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Phonology as an Intelligent System

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"Par où on commence? demande Viole. Par le haut ou par le bas?
Il n'y a pas de règle, observe Dumont.
Il révèle ses hantises, les anciens.
En général, par le haut, quand même, dit Dumont.
(La mort dans une séisme solaire, p. 66 Hugues Pagan)

INTRODUCTION

The phrase "phonology as an intelligent system" suggests a contrast: a contrast with other views such as "phonology as an articulatory system," "phonology as a communicative system," "phonology as a social system," and "phonology as a mechanical system." Each of these views has something important to contribute to the study of phonology, but there is an important side of the matter that has been underplayed, and which today we should bring out and to the fore.

The most interesting aspect of language is its role in the expression of human thought and intelligence, and yet until recently it seemed that there was a serious rift between those aspects of syntax and semantics that reflect thought, on the one hand, and the principles that govern phonology, on the other. 1

1A recent perspective on this subject, but one taking a very different point of view, may be found in Bronsberger and Halle, 1989. They suggested that phonology is fundamentally different from syntax in certain respects—which it indeed may be—but among the differences Bronsberger and Halle suggest is the need for strict rule ordering in phonology. They offered one example, the well-known case involving the choice of the allophones of the diphthong (AE) in front of a voiced
This will no longer gives the impression of being quite so immense and so
bridgethe. This is too to say that phonology encodes propositional material;
or, the principles that govern the structure of the phonological components
or a grammar, it is becoming clear, operate in accordance with some general
principles that offer some hope of being understood within the larger context
of cognition; and this is the possibility that I wish to consider. Thus we may
emphasize how phonology as a cognitive system, one that organizes informa-
tion first and foremost, the sound, associated with the elements of the phonological
system, not the social or communicative context, but rather the system of con-
trasts or constructs which is the essence of the phonological system within
the grammar.
I focus on the goal-directedness of phonological processes in the following
discussion, because there is a clear connection between goal-directedness and
intelligence. If we were to find a system that displayed no goal-directedness
in its behavior, no matter how broadly construed, we would be hard-pressed to
imagine a reason for calling the system intelligent. If, on the other hand, it
did manifest some goal-directed behavior, then to that extent we would likely
be willing to grant it a rudimentary portion of intelligence. Intelligence, for
our purposes, we may take to be the ability to consider alternatives-to be
where one presently is, and to select the alternative that best suits one's cur-
rent requirements. Phonological systems, in their own primitive way, I shall
suggest, illustrate that kind of operation.

RULES IN CLASSICAL GENERATIVE PHONOLOGY

Phonological rules in classical generative phonology act, in each instance, as
rules that modify a representation just in case their structural description
met (with further external conditions placed as well involving, for the most
part, questions of rule ordering that we may comfortably leave aside for our
present purposes). These rules' ability to effect a change in a representation
comes, so to speak, from within; our conception of these rules is based on an
implicit metaphor according to which these rules are internally-powered
literacy-operated, so to speak. Nothing further need be true for a rule to apply
but that its structural description be satisfied. This conception of rules applying
to representations is the generative heritage from two sources: first, from
logicians' formalization of logical derivation—in particular, Post's notion of
a production system, and second, from historical linguists' notion of regula-
ry sound change, in which ordered sequences of rules correspond simply and
directly to stages in the evolution of a language.

I hope to show that this conception of rule application—which is by now
thoroughly established in our mode of thinking—has both a necessary and
satisfactory, and that its rejection in no way entails a retreat or return to the
statical mode of thinking associated with structuralist conception. We can
(used, as I will suggest, we have already begun to) establish a conception of phonol-
ogy that largely (though not in every detail, to be sure) rejects this earlier govern-
ing metaphor, and replaces it with one that is more congruent to the modes
of analyzing intelligence that have arisen in other disciplines.

CURRENT WORK IN PHONOLOGICAL THEORY

Work in autosegmental, metrical, and syllable phonology over the past 15 years
has led to a picture of phonology that is quite different from a number of ways
from the image established in the classical period of generative phonology, the
period characterized by Chomsky's (1968) and Halle's (1964) work. The
most striking differences have been in the relative importance and articulation
of the nature of phonological representations, on the one hand, and the class
of phonological rules, on the other. In the classical period of generative phono-
ology, representations consisted simply of linearly ordered sets of segments,
thereby bundles of distinctive features. Today, complex multiheaded struc-
tures are routinely explored to account more satisfactorily for phenomena
from overtlaeving to intrusive consonant insertion. In early generative phonolo-
13. PHONOLOGY AS AN INTELLIGENT SYSTEM

by syllabified—to put it simply, just in case its output is better than its input. To put the matter in such terms, of course, we need a general vocabulary and theory of syllabification, and as I have noted, we have taken many steps towards such an account in the last decade (for a recent discussion, see ibid, 1989). But the classical theory of generative phonology has no room at all for such notions; this theory is based on the notion of a rewrite rule that applies just in case its input conditions, or auxiliary description, are met by a representation. A classical generative rule does not aim at its output or target structure; it is, not we say, operating phonologically, with an eye to the structure that it is creating, and there is no sense in which we should understand it as acting as a target schema. But that is just the property of vowel insertion and deletion rules that has emerged out of phonological research over the past two decades.

For example, Kisseberth (1975) pointed out that the epenthesis of the vowel i in Yawelmani Yukus is the response of the phonological grammar to a situation where not all the phonological material is properly syllabified. Phonology in Yukus may contain no more than one consonant in the onset and one in the coda, so sequences of three consonants can never be properly syllabified.

In (1d), for example, the sequence of three consonants jkt is not syllabifiable as such, and the epenthetic vowel is inserted in order to achieve proper syllabification of all the phonological material. Hypothetical in the underlying and surface forms indicate breaks between morphemes; syllabification is not marked as such, but may be inferred from the generalizations just given.

\[
\begin{array}{ccc}
\text{surface} & \text{underlying} & \text{surface} \\
\text{sar-bin} & \text{[sar-bi/} & \text{sar-bi/} \\
\text{bak-bik} & \text{[bik-bik/} & \text{bak-bik/} \\
\text{dox-bik} & \text{[dox-bi/} & \text{dox-bi/} \\
\text{lag-bik} & \text{[lag-bik/} & \text{lag-bik/} \\
\end{array}
\]

Similarly, early work in autosegmental phonology (Goldsmith, 1976) emphasized the importance of processes that spread autosegmental association over unbounded distances, up to (but not including) this question, I believe, positive. Such an answer finds support in my own work, and draws together the work of many others currently working in phonological theory who have made less sweeping generalizations pointing in the same direction. Two brief examples might be helpful now, and we return to the matter in more detail later.

A growing (and by now quite large) literature on vowel epenthesis and deletion, beginning perhaps with Kisseberth’s influential work (1970) on conspiracies, has established that the bulk of vowel epenthesis and deletion rules are sensitive to the syllable boundary.

A rule of epenthesis will typically apply just in case two conditions hold: its output contains sequences of well-formed syllables and its input is not proper
HARMONIC APPLICATION

The picture that emerges from examples like these, and many others, is one in which harmonic application is a habitus (of the relevant level). It is not, then, that every phonological rule in the system is a habitus, which is to say, they apply just in case their output is better than their input with respect to some criteria specified by a phoneme (of the relevant level). A phoneme, then, then apply for a good reason: in order to make a representation better match a pattern, or template, or phoneme. This is crucially put, to be sure; many of the most important expectations involve patterns that are quite intricate, and other patterns involve structure. For example, the single most important template towards which phonological rules move a representation is that according to which all segments are well integrated into a pattern of syllables. Thus, the ejection of syllable structure, as well as that of metrical structure, on a word in part of the pattern of a well-formed word that the phonological rules are pushing the representation toward. Passivas need not be merely at the level of overt sequences of phonetic segments; they may involve any item in the phonological vocabulary.

Such a notion smacks of the commonplace from the point of view of psychology, for example, where notions such as a schema—note to mention pattern recognition—are perfectly familiar. Such notions presuppose a global construe in which a number of properties are expected by the system to occur together. In the absence of reason, the contrary, a system utilizing schemata may use the information inherent to a given schema to increase the information available to a given situation, or even to modify information transparently available. For example, believing that someone is a parent may lead us to further assume that they are adult, though that need not necessarily be true, and believing that someone has applied for a particular job and that he has not yet begun his dissertation may lead us to revise that second belief, on higher-order grounds: one would hardly be applying for such a job (for any reason) if one’s dissertation were not done, or nearly done; we revise our assumptions in the light of our global knowledge. Phonological operations operate to certain parallel respects: Default specifications may be filled in, in accordance with both language-particular and universal principles, and phonological information may actually be changed on the basis of calculating the simplifications that would be achieved by modifying the representation in a derived environment (see the following discussion of lexical phonology for more on this).

13. PHONOLOGY AS AN INTELLECTUAL SYSTEM

One thing that makes a system that understands special is that it shifts its representations in a predetermined (or already definable) directions. That is, modifications of one’s belief structures are made both in order to satisfy additional external information, of course, and in order to meet various (equivalently, phonological, or again, well-formedness conditions) and phonological rules play an important role, in a maximally supportive fashion, in a way that we may summarize as follows: All phonological rules apply in a harmonic fashion, which is to say, they apply just in case their output is better than their input with respect to some criteria specified by a phoneme (of the relevant level). A phoneme, then, then apply for a good reason: in order to make a representation better match a pattern, or template, or phoneme. This is crucially put, to be sure; many of the most important expectations involve patterns that are quite intricate, and other patterns involve structure. For example, the single most important template towards which phonological rules move a representation is that according to which all segments are well integrated into a pattern of syllables. Thus, the ejection of syllable structure, as well as that of metrical structure, on a word in part of the pattern of a well-formed word that the phonological rules are pushing the representation toward. Passivas need not be merely at the level of overt sequences of phonetic segments; they may involve any item in the phonological vocabulary.

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LEVELS IN HARMONIC PHONOLOGY

The picture that has emerged at this point may be described in the following way. A phonological description must include at least two things: a set of rules which describe the transitions that a given language permits, and a set of statements regarding relative well-formedness of various phonological structures. We may refer to this latter set of statements as phonotactics, and their role is to interact with the rules as described previously in relation to harmonic application. Rules apply just in case their output is better formed—better satisfies the phonotactics—than the input.

We may revise our mental image of this in the following way. Rules specify (mis)use (and unordered) transitions between pairs of states (a word with and without a final consonant, for example, or with and without stress on the first syllable); there are language-particular statements, and can be conceived of as linking points on a large map that represents all possible phonological representations of a given language. The purpose of the phonotactics is to give a sense of peaks and valleys to that map, in such a way that the higher a representation is, the more poorly formed it is in low step with the phonotactics.

*This has nothing—unusually nothing—to do with evaluation notices of the sort considered and often discussed in prescriptive grammars, which involves the issue of selecting a grammatical on the basis of a given corpus of usage—specifically, of selecting from a class of possible grammars, which all satisfy the boundary conditions set by the observed data. On such a view of grammar selection (better as a methodology or as a theory of language acquisition), grammars are compared on the basis of acceptability; the matter discussed in the text involves the modification of representations within a grammar on the basis of acceptability considerations, broadly construed.
such as spak (underlyingly agak) lose its final consonant in the unaffected form, surfacing then as spaq. (It represents a single, normal dental consonant, and is apical as well.)

(?) a. tippi species of rock end
mela sea
wanka arm
kungka grin
ngaka water
kaps child
ngewa wife
ngak story
paru short
murkuni nullah
ngu-nunga termite
b.
yalul flame
mayar rainbow
viwai bush tanggo
karuk butter-flies
yiyiy species of oyster
yukar husband
wutn species of fruit
wugaj mean
karukam red
kukwar species of water
c. underling form of venom
thurang thuvara thuranga-ing thuranga-kur shark
nguluk ngalu ngalu-en ngalu-up story

If a word with three or more syllables ends in a vowel underlyingly, however, it loses that vowel, as in the unaffected (first column) forms in (3a), and if this vowel loss leads to a situation in which a nonapical consonant is now "word-final, then these nonapicals are lost, just as before; this is illustrated in (3b). The crucial point for us in that the loss of the vowel is not motivated by a need to satisfy a phonotactic, for word-final vowels are perfectly satisfactory, and the shift from (e.g.) musakwe to musakwe (which is then fol-

1 The sufficiency of Landt's (1962 and elsewhere) stratificational models was argued by Pottel (1986) in the grounds of the commitment of finding rules in natural languages. A revised and updated version of this argument was made by Lacroix (1988, pp. 201-05) against con-

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4 We slip here into derivational idiom, but only for a moment, and it should be taken as a touch of irony.
moves away from satisfaction of the phonotactics. Hence there are at least some rules with this nonharmonic property, and we must deal with that fact, (i represents a single, laminal alveopalatal consonant, and i at a single laminal den-
tal consonant).

(3) a.
yalulu  yuma  yukwa  yiyilli
maya  mayera  mayara
wiwala  karkari  yiyilli
yiwiwi  karkari
yiwiwi-n  karri
yiwiwi-l-n  karri
yiwiwi-wur  karri
yiwiwi-

b.

putuka  putukun
murkunima  murkunima
ngwangwau  ngwangwau-n
titipili  titipili
chapotji  thapu
munkunmunu  munkunmunu

These hard, unpleasant facts of phonological life force us to recognize that the image of rules as transitions on a phonological landscape is only a part of a larger picture, and that that part corresponds to the traditional notion of levels in linguistic theory. That is, what constitutes a level, in traditional terms, is a set of generalizations regarding the linguistic representation; these generalizations may be restated in entirely nonphonotactics (or, in our metaphor, as statements regarding what is higher than what, and what is lower than what, on the landscape). A level is not, then, one stage in a derivation; it is not even a single representation. It is (and this is the point of this paper) a set of phonotac-
tics, and a representation of a given utterance U on a level L is a path from a starting point R₁ to a final resting point R₂. The final resting point R₂ is that representation which is the head-formed (i.e., the lowest on the landscape) of all points accessible to R₁ via the paths made available by the rules of the language on that level.

Each level, then, contains a set of rules, which we may refer to as intralevel rules, and these rules will necessarily apply in a harmonic fashion. But as we have just suggested, there is more than one level in a phonology of a natural language. A fair amount of exploration suggests that although two phonologi-
cal levels is inadequate, a model with three levels is sufficiently rich to deal

with the phenomena that have come to light. Such a model will contain three levels—which we will refer to as M-level (essentially the underlying, or mor-
phophonetic, level), the W-level (the level at which pure syllable structure is established), and P-level (phonetic level). Each level consists of the state-
ment of tactics at its level, plus a set of intralevel rules. The three phonological levels, we may assume, relate to each other in much the same way that the other linguistic levels relate to one another (I draw heavily here on Sadock 1985, 1990). That is, the relation between the W-level and the M-level is logically parallel to that between the syntax and the morphology: the two tend to line up, in general, in a natural way, but do not need to do so in any particular case. The rules that relate levels (whether they be M-level or syntactic) are interface rules, in Sadock’s terminology (or cross-level rules). In principle, then, there should be six classes of phonological rules: three intralevel sets—M-
level, W-level, and P-level intralevel rules; (M,M), (W,W), (P,P), and three cross-level rule sets: (M,W), (W,P), and (M,P). If there is a hierarchization of levels in phonology, the last one—(M,P)—may not exist (as I shall assume for expository reasons), and we would arrive at a picture as follows:

13. PHONOLOGY AS AN INTELLIGENT SYSTEM

Ultimately, the three levels of phonological theory should be viewed as not differ-
et in kind from the other levels of grammatical theory, such as the morpho-
These patterns are established at the W-level, and involve reference to two types of conditions at this level. First, and quite generally across languages, there is a preference for binary syllables to be stressed, rather than unaccented (a condition referred to by Prince, 1987, as Quantity-Sensitivity). Stress is assigned to satisfy this requirement. In addition, syllables must be organized into feet, and these are iambic in Yupik (i.e., weak-strong). In short, at this level, stress is assigned to match inharmony quantity of the syllables. At P-level, a richer deeper process occurs, by which syllable weights are modified to match the stress pattern that was established at the W-level. In essence, what happens is that if a syllable is stressed, it must be heavy; if it is already—indeed—heavily by virtue of having a long vowel or being closed, that is sufficient; otherwise, the syllable is made heavy by one move or another (essentially, lengthening the vowel of the syllable unless that vowel is a schwa, in which case the consonant of the following root is geminated, creating a...
closed syllable, except in Central Siberian). This is illustrated in (6). Thus the effect of the generalizations on the two distinct levels is to make the effect of each level less obvious, even though the effects within each individual level are simple and direct. Each level—W and P—serves to achieve a simple matching between the accent and the weight of the syllables, though the two levels achieve this (to the extent that they succeed) in opposite directions.

(6) a. W-level: qa as pig as si surface: [qa se piq se ni] meaning: big own future authentic
b. P-level: ang si s a ha surface: [ang si a ha] meaning: big boy

LEXICAL PHONOLOGY

Lexical phonology (Kiparsky, 1982) makes a particular suggestion that has not been especially pursued by most phonologists endorsing that research program, one that is relevant to our discussion (see also Goldsmith, 1990, chapter 5). The suggestion is that the class of lexical phonological rules is associative with the set of rules that establishes markedness for lexical items. For example, if the rule of primary stress lowering (7) is a lexical phonological rule of English, operative in such hearse examples as dissonance to shorten the first vowel of the suffixed, derived nominal, it also functions to express the generalization that any vowel followed by an unstressed syllable and another syllable ought to be short, and will be long only under marked conditions; in that sense, English, with its short first vowel, is better than Russian, with its long first vowel.

(7) V -> [long] \( \rightarrow \) CV \( \rightarrow \) CV', where V, CV, C V

Lexical phonology unfortunately offers no explicit means for the language learner to figure out what the lexical redundancy rules of his or her language are, but it does suggest that once such rules have been established, they are now operative in analyzing morphophonemic alternations, or in lexical phonology terminology, they function as lexical phonological rules. Put another way, if we take statements of markedness with regard to lexical redundancy to be contributions to the information of relative well-formedness—either M-level or W-level, with better formed (i.e., less marked) representations being lower on the landscape then minimally different, but marked, representations, then lexical phonological rules will always be a representation move downward, that is, harmonically. Repeating the last example, if a short vowel if less marked than a long vowel in the position \( \rightarrow \) CV, then when a long vowel becomes short (in diphthong) during the derivational process that is responsible for the diphthongal nominal, the shift involved is one that simplifies the representation, or pushes the representation downward. Thus even the rules of lexical phonology, understood in this way, have the harmonic property that we are focusing upon.

CYCLICITY

The simple model described earlier in (4), Fig. 13.1, with its three levels, appears to say nothing about the concept of cyclicity, a notion central to lexical phonology and a good deal of recent work in phonology. The present model does offer an interesting and attractive reanalysis of some of the fundamental properties of a cyclic account however.

On most accounts, the notion of cyclicity involves particular details of rule application and reappraisal. For lexical phonology, which is bravely committed to a processual and derivational conception of phonological analysis, cyclic steps are organized in such a fashion that after each successive affix is attached, a sequence of phonological rules is applied, as their individual structural descriptions are met, there will be as many opportunities for the entire set of rules to apply as there are affixes attached.

This notion of cyclicity has no place in the present model, because the overwhelmingly derivational model of phonology is assumed by lexical phonology has no place here. Let us take the opposition marked and unmarked which is involved in consideration of cyclicity. We find in general two schools of thought of the subject. On the one hand, there is the word-based school of cyclicity, discussed in Baume (1972a, 1974), Aronoff (1976), Harris (1983), Kiparsky (1982), and Goldsmith (1990), according to which the word is the unit to which further operations may be performed to yield derived words, schematically, as in (8); the domains marked \( \{W'\} \) and with units smaller, are subject to cyclic reappraisal. On the other hand, there is another view of cyclicity according to which cyclicity has to do with the phonological word, and devolves rather from the dynamic process of word formation, as discussed in (for example) Chomsky and Halle (1968), and more recently, Pozer (1989). The last example is useful in establishing a contrast between these conceptions.

(8) \( \{w \} \rightarrow b \}

Pozer, based on work of Peter Austin, discussed the case of Diyar, a language in which stress is assigned to alternate syllables, starting on the left, within each morpheme of a word, as illustrated in (9), with morpheme-final syllables not receiving stress in any event. Rather than allow a grammar

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\( \text{Peter cited lexical phonology throughout, seemingly unaware that Kiparsky's (1982) statement of lexical phonology requires that cyclic domains be minimal words.} \)
the ability to say such a thing directly, Pozer suggested that the effect should be derived indirectly, in the following way: A cyclic analysis, as he described it, will leave visible only the root on the first cycle, and on each successive cycle, under the principle that the grammar will find one or more affixes that it did on the cycle before. Therefore, he suggested, a cyclic account may assign alternating (left to right) affixes to the root, and again on each successive cycle, just as long as the stress again shifts. However, when the cyclic cycle is left unattached to the last cycle(s). In such a way, each cycle will affect only the material that is new on that cycle, and by the way things have been set up, each affix will have exactly one cycle during which it is the new affix to which no stress has yet been assigned. Crucial to Pozer’s account is that the morphemes in question are not way and in no sensor words.

(9) a tawo-wata-titi
b. tawo-wata-sita-ka

Such a view of cyclicity has little or nothing in its favor in this case (or others), as far as I can see, except that it permits one an indefinite fashion of saying what one might as well say directly, which is that the relationship established between syllables and the segmental grid may be sensitive to morpheme identity—just as the syllable-initial association that can, in many tonal languages (e.g., in Lhogori, Leong, 1965; Golofim, in press c), where the initial tone association of each tone must be to the leftmost vowel of the morpheme that is logico-syntactically associated with that tone, the process is thus a morpheme-by-morpheme process, not a word-level process. The tawo-significance of cyclicity, as Braine and the others cited earlier argued, is that there are phonological cases in which one can argue that there is a set of bracketed phonological words, as in [s to] a b]; cf. (9). Cyclicity then enters into the analysis in two ways: first, phonological processes may be affected within Ws because it is a phonological word, processes that would not occur otherwise (i.e., processes that would not occur if the material marked as “a” were not treated as a word); and second, effects that we otherwise expect to take place within a phonological word may be blocked across the segmental separation W1 and W2, that is, between the base and the suff. The first case is exemplified in Selaware (as discussed by Mikhon & Berta, 1996), where we find that what seems to end in “s, and the affix must have an epenthetic vowel (identical to the preceding vowel) added to them if they are to serve as full phonological words, whereas “long” is before surfaces as [tamba], for example. When a suffix such as “-ka” is added, the word is not treated as a separate word, and we find no epenthetic vowel, as in [tamba-ka] “longer.” However, there are other suffixes which attach to units that must be analyzed as full phonological words, these on an earlier position suffix s, for example, attaches to the word nata “profit” (from underlying /nata/), no give the complex form /nata-suta/, which has the structure [u *nata-pla] us. Concerning the second effect of cyclicity or, as we may equally refer to it, recursive phonological word structure, we find cases as in, for example, English tawo-duran (a speech pattern peculiar to Pidgin) in which phonostatistics regularities that otherwise hold for English are blocked across a boundary. Here, we have a sequence of schwa plus high vowel, which can otherwise be found in English only across full word boundaries, but never inside a single phonological word. When the suffix -sitt is attached to a base without the recursive word structure of (9), the schwa is deleted (in kawo-t-sitt > kawo-t-sitt), but this process of deletion does not happen to the schwa at the end of the inner cycle in [tindan-jen], an example of the second effect of cyclicity. These two effects are, I believe, the only robust effects that can be attributed to cyclicity, and both can be reconstructed from a point of view that reconstructs derivations in the way I have suggested in this paper. 11 Regarding the first point, if a subpart of a larger phonological word is itself a phonological word, as in (8), then we must satisfy the language’s tactics for being a well-formed word, just as an embedded clause must satisfy all the grammatical conditions for being a clause, even though it may well be (irreducibly) embedded within a larger, matrix clause. Regarding the second point, we must observe that it is still an open question in what ways the rules apply across such boundaries: ‘are there any conditions on the rules that apply to, one of two alternatives may be the case: (a) in the case of rules such as

11 A similar case can be found in Hall, 1989, where the distribution of Germanic and (a) is explored from the point of view of lexicon phonology. As Hall pointed out, a structure of the form sitt is regarded as being not viable since it cannot be correctly analyzed as the phonological word as an abstract, but as a form in such cases as the English: tawo-duran (a patois pattern of Pidgin), which has the form [u *nata]. 12 As Hall observes, attempts to formulate the observation in derivational terms results in the principle (t to) and, which is the natural way of doing things in phonology, and morphology each independently of variations of other principles that are equally central to lexical phonology. 13 From one point of view, it is probably that the facts of this kind of phenomenon have to be reanalyzed: it is often that the morphemic cycle can be respectively in (or rather, reduced to) methodological status.
264 GOLDSMITH

Triplyfacial shortening, applying to done so to form divinity with a short second vowel, the phonological structure is not as in (B), but simply divinity. that is, phonological structure need not match morphological structure (or, to put it another way, word-based morphology need not always give rise to neat phonological word-structure); (B) in the case of stress rules, as Halle and Vergnaud (1988) demonstrated, each word-cycle may construct its own mental grid, independent of the grid associated with the embedded phonological word; this gives the appearance of the grid constructed with outer word cycle overriding that constructed on an embedded cycle.

DISCUSSION AND CONCLUSION

The picture that emerges of the phonological system, then, is one in which rules serve as a means for getting representations to maximally satisfy phonotactics of the individual phonological levels of the grammar. How, we may ask, does this picture fit in with other conceptions of grammar and of cognition?

Recent work on connectionism speaks in a kindred fashion. Rumelhart and McClelland, for example, offered the following observation.

"Image is a computational system that has as a primitive, "Role in a state that represents an optimal global interpretation of the current input." This would be, of course, an extremely powerful place to begin building up a theory of higher-level comparisons ... The sort of primitives ... are the kind of emergent properties that FDP mechanisms give us, and it seems very likely that the availability of such primitives will change the shape of higher level theory considerably." (Rumelhart & McClelland, 1986, p. 196–197)

This appears to be exactly the sort of higher-level vocabulary that is required by the type of phonology—harmonic phonology—that I have advocated in this paper. Various discussions in the current literature have raised questions regarding the relevance of connectionist modeling to linguistic problems (for example, Lashley & Bever, 1988, Fischer & Prince, 1988). I interpret the difference between their pessimism and my optimism as based largely on how satisfied one is that the current models of phonology (or grammar, more generally) are within shooting distance of the final truth. If our current derivational models are—minor details aside—essentially correct models of the truth, then connectionist revisions are neither welcome nor helpful. If, on the other hand, serious reconsideration of even the most basic questions of the organization of phonological derivations and rule application are the order of the day, as I have suggested here, then it is certainly within the realms of the conceivable that the types of generalizations that emerge from connectionist models may be closer to the sort that we need in the newer model of phonology. 13

REFERENCES
