DISJUNCTIVE OR CONJUNCTIVE (?) AND INTRINSIC OR EXTRINSIC (?) ORDERED RULES IN PHONOLOGY

It is well accepted by now that the phonological rules which map abstract underlying representations into derived phonetic representations are linearly ordered.[1] By imposing an ordering on rules it becomes possible to simplify the environments of rules--in particular, to state similar environmental conditions only once--hence to capture generalizations operating within the phonology. If one consults the literature on ordered rules, one finds that two different kinds of ordering have been discussed: first, intrinsic vs. extrinsic ordering, which has to do with the determining of the appropriate ordering of two or more rules; more recently, disjunctive vs. conjunctive ordering, which is concerned with conditions on how the ordered rules are to be applied.

In Part I of this paper I present examples of rules which are intrinsically or extrinsically ordered and of rules which are disjunctively or conjunctively ordered. The examples and discussion are intended as background for what is to follow. After having established the notions of intrinsic-extrinsic ordering and of disjunctive-conjunctive ordering, in Part II I turn to their inter-relation--that is, how intrinsic-extrinsic ordering interacts with disjunctive-conjunctive ordering. I shall try to show that the constraints on interaction are quite severe. Since the principle of disjunctive-conjunctive ordering is tied up with certain notational devices--in particular, the use of parentheses and braces--I shall also be concerned with these notations and the conventions for their interpretation. In Part III I consider rules which can be expressed through more than one notational device and shall offer suggestions as to which of the possible notations is to be preferred.

I

The following example illustrates the difference between unordered and ordered rules. Consider a hypothetical language containing the morphemes:

(a) ti

(b) te

(c) ta

(d) to

(e) tu

Whenever these morphemes are followed by a morpheme which begins with a vowel (for example, the morpheme al), they exhibit the following forms:

(a') ti+al → tyal

(b') te+al → tal

(c') ta+al → tal

(d') to+al → tal

(e') tu+al → twal

Thus we see that when two vowels come together at a morpheme boundary, the first of these vowels becomes a glide if it is a high vowel but it is deleted if it is a nonhigh (i.e. mid or low) vowel. The following two rules state these changes:

(1) $\begin{bmatrix} V \\ +\text{ high} \end{bmatrix} \rightarrow [\text{ - vocalic}] / \_\_ + V$

(2) $\begin{bmatrix} V \\ -\text{ high} \end{bmatrix} \rightarrow \emptyset / \_\_ + V$

Note that these rules need not be ordered since the segments which undergo change are mutually exclusive (i.e. the class of high vowels and the class of nonhigh vowels). It makes no difference whether the order of these two rules is (1), (2), or (2), (1), since whichever order is taken all vowels will be changed in the appropriate manner. This is because we have spelled out in detail the environmental conditions for the two types of changes--that is, we have said that something happens to high vowels and that something else happens to nonhigh vowels.

Alternatively, we could have said that, first, high vowels become glides, then, all remaining vowels are deleted. The following two rules reflect this way of looking at these changes.

$$(1') \quad \begin{bmatrix} V \\ +\text{high} \end{bmatrix} \rightarrow [-\text{vocalic}] \,/\, \_\_ + V$$

$$(2') \quad V \rightarrow \emptyset \,/\, \_\_ + V$$

Rule (1') is identical to rule (1); however, rule (2') is simpler than rule (2) since the [- high] specification to the left of the arrow in rule (2) has been eliminated in rule (2'). But this simplification becomes possible only if the two rules are ordered with respect to each other--with rule (1') being applied before rule (2'). Rule (1') will convert prevocalic i to y and prevocalic u to w. Since y and w are no longer vowels they will not be affected by rule (2') which then deletes all remaining prevocalic vowels--namely, e, a, and o. If, on the other hand, we were to apply rule (2') first, then all vowels (including i and u) would be deleted. The vowels i and u would then no longer be present in the representations and could not be converted to y and w respectively by rule (1'). Hence, if the ordering were (2'), (1') then rule (1') could never apply to any of the high vowels.

If we assume that every rule in the phonology must apply to some form or other--that is, there is no point in having a rule which never applies to any form--then the appropriate order of the above two rules can be determined simply by examining the rules themselves. Thus, whenever there are two rules such that one rule would wipe out or change all the segments to which the other rule would apply, making the rule completely vacuous, then it must be the case that this other rule applies first. This type of ordering is known as intrinsic ordering. Intrinsic ordering implies a unique ordering.[2]

Not all ordering can be so uniquely determined, however. Consider the following two well-known rules of English:

$$(3) \quad V \rightarrow [+\text{long}] \,/\, \_\_ \begin{bmatrix} C \\ +\text{voiced} \end{bmatrix}$$

$$(4) \quad \begin{Bmatrix} t \\ d \end{Bmatrix} \rightarrow D \,/\, \acute{V} \_\_ V$$

Rule (3) states that vowels are lengthened before voiced consonants (e.g. the vowel of bid or bin is longer than the vowel of bit). Rule (4) states that a poststressed intervocalic t or d becomes a voiced flap (i.e. the segment [D])--e.g. the intervocalic dentals of butter or ladder. Rule (3) applies also to complex vocalic nuclei, so that write is phonetically [rIt] and ride is phonetically [rI:d] (where I represents the diphthong [ay]).

Rules (3) and (4) together are relevant for deriving forms such as writer (phonetic [rIDər]) and rider (phonetic [rI:Dər]). These are derived from underlying rIt+ər and rId+ər respectively. Rule (3) lengthens the vowel of rId+ər since it is before a voiced consonant yielding rI:d+ər; rule (4) then converts both intervocalic dentals to flaps yielding rID+ar and rI:D+ər respectively.

Rules (3) and (4) are not intrinsically ordered. If the opposite order is adopted both rules are still applicable, although the results will be different. If we were to apply rule (4) first, then both dentals would become flaps--that is, rIt+ər would be converted to rID+ər and rid+ər would also be converted to rID+ər. Rule (3) would then lengthen the vowel preceding the flap since the flap is a voiced consonant, yielding rI:Dər as the final form for both writer and rider. In fact, some dialects of English actually exhibit this homophonous form. Thus, the ordering of rules (3) and (4) is not uniquely determined. Either order is a possible ordering and the appropriate one will depend on the desired phonetic results. This type of ordering is known as extrinsic ordering. Extrinsic ordering allows for more than one possible ordering. Each ordering will yield a different output, the correct one being determined from the phonetic facts. [3]

So far we have considered separate rules which must be ordered with respect to one another--the ordering being either uniquely determined (intrinsic ordering) or else determined on the basis of the phonetic results (extrinsic ordering), the difference being that intrinsically ordered rules can have only one possible order. However, intrinsically ordered rules possess another property, which is not necessarily shared by extrinsically ordered rules--namely, a set of intrinsically ordered rules can always be replaced by a set of essentially unordered rules, although, of course, at the cost of increasing the environmental complexity.

Consider again the two intrinsically ordered rules (1') and (2'). If we were to add the specification [- high] to the V to the left of the arrow in rule (2') then this additional environmental specification will have the effect of converting rule (2') to rule (2). (Recall that rules (1') and (1) are identical in their formulation.) We have already seen that rules (1) and (2) do account for all the phonological facts and furthermore that these two rules are unordered.

Extrinsically ordered rules, however, cannot always be replaced by a set of unordered rules. Consider again the two extrinsically ordered rules (3) and (4). If we want to describe those dialects which have the forms [rIDər] and [rI:Dər], then the rules must be applied in the order (3), (4). Is it possible to rewrite these as unordered rules? Not if one of

the rules is of the type (4), which causes two different segments to merge. If rule (4) were to apply first, intervocalic t and d will become D. Then there would be no way of determining which D allows a preceding vowel to be lengthened. Hence, with extrinsically ordered rules it may not always be possible to replace them by a set of unordered rules.[4]

Let us turn now to other conditions on ordered rules.

In Latin stress is assigned to words as follows:

(a) in monosyllables stress occurs on the final (i.e. the only) vowel.

(b) in bisyllables stress occurs on the penultimate (i.e. the first) vowel.

(c) in polysyllables (i.e. trisyllables or longer) stress occurs on either the penultimate or the antepenultimate.

(i) stress is on the penultimate if it contains a long vowel or any vowel followed by two or more consonants.

(ii) stress is on the antepenultimate if the penultimate contains a short vowel followed by no more than one consonant.[5]

In every word only one vowel can be stressed. The above rules will account for all stresses. These rules as given need not be ordered with respect to one another since each rule explicitly indicates all the environmental conditions; furthermore, these environments are mutually exclusive. However, by capitalizing on ordering, the rules can be considerably simplified, with many of the environmental constraints reduced.

I. Stress is on the antepenultimate if the penultimate contains a short vowel followed by no more than one consonant.

II. Otherwise stress is on the penultimate (i.e. if there are at least two syllables).

III. Otherwise stress is on the final vowel.

Statement I is equivalent to (c ii), Statement II is equivalent to (b) and (c i) and Statement III is equivalent to (a). These statements can be converted into formal rules, where $\breve{V}$ is a short vowel, V is either a long

or a short vowel, C_o means zero or more consonants, C_o^1 means zero or one consonant, and # indicates the end of the word.

(5) I. $V \rightarrow$ [+stress] / $\_\_\ C_o \overset{\smile}{V} C_o^1 V C_o \#$

II. $V \rightarrow$ [+stress] / $\_\_\ C_o V C_o \#$

III. $V \rightarrow$ [+stress] / $\_\_\ C_o \#$

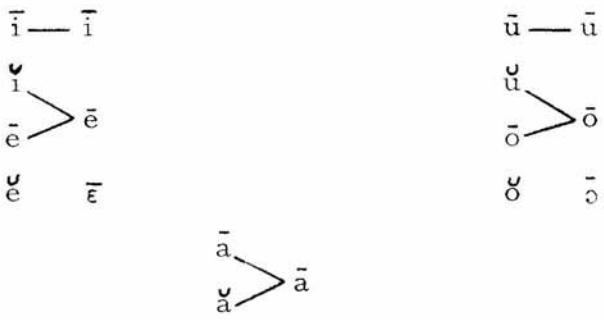
Rule 5 I places stress on the antepenultimate vowel of polysyllables containing a short penultimate vowel followed by no more than one consonant. Rule 5 II places stress on the penultimate of all polysyllables which were not stressed by rule 5 I (namely, polysyllables containing either a penultimate long vowel or a penultimate vowel followed by more than one consonant). Rule 5 II also places stress on the first syllable of all bisyllabic words. Rules 5 I and 5 II will have placed stress on all words containing two or more syllables. Rule 5 III then assigns stress to words not stressed by rules 5 I or 5 II--i.e. monosyllables--it assigns stress to the only vowel.

The rules of (5) must be applied in the order given. If rule 5 III applied before the other two, then every word (whether monosyllabic, bisyllabic or polysyllabic) would receive stress on the final vowel. If rule 5 II preceded rule 5 I then every polysyllabic form would receive penultimate stress. But it is not sufficient that the three cases apply in the order given. Their application must also be mutually exclusive. If one rule applies then any following rule cannot subsequently apply. Thus, if rule 5 I applies then rules 5 II and 5 III must not apply since they would place stress on the penultimate vowel and the final vowel respectively yielding incorrect forms--that is, words with more than one stress. Similarly, if rule 5 II applies then rule 5 III must not, otherwise all penultimate stressed forms would incorrectly receive an additional final stress. Thus, we must establish the convention that whenever a rule applies, any following rule in this set of ordered rules must be skipped. This type of ordering is known as disjunctive ordering--ordered rules are treated as if they were mutually exclusive, in spite of the fact that later rules do meet the environmental conditions for application. Thus, in any one derivation only one rule out of the ordered set will ever apply. [6]

Conjunctive ordering, on the other hand, allows for more than one rule from the ordered set to apply in a particular derivation. The rules are of course ordered but this time it may in fact be the case that the output of one of the rules becomes the input to a subsequent rule. That is, if one of the ordered rules of the set applies, then one does not skip

the remaining rules of the set, but instead tries them as well, and if the appropriate environmental conditions are met then the rule is applied. (Most ordered rules are of this type.)

Classical Latin had a five vowel system, each vowel could be tense (long) or lax (short)--a total of ten vowel segments. Vulgar Latin had a seven vowel system, all vowels being tense.[7] The following changes occurred from Classical Latin to Vulgar Latin.



Note that the tense vowels were not affected. Lax vowels were lowered (mid vowels became low and high vowels became mid) and were made tense.

(6a) $\begin{bmatrix} V \\ -tense \\ -high \end{bmatrix} \rightarrow \begin{bmatrix} +tense \\ +low \end{bmatrix}$

(6b) $\begin{bmatrix} V \\ -tense \\ +high \end{bmatrix} \rightarrow \begin{bmatrix} +tense \\ -high \end{bmatrix}$

Rule (6a) converts e and o to $\bar{\varepsilon}$ and $\bar{\text{o}}$ respectively, and it converts a to $\bar{\text{a}}$ (it is already low). Rule (6b) converts i and u to $\bar{\text{e}}$ and $\bar{\text{o}}$, respectively These rules are furthermore unordered. By ordering them we can simplify these two rules and bring out some of the generalizations in them (for example, that all of the lax vowels ultimately become tense).

(6c) $\begin{bmatrix} V \\ -tense \end{bmatrix} \rightarrow [+low] \; / \; \begin{bmatrix} \overline{\quad} \\ -high \end{bmatrix}$

(6d) $\begin{bmatrix} V \\ -tense \end{bmatrix} \rightarrow \begin{bmatrix} +tense \\ -high \end{bmatrix}$

Rule (6c) makes lax vowels low if these lax vowels are nonhigh. Rule (6d) makes lax vowels tense and nonhigh. Rule (6c) does not apply to i and u; rule (6d) does apply to these two segments converting them to

$\bar{e}$ and $\bar{o}$ respectively. However, rule (6c) will apply to e and o converting them to ɛ and ɔ respectively; rule (6c) applies vacuously to a since it is already [+ low]. But, ɛ, ɔ, and a will not become tense by rule (6c) since (6c) has no provision for making these lax vowels tense. However, if these [- tense] vowels are subsequently subject to rule (6d) they will all be made [+ tense] (they are already [- high]). Thus, it must be the case that (6d) can apply to the output of (6c) if one is to obtain the correct results. This type of ordering is known as conjunctive ordering--the ordered rules are not mutually exclusive; that is, more than one rule may apply in any one derivation, providing, of course, that the appropriate environmental conditions are met.

Within our examples of disjunctively ordered rules and conjunctively ordered rules, the rules within each ordered set all involve similar phonological processes. Thus, the disjunctively ordered set of Latin stress rules all do the same thing--namely, assign stress to some vowel in the word. The two conjunctively ordered rules for Vulgar Latin also have the same effect--namely, they adjust the vowel height and tenseness of original lax vowels. In both cases we have separate rules which are contiguous in their ordering and which share many features in common. Such instances of separate rules can usually be collapsed into a single rule through the use of either the parenthesis notation or the brace notation. For example, given the two similar rules (7a) and (7b), and the two similar rules (8a) and (8b), the first pair can be replaced by rule (7c) whereas the second pair can be replaced by rule (8c).

(7a) $X \rightarrow Y \;/\; \_\_\; A\ B$

(7b) $X \rightarrow Y \;/\; \_\_\; B$

(7c) $X \rightarrow Y \;/\; \_\_\; (A)\ B$

(8a) $X \rightarrow Y \;/\; \_\_\; A$

(8b) $X \rightarrow Y \;/\; \_\_\; B$

(8c) $X \rightarrow Y \;/\; \_\_ \begin{Bmatrix} A \\ B \end{Bmatrix}$

Rules (7c) and (8c) then become abbreviatory schemata for the two rules (7a), (7b) and (8a), (8b), respectively.

Recent work in generative phonology has shown that the notions of disjunctive and conjunctive ordering can be formally captured with these notational devices--where the parenthesis notation implies disjunctive

ordering and the brace notation conjunctive ordering--providing certain conventions are established for the expansion of the parenthesized and braced elements in such rules.[8] In expanding a rule containing parentheses into a set of ordered rules the longest environment (i.e. with all parenthesized elements) is expanded first, then the next longest, etc., with the shortest environment (i.e. with no parenthesized elements) expanded last. In expanding a rule containing braces into a set of ordered rules the elements are expanded according to their order within the braces, so that the topmost element is expanded first, then the next one down, etc. Thus, in expanding the schemata (7c) and (8c) into sets of ordered rules, (7c) yields the two rules (7a), (7b) applied in that order and (8c) yields the two rules (8a), (8b) applied in that order.

Let us examine how the parenthesis notation provides explicitly for disjunctive ordering and how the brace notation allows for conjunctive ordering. Using the parenthesis notation we can abbreviate the Latin Stress rules given earlier.

(9) $V \rightarrow [+\text{stress}] / \_\_ C_o((\breve{V}C_o^1)\ VC_o)\ \#$

According to the conventions on the expansion of parentheses, we expand the longest environment first (all the parentheses), then the next longest environment (everything except the innermost parentheses), and then finally the shortest environment (excluding all parentheses).

I. $V \rightarrow [+\text{stress}] / \_\_ C_o \breve{V} C_o^1 VC_o\#$

II. $V \rightarrow [+\text{stress}] / \_\_ C_o VC_o\#$

III. $V \rightarrow [+\text{stress}] / \_\_ C_o\#$

These rules are equivalent to the three rules given earlier as (5). As we saw there these three rules must be disjunctively ordered. Thus, the parenthesis notation guarantees this disjunctive ordering.

The rule for tensing lax vowels in Vulgar Latin can also be abbreviated

(10) $\begin{bmatrix} V \\ -\text{tense} \end{bmatrix} \rightarrow \begin{cases} [+\text{low}] / [-\overline{\text{high}}] \\ \begin{bmatrix} +\text{tense} \\ -\text{high} \end{bmatrix} \end{cases}$

According to the convention on the expansion of braces, we expand the

topmost environment first, then the one beneath that.

(10a) $\begin{bmatrix} V \\ -tense \end{bmatrix} \rightarrow [+low] / [-\overline{high}]$

(10b) $\begin{bmatrix} V \\ -tense \end{bmatrix} \rightarrow \begin{bmatrix} +tense \\ -high \end{bmatrix}$

These two rules are identical to the two separate rules (6c) and (6d) presented earlier. As we saw there the two rules had to be conjunctively ordered--that is, both rules must be able to apply within a derivation. Thus, the brace notation guarantees this conjunctive ordering.

In summary, similar phonological processes can be expressed by single rules--instead of separate rules--by making appropriate use of notational devices such as parentheses and braces. These are rule schemata, which are to be expanded by convention into a block of ordered rules. When the schemata have parentheses then the expanded rules are disjunctively ordered--only one rule from the set can be applied in any one derivation. When the schemata contain braces then the expanded rules are conjunctively ordered--more than one rule from the set may be applied in any one derivation.

We must note, however, that not all instances of parentheses or braces that occur in phonological rules entail necessarily disjunctive or conjunctive ordering. Very often the expanded set of rules is really an unordered set. In such cases there is little point in talking about disjunctive or conjunctive ordering.

In French a vowel becomes nasalized whenever it is followed by a nasal consonant which in turn is followed by a consonant. The consonant after the nasal consonant may be in the same morpheme (e.g. vend+ez 'you sell'), in a following morpheme (e.g. bon+té 'goodness') or in a following word (e.g. bon#garçon 'good boy'). The following rule states the conditions for nasalization.

(11) $V \rightarrow [+ nasal] / \_\_ \begin{bmatrix} C \\ + nasal \end{bmatrix} (\#)\ C$

Rule (11) expands to two cases:

(11a) $V \rightarrow [+ nasal] / \_\_ \begin{bmatrix} C \\ + nasal \end{bmatrix} \#\ C$

(11b) $V \rightarrow [+ nasal] / \_\_ \begin{bmatrix} C \\ +nasal \end{bmatrix}\ C$

Case (11a) handles nasalization across word boundary; case (11b) handles nasalization across morpheme boundary as well as within a single morpheme (accepting the convention that a rule which does not specifically mention + applies nonetheless across morpheme boundary).

Cases (11a) and (11b) are <u>not</u> really ordered, however, since whichever order is established the correct results are always obtained. This is because the environments are mutually exclusive; one case applies across word boundary, while the other applies across morpheme boundary or within a single morpheme. Hence, if the two cases are really unordered, then it follows that they are <u>not</u> disjunctively ordered. (They are disjunctively ordered only in a trivial sense; namely, that the convention for parenthesis expansion requires one to take the parenthesized elements first.)

Nor does the brace notation always yield conjunctive ordering. Consider a language with morphemes that may terminate in VC. This final consonant is then deleted either before another consonant or else before a word boundary.

(12) $C \rightarrow \emptyset \; / \; \_\_ \begin{Bmatrix} C \\ \# \end{Bmatrix}$

Rule (12) is equivalent to the following two expansions:

(12a) $C \rightarrow \emptyset \; / \; \_\_ \; C$

(12c) $C \rightarrow \emptyset \; \_\_ \; \#$

Cases (12a) and (12b) are unordered, for whichever order is taken the correct results are always obtained. Again, the environments are mutually exclusive: one case applies before consonants, the other before word boundaries. If the two cases are unordered then they cannot be conjunctively ordered. (They are conjunctively ordered only in a trivial sense--namely, that the convention for the expansion of braces requires one to take the topmost element first.) I shall not be concerned further with this kind of trivial ordering and instead shall concentrate only on those rules which utilize parentheses or braces where the order of the expanded subparts is really significant.

II

Thus far we have found two principles according to which two or more rules may be ordered: by one principle rules may be either

intrinsically or extrinsically ordered; by the other principle rules may be either disjunctively or conjunctively ordered. We have treated these two principles as separate phenomena.

The principle of intrinsic-extrinsic ordering has to do with the establishing of the appropriate ordering. If there is only one possible order--that is, if the opposite order were tried one or more rules would always be vacuous--then the ordering is intrinsic. On the other hand, if more than one ordering is at least possible with no rules being vacuous then the ordering is extrinsic. Intrinsically ordered rules can yield only one possible output. Extrinsically ordered rules will always yield different outputs, only one of which is the appropriate one. If a set of rules always yields the same output no matter what the order is, then the rules of the set are neither intrinsically ordered nor extrinsically ordered but are in fact unordered.

The principle of disjunctive-conjunctive ordering has to do not with the establishing of the appropriate order of the rules, but rather with conditions on how the set of ordered rules is to be applied in derivations. For disjunctively ordered rules only one rule out of the set may be applied. The rules are tried in order. If any rule is applicable then any later rules in the set are skipped. When the rules are conjunctively ordered, on the other hand, then more than one rule in the set may be applied. For conjunctively ordered rules, then, the output of an earlier rule in the set may become the input to a later rule in the set.

How does one know whether the set of rules is disjunctively ordered or conjunctively ordered? By noting whether the rules can be stated through the parenthesis or brace notations. Rules which can be formulated with parentheses imply disjunctive ordering, whereas rules which can be formulated with braces imply conjunctive ordering. Parentheses and braces are used for abbreviating a set of rules where all rules of the set are concerned with a similar phonological process. Hence, it follows that rules which are disjunctively ordered or conjunctively ordered are rules which form a natural block. No such constraint has been imposed on intrinsically ordered or extrinsically ordered rules. Such rules may be concerned with similar phonological processes as well as with vastly different phonological phenomena.

Having established two different principles for ordering, we can now ask what relation there might be between intrinsic-extrinsic ordering and disjunctive-conjunctive ordering. Since it goes without saying that disjunctively ordered rules and conjunctively ordered rules are ordered, it follows that the ordering must be determined either intrinsically or extrinsically. Hence four kinds of ordered rules would seem possible:

disjunctively ordered rules which are intrinsically ordered; disjunctively ordered rules which are extrinsically ordered; conjunctively ordered rules which are intrinsically ordered; and conjunctively ordered rules which are extrinsically ordered. Can all four kinds of ordering be found or are there constraints which only permit some of these? I should like to suggest that there are indeed constraints operating, namely:

Principle I. Disjunctive or conjunctive ordering implies intrinsic ordering.

Principle II. Extrinsic ordering implies different phonological processes--i.e. rules which cannot be collapsed with parentheses or braces.

These two principles assert the following: Rules which can be abbreviated using the conventions for parentheses and braces are always intrinsically ordered. Rules which cannot be so abbreviated may be either intrinsically ordered or extrinsically ordered.

We shall now turn to some examples of disjunctively ordered and conjunctively ordered rules which are also intrinsically ordered. First, cases I, II, and III of the Latin Stress rule, where the three cases are disjunctively ordered.

I. $V \rightarrow [+\text{stress}] / \_\_ C_o \breve{V} C_o^1 V C_o \#$

II. $V \rightarrow [+\text{stress}] / \_\_ C_o V C_o \#$

III. $V \rightarrow [+\text{stress}] / \_\_ C_o \#$

Assume we do not know what the correct ordering ought to be. Assume further that we do know that every word must contain only one stress. Hence, only one of the rules can apply to a given word. Then, the correct ordering of cases I, II, and III can be determined merely by examining the rules themselves. Case III must be last; otherwise all words would receive final stress and cases I and II would never apply. Case II must follow case I; otherwise all polysyllables would receive penultimate stress and hence case I would never apply. Thus, cases I, II, and III are not only disjunctively ordered but they are also intrinsically ordered. That is, the appropriate ordering can be determined by examining the three cases (intrinsic ordering); once this order is established then whenever a particular case applies any subsequent case must not apply (disjunctive ordering).

Another example of disjunctive ordering (and hence intrinsic ordering) is examplified through the main stress rule in English for lexical items.[9]

$$(13)\quad V \rightarrow [+\text{ stress}] / \_\_\ C_o(VC)\left\langle <+C_o>VC_o\right\rangle]\left\langle <A>N\right\rangle$$

In this rule the angles are a special type of parentheses for indicating discontinuous dependencies--that is, both of the angled parts must be taken together. Hence a rule of the form $X \rightarrow Y / <A>\ \_\_\ B<C>$ is equivalent to two rules disjunctively ordered as follows:

$$X \rightarrow Y / A\ \_\_\ B\ C$$

$$X \rightarrow Y / \_\_\ B$$

Rule (13) can be expanded into three subcases:[10]

$$(13i)\quad V \rightarrow [+\text{ stress}] / \_\_\ C_o(\breve{V}C) + C_o\breve{V}C_o]_{A\ N}$$

$$(13ii)\quad V \rightarrow [+\text{ stress}] / \_\_\ C_o(\breve{V}C)\breve{V}C_o]_{N}$$

$$(13iii)\quad V \rightarrow [+\text{ stress}] / \_\_\ C_o(\breve{V}C)]$$

Case (i) applies to adjectives or nouns containing a final suffix with a lax vowel (e.g. -ty, -al, -ant, -ous, etc.) placing stress two syllables before the suffix if the syllable preceding the suffix contains a lax vowel with no more than one consonant following (hereafter referred to as a weak syllable)--e.g. pérsonal, precípitous, significant. Otherwise, stress is placed on the syllable immediately before the suffix--e.g. ancedótal, adjácent, dialéctal, depéndent.

Case (ii) applies to nouns whose final syllable contains a lax vowel. Stress is placed on the antepenultimate if the penultimate is a weak syllable--e.g. América, análysis; otherwise, stress is placed on the penultimate--e.g. aróma, horízon, agénda, consénsus.

Case (iii) is the "elsewhere" case. Stress is placed on the penultimate syllable if the final syllable is weak--e.g. verbs such as édit, astónish, adjectives such as cértain, vúlgar; otherwise, stress is on the final syllable--e.g. verbs such as eráse, decíde, collápse; adjectives such as supréme, absúrd, nouns such as machíne, canóe, and all monosyllables such as júmp, sád, dóg.

The three cases are disjunctively ordered.

Case (iii) must follow cases (i) and (ii) since case (iii) has no provision for antepenultimate stress; if case (iii) were to apply to words such as America, personal, they would receive stress on the penultimate. Case (i) must precede case (ii) because of nouns like advertisement (with the pronunciation [ædvə́rtismənt]). This noun can be stressed by case (i) since it terminates in the suffix -ment. The syllable preceding -ment is weak; hence, stress is placed on the syllable preceding this weak one. Case (ii) does not subsequently apply because of the disjunctive ordering. However, if case (ii) were to apply first, stress would be incorrectly placed on the penultimate syllable. Since advertisement is a noun whose final syllable contains a lax vowel, the word meets the environmental conditions for case (ii). (Recall that rules which do not specifically mention the + boundary nonetheless apply across morphemes.) The final lax vowel is preceded by two consonants (i.e. a strong syllable)--is+m, so that stress would be placed on this strong syllable. Thus, it is seen that the convention for parenthesis expansion yields the appropriate disjunctively ordered block of rules.

An examination of the English stress rules reveals that these rules are intrinsically ordered. Assuming that only one of these cases can apply in any one derivation,[11] then it is evident that case (iii), the "elsewhere" case, must apply last, since every lexical item meets the appropriate environmental conditions. If (iii) were to apply first then (i) and (ii) would never apply. Similarly, (ii) must follow (i): all nouns terminating in a suffix with a lax vowel (such as advertisement) meet the conditions for being stressed by case (ii); hence, there would never be any nouns with suffixes to which case (i) could ever apply; therefore, case (i) must precede case (ii). Thus, all nouns whose final syllable contains a lax vowel are stressed by case (i) if the lax vowel is part of a suffix (e.g. advertisement), otherwise by case (ii) (e.g. America).

Let us return to the Vulgar Latin rule (10) which tenses lax vowels--a rule exemplifying conjunctive ordering.

$$(10)\quad \begin{bmatrix} V \\ -\text{tense} \end{bmatrix} \rightarrow \begin{cases} [+\text{ low}] \;/\; [-\overline{\text{high}}] \\ \begin{bmatrix} +\text{ tense} \\ -\text{ high} \end{bmatrix} \end{cases}$$

Recall that all lax vowels become tense; in addition, the high and mid vowels are lowered, so that i and u become $\bar{e}$ and $\bar{o}$ respectively, and e and o become $\bar{\varepsilon}$ and $\bar{\text{o}}$ respectively, while a becomes $\bar{a}$.

The first subpart of the rule applies to e and o converting them

to ɛ and ɔ, respectively; it applies vacuously to a since it is already [+ low]. The second subpart makes these three vowels tense (they are already [- high]); it also applies to i and u making them nonhigh and tense--i.e. converting them to ē and ō respectively. For the original lax nonhigh vowels it must be the case that the output of the first subpart becomes the input to the second subpart (conjunctive ordering). Furthermore, the subparts must apply in the order given. If the second subpart were to apply first, then all lax vowels (including i and u) would become nonhigh and tense, causing i and e to merge to ē and u and o to merge to ō. There would then be no more lax vowels left and the first subpart of the rule would never apply to anything. Hence, the two subparts are intrinsically ordered.[11a]

As another example of conjunctive ordering let us reconsider rules (1') and (2') given earlier.

$$(1') \quad \begin{bmatrix} V \\ +\text{ high} \end{bmatrix} \rightarrow [-\text{ vocalic}] \; / \; \_\_ + V$$

$$(2') \quad V \rightarrow \emptyset \; \_\_ + V$$

These two rules involve similar phonological processes: something happens to a vowel whenever it precedes another vowel. Hence, these two rules can be collapsed into a single rule through the brace notation.

$$(14) \quad V \rightarrow \left\{ \begin{matrix} [-\text{ vocalic}] \; / \; [+ \overline{\text{high}}] \\ \emptyset \end{matrix} \right\} / \; \_\_ + V$$

When the rules are expanded according to the conventions for the brace notation we obtain two cases, equivalent to (1') and (2'). These two cases must be applied in the order given: that is, before a vowel high vowels are first converted to glides, then all remaining (i.e. all nonhigh) vowels are deleted. As we noted earlier these two rules are intrinsically ordered, since if the second part of the rule were to apply first, all vowels would be deleted and there would be no high vowels left for the first part of the rule to operate on. Note that although the rules are ordered it will never be the case that a form will be subject to both parts of the expansion. The first subpart converts high vowels to glides; since these vowels are now glides, they will no longer meet the environmental conditions for the second part of the rule. Although conjunctive ordering allows for the possibility of the output of one subpart to become the input to the next subpart, there is no reason to suppose that this possibility should be present in all situations. Conjunctive ordering in one rule is exactly like linear ordering among several contiguous rules. That is, the rules must be ordered and the output of one rule may become the input to the

next rule providing, of course, that the appropriate environmental conditions happen to be met.

So far we have claimed that both disjunctive ordering and conjunctive ordering imply intrinsic ordering. As for extrinsic ordering we have said that it implies separate phonological processes--rules which cannot be collapsed into a single rule by using parentheses or braces. Rules (3) and (4) were examples of extrinsically ordered rules.

$$(3) \quad V \rightarrow [+\,\text{long}] \,/\, \_\_ \begin{bmatrix} C \\ +\,\text{voiced} \end{bmatrix}$$

$$(4) \quad \begin{Bmatrix} t \\ d \end{Bmatrix} \rightarrow D \,/\, \acute{V} \_\_ V$$

Rule (3) lengthens vowels before voiced consonants, whereas rule (4) converts an intervocalic t or d to a flap. It is evident that different phonological processes are involved here.

Another example of extrinsic ordering is exemplified by the following two rules found in some German dialects.[12]

$$(15) \quad V \rightarrow [-\,\text{back}] \,/\, \_\_ X$$

$$(16) \quad \bar{a} \rightarrow \bar{\text{ɔ}}$$

The first rule is an umlauting rule, causing vowels to become front in some environments, for example, the comparative. The second rule converts $\bar{a}$ to $\bar{\text{ɔ}}$. In some dialects the rules are applied in the order (15), (16). In these dialects the word špāt 'late' does not undergo umlauting (rule (15)). The second rule, however, will apply, converting špāt to špɔ̄t. In the comparative, on the other hand, rule (15) will apply converting špātər 'later' to špātər. Rule (16) will not apply since the underlying $\bar{a}$ has been changed by rule (15).

In other dialects the rules are applied in the order (16), (15). Rule (16) converts špāt to špɔ̄t and špātər to špɔ̄tər. Rule (15) then applies only to the latter, converting it to špötər.

Rules (15) and (16) are extrinsically ordered since different results are obtained depending on the order chosen. Furthermore, the two rules are not collapsible into a single rule since different phonological processes are involved: in one case, all vowels are umlauted in a specific environment under very general conditions; in the other case, the low central vowel $\bar{a}$ undergoes rounding.

We want to claim that extrinsically ordered rules always entail separate phonological processes. However, this does not exclude there being intrinsically ordered rules involving separate phonological processes. Such rules are fairly common. For example, I have shown for French that stress at the word level is predictable--so that stress is never marked in underlying representations but is always introduced by rule.[12a] Furthermore, there are various phonological processes which depend on the presence or absence of a stressed vowel--diphthongization, schwa reduction, vowel truncation, glide conversion. These rules all mention [+ stress] or [- stress] in their environments. They can only apply if the stress rule has preceded them, since it is this rule which uniquely assigns stress. Thus, the stress rule is intrinsically ordered with respect to any rule which mentions stress in an environment.

Separate rules not reducible to a single rule (because unrelated phonological processes are involved) can either be extrinsically or intrinsically ordered. Rules reducible to a single rule using parentheses or braces (rules which reflect similar phonological processes) are always intrinsically ordered. What we must show is that they cannot be extrinsically ordered.

In terms of notation, parentheses do not allow the possibility for extrinsic ordering--that is, one has no choice of ordering inside the parentheses. For example, (A) B can only be expanded as AB followed by B. There is no way to obtain the opposite order using parentheses--B followed by AB--since the convention for the expansion of parentheses requires that the longest environment be expanded first. Thus, for parentheses the order must always be uniquely determined--i.e. intrinsic.

But assume that we drop the convention for interpreting parentheses and allow either possibility; that is, AB followed by B or else B followed by AB. Can these ever be extrinsically ordered--where no rule is vacuous with either ordering and the outputs are different? The answer is no. The parenthesis notation is the formal means for capturing two similar rules where one rule has some environmental restrictions not found in the other rule, which is the most general formulation since it is the "elsewhere" case. But the "elsewhere" environment will always be met. Thus, if it is the first rule it will always apply and the other rule (the less general) could never be applied--we are assuming, of course, disjunctive ordering. This would mean that the less general rule would always be vacuous--an intolerable situation. Therefore, the rules must be intrinsically ordered. Hence, disjunctive ordering must always entail intrinsic ordering.

We also want to claim that conjunctive ordering entails intrinsic

ordering. That this claim should be true is not so obvious since the brace notation, unlike the parenthesis notation, formally would allow extrinsic ordering. Recall that the convention for expanding braces requires that the topmost element be expanded first. Therefore, different orderings are possible if the order of the elements in the braces is different. For example, $\{^{A}_{B}\}$ C will be expanded into AC and BC in that order, whereas $\{^{B}_{A}\}$ C will be expanded into BC and AC in that order. Hence, for the brace notation extrinsic ordering ought to be possible. Since for braces different orderings cannot be ruled out formally--that is, as a consequence of the notation--instead I shall try to show that extrinsically ordered conjunctive rules do not occur in natural languages, in spite of the fact that it is easy enough to construct such rules.

Consider again the rule given earlier as (12).

(12) $C \rightarrow \emptyset \; / \; \_\_ \{^{C}_{\#}\}$

Assume a language with the following underlying forms:

(a) VCCV

(b) VCC#

(c) VC#

The first subpart of the rule will apply to the first consonant of (a) and of (b), the second part of the rule will affect the final consonant of (b) and of (c), yielding:

(a') VCV

(b') V#

(c') V#

If the subparts are applied in the opposite order, then the second subpart will first delete the final consonant of (b) and of (c), and the first subpart will only delete the first consonant of (a). The first subpart would not affect (b) since the word final consonant has already been deleted. Applying the second subpart before the first then yields:

(a'') VCV

(b'') VC#

(c'') V#

We see that by applying the subparts of rule (12) in different orders different results are obtained. This appears then to be a clear case of extrinsic ordering. However, if we examine the two different results we see that the forms (a'-c') are natural in a way in which the forms (a''-c'') are not. For the former, in medial position, the first of two consonants is deleted, whereas in final position, one or two consonants are deleted. The effect of these deletions is to produce open syllables--a fairly common phenomenon. However, in the forms (a''-c'') the results are somewhat strange. In final position the second of two consonants is deleted, whereas in medial position the first of two consonants is deleted, and a single final consonant is always deleted. Whether there are languages which exhibit the properties of (a''-c'') remains to be seen. The processes appear to be contrived and not of any real linguistic significance. On the other hand, there are indeed languages which exhibit the properties of (a'-c'). Such a case is French, where the purpose of the elision and liasion rules is to delete consonants before consonants and boundaries allowing for open syllable structure.

Looking back at (a'-c') we see that what has happened is that in word final position a sequence of consonants is deleted whereas in medial position all consonants but the last one are deleted. A rule for stating the change in this way can be written using C_o to the left of the arrow, where C_o means any number of consonants.[13]

$$(17) \quad C_o \rightarrow \emptyset \; / \; \_\_ \begin{Bmatrix} C \\ \# \end{Bmatrix}$$

The above rule states that any number of consonants is deleted before a consonant or before a word boundary. However, once the rule is written in this more general form, then the subparts within the braces are no longer extrinsically ordered--but in fact are unordered--since no matter which subpart is applied first to (a-c), the correct results will always be obtained. Thus, if it is true that (a'-c') are conceivable outputs but (a''-c'') are not, the permitted (a'-c') can be derived without having to impose extrinsic ordering on the rules. Thus, we will maintain that the subparts of elements within braces are either unordered or else intrinsically ordered, but not extrinsically ordered. Extrinsic ordering implies separate rules which cannot be abbreviated by means of the conventions for parentheses and braces.[14]

III

I should now like to examine cases where the same rule can be expressed by several different notational devices and to see whether

there is any basis for choosing among them. Consider once again the Vulgar Latin rule for lax vowels, which is repeated below.

(18a) $$\begin{bmatrix} V \\ -\text{ tense} \end{bmatrix} \rightarrow \begin{cases} [+\text{ low}] \;/\; [-\overline{\text{high}}] \\ \begin{bmatrix} +\text{ tense} \\ -\text{ high} \end{bmatrix} \end{cases}$$

This rule makes use of the brace notation. We have seen that the two subparts are intrinsically ordered and that the output of the first subpart may become the input to the second subpart (conjunctive ordering). However, this same rule can be formulated using angled parentheses with exactly the same features being specified.

(18b) $$\begin{bmatrix} V \\ -\text{ tense} \\ \langle -\text{ high}\rangle \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ tense} \\ -\text{ high} \\ \langle +\text{ low}\rangle \end{bmatrix}$$

The parenthesis notation requires that this rule be expanded into two subcases, the longest environment (i.e. the parts in angles) being taken first.

$$\begin{bmatrix} V \\ -\text{ tense} \\ -\text{ high} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ tense} \\ -\text{ high} \\ +\text{ low} \end{bmatrix}$$

$$\begin{bmatrix} V \\ -\text{ tense} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ tense} \\ -\text{ high} \end{bmatrix}$$

The first subcase applies to <u>e</u>, <u>o</u>, and <u>a</u> converting them to $\underline{\bar{\varepsilon}}$, $\underline{\bar{\text{ɔ}}}$, and $\underline{\bar{a}}$, respectively. The second subcase takes all lax vowels left over--namely, <u>i</u> and <u>u</u>, converting them to $\underline{\bar{e}}$ and $\underline{\bar{o}}$ respectively. Note again that these two subparts are intrinsically ordered. If the second subpart were to apply first it would convert all the lax vowels to tense nonhigh vowels and then there would no longer be any <u>lax</u> vowels in the system for the first subpart to act on.

There is another interesting aspect about the subparts of this rule. We have seen that with disjunctively ordered rules if a subpart applies then any subsequent subpart must not apply. However, in the above rule--unlike the stress rules, for example--even if one tried to apply the second subpart after the first it would not be applicable. Since the first subpart changes the tenseness of the underlying vowels to which it applies, any vowels having undergone the first subpart would not be affected by the second subpart. Hence, the notion of disjunctive ordering

is not really relevant here. But all disjunctive ordering means is that if the second subpart happens to meet the appropriate environmental conditions, it must not be allowed to apply. There is no reason to suppose that the later subparts of rules abbreviated with parentheses must always satisfy the environmental conditions for all forms.

We can assert the following about rules containing parentheses or braces. These are abbreviatory schemata which can be expanded in a particular manner into a sequence of rules (subparts). The subparts of the expansion are related in various ways: (1) Each subpart may be mutually exclusive of every other subpart so that the subparts of the expansion are in essence unordered. (2) The subparts are not mutually exclusive, in which case they are ordered. Then one of two possibilities obtains. (a) The output of an earlier rule does not meet the environmental conditions for a later rule. This situation arises whenever the earlier rule changes the underlying segment in such a way that the environmental conditions for the later rule would never be met; in such cases, although the rules are intrinsically ordered, the question of disjunctive or conjunctive ordering does not really arise. (b) The output of an earlier rule does meet the environmental conditions for a later rule; if the later rule is not to be applied, then the subparts are disjunctively ordered; if, on the other hand, the later rule is to be applied, then the subparts are conjunctively ordered. Furthermore, subparts which are disjunctively ordered can be abbreviated through parentheses while subparts which are conjunctively ordered can be abbreviated through braces. Thus, the notions of disjunctive and conjunctive ordering are not coextensive with the notations utilizing parentheses and braces. As we have seen not all parentheses imply disjunctive ordering nor do all braces imply conjunctive ordering. Nor is it even the case that all parentheses or braces imply intrinsic ordering, since very often the expansions are mutually exclusive--hence, unordered.

Let us return now to the Vulgar Latin rule for lax vowels, which could be expressed in two different notations--with braces and with angled parentheses. We noted that both rules require exactly the same number of feature specifications. This same rule can be expressed in yet a third notation--the alpha notation--again with exactly the same number of feature specifications.

$$\text{(18c)} \quad \begin{bmatrix} \text{V} \\ \text{- tense} \\ \alpha \text{ high} \end{bmatrix} \rightarrow \begin{bmatrix} \text{+ tense} \\ \text{- high} \\ \text{- } \alpha \text{ low} \end{bmatrix}$$

Rule (18c) is equivalent to the two expansions:

$$\begin{bmatrix} V \\ -\text{ tense} \\ +\text{ high} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ tense} \\ -\text{ high} \\ -\text{ low} \end{bmatrix}$$

$$\begin{bmatrix} V \\ -\text{ tense} \\ -\text{ high} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ tense} \\ -\text{ high} \\ +\text{ low} \end{bmatrix}$$

The first expansion converts i and u to $\bar{e}$ and $\bar{o}$ respectively; whereas the second expansion converts e, o, and a to $\bar{\varepsilon}$, $\bar{\text{o}}$, and $\bar{\text{a}}$ respectively.[15] Given, then, that a rule, such as the Vulgar Latin rule for tensing lax vowels, can be expressed in three different ways, is there any basis for choosing one of these notations? What we must do is to examine other rules and to see whether they too can be expressed in all three notations or whether some of the notations are excluded.

In Old High German there is a rule which umlauts vowels.[16] The umlauting occurs before a syllable containing the vowel i. In this environment all vowels are fronted (i.e. become [- back]). In addition, all lax vowels become nonlow.

$$\text{(19a)} \quad \begin{bmatrix} V \\ \langle -\text{ tense}\rangle \end{bmatrix} \rightarrow \begin{bmatrix} -\text{ back} \\ \langle -\text{ low}\rangle \end{bmatrix} \; / \; \_\_ \; C \; i$$

According to this rule $\bar{u}$, $\bar{o}$, and $\bar{a}$ will be converted to $\bar{y}$, $\bar{\phi}$, and $\bar{æ}$ respectively, and u, o, and a will become y, ɸ, and e, respectively. The umlauting rule can also be formulated in the brace notation.

$$\text{(19b)} \quad V \rightarrow \left\{ \begin{matrix} [-\text{ back}] \\ [-\text{ low}] \end{matrix} \; / \; [-\overline{\text{ tense}}] \right\} / \; \_\_ \; C \; i$$

Note that the two subparts are actually unordered--that is, both subparts may apply but the order in which they apply is not crucial. That is, although we are making use of the brace notation we do not have "true" conjunctive ordering.

Although the umlauting rule can be expressed with angled parentheses or with the brace notation it cannot be expressed in the alpha notation.

$$\text{(19c)} \quad \begin{bmatrix} V \\ \alpha\text{ tense} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{ back} \\ \alpha\text{ low} \end{bmatrix} \; / \; \_\_ \; C \; i$$

Rule (19c) is not equivalent to rules (19a) and (19b). Rule (19c) will make lax vowels appropriately nonlow, but it will also perform the converse

and make all tense vowels low, which, of course, is not the desired effect. The umlauting rule, then, can be expressed only in two of the three notations--angled parentheses or braces.

As a final example illustrating different notations consider the velar softening rule of English. Before a nonlow front vowel (i.e. before i or e), k becomes s whereas g becomes ǰ--e.g. electric, electricity; analogous, analogy.[17]

(20a) $$\begin{bmatrix} +\text{ obstruent} \\ -\text{ strident} \\ -\text{ diffuse} \\ \langle -\text{ voiced}\rangle \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ strident} \\ -\text{ grave} \\ \langle +\text{ diffuse}\rangle \\ \langle +\text{ continuant}\rangle \end{bmatrix} \; / \; - \begin{Bmatrix} \text{i} \\ \text{e} \end{Bmatrix}$$

The part of the rule which includes angles applies to k converting it to a dental (diffuse and nongrave) strident continuant. The nonangled part of the rule applies to any velar stops which are left over (specifically g) converting it to a palatal (nongrave) affricate (strident).

The velar softening rule can also be stated in the alpha notation.

(20b) $$\begin{bmatrix} +\text{ obstruent} \\ -\text{ strident} \\ -\text{ diffuse} \\ \alpha\text{ voiced} \end{bmatrix} \rightarrow \begin{bmatrix} +\text{ strident} \\ -\text{ grave} \\ -\alpha\text{ diffuse} \\ -\alpha\text{ continuant} \end{bmatrix} \; / \; - \begin{Bmatrix} \text{i} \\ \text{e} \end{Bmatrix}$$

Taking alpha as +, the rule converts g to a strident, nongrave, nondiffuse, noncontinuant (namely, ǰ). Taking alpha as -, the rule converts k to a strident, nongrave, diffuse, continuant (namely, s).

Although the velar softening rule can be expressed with angled parentheses or with the alpha notation, it cannot be formulated in the brace notation using the same number of features.[18]

(20c) $$\begin{bmatrix} +\text{ obstruent} \\ -\text{ strident} \\ -\text{ diffuse} \end{bmatrix} \rightarrow \left(\begin{bmatrix} +\text{ diffuse} \\ +\text{ continuant} \end{bmatrix} / \left[- \overline{\text{voiced}} \right] \right) / \; - \begin{Bmatrix} \text{i} \\ \text{e} \end{Bmatrix}$$

$$\begin{bmatrix} +\text{ strident} \\ -\text{ grave} \end{bmatrix}$$

The first subpart will apply to k converting it to f, causing it to merge with original f. But even if the merging were not a problem there would still be no way to take f to s by the second part of the rule, since the rule applies to velars and f is no longer a velar. In an analogous manner if

one tried to apply the second part of the rule first, it would convert g to ǰ and k to č, causing the latter to merge with original č. Rule (20c) is not a possible formulation for velar softening, since each subpart of the rule changes features specified to the left of the arrow. Therefore, a form could never undergo both parts of the rule for it will have been changed after having undergone either part first.

Let us summarize the examples of (18), (19), and (20). The Vulgar Latin rule for lax vowels can be expressed in three notations: angled parentheses, brackets, and alphas. The German umlauting rule is expressible in two notations: angled parentheses and brackets. The English velar softening rule is expressible in two notations: angled parentheses and alphas. Thus, brackets are excluded for velar softening and alphas are not possible for the umlauting rule, but angled parentheses are possible for all three rules. This suggests then that angled parentheses are the appropriate notational device in cases where there is a choice of notation. That is, whenever a rule can be expressed in several notations, among which is the angled parenthesis notation, and the different notations all contain the same number of feature specifications, then the angled parenthesis notation is the appropriate one.

SUMMARY

In this paper we have looked at types of ordered rules: first, intrinsic and extrinsic. We noted that contiguous rules sharing similarities can be collapsed into a single rule using parentheses, braces or alphas. The expansions of the parenthesis and brace notations may be either unordered (that is, the environments are mutually exclusive) or else ordered. When the expansions are ordered the parenthesis notation entails disjunctive ordering, while the brace notation entails conjunctive ordering. We have suggested that these two types of ordering are connected to intrinsic and extrinsic ordering in the following way: disjunctive and conjunctive ordering imply intrinsic ordering. Extrinsic ordering implies separate phonological processes not collapsible into a single rule. Finally, we noted that whenever a rule can be expressed in several notations, among which is the angled parenthesis notation, and the different notations all contain the same number of feature specifications, then the angled parenthesis notation is the appropriate one.

Notes

1. Chomsky 1962, 1967; Chomsky and Halle 1968; Postal 1967. Actually the rules are only partially ordered. That is, there may be rules A, B, C, such that A must precede B but C could apply at any point. Then ABC, ACB, and CAB are all possible rule orderings.

I wish to express my appreciation to S.-Y. Kuroda for valuable discussions which we had on many of the issues raised in this paper. In particular, I am grateful for many suggestions which I have incorporated into this study.

2. For a discussion of intrinsic and extrinsic ordering, see Chomsky 1965; Chafe 1968.

3. For the implications of extrinsic ordering for dialect studies and historical phonology, see Kiparsky 1965.

4. Some cases of extrinsic ordering can be handled by unordered rules. Thus, in the dialect where writer and rider are both [rI:dər], the following unordered rules will account for the facts:

$$V \rightarrow [+\,\text{long}] \,/\, \_\_ \begin{bmatrix} C \\ +\,\text{voiced} \end{bmatrix}$$

$$\acute{V} \rightarrow [+\,\text{long}] \,/\, \_\_\, t\ V$$

$$\begin{Bmatrix} t \\ d \end{Bmatrix} \rightarrow D \,/\, \acute{V}\ \_\_\ V$$

Rules (3) and (4) both affect a single segment (mentioned to the left of the arrow), so that in each rule only one segment ever undergoes change. We have assumed in the above discussion that this constraint (only one segment may be changed at a time) found in the set of ordered rules must be carried over into the set of unordered rules, so that they too must only affect a single segment. Because of this constraint the dialect which exhibits the forms [rIDər] and [rI:Dər] cannot be described with unordered rules. On the other hand, if one allows rules that can change more than one segment at once, then it is possible to describe this particular dialect with unordered rules; namely,

$$V \rightarrow [+\,\text{long}] \,/\, \_\_ \begin{bmatrix} C \\ +\,\text{voiced} \end{bmatrix}$$

$$d \rightarrow D \,/\, \acute{V}\ \_\_\ V$$

$$\acute{V}t \rightarrow \acute{V} : D \,/\, \_\_\ V$$

We are also assuming in this discussion that the output of one rule may become the input to the next rule. If, on the other hand, one imposes the condition that all rules apply only to the underlying representations--i.e.

there are no intermediate forms--it is then possible to write unordered rules for describing any phonological phenomena, although such rules will in general be inordinately complex, repeat similar environmental constraints, and, hence, miss generalizations. It is essentially this approach which has been adopted in stratificational phonology.

5. The Latin stress rule has been slightly simplified as stated here. Actually in polysyllables stress is on the antepenultimate if the penultimate contains a short vowel followed by no more than one consonant or by two consonants if the first is an obstruent and the second a liquid or a glide.

6. The conventions for disjunctive and conjunctive ordering are those given by Chomsky and Halle 1968.

7. With the advent of the seven vowel system in Vulgar Latin length ceased to be contrastive at the phonetic level; for simplicity, we will therefore assume that all seven vowels were phonetically tense. However, for the underlying forms of Vulgar Latin it is necessary to recognize both tense and lax vowels in order to account for stress placement, vocalic alternations, etc. Therefore the rules converting the Classical Latin lax vowels to Vulgar Latin tense vowels are the same as those needed for a synchronic description of Vulgar Latin. The changes occur only with stressed vowels.

8. The conventions for expanding parentheses and braces are those given by Chomsky 1967 and Chomsky and Halle 1968.

9. The stress rule as given is essentially cases (a), (b), and (e) of a larger rule given in Chomsky and Halle 1968, where case (a) applies to adjectives or nouns terminating in a suffix containing a lax vowel, where case (b) applies to nouns whose final syllable contains a lax vowel, and where case (e) applies to all other lexical items. In our rule the square bracket on the right refers to a constituent boundary and A (for Adjective) and N (for Noun) refer to the labeling of the bracket.

10. Within the three subcases of (13) the specification $\_\_C_0(VC)$ immediately following the environment bar represents, of course, two disjunctively ordered subparts; namely, $\_\_C_0VC$ and $\_\_C_0$, expanded in this order.

11. In reality, more than one case may apply in a particular derivation, since the stress rule is incorporated within the phonological cycle. Therefore, we should say that only one of these cases can apply in any one cycle.

11a. Case (c) of the Main Stress Rule as given in Chomsky and Halle 1968 is shown to be conjunctively ordered with respect to cases (a) and (b).

Case (c) throws the stress of a final syllable onto either the antepenultimate or the penultimate vowel. Since case (c) specifically mentions a stressed vowel in its environment, if case (c) is to apply, then stress must have already been assigned to the word by some earlier rule--for example, in a previous cycle. However, if case (c) is to apply in the first cycle then it must apply to the output of either case (a) or case (b), which provide the main stress needed for (c) to operate on. (Actually case (c) can apply only after (a)--all the relevant examples contain the -y suffix--but never after (b) since (b) cannot assign final stress.) Hence, cases (a) and (c) are intrinsically ordered as well as conjunctively ordered.

12. The data are taken from Kiparsky 1965. The order (15) (16) is exemplified by the Low German dialect of Bleckede or the Swiss dialect of Mutten. The opposite order occurs in the Swiss dialect of Schaffhausen.

12a. Schane, 1968.

13. C_0 is the most general specification for consonants; it captures the notion of consonant cluster (as well as allowing for one consonant or no consonants). Alternatively, in our rule we could have used C_1 meaning one or more consonants.

14. The claim that extrinsic ordering implies separate phonological processes may be too strong. Yet in going through various generative phonological descriptions I have found no rules which violate this assumption. There were no rules with braces where the subparts were extrinsically ordered. There were a number of rules with braces where the subparts were intrinsically ordered. However, the vast majority of rules with braces had subparts which were unordered.

15. Alpha rules are disjunctively ordered--that is, if one part of the expansion applies then the other part cannot. However, unlike the parenthesis notation the subparts of alpha rules are not intrinsically ordered. Nor are they extrinsically ordered. The subparts are unordered. Alpha rules then are a special case of disjunctively ordered rules whose subparts are unordered.

16. The German umlauting rule is taken from Kiparsky 1965.

17. In Chomsky 1967 and Chomsky and Halle 1968, velar softening takes place in two steps: first, g becomes ǰ, while k becomes ts; then, ts is converted to s. However, this two-step process does not change the substance of our argument since the [- voiced] segment must still be made [+ diffuse].

18. It is of course possible to use the brace notation by adding more features to the change in the first element of the brace; but then generalizations are lost, since the first element of the brace repeats features found in the second element, e.g.

$$\begin{bmatrix} +\text{ obstruent} \\ -\text{ strident} \\ -\text{ diffuse} \end{bmatrix} \rightarrow \left\{ \begin{bmatrix} +\text{ diffuse} \\ +\text{ continuant} \\ +\text{ strident} \\ -\text{ grave} \end{bmatrix} \begin{bmatrix} +\text{ strident} \\ -\text{ grave} \end{bmatrix} \right. \quad / \; [-\overline{\text{voiced}}]$$

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