leben's proposed instrument, we establish the point that it is given by Hayes (1980).

We must thus conclude that the internal structure of metrical representations cannot in general be dispensed with; but on the other hand, it is equally true that there are substantial domains in which it cannot be motivated. The answer to this dilemma, of course, is to constrain metrical theory in such a way that it does not apply (with the concomitant necessity of imposing unmotivated internal structure) in such areas. In particular, it seems clear that it is the extension of metrical analyses to facts of straightforwardly segmental character that is largely responsible for the problem. We leave the issue of internal structure for feet unresolved: in the general development of metrical theory the foot is evidently the least well understood of the various structural entities that have been posited. With this possible exception, we should recall that it is precisely the assumption of internal hierarchical structure that constitutes the important central point of metrical analyses. It would thus be a considerable loss to abandon this, as Leben proposes. We can avoid his conclusion, however, by confining metrical analyses to facts of a metrical nature, and describing segmental changes within some theory such as that of GV rules.

## 2. Directionality

Another apparent difference between analyses within the framework of metrical phonology and those carried out in autosegmental terms rests on the fact that the construction of metrical trees is performed on a directional basis, while the spreading of autosegmental associations is inherently directionless. Indeed, Halle & Vergnaud (1981) make use of exactly this difference in their characterization of harmony systems. Some of these, they suggest, are bidirectional ("dominant" harmony), while others are directional, and they propose that this difference should be represented as the distinction between autosegmental and metrical treatments.

Leben suggests that this, like other differences between the two frameworks, is largely illusory. He argues that autosegmental analyses sometimes need to make use of directional determinations (to determine the location of "anchoring" of floating tones), and that metrical analyses sometimes have bidirectional aspects. On this basis, Leben proposes to unify the two formalisms; his suggestion is a system in which (internally unstructured) trees are constructed in a directional fashion, presumably with an option as to whether binary or unbounded structures are the result. Bidirectional processes are, on this view, to be treated as the simple conjunction of two symmetric directional sub-cases.

Without questioning all of the parts of this claim, we can note that Leben's proposed instance of a bidirectional metrical rule does not really establish the point it is intended to make. In the analysis of Garawa stress given by Hayes (1980), it is observed that *main* stress is determined by a

principle that operates from left to right, while *secondary* (and tertiary) stress are determined by a rule that operates from right to left. Since these are two quite separate rules, however, this fails to establish the point that *individual* metrical processes may be bidirectional.

In fact, while the two formalisms may not be mutually exclusive (because of the possibility of directionally restricted autosegmental associations), it is apparent that they differ from one another in this respect. Metrical structures (taken individually) seem quite resolutely directional in character, while autosegmental processes at least admit the possibility of bidirectional application (indeed, this is clearly the most common case). Since in some domains (e.g., vowel harmony and similar assimilations) the directional/bidirectional distinction seems to have a typological significance, we might feel that it is appropriate to capture it by the metrical/autosegmental difference.

The conclusion that metrical and autosegmental formalisms must be extended into the area of harmony processes in order to capture the difference between directional and bidirectional rules is not at all a necessary one, however. In fact, the theory of GV rules already contains a device which represents this parameter in a simple and direct fashion. Discussion within this framework, originating with the work of Bach (1968) and continuing in Anderson (1974) and other references, has argued that a class of *mirror-image* rules must be recognized in phonology, as well as the class of ordinary directionally unique rules. A mirror-image rule, of course, is exactly a (systematically recognised) pair of symmetrically related directional rules, similar to Leben's analog of bidirectional processes, but without the assumption of any crucial structure beyond that of the sequence of segments.

We can completely accept Halle & Vergnaud's proposed distinction between "dominant" and "directional" harmony rules, then, but without moving outside of the domain expressible by GV rules: directional harmony corresponds to the simple case of an ordinary assimilation rule, while dominant harmony corresponds to the mirror-image version of essentially the same rule. Again, the decisive facts in the area for which Leben argues for similarity between autosegmental and metrical accounts turn out to be completely expressible without loss of generality in the more traditional theory. Indeed, in this case, the issue has already been addressed quite explicitly in the literature of that theory.

#### CONCLUSIONS

In the above discussion we have found (on the basis of Leben's previous discussion) a number of areas in which metrical and autosegmental formal-

isms have similar properties. We tend, by and large, to use the same mental rules. Among the characteristics of prominent elements are that they are not derived from more prominent elements ("derived" elements are not derived unchanged from more prominent elements) (lexicalised) specific elements do not over-ride a competing element's property by general rule.

In other areas, however, the formalisms can only be distinguished by their (potential) theoretical properties. The fact that the imposition of projections on which we base the theory is not a necessary rule. We also saw that bounded processes in the literature, as the domain that do. Indeed, it is to express processes that are interestingly restricted that the formalisms fall out in place of the device of. Finally, metrical and autosegmental formalisms (motivating cases) seem to be (or directionality), and this introduces the conceptual difference.

The principal theoretical question has been to question the mechanisms have some of these apparent differences. The question are extended to be motivated to account for these proposed extensions. The content of the two theories in question are already addressed in the mental rules.

For example, we can distinguish between the well-formedness conditions and the set of conditions generated by the theory. There are certain cases

secondary (and tertiary) right to left. Since these establish the point that

mutually exclusive (be-cause autosegmental associat-ions) in this respect. The resolutely directional admit the possibility of (the most common case). (Similar assimilations) the typological significance, by the metrical/autoseg-

al formalisms must be in order to capture the rules is not at all a ne-glect already contains a role and direct fashion. In the work of Bach (and other references, has been recognized in phonology, as rules. A mirror-image (reversed) pair of symme-trical analog of bidirectional structure beyond

proposed distinction rules, then, but without the directional harmony assimilation rule, while the version of essentially for which Leben argues accounts turn out to be the more traditional has been addressed quite

s of Leben's previous autosegmental formal-

isms have similar properties; and we have seen that these similarities extend, by and large, to descriptions in terms of traditional ("GV") segmental rules. Among these properties, which evidently constitute general characteristics of phonological systems, we can cite the distinction between prominent elements ("determinants") and less prominent, or subordinated elements ("foci"); the principle that unreferenced structure is conserved unchanged under the operation of a rule; and the principle that the (lexicalised) specification of a property in a way idiosyncratic to a form over-rides a competing but incompatible specification of the same property by general rule.

In other areas, however, we find that differences between these formalisms can only be eliminated at the cost of depriving them of some of their (potential) theoretical significance. For instance, we have argued above that the imposition of significant limitations on the range of possible projections on which a given rule may be based will only be possible if we base the theory of projections on a maximally articulated typology of rules. We also saw above that the distinction between strictly local and unbounded processes is one which has already been discussed in the traditional literature, as the difference between rules that do not iterate and those that do. Indeed, it is argued by Anderson (1974) that the use of iteration to express processes extending across unbounded segmental domains is an interestingly restrictive one<sup>12</sup>. Until it can be shown that comparable constraints fall out in other formalisms, it would seem to be undesirable to replace the device of iterative application with a less restrictive mechanism. Finally, metrical and autosegmental processes (at least in their central motivating cases) seem to differ significantly in their degree of symmetry (or directionality), and the attempt to eliminate this difference again reduces the conceptual content of both theories.

The principal thrust of the discussion in this paper, however, has not been to question Leben's conclusion that metrical and autosegmental mechanisms have significant similarities. Rather, it is to point out that some of these apparent similarities arise precisely when the formalisms in question are extended beyond the areas in which they were originally motivated to accommodate phenomena of a "segmental" sort. If we admit these proposed extensions, the result is a major weakening of the empirical content of the two theories; but we need not do so, since the domains in question are already accommodated within the traditional theory of segmental rules.

For example, we saw above that there is a significant amount of overlap between the well-formedness constraints applicable to autosegmental representations and the character of metrical trees. In order to extract a set of conditions generally applicable to phonological principles, however, there are certain cases which must be excluded. We would like to claim

that metrical trees, like autosegmental representations, are subject to a condition of exhaustiveness which requires that all of the elements of their projection be incorporated. Analyses of segmental phenomena such as vowel harmony, however, violate this condition since some elements of their projections must be systematically pruned from the metrical tree. Again, metrical trees for well-motivated properties such as stress and syllable structure are subject to conditions of non-overlap quite similar to the requirement that autosegmental association lines do not cross; but the trees constructed *ad hoc* for particular segmental rules may well overlap, regardless of the features that define the elements on which they are constructed. In both of these instances, the general condition suggested by Leben as a similarity between metrical and autosegmental formalisms can only be maintained if we limit the class of processes which these describe.

The most important reason to restrict the application of non-segmental mechanisms to segmental processes is that the failure to do so has direct consequences for their underlying empirical content. The essence of metrical representations, for example, is the imposition of an articulated hierarchical structure on a string of segments; but precisely in the extension of the metrical tree device to segmental phenomena, we encounter the objection that the internal structure assigned is unmotivated by any but theoretical considerations. By contrast, the internal structure of genuinely metrical representations such as those for stress and syllable structure is abundantly motivated by the facts themselves.

A similar point can be made with respect to autosegmental structure. The important insight of this theory is that the phonetic properties of speech, while generally coordinated and synchronized in a unitary way as expressed by the notion of the segment, may also display a certain amount of independence from one another in this regard. The formal reflection of this fact is the representation of distinct phonetic properties as distinct tiers of autosegmental structure, with the coordination among them represented by lines of association between the units on different tiers. When autosegmental analysis is extended beyond domains such as tone and nasality, however, and made to accommodate vowel harmony and the like, this conceptual content must evidently be greatly reduced. Analyses of vowel harmony must evidently allow the *same* phonetic property to be simultaneously and independently represented on two or more autosegmental tiers. This move vastly reduces the extent to which autosegmental theory is a claim about phonetic structure, and converts it into a mere mechanism for stating certain processes algorithmically.

Such moves might well be justified if they were unavoidable, in that only metrical or autosegmental accounts could properly express the properties of rules such as those of vowel harmony. This is far from

being the case, however, of assimilation forms where appropriate are quite capable of being constrained in a fashion of a degree of empirical generality that is far removed from such areas.

This does not at all mean that the current formulations of all rules are equally good. For example, it is quite possible that strings of segments that lack syllabic structure. A rule that makes of metrical description, and the usual change (e.g., as a matter of higher level nodes and association lines). If correct, then they naturally metrical and forms to which rules reason to prevent an

However, we should not blind us to the fact that the theory and that the theory accommodating many is a complete, fully there clearly remain is not obvious, how bly more successful, therefore warrant further. Rather, we should theory has taught us domains that had previously consolidate the gains possible the aspects of tly available to us isstantial internal structure overall view of the internal homogeneity

being the case, however. As argued in Anderson (1980), segmental rules of assimilation formulated within a theory of GV rules, applied iteratively where appropriate and either unidirectionally or in mirror-image fashion, are quite capable of expressing the properties of harmony systems in a constrained fashion. As a result, we should prefer to retain a maximal degree of empirical content for non-segmental formalisms by excluding them from such areas.

This does not at all entail the conclusion that the insights of metrical and autosegmental phonology should be abandoned, or that segmental formulations of all rules traditionally treated in such terms are appropriate. For example, it is quite clear that many rules usually written in terms of strings of segments are more appropriately formulated by reference to syllabic structure. We must distinguish here, however, between the use a rule makes of metrical (or autosegmental) structure in its structural description, and the utilisation of the associated formalism in stating its change (e.g., as a matter of tree construction, with properties assigned to higher level nodes then percolating down; or as a matter of redrawing association lines). If the claims of recent work in phonology are generally correct, then they must result in the conclusion that speech has an essentially metrical and autosegmental structure. If this is the case, and the forms to which rules apply necessarily have these aspects, there is no reason to prevent analyses which refer to them.

However, we should not allow the insights achieved in recent years to blind us to the fact that speech also has a segmental aspect, apparently; and that the theory of segmental rules is actually quite successful in accommodating many phonological properties. This is not to say that there is a complete, fully determined theory of "GV-rules": far from it, since there clearly remain many open questions to be resolved in that area. It is not obvious, however, that non-segmental alternatives have been notably more successful to date in dealing with these issues, and that there is therefore warrant for a wholesale replacement of the traditional theory. Rather, we should recognize that work in autosegmental and metrical theory has taught us *new* things about phonology, ways of looking at domains that had previously been recalcitrant to analysis. The best way to consolidate the gains of this work is to attempt to delimit as carefully as possible the aspects of structure for which each of the mechanisms currently available to us is appropriate. A richly articulated theory, with substantial internal structure, is much more likely to provide an adequate overall view of the nature of language than one which displays complete internal homogeneity.

## NOTES

1. A comparison between autosegmental and segmental treatments of vowel harmony was made in Anderson (1980), where it was concluded that autosegmental analyses offered no serious advantages over traditional accounts (once these are adequately formulated), and in fact seem inferior to these on some counts. Although Halle & Vergnaud deal with some of the same examples, they do not in fact address the arguments presented for this conclusion, and their own paper does not furnish (at least in my opinion) grounds for reversing this earlier judgement.
2. In the isolation form of this word, the final vowel is devoiced and raised to [e̥]; the penultimate /a/ is thus preserved (since it does not precede /a/), but the antepenultimate /a/ is dissimilated. In the "possessed" form, on the other hand, no change takes place in the final vowel, and it is thus the penult (of the stem) which dissimilates. After this change, of course, the initial vowel is no longer followed by /a/, and is thus preserved.
3. The notion of a "projection" will be further discussed below.
4. When a [+high, +round] vowel is encountered, it initiates a new tree of which it serves as the leftmost branch.
5. This is because [+high, +round] vowels do not trigger harmony, and [+high, -round] ones are transparent (or "neutral") with respect to the propagation of harmony from a preceding vowel.
6. Notice that it would not suffice simply to define the rule on the projection of [-high] vowels in a word, since rounded high vowels, while they do not initiate or undergo harmony, block its propagation to their right.
7. We can note that this latter portion of the proposed constraint is quite close to the issue discussed by Anderson (1974) in connection with the prohibition of the "(X)\*" notation of Chomsky and Halle (1968), and its replacement by iterative re-application of a single, simple rule. The spirit of the constraint, that is, is to prohibit phonological action at a distance except where intermediate elements exist which themselves are changed by the rule in question into potentially "local" determinants.
8. A somewhat different analysis of *t*-flapping, not based on a rule sensitive to foot structure, is argued for by Hammond (1982).
9. According to Loos (1969: 178f), this happens when the nasal is a) final; b) followed by a continuant consonant or a glide (including [ʔ]); or c) medial in a three consonant cluster.
10. It may well be that this specification is partly a global property of languages, rather than simply a local property of rules. It has often been suggested, that is, that languages differ to some extent in the amount to which they are "autosegmentalized". In some languages, properties such as tone, nasality, etc. behave exactly as any segmental feature, and apparently appear on the same tier with other features. Other languages, in contrast, allow considerable autonomy in such properties. It might be suggested that the amount of specification necessary for particular rules is a function of the amount of autosegmental independence displayed by the language as a whole.
11. The theory of markedness proposed by Chomsky and Halle (1968) constitutes a possible exception to this observation, since the notion of "linking rules" which forms a part of this theory is an explicit provision for changes (by convention) in features not mentioned explicitly in the rule. It must be said, however, that this theory has been little discussed since its initial presentation, and few phonologists would probably feel that the notion of "linking rules" forms a substantive part of phonological theory. One exception, perhaps, is to be found in the case of features which are incompatible by their logical nature, and for which we must assume some adjustments by convention; thus, when a rule makes a segment [+low], it must also

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12. This follows from an iterative rule must c primary determinant. 1 between focus and dete

become [-high] by virtue of the definition of the feature system. Such cases, we assume, are comparatively limited in their import for the principles under discussion here.

12. This follows from the fact that, in order to apply across an unbounded domain, an iterative rule must create outputs that also satisfy the structural description of its primary determinant. No comparable constraint appears to exist on the relation between focus and determinant in unbounded metrical processes.

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