On Process Model Phonology

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ABSTRACT

This paper attempts a formal reinterpretation of the standard slash-dash notation of phonological environments in terms of a more process oriented model of phonological description. Two process modes of phonological rules are presented - i.e., interpretive and productive. Each process mode is related to the task of an interpreter and a producer. The phonological model presented is shown to have the advantage of both the direct mapping hypothesis and the sequential application hypothesis. Finally the general theoretical consequences of employing the process model presented are investigated and the possible future directions of research are indicated.

§1. Very intuitively speaking,[1] an interpreter's task is to determine the higher lines of derivation, given a certain line (ideally, a surface form). A producer's task is to work one's way down the derivation, given a certain line (ideally, an underlying form). The phonological rules with slash-dash environments are neutral with respect to the tasks of both an interpreter and a producer. One way to modify the phonological theory is to allow for the rules that have more direct relevance with either interpretation or production. Such a modification is possible if we let phonological rules be able to refer to either only the higher of the two derivational lines or only the lower of the two derivational lines we are concerned with. Let us call rules of the former sort "productive rules" and write as: $A \rightarrow B\downarrow X\text{–}Y$. Correspondingly let us call the rules of the latter sort "interpretive rules" and write as: $A \rightarrow B\uparrow X\_Y$. The productive rule may be read, "A corresponds to B when A is flanked by X and Y." The interpretive rule may be read, "A corresponds to B when B is flanked by X and Y." Such rules have, in certain clear cases, the effect of shortening the derivation, which, other things being equal, renders the phonology more concrete. Such a conception of phonological rules is thus worth investigating in that it has the potential of making a phonological description more realistic.[2]

§2. Consider, for instance, the following mini-derivation:

{bʌ ʔn̩, bʌn̩, bʌ̃n̩} : *button*

This derivation would be allowed by rules: *Glottal Deletion* (GL) (optional) and *Vowel Nasalization* (VN) before nasal in this order (cf. Stampe (1972)). But by modifying the rules in the way mentioned in the preceding section, we can account for the same facts with a shorter derivation. Thus, with the rules: GD: $? \rightarrow \phi \downarrow V\_\ n$, VN: $V \rightarrow \tilde{V} \uparrow \_\ N$, we will have the following two line derivation:

{bʌ ʔn̩, bʌ̃ n̩} : *button*

A similar example involving VN and *Consonant Nasalization* (CN) (ibid.): $C \rightarrow \tilde{C} \downarrow \_\ N$ is:

{wudn̩, wũnn̩} : *wooden*

Cf.: {wudn̩, wunn̩, wũnn̩}

Thus, where we would ordinarily require VN to apply to the output of both GD and CN, productive and interpretive rules jointly obviate this necessity, thereby reducing the number of lines of derivation mediating two forms.

In effect, then, productive and interpretive rules are similar to the simultaneous application of phonological rules, and yet, since they can refer to either the higher or lower line of derivation, they seem more powerful than the simultaneous application of rules. Next task is then to see whether the process model phonology introduced in the preceding section can stand the criticism usually directed against the simultaneous application of rules (The position that espouses this manner of rule application is also called "the direct mapping hypothesis," and I will use the two terms synonymously in what follows.).

§3. Consider Russian rules of *Devoicing* which devoices word final obstruents and *l-Drop* which drops the word final *l* when preceded by consonants (cf. Kenstowicz, Kim and Kisseberth (1974)):

Devoicing: $\begin{bmatrix} C \\ +\text{obst} \end{bmatrix} \rightarrow$ [-voice] / ____ #

1-Drop: l $\rightarrow$ ϕ / C ____ #

Given an underlying form/grebl/, the direct mapping hypothesis predicts **greb*, which is unacceptable. The surface form is *grep*. Thus this is an argument against direct mapping hypothesis. If we adopt a process model phonology, we can not only shorten the derivation but also account for the correct surface form:

Devoicing: $\begin{bmatrix} C \\ +\text{obst} \end{bmatrix} \rightarrow$ [-voice] $\uparrow$ ____ #

1-Drop: l $\rightarrow$ ϕ $\downarrow$ C ____ #

Derivation: {grebl, grep}

Actually there is indeterminacy as to whether *l-Drop* is a productive or an interpretive rule. But the point being made here is not affected in any way by this indeterminacy.

Another argument against direct mapping hypothesis is found in the data from Yawelmani (cf. Kisseberth (1972)). Yawelmani has, among others, the following rules:

Vowel Epenthesis: $\phi \rightarrow$ i/C _ CC
Vowel Shortening: V $\rightarrow$ [-long] / _ CC

The following two derivations are well-formed in the direct mapping hypothesis:

?a: ml+al		?a:ml+hin	
|		|	
?aml+al	(VS)	?amil+hin	(VS) & (VE)

But the second derivation predicts an incorrect form. Thus in Yawelmani, **?amilhin.* The correct form is *a:milhin.* This can be accounted for in a sequential application model by ordering VE before VS. In that case the derivation will be a three line derivation. Using our process model phonology, we can not only account for the correct surface form but also shorten the derivation to two lines:

VE: $\phi \rightarrow$ i $\downarrow$ C _ CC
VS: V $\rightarrow$ [-long] $\uparrow$ _ CC

Derivations

?a:ml+al	?a:ml+hin
?aml + al	?a:mil+hin

Let us take in what follows the strongest position of the process model, and assume that every derivation can be reduced to two lines and investigate problems that may arise with respect to this position, making, where necessary, our position weaker.

§4. Not unrelated to the direct mapping hypothesis is the free reapplication hypothesis, which maintains that the set of phonological rules are applied simultaneously to an underlying form, deriving a form F_1, to which the same set of rules are again applied simultaneously, yielding F_2, and so on, yielding F_n, to which none of the rules is applicable, thereby characterizing as well-formed the derivation $\{F_1, F_2, \ldots, F_n\}$. Our process model makes different predictions as to the correct surface forms from either the direct mapping hypothesis or the free reapplication hypothesis. Thus consider Modern Hebrew (cf. Kenstowicz, Kim and Kisseberth (1974)); the crucial rules here are:

$$\text{Voicing Assimilation: } \begin{bmatrix} C \\ +\text{obst} \end{bmatrix} \longrightarrow [\alpha\text{voice}] \ / \ \_\_\_ \begin{bmatrix} C \\ +\text{obst} \\ \alpha\ \text{voice} \end{bmatrix}$$

$$\text{e-Insertion: } \phi \longrightarrow \text{e} \ / \ \underline{\qquad} + \text{ti}$$

(optional)

Given a representation such as /yarad+ti/, both direct mapping hypothesis and free reapplication hypothesis require that *Voicing Assimilation* (VA) apply since it is obligatory. Thus they predict the incorrect *yarat-eti as an optional variant of *yarat-ti*, rather than the correct *yarad-eti.* In the sequential application model, the correct surface is predicted by ordering *e-Insertion* before VA:

{ yarad + ti, yarat + ti } ——— VA

{ yarad + ti, yarade + ti } ——— e-Insertion; VA inapplicable.

The process model can also account for the surface forms with the following rules:

$$\text{VA: } \begin{bmatrix} C \\ +\text{obst} \end{bmatrix} \longrightarrow [\alpha\text{voice}] \uparrow \text{—} \begin{bmatrix} C \\ +\text{obst} \\ \alpha\text{voice} \end{bmatrix}$$

$$\text{e-Ins: } \phi \longrightarrow \text{e} \downarrow \text{———} +\text{ti (optional)}$$

(The derivation is the same as the one given under the sequential application model.)

Thus the evidence that is adduced against both the direct mapping hypothesis and the free reapplication hypothesis (and in favor of the sequential application hypothesis) does not constitute a counterexample against the process model we are now considering.

Similarly, consider Russian, which, in addition to *l-Drop* mentioned in §3, has a rule that deletes a dental stop before 1:

$$\text{1-Drop: } 1 \longrightarrow \phi \ / \ C \_ \#$$

$$\text{Dental Stop Deletion (DSD): } \begin{bmatrix} C \\ +\text{ant} \\ -\text{cont} \\ +\text{cor} \end{bmatrix} \longrightarrow \phi \ / \ \text{———} \ 1$$

Given an underlying form /plet-1/, the direct mapping hypothesis and the free reapplication hypothesis incorrectly predict **ple,* where the correct form is *ple-l,* The sequential application model predicts the correct form by ordering DSD before *l-Drop.* Our process model is equally adequate, given the following rules:

$$\text{1-Drop:}\quad 1 \longrightarrow \phi \uparrow C \underline{\qquad} \#$$

$$\text{DSD:}\quad \begin{bmatrix} C \\ +\text{ant} \\ -\text{cont} \\ +\text{cont} \end{bmatrix} \longrightarrow \phi \downarrow \underline{\qquad} 1$$

Derivation

plet-1

|

ple-1

Note the derivation { plet-1, plet } is ill-formed, given the above process model phonological rules.

§ 5. One most interesting case against the simultaneous rule application hypothesis and the free reapplication hypothesis comes from the Lardil data (cf. Ringen (1973)). The crucial rules involved are:

Apocope (Apoc): $V \longrightarrow \phi \,/\, VC_1VC_1 \underline{\qquad} \#$

Cluster Simplification (CS): $C \longrightarrow \phi \,/\, C \underline{\qquad} \#$

Non-apical Deletion (NAD): $\begin{bmatrix} -\text{syll} \\ -\text{apical} \end{bmatrix} \longrightarrow \phi \,/\, \underline{\qquad} \#$

The following two derivations, which are incorrectly predicted to be well-formed by the direct mapping hypothesis:

puṭuka	kantukantu
|	|
puṭuk	kantukant

should actually be replaced by the following within the sequential application model with the given ordering of rules, which then predicts the correct surface forms:

puṭuka		kantukantu	
|	(Apoc)	|	
puṭuk		kantukant	(Apoc)
|	(NAD)	|	
puṭu		kantukan	(CS)

The following two derivations show that the free reapplication hypothesis is wrong:

ŋawuŋawu		tjumputjumpu	
|		|	
ŋawuŋaw	(Apoc)	tjumputjump	(Apoc)
|		|	
ŋawuŋa	(NAD)	tjumputjum	(CS)
|		|	
ŋawuŋ	(Apoc)	tjumputju	(NAD)
|		|	

ŋawu	(NAD)	tjumputj	(Apoc)
		|	
		tjumput	(CS)

The correct forms are *ŋawuŋa* and *tjumputju*. These forms are accounted for in the sequential application hypothesis by ordering rules Apoc - CS - NAD. The derivation stops as soon as the NAD is applied for the first time. All the four surface forms can be accounted for in our process model by the following productive and interpretive rules:

$$\text{Apoc: } V \longrightarrow \phi \downarrow VC_1VC_1 \underline{\qquad\qquad} \#$$

$$\text{CS: } C \longrightarrow \phi \uparrow C \underline{\qquad} \#$$

$$\text{NAD: } \begin{bmatrix} \text{-syll} \\ \text{-apical} \end{bmatrix} \longrightarrow \phi \uparrow \underline{\qquad} \#$$

Derivations

puṭuka	kantukantu	ŋawuŋgawu	tjumputjumpu
|	|	|	|
puṭu	kantukan	ŋawuŋa	tjumputju

Note that Apoc is a productive rule while CS and NAD are interpretive rules.

Ukranian, in addition to the same rules as Russian mentioned in § 4, has the following rule:

$$1 \longrightarrow w \,/\, \_\,. \text{ (i.e., syllable finally)}$$

Given the underlying form /kladl/ (omitting morpheme boundary), the correct surface form is *klaw*. The direct mapping hypothesis and the free reapplication hypothesis incorrectly predict the surface form **kla* in addition to the correct *klaw*. The sequential application mddel predicts the correct surface form by ordering DSD before the rule mentioned immediately above. Our process model can account for the correct surface form by making the above rule an interpretive rule together with the rules mentioned in § 4. Here again we have the two line derivation:

{ kladl, klaw }

§ 6. Consider now the data from Schaffhausen, a Swiss-German dialect (see Kiparsky (1968)):

Sg.	Pl.
bogə	bögə
bɔidə	bödə

Assuming, after Kiparsky (1968), that Schaffhausen has the following rules and underlying forms:

Rules: Umlaut: V ⟶ [-back] / . . . Umlaut Context

Back Vowel Lowering (BVL):

$$o \longrightarrow ɔ \;/\; \_\_\_ \begin{bmatrix} +\text{cons} \\ -\text{grave} \\ -\text{lateral} \end{bmatrix}$$

Underlying forms:	Sg.	Pl.
	/bodə/	/bodə + Pl./
	/bogə/	/bogə + pl./

we find that our process model cannot account for the surface form [bödə] no matter what process mode we employ for the above two rules although the sequential application model can explain the surface form by ordering Umlaut before BVL. The reason our process model cannot account for the surface form [bödə] is that the omnipresence of *d* causes BVL to be applied whether it be productive or interpretive so long as we maintain the position that every derivation of process model phonology consists of two lines, i.e., the underlying form and the surface form. There are a couple of ways to remedy the situation. One most interesting possibility is this: Phonological rules are divided into two subsets - one consisting solely of productive rules and the other consisting solely of interpretive rules; given an underlying form F_u, the productive rules are applied first simultaneously to this form, yielding F_p, to which interpretive rules are applied simultaneously to yield the surface form F_s. In this weakened process model, the derivation consists of three lines; the first two are mediated by productive rules and the second and the third lines are mediated by interpretive rules. Schematically:

F_u (Underlying Form)

↓

Productive Rules

↓

F_p (Intermediate Form)

↓

Interpretive Rules

↓

F_s (Surface Form)

Such a process model can now account for the Schaffhausen surface forms in a trivial fashion. Suppose Umlaut is productive and that BVL is interpretive; we have then the following four well-formed derivations:

F_u	bodə	bodə + Pl.		bogə	bogə + Pl.	
	|	|		|	|	
F_p	bodə	bödə		bogə	bögə	
	|	|		|	|	
F_s	bɔdə	bödə		bogə	bögə	

§7. The dialect variation can be accounted for by switching the process mode of rules involved. Consider the two Finnish dialects A and B (see Kiparsky (1968)). The situation is this: both dialects share the rules *Diphthongization* (Diph) and *Velar Deletion* (VD); given the underlying form /teγen/, A's surface form is *teen,* and B's surface form is *tien.* Such dialectal difference can be accounted for by the following process model phonological rules:

Dialect A: *Rules*

$$\text{Diph:}\quad \begin{bmatrix} +\text{syll} \\ -\text{high} \\ -\text{low} \\ F \end{bmatrix} \longrightarrow [+\text{high}]\downarrow \underline{\qquad} \begin{bmatrix} +\text{syll} \\ -\text{high} \\ -\text{how} \\ F \end{bmatrix}$$

$$\text{VD:}\quad \gamma \longrightarrow \phi \uparrow V\underline{\qquad}V$$

Derivation

teγen	F_u
|	
teγen	F_p
|	
teen	F_s

Dialect B: *Rules*

$$\begin{bmatrix} +\text{syll} \\ -\text{high} \\ -\text{low} \\ F \end{bmatrix} \longrightarrow [+\text{high}]\uparrow \underline{\qquad} \begin{bmatrix} +\text{syll} \\ -\text{high} \\ -\text{low} \\ F \end{bmatrix}$$

$$\text{VD:}\quad \gamma \longrightarrow \phi \uparrow V\underline{\qquad}V$$

Derivation

teγen	F_u
|	
teγen	F_p
|	
tien	F_s

Since the transition from Dialect A to Dialect B represents a diachronic change in Finnish, our process model can also describe a diachronic change. Following the analogy of maximum utilization of rules in a feeding relationship in the sequential application hypothesis, let us say (very tentatively) that productive rules tend to become interpretive rules in the course of the diachrony of a language. Such a prediction is confirmed in the following two Swiss-German dialects (: for ease of exposition and contrast I will repeat part of the data presented in the preceding section). The transition from Schaffhausen dialect to Kesswil reflects the diachrony of Swiss-German (Kiparsky (1968)):

Schaffhausen		Kesswil	
Sg.	Pl.	Sg.	Pl.
bogə	bögə	bogə	bögə
bɔdə	böd̈ə	bɔdə	bɔ̈də

Assuming that the two dialects have the same underlying forms, we can account for the dialect variation and the diachronic change based on the above principle with the following set of process model rules for each dialect:

Schaffhausen:

Umlaut: V ⟶ [-back] ↓ . . . Umlaut Context

BVL: o ⟶ ɔ ↑ — [+cons, -grave, -lateral]

Derivation

F_u	bodə	bodə + Pl.	bogə	bogə + Pl.
F_p	bodə	böd̈ə	bogə	bögə
F_s	bɔdə	böd̈ə	bogə	bögə

Kesswil:

Umlaut: V ⟶ [-back] ↑ . . . Umlaut Context

BVL: o ⟶ ɔ — ↑ [+cons, -grave, -lateral]

Derivation

F_u	bodə	bodə + Pl.	bogə	bogə + Pl.
F_p	bodə	bodə + Pl.	bogə	bogə + Pl.
F_s	bɔdə	bɔ̈də	bogə	bögə

Thus the transition from the conservative Schaffhausen dialect to Kesswil dialect which represents the diachrony of the language can be described as a change in the mode of process of Umlaut, i.e., from productive to interpretive. In the next section, let us consider the general implications of our process model, particularly with respect to the tasks of producer and interpreter.

§8. We have seen, so far, that arguments that are directed against the simultaneous application hypothesis and the free reapplication hypothesis and in favor of the sequential application hypothesis do not constitute arguments against the process model that was sketched briefly in § 1 and was revised in § 6. We have also seen that such a process model is also adequate for describing dialect variation and diachronic change. Thus, *ceteris paribus,* such a model is to be preferred to the

sequential application hypothesis since our model has the characteristic of shortening the derivation, thereby rendering the phonological description more concrete (cf. fn. 2). We will further examine the consequences of adopting the process model in the next section, but before going to the next and final section, let us see what our process model says regarding the performance of a speaker and a hearer. First let us note that the revision that was proposed in § 6 was not based on the arbitrary decision as to the priority of application of productive and interpretive rules. Thus recall here what an interpretive rule does: it refers to the lower line of derivation for environmental restrictions. This means that such environmental restrictions are present after the application of the interpretive rule. Or rather, such environments must be present after its application. In other words, it is required that, for an interpretive phonological process, surface clues be present after the rule application. Thus it is only natural for such interpretive rules to apply after productive rules because the application of interpretive rules always guarantees the presence of the environments under which processes take place, leaving the traces according to which an interpreter can construct a higher line of derivation. This makes clear why an absolute neutralization is intolerable, particularly as an interpretive phonological process. Because such an unconditional merger leaves no surface clues. Thus, it would be an interesting limitation on phonological processes if we could generally say that phonological processes must refer to environments non-vacuously (non-vacuously in the sense that the environment must not be null). This is certainly what is required by our interpretive rules. Thus our interpretive rules are more directly related to the task of an interpreter. Such a limitation on phonology is thus perferable in the sense that it comes closer to reality of human (phonological) processes. Our process model further implies that an interpreter's first guessing is done by simultaneous processing rather than linear processing. It also implies that a producer's near-surface processing is simultaneous rather than linear. Since it is reasonable to assume that our near surface processing is mostly phonetically and physiologically motivated processes, it would be an interesting problem to see if we can find basic similarity between interpretive rules and phonetically motivated processes. Consider, for instance, the fact that most of the so-called natural rules have conditioning environments immediately before or after the segment affected and our claim that interpretive rules always require the presence on the surface of the environments that trigger the application of the rules. Global rules that refer back the derivation can then be neither natural nor interpretive. Another interesting problem to investigate is whether our level F_p is identical with the traditional phonemic level. The Swiss-German examples suggest that this is not the case. But still it is an interesting possibility. The diachronic change from productive to interpretive rules may be said to be a result of the tendency to retain as much information on the surface as possible, thereby reducing the number of allomorphs (cf. the notion of paradigm regularity as in Kiparsky (1971)).

§9. Our examples so far have contained the interaction of at most three rules. This has been necessarily so because our main concern was to pursue the possibility of a process model phonology that had the advantage of both the direct mapping hypothesis and the sequential application hypothesis. Note that we need have only a couple of rules to refute the simultaneous application hypothesis. Now consider the following derivation in Kasem taken from Howard (1969) (I omit the specification of each rule; roughly *Velar Elision* (VE) elides the velar before high non-back vowels; *Metathesis* (MET) metathesizes the first two of three consecutiae vowels; *Vowel Contraction* (VC) converts *ai* to *e*; and *Glide Formation* (GF) makes the high vowel into a corresponding glide before another vowel):

kaug+i	čauŋ+i	
kau+i	čau+i	VE
kua+i	čua+i	MET
kue	čue	VC
kwe	čwe	GF

Such surface forms from the corresponding underlying forms can be easily accounted for in the sequential application model by ordering the rules in the way they are given. But it is impossible to predict such forms, using the similar rules in our three line process model. Thus this Kasem data constitutes counter-evidence to our process model. Such examples are numerous in the current phonological description. Many suggestions come to mind regarding this kind of phonological description. Some of them are: that such a phonological description is wrong; that our process model has thus been proved wrong; that productive rules are applied sequentially, yielding an input to interpretive rules, which then apply simultaneously; that productive rules and interpretive rules are interspersed in the grammar, . . . , etc. Consider the possibility of such a description being wrong. Particularly note the remarkable difference between the underlying and surface forms in the above derivation. Thus this analysis totally disregards the substantive aspect of phonological description. It is not clear whether such a powerful description allowed by the sequential application hypothesis is to be regarded as predicted virtue or unavoidable vice inherent to the theory. Consider now the possibility of the interspersed productive and interpretive rules. Such a grammar can shorten the derivation for sure compared with the sequential application hypothesis. In effect such a model allows the simultaneous application of rules whenever possible as well as the sequential application. But it is not clear what kind of claims such a model makes as to the human language processing. One most interesting possibility would be to allow productive rules to be sequentially applied and the interpretive rules to be simultaneously applied en bloc maintaining the basic division mentioned in §6. Thus rules that must leave the surface clues as to their application are interpretive rules

while those that do not necessarily do so are productive rules. In this sense, productive rules are more abstract than interpretive rules. And such a model may reflect the reality of language processing better than any other model.

Footnotes

1. The original idea of the process model outlined in §1 is due to Greg Lee (1974) "Interpretive and productive phonological rules without sequential application" (Unpublished). I am grateful to him for kindly giving me a copy of this paper. Other views and analyses that are presented are all mine, and I am to blame for any possible mistake. Part of the paper was presented at a monthly meeting of Osaka Gaidai Linguistic Circle in October, 1976. I am grateful for comments and criticisms that I received at this meeting.
2. As for the various senses of abstractness of phonological description, see my paper Sugimoto (1976).

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