Where Binarity Fails

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0. Introduction.

The Sound Pattern of English calls for gradual conversion of most binary feature specifications into nonbinary numerical coefficients. It is claimed that phonological rules carry out this work of debinarization and that the task is not done exclusively by last-ordered surface rules but also by sequentially ordered rules of the phonology. Possibly because Chomsky and Halle only used this aspect of their theory when writing stress rules, subsequent writers, if they have assumed underlying binarity, have conservatively refused to use any but binarily specified features except in the output of final rules. In fact, even final rules assigning numerical coefficients are almost always omitted from phonological descriptions. This is perplexing since the reason Chomsky and Halle provide for the absence of nonfinal numerical values to characterize segmental phenomena in The Sound Pattern of English is that their study is restricted, for the most part, to higher level rules.

This paper will criticize the claim that nonbinarity must be limited to the output of final 'rules of phonetic interpretation', as they are often called, and argue for the contrary claim that nonbinarity should be extended to the structural descriptions of rules and to the output of nonfinal rules. These arguments are not intended to bear directly on the debate over whether features should be specified binarily in underlying representations, and, for purposes of argument, they do not question the appropriateness of feature notation for all processes, nor the appropriateness of discrete feature coefficients--the outcome of these issues should not effect the present claims.

1. Rule Ordering.

The first example is contingent on the assumption that extrinsic rule ordering costs something. Consider rules (1) and (2) posited for Akan by Schachter and Fromkin.

1.

$$[-\text{voc}] \rightarrow [+\text{nas}] \;/\; \left\{ \begin{bmatrix} \overline{} \\ +\text{cons} \\ +\text{vcd} \end{bmatrix} \;\; \begin{bmatrix} \overline{} \\ -\text{cons} \end{bmatrix} \right\} \;/\; \_\_ \begin{bmatrix} +\text{voc} \\ +\text{nas} \end{bmatrix}$$

2. $\begin{bmatrix} +\text{voc} \\ +\text{high} \end{bmatrix} \rightarrow [+\text{nas}] \; / \; \_\_ \; \begin{bmatrix} +\text{cons} \\ +\text{nas} \end{bmatrix}$

3.

/bã/	→	[mã]	'give'
/dã/	→	[nã]	'and'
/jã/	→	[ɲ̃ã]	'receive'
		~[ñʒ̃ã]	
/wadɪ/	→	[w̃ãnʧ̃]	'scrape'
		~[ŋʷ̃ãnʧ̃]	
/hu/	→	[ñũ]	'fear'

4.

$\begin{bmatrix} -\text{vcd} \\ -\text{nas} \\ \text{C} \end{bmatrix}$	V	[nsa] 'hand', [pam?] 'sew'
$\begin{bmatrix} -\text{vcd} \\ -\text{nas} \\ \text{C} \end{bmatrix}$	$\tilde{\text{V}}$	[nsã] 'liquor', [pãm?] 'confederate'
$\begin{bmatrix} +\text{vcd} \\ -\text{nas} \\ \text{C} \end{bmatrix}$	V	[ba] 'child'
$*\begin{bmatrix} +\text{vcd} \\ -\text{nas} \\ \text{C} \end{bmatrix}$	$\tilde{\text{V}}$	---

5.

dum	→	[dũm] 'extinguish'
dɪŋ	→	[dĩŋ] 'difficult'

Rule (1) nasalizes voiced consonants and the glides h, y, and w before underlying nasal vowels, as shown in (3). There are two reasons why one would not want to set up the surface forms on the right in (3) as basic. First, this would fail to account for the distributional facts in (4), and second, without rule (1) we would be forced to set up the dubious underlying segments ñ, ỹ, and w̃. Since this second motivation would require experimental confirmation of the surface phonetics, and the first motivation is purely distributional, the existence of rule (1) appears somewhat doubtful, but we will content ourselves with showing that even if (1) is a rule of Akan, there is a better solution than the one proposed by Schachter and Fromkin, but a solution that is only available if the standard working assumption of binarity above the surface is abandoned. Rule (2) nasalizes high vowels before syllable-final nasal consonants, as shown in (5).

Consider the ordering of these two rules. To express the fact that underlying nasal vowels, as in (3), trigger consonant nasalization,

while contextually nasalized vowels, as in (5), do not, the order (1), (2) is required. This is the solution proposed by Schachter and Fromkin. But suppose we were to mark contextual vowel nasalization as distinct from underlying nasalization. Then we could eliminate rule ordering by writing rules (6) and (7).

6. $$[-\text{voc}] \rightarrow [+\text{nas}] \; / \left\{ \begin{bmatrix} \_\_\_ \\ +\text{cons} \\ +\text{vcd} \end{bmatrix} \right\} / \_\_ \begin{bmatrix} +\text{voc} \\ +\text{nas}_u \end{bmatrix}$$

7. $$\begin{bmatrix} +\text{voc} \\ +\text{high} \end{bmatrix} \rightarrow [+\text{nas}_c] \; / \; \_\_\_ \; \begin{bmatrix} +\text{cons} \\ +\text{nas} \end{bmatrix}$$

Of course, this solution requires apparently ad hoc markers to distinguish two types of nasalization, but there is evidence for such a distinction. Regressive contextual nasalization is apparently always weaker than distinctive nasalization. This is attested in, for example, Ayutla Mixtec, Navaho, Pame, Picuris, and Guarani. I know of no counterexamples. Second, there is the language-specific limitation of nasalization in Akan to high vowels. If the velum is simply lowered a given small amount, it stands to reason that high vowels will be nasalized since proportionally more vibrating air will be shunted through the nasal passages for these vowels. Although languages generally tend to nasalize low vowels more readily than high, the opposite hierarchy operates not only in Akan, but also Sora and other Munda languages in which, according to Stampe (personal communication), high vowels are heavily nasalized, mid vowels less so, and low vowels least. In Akan the velum must be lowered more completely for underlying nasal vowels since there are underlying low nasal vowels in the language.

We can now substitute the specifications '++nasal' and '+nasal' for the ad hoc markers in (6) and (7) respectively, yielding rules (8) and (2), also unordered. No importance is attached to the coefficients '++' and '+'--what is important is that there is a distinction in degree.

8. $$[-\text{voc}] \rightarrow [+\text{nas}] \; / \left\{ \begin{bmatrix} \_\_\_ \\ +\text{cons} \\ +\text{vcd} \end{bmatrix} \right\} / \_\_ \begin{bmatrix} +\text{voc} \\ ++\text{nas} \end{bmatrix}$$

2. $\begin{bmatrix} +\text{voc} \\ +\text{high} \end{bmatrix} \rightarrow [+\text{nas}] \; / \; \_\_ \; \begin{bmatrix} +\text{cons} \\ +\text{nas} \end{bmatrix}$

It is worth noting that in the binary solution the rule ordering is marked no matter what criterion is chosen. The order (1), (2) is anti-feeding, renders rule (1) opaque, and would make for less paradigmatic regularity.[1]

2. Scapegoat Features.

Portuguese denasalizes the first vowel of the combinations in (9), while leaving those in (10) alone. Vowel quality and morphological conditioning aside, we would have to write rule (11), and this is essentially the rule Saciuk writes.

9. ãã́ õa õa ũa õo (õo in verbs only)

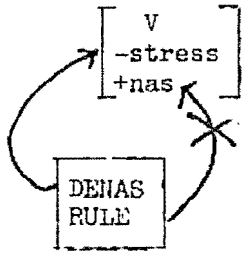
10. ã́a ĩa ĩo

11. $V \rightarrow [-\text{nas}] \; / \; \left[\overline{} \; -\text{stress} \right] \; V$

The problem is that (11) is at one remove from its phonetic motivation, for there is, beyond the common sense argument that stress intensifies all parameters, evidence that nasalization is heavier on stressed vowels than on unstressed. This shows up in the willingness of unstressed, but not stressed, vowels to lose all perceptible nasalization, as in Upper Austrian German, Breton, and early Icelandic, and is directly attested in Island Carib. If (11) were to directly capture the fact that Portuguese loses weak nasalization in certain environments, it would be written as (12), which doesn't affect stressed vowels because they are specified heavily nasal. As the diagram in (13) shows, the assumption of pure binarity above the surface forces sidestepping of the relevant phonetic parameter. Consider the standard solution in more detail.

12. $V \rightarrow [-\text{nas}] \; / \; \left[\overline{+\text{nas}} \right] \; V$

13. $\begin{bmatrix} V \\ +\text{stress} \\ +\text{nas} \end{bmatrix}$



Can't refer to nasality since this would force the rule to distinguish between degrees of nasality. Refers instead to a correlated feature.

Rule (11) would be needed and also a last-ordered rule to state that stressed vowels are heavily nasal. But this solution first provides for denasalization of unstressed vowels, then, only in a later rule, provides the factor that makes stress relevant in the first rule; this kind of globalness in low level rules is highly suspect, especially when it disguises phonetic motivations.

Consider a clearer example of almost the same thing. Neeld has established that palatalization is primarily conditioned by height of adjacent (usually front) vocoids; thus, a language will palatalize adjacent to front vocoids of a specifiable language-particular height and higher, but not lower. Now consider the environment of the rule usually written for languages that palatalize only before j, which is the uppermost member of the height hierarchy. Some such languages are given in (14). The rule would be written as (15) which, however, completely misses the generalization that height is the relevant parameter since it uses extraneous features to explain why high front vowels don't palatalize while j does. Clearly, what is needed is an environment statement with a nonbinary coefficient on a height feature higher than the coefficient for high front vowels.

14. English:
dɪd ju → dɪʒ(j) u 'did you'
dɪd iən →*dɪʒ iən 'did Ian'
also:

$$\begin{bmatrix} -\text{sonor} \\ +\text{cor} \end{bmatrix} \rightarrow \begin{bmatrix} -\text{ant} \\ +\text{strid} \end{bmatrix} / \_\_ \begin{bmatrix} -\text{back} \\ -\text{voc} \\ -\text{cons} \end{bmatrix} \begin{bmatrix} -\text{con} \\ -\text{stress} \end{bmatrix}$$

(SPE, 230)

Oneida:
s → ʃ / __ j

Spanish

$$\begin{bmatrix} +\text{obst} \\ +\text{cor} \\ +\text{S} \end{bmatrix} \rightarrow [+\text{high}] / \begin{bmatrix} -\text{voc} \\ -\text{back} \\ +\text{high} \end{bmatrix} \_\_$$

(part of a more general rule: Harris)

East Slavic:

$$[+\text{cor}] \rightarrow [+\text{high}] / \_\_ \begin{bmatrix} -\text{voc} \\ -\text{cons} \\ -\text{back} \\ +\text{high} \end{bmatrix}$$

(SPE, 429)

Italian:

$$\begin{bmatrix} +\text{cons} \\ -\text{voc} \\ -\text{cnt} \end{bmatrix} \rightarrow [+\text{shp}] / \_\_ + \begin{bmatrix} -\text{voc} \\ -\text{cns} \\ +\text{grv} \end{bmatrix}$$

(palatalization?; Saltarelli)

15. $$C \rightarrow [+high] \; / \; \_\_ \; \begin{bmatrix} -cons \\ -voc \\ +high \end{bmatrix}$$

3. Rule Collapsibility.

In Portuguese vowels are nasalized before and after nasals, as in (16).

16. [kãmã] 'bed', [sĩnõr] 'mister', [kõmẽ] 'they eat'

Progressive nasalization is weak, as determined, Saciuk tells us, 'by mechanical devices'. Not unexpectedly, a rule raising low nasalized vowels acts only on regressively nasalized vowels. In a binary solution, the failure of progressive nasalization to trigger this rule must be explained by rule ordering, as in (17).

17. (i) Regressive Nasalization
(ii) Raising
(iii) Progressive Nasalization

In the nonbinary solution the fact that progressive nasalization is physically distinct from regressive nasalization is used to eliminate the ordering of progressive nasalization after raising, thus admitting the possibility of collapsing regressive and progressive nasalization into a single rule. This nasalization rule would assign more than one degree of nasalization, a point for which evidence will be given later.

But this argument can be made much stronger. There are a few words in Portuguese that exhibit heavy progressive nasalization. Since the degree is different from that for ordinary progressive nasalization, it appears reasonable to write a separate rule for these aberrant forms, as Saciuk does. But Saciuk might have had another reason for nasalizing these forms by a separate rule--they undergo raising. This necessitates the ordering in (18).

18. (i) Regressive Nasalization, Minor Progressive Nasalization
(ii) Raising
(iii) Progressive Nasalization

If we could show that minor progressive nasalization (the rule providing heavy progressive nasalization) is a subpart of the major progressive nasalization rule, we would be forced to the conclusion that a single progressive nasalization rule assigns at least two degrees of nasalization and that raising follows this rule and discriminates between these two degrees of nasalization. There are good reasons to write only one progressive nasalization rule for Portuguese. First notice that the minor rule nasalizes vowels only after nasals--thus its environment is a subset of the environments in which ordinary

progressive nasalization occurs. Second, consider the particular forms in question, listed exhaustively in (19).

19. [nĩnũ] 'nest' [mũjntu] 'much, very'

[mũj] 'very' [mɐ̃jj] 'mother'

[mĩña] 'my' [mĩ] 'me, myself'

It is immediately clear that there are in fact phonetic conditioning factors which Saciuk failed to notice. The vowel to be nasalized must be stressed, and it must follow an initial nasal. Moreover, if the vowel is not the only vowel in the word, it must be both preceded and followed by a nasal. Now all of these conditions are conducive to increased nasality. Position between two nasals is extremely conducive to nasalization; structuralist grammars often comment that there is nasalization between two nasals even in a language which has no clearly distinguishable nasalization elsewhere. The contributions of monosyllabicity and position after an initial m are exemplified in Hindi-Urdu which, according to a recent analysis (Narang and Becker), nasalizes words whose phonetic shape is mã, mẽ, and mɐ̃, by a separate rule, and in Warao, which has extra heavy nasalization on the words mĩ, mẽ, mã, mõ, and mũ. It appears, therefore, that rule division is unfair in this case.

4. Extra Rule.

If we choose a binary solution like (17) to the Portuguese raising problem, we are faced with the necessity of stating somewhere in the grammar that regressive and progressive nasalization differ in degree. Under current working assumptions such degrees could only be specified in the output of final rules. The solution in (17) would thus be able to state the degree of progressive nasalization, but would require a new last-ordered rule to state the degree of regressive nasalization.

5. Universals.

Richard DeArmond claims that 'in Polish there is an inverse relation between vowel nasality and the strength of following syllable-final consonants' as determined by spectrography. He adds that there is a small amount of nasalization in vowels before syllable-initial nasals. There is independent evidence that DeArmond's estimations are essentially correct. In a paper read at this summer's LSA Meeting, I gave comparative evidence from numerous languages to show that the universal schema for vowel nasalization is (20), which is, however, still considerably lacking in detail.

20. $$\begin{bmatrix} V \\ +\text{stress!} \\ +\text{low!} \\ +\text{back!} \end{bmatrix} \rightarrow [+\text{nas}] \;/\; \_\_\; N \begin{Bmatrix} [-\text{seg}] \\ \begin{bmatrix} C \\ +\text{cont} \end{bmatrix} \\ \begin{bmatrix} C \\ -\text{cont} \end{bmatrix} \\ V \end{Bmatrix} (\_\_ \text{ i.e. } / \_\_ N.)$$

The hierarchy of postnasal conditioning factors is strict and predicts that if a language has nasalization before a given element of the hierarchy, it will also nasalize vowels before all elements above that one in the hierarchy. This schema also predicts that the degree of nasalization will be greater before elements higher up in the hierarchy. If DeArmond's statements are correct (and it would be quite strange if they are not), Polish appears to obey this hierarchy to the extent that the appropriate environments occur in Polish.

Now consider a rule lowering nasalized vowels in Polish; this rule lowers all nasalized vowels except those before syllable-initial nasals. To express this fact within current working assumptions, DeArmond writes one nasalization rule that nasalizes all prenasal vowels except those before syllable-initial nasals, then orders lowering after this rule, and finally allows nasalization to occur before syllable-initial nasals. Now, since it is necessary to state the degrees of nasalization anyway, and since, if this could be done by the nasalization rule itself, there would be at least one less rule in the grammar, and since the single nasalization rule in question would incorporate the postnasal hierarchy of the universal schema for vowel nasalization, there are good reasons to write a nonbinary solution here. But there is even an additional compelling reason to abandon binarity in this case, for if Polish vowel nasalization is broken into two rules, one of these will have the form of no rule known to exist in any natural language--and in fact a form which research into the form of nasalization rules shows to be extremely unlikely since in the universal schema vowels preceding syllable-initial nasals are at the very weakest point in the hierarchy.

6. Power.

One might argue that extending the domain of nonbinarity upward in derivations increases the power of phonological rules beyond the excessive power they already possess. But this would only be the case if nonbinary specifications were used as ad hoc markers without any phonetic basis. In fact, it is likely that revision of working assumptions along the lines suggested here would further constrain phonological theory. Consider, for example, what was until recently[2] the clearest example of a global phonological rule--that governing the alternation of vowel length in Klamath. A rule was posited to change certain glides to vowels, and these vowels were claimed to alternate

between long and short. But it is difficult to write a rule shortening long derived vowels since there exist underlying long and short vowels that the rule would have to ignore. Kisseberth concluded that, therefore, the rule changing vowel length must look back to the source of the segments it affects and apply only to derived vowels. But if the assumption of pure binarity above the surface is abandoned, Kisseberth's solution requires for its adequate defense exact determination of the vowel lengths in Klamath. Even a small distinction between underlying vowel length and the length of derived vowels would permit a nonbinary solution which would eliminate the globalness. As a reminder of the dangers of audio-impressionistic determination of vowel length, we have the case of the misanalysis of German spotted by Dinnsen and Garcia-Zamor, who did their experimental homework.

But regardless of what the right analysis of Klamath is, this discussion of power brings to light an important point: phonology with pluses and minuses is a lot easier to do than phonology with additional possible specifications. The assumption of pure binarity legitimatizes the phonologist's disregard of phonetic detail and makes it possible to draw conclusions without the help of experimental phonetics; carrying this one sentence further, it is the binarity assumption that makes it possible to trust structuralist grammars as a sufficient source for phonological data.

7. Conclusion.

Probably no one has questioned the need for nonbinary specification at the surface. I have argued that fear of extending nonbinarity to higher points in derivations has led to illicit use of rule ordering to avoid stating phonetic motivations that cannot be directly stated using binarily specified features, to the use of scapegoat features to the same end, to positing extra rules of phonetic interpretation, to the division of single rules into two, and has nicely complemented the unwarranted assumption of the irrelevance of phonetic detail.

It is tempting, and I think correct, to draw an analogy here between, on the one hand, the dichotomy phonological rule/phonetic interpretation rule and, on the other, syntactic rule/semantic rule. It was possible until recently in syntax to push troublesome matters into the semantic component, excluding them from present consideration. Syntacticians have become uncomfortable about the size of the bulge under that carpet. This paper suggests that phonologists should become more self-conscious about sweeping things under the carpet of 'phonetic interpretation'.

Footnotes

1. A similar situation exists in Sango (Samarin) in which derived nasal vowels which are only lightly nasal fail to lower, while underlying nasal vowels (or at least those not adjacent to surface nasals) do lower:

[wɛ̃^{V}] 'iron', [yɛnɛ̃] 'anus'

2. This paper was read at the winter LSA meeting, Dec. 27, 1972, in Atlanta, Georgia. On the same day, in the morning, a paper by Robin Barbara White was read in which she presented a viable nonglobal reanalysis of the Klamath problem.

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