Derived Environment Effects: A Functional Approach*

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This paper examines the transparent and opaque surface realizations observed in derived environments, and investigates the interaction between phonological well-formedness and paradigm strength. Contrast between hiatus resolution and hiatus maintenance in Korean verbal conjugations is shown to result from various paradigmatic principles: paradigm stability, paradigm economy and paradigm regularization. Such a functional approach can eliminate the stipulative mechanism of rule reordering or constraint reranking, and thus achieve a greater degree of explanatory adequacy than ever before.

1. Introduction

A central hypothesis of rule-based derivational phonology is that cyclic rule application is limited to derived environments which are created either by morphological concatenation or prior rule application. This generalization is encapsulated in the principle of strict cyclicity (Mascaró 1976).

With respect to the morphologically derived environment effects, this paper argues that the emergence of the unmarked in derived environments and the blocking effects in nonderived environments are directly captured by using a notion of local conjunction. By conjoining a markedness constraint and a faithfulness constraint, it is shown that the violation of alignment constraint by morpheme concatenation activates the relevant phonological process.

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examines the previous derivational and optimality theoretic approaches and argues that the opacity problem can be said to be due to the paradigm force, and that opacity effects of underapplication and overapplication of phonology can be best explained in terms of paradigm strength. On the basis of data from Korean verbal conjugations that involve opacity of vowel hiatus, it is shown that phonology preferences are relatively weak and can be overridden by various constraints on paradigm.

To recapitulate, the aim of this paper is to show that transparency effects can be captured within Optimality Theory (OT) framework by making use of local conjunction, and that opacity effects can be understood under the functionalism of paradigm strength.

This paper is organized as follows. Section 2 presents the morphologically derived data, followed by a rule-based, an underspecification-based, and a parallel analysis using local conjunction. Section 3 contains the phonologically derived data showing opacity effects, provides previous derivational and parallel analysis, and discusses their problems in explaining hiatus resolution. Section 4 then turns to my algorithm for a possible alternative to the previous approaches, a functionalism-oriented approach based on paradigm strength. The stem preservation in *s*-irregular verbs at the expense of violating phonological markedness is shown to be the result from the principle of preserving paradigm stability. And this proposal also gives principled explanations for the dialectal variations and for the contrast between formal and informal casual speech. Finally, section 5 contains a brief summary of our analysis and some remarks for further research.

2. Morphologically Derived Environment Effects

The famous examples of cyclic rule application come from many languages, some of which are presented below:

(1) Finnish Assibilation (Kiparsky 1973): t → s / __ i
/tilat+i/ → tilasi
/koti/ → *kosi

(2) Sanskrit ruki-Rule (Kiparsky 1973): s → [+high] / i, u, r, k ___
/agni+su/ → agnişu
/kusuma/ → *kusuma

(3) Catalan Devocalization (Mascaró 1976): i, u → y, w / V ___
/de+u/ → déw
/ruin+os/ → *ruynós

(4) Korean Palatalization[1]

a. no coronal palatalization in tautomorphemic sequences

ə[ti]	'where'
[ti][ti]ta	'to step on'
ma[ti]	'knot'
can[ti]	'grass'
[t^{h}i]k'ɨl	'a bit'
nɨ[t^{h}i]namu	'zelkova tree'

b. coronal palatalization across a morpheme boundary

ma[ci] (<mat-i)	'the eldest'
hæto[ci] (<hætot-i)	'sunrising'
ta[c^{h}i]ta (<tat-hi-ta)	'to be closed'
pa[c^{h}i] (<pat^h-i)	'field-Nom'
ka[c^{h}i] (<kat^h-i)	'together'
ta[c^{h}y]ə (<tat-hyə)	'to be closed'
pu[c^{h}y]ə (<put^h-yə)	'to be attached'

c. palatal segments in lexical representations

k'a[c^{h}i]	'magpie'
ta[c^{h}i]ta	'to be hurt'
na[ci] (<nac-i)	'day-Nom'
ka[ci]	'eggplant'
[ca]ki	'oneself'

As can be seen above, there is no phonological process active when the trigger and target belong to the same morpheme. To take coronal palatalization from Korean as an example, coronal palatalization turns coronal stops into postalveolar affricates before front high vowels and glides. But palatalization only applies before a derived *i* as in (4b). Before

[1] The palatalization phenomenon is actually somewhat more complicated than presented here. Postlexically, all coronal consonants /t, t^h, c, c^h, s, n, l/ are palatalized /ʈ, ʈ^h, ç, ç^h, ʂ, ɳ, ɭ/ before *i*. Such non-structure preserving postlexical palatalization applies uniformly to all coronals before *i*, regardless of whether the environment is derived or not. Here we will treat only the lexical palatalization phenomenon.

tautomorphemic *i*, that is, where the trigger and target belong to the same morpheme, there is no coronal palatalization as in (4a). It is postulated within the framework of Lexical Phonology that palatalization is a cyclic rule and therefore subject to the Strict Cycle Condition (SCC); it is restricted to apply only when the trigger and target of the process are heteromorphemic, that is, after word formation rules on cycle two. This is shown schematically in (5).

(5) SCC Account of Korean Palatalization

[#mati#]	[#[mat] + i#]	[#kaci#]	
blocked by SCC			Cycle 1
	c	_	Cycle 2 (palatalization)
[mati]	[maci]	[kaci]	

Although SCC is the general condition on rule application, there is disagreement as to how much of the lexical phonology of a language must be said to be subject to SCC. Some phonologists claim that there may be cyclic rules which do not obey the derived environment constraint, as well as noncyclic and postlexical rules which apply only in derived environments. To name a few, Kiparsky(1993) gives an example of Finnish vowel coalescence, a cyclic rule, applying freely in a non-derived environment. Kaisse(1986) further shows that a noncyclic word-level rule of stop devoicing in Turkish is prevented from applying in a non-derived environment. Finally Kiparsky(1993) argues that the postlexical ruki rule in Vedic Sanskrit must be subject to Non-Derived Environment Blocking (NDEB), so that it does not apply morpheme-internally. Still how much of the core of SCC will survive remains to be seen.

Kiparsky(1993) presented a new interpretation which resolves this dilemma. He argues that NDEB effects are independent of the rule cyclicity or lexicality status, and that NDEB effects can be derivable from segmental underspecification instead. In his underspecification account, NDEB is the result of structure-building rules applying to radically underspecified representations.

In the analysis of Korean palatalization, the difference between the application of palatalization in derived environments and non-applicaton in non-derived environments follows directly from their different lexical representations and from the structure-building status of the rule. The minimally specified lexical representations of alternating and non-alternating

coronals are then as follows:

(6)	/t ~ c/ /t^h ~ c^h/	/t/	/c/
Before i:	[0Ant]	[+Ant]	[0Ant]
Elsewhere:	_____	[0Ant]	[-Ant]

Given these underlying representations, the Korean palatalization would be a structure-building rule that assigns the feature specification [-anterior] to underspecified coronal stop before *i*. Elsewhere, coronal stops will be assigned the default specification [+anterior] and realized as [t].

(7) a. [+Cor] → [-Ant] / _____ i
b. [+Cor] → [+Ant]

The derivations in (8) show how this works (capitals denote segments unspecified for the feature [±anterior]).

(8) /mati/	/maT + I/	/TaTami/	/kaTi/	/caki/	
	c		c		(7a)
		t t			(7b)
[mati]	[maci]	[tatami]	[kaci]	[caki]	

The superiority of underspecification account is that it derives the blocking effects directly from more general assumptions, namely that lexical representations can be underspecified, that phonological rules can apply in structure-building mode, and that learners construct the simplest grammar. But this is not without any problems. As Kenstowicz(1994: 516) noted, it is unclear whether the strong claim that no lexical cyclic rule can depend on word-level features can be maintained. If the same underspecified feature is specified before the application of the phonological rule referring to that feature, and at the same time it must be specified after that rule, it necessarily leads to an ordering paradox. More generally, it remains to be seen whether a consistent grammar can be constructed so as to maintain strict adherence to feature-filling operations. In addition, it is unclear how this approach is to be extended to the geometry of phonological representations.

So far we have shown how derived/nonderived environment effects have

been understood within the operative frameworks. How can the derived environment effects be accounted for in the framework of Optimality Theory? Evidence for cyclicity that a phonological process is restricted to apply only to derived forms seems to pose a serious challenge to nonderivational output-oriented approach to phonology.

Recent work in OT claims that cyclic effects are an epiphenomenon resulting from constraints on alignment between morpheme edges and prosodic constituents. This approach is based on the tacit assumption that all cyclic effects occur near morpheme junctures. In (4b), we note that the target of palatalization is input stem final, and that the addition of palatalizing suffix always results in the violation of stem:syllable alignment, which does not so in the case of (4a). Here we see a new connection between two classical themes of phonology, transparency and derivedness, which is worth exploring. In this respect, recent work by Łubowicz(1998) on derived environments in OT becomes important. Her idea is that the low-ranked markedness constraint M will be activated if and only if there is a violation of the faithfulness constraint F, namely only in derived environments. This is achieved by locally conjoining the markedness constraint and the faithfulness constraint.

For the case at hand, the relevant [M&F] conjunction is [PAL $\wedge$ ALIGN-R], where the markedness constraint calling for palatalization is locally conjoined with the faithfulness constraint guarding stem:syllable alignment. Generally speaking, a constraint formed by local conjunction is violated if and only if all of its conjuncts are violated within the relevant domain, here between adjacent segments. Consequently, it is significant that the violation of stem:syllable alignment activates the markedness constraint demanding palatalization. The relevant constraints are given in (9) and the constraint ranking is in (10).

(9) ALIGN-R(Stem; σ): Every stem is aligned at its right edge with the right edge of some syllable.

IDENT(cor): Let α be a segment in S_1 and β be a correspondent of α in S_2. If α is [γF], then β is [γF].

(10) [PAL $\wedge$ ALIGN-R] $\gg$ IDENT(cor) $\gg$ PAL

The following tableaux in (11) illustrate how the interaction of the constraints works.

(11) a. no palatalization in tautomorphemic sequences

$[mati]_{stem}$	[PAL ∧ A_{LIGN}-R]	I_{DENT}(cor)	PAL
ⓐ ma.ci.		*!	
ⓑ ma.ti.	(*)		*

b. no alternation in tautomorphemic sequences

$[k'ac^{h}i]_{stem}$	[PAL ∧ A_{LIGN}-R]	I_{DENT}(cor)	PAL
ⓐ k'a.c^{h}i.			*
ⓑ k'a.t^{h}i.	(*)	*!	

c. palatalization across a morpheme boundary

$[mat]_{stem}$-i	[PAL ∧ A_{LIGN}-R]	I_{DENT}(cor)	PAL
ⓐ ma.ci.	(*)	*	
ⓑ ma.ti.	(*) *! (*)		*

As seen in (11c) above, the addition of a palatalizing suffix always results in violation of stem:syllable alignment; the rightmost segment of the input stem does not coincide with the right edge of the syllable in the output. This violation of stem:syllable alignment activates palatalization for the conjoined constraint to be satisfied, so therefore the phonologically unmarked palatalized form emerges. In case where there is no violation of alignment as in tautomorphemic sequences, the conjoined constraint is always satisfied irrespective of the presence of the palatalized segment, and so lower-ranked constraints are decisive in choosing the optimal output. This is illustrated in (11a) and (11b). Here we can see the blocking effects in the non-derived environment and the emergence of the unmarked in the derived environment.

So far we have argued that local conjunction accounts for the transparent cases of derived environments by morpheme concatenation. Local conjunction account has some advantages over the previous approaches. First, in contrast to SCC which connects NDEB with the cycle, the local conjunction account makes no such unmotivated connection and draws the feeding order effects directly from the constraint conjunction. Secondly, it is empirically more adequate in that it predicts that the trigger and target of a

process must be adjacent in some local domain and that it is not the mere presence of a morpheme boundary but the violation of alignment which matters in morphologically derived environments.

Needless to say, many open questions remain. Most pressing is the further study of the power and limits of local constraint conjunction: what kinds of constraints can be conjoined and what are the local domains? Unrestricted conjoinability of constraints would appear to result in excessive descriptive power. I tentatively assume that local conjunction be limited to the conjunction of markedness constraints with faithfulness constraints. This task, however, we must leave to future researches. In the next section we will approach the phonologically derived environment effects from a somewhat different angle.

3. Phonologically Derived Environment Effects

The interaction of phonological rules is two-fold; transparency effect of feeding order and opacity effect of counterfeeding and counterbleeding order. Consider the followings:

(12) Transparency Effects

a. Velar Palatalization and Spirantization in Polish (Rubach 1984)
ro[g]+ek → ro[ǰ]+ek → ro[ž]+ek
wa[g]+i+ć → wa[ǰ]+i+ć → wa[ž]+y+ć
śnie[g]+ĭc+a → śnie[ǰ]+ĭc+a → śnie[ž]+yc+a
ban[ǰ]+o → ban[ǰ]+o, *ban[ž]+o
[ǰ]em+ɨ̆ → [ǰ]em, *[ž]em

b. Vowel Lengthening and Diphthongization in Slovak (Rubach 1995)
Vowel Lengthening: V → [+long] / ____ $C]_{gen.pl.}$
Diphthongization: é, ó, ǽ → ie, uo, ia
č[e]l+µ → č[e:]l → č[ie]l
š[o]p+µ → š[o:]p → š[uo]p
dc[e:]r+a → dc[e:]ra, *dc[ie]ra
m[o:]d+a → m[o:]da, *m[uo]da

c. Consonant Deletion and Vowel Lowering in Estonian
siga → sia → sea
tegu → teu → teo
kiu → kiu, *keo (Kenstowicz/Kisseberth 1970)

(13) Opacity Effects

(i) Underapplication of counterfeeding order

a. Velar Softening in Chukchee (Krause 1979):

/kC/ → [ɣC]

/ɣ Lab/ → [w Lab]

/km/ → [ɣm] → *[wm]

b. Flapping and Lengthening in English

latter → [lærə̯] → *[læːrə̯]

ladder → [læːrə̯]

c. *s*-Deletion and Hiatus Resolution in Korean

/cis-ə/ → ciə → *cyə 'to build'

/pus-ə/ → puə → *pwə 'to pour'

/cas-a/ → caa → *ca 'to spin out'

(ii) Overapplication of counterbleeding order

a. *u*-Umlaut and Deletion in Icelandic (Anderson 1974)

u-umlaut: a → ö / ___C_0u

/bagg+ul+i/ → bögguli → böggli, *baggli

b. Vowel lengthening and Final devoicing in German (Kiparsky 1972)

/lob/ → loːb → loːp, *lop

/veg/ → veːg → veːk, *vek

c. Nasalization and Consonant deletion in French (Carr 1993)

/grande/ → grãnde → grãde, *grad

/kopɛn/ → kopɛ̃n → kopɛ̃, *kopɛ

Phonologically derived transparent cases of (12), which always lead to the violation of feature identity by prior application of some phonological rule, can be explained by the extension of local conjunction. In Polish (12a), for example, velar palatalization creates a derived environment for spirantization. The voiced postalveolar affricate ǰ turns into a fricative ž only in segments that have undergone palatalization. Otherwise, the affricate ǰ is faithfully parsed in the output; spirantization takes place only when I_{DENT}(coronal) is violated. From Local Conjunction perspective, the relevant tableaux can be illustrated as below:

(14) a. transparency in derived environment

/rog+ek/	*ǰ ∧ I_{DENT}(cor)	I_{DENT}(cont)	*ǰ
ⓐ rojek	(*) *! (*)		*
ⓑ rožek	(*)	*	

b. blocking in nonderived environment

/banǰ+o/	*ǰ ∧ I_{DENT}(cor)	I_{DENT}(cont)	*ǰ
ⓐ banžo		*!	
ⓑ banǰo	(*)		*

When there is a voiced stop in the input as in (14a), the markedness constraint ǰ is activated by the violation of I_{DENT}(cor), and so the locally conjoined constraint *ǰ∧I_{DENT}(cor) chooses the second candidate *rožek*, with double violation of faithfulness, as optimal. This is another case of the emergence of the unmarked. When, however, the affricate ǰ is already in the input as in (14b), and so there is no violation of I_{DENT}(cor), then the locallyconjoined constraint has no force. In this case, the second candidate *banǰo*, with no spirantization, becomes the winner. This shows another blocking effect in the nonderived environment. The Local Conjunction account presented here explains in a uniform way both the transparency and blocking effects observed in morphologically and phonologically derived environment .

We now turn to the cases of opacity in (13). The concept of opacity and the original definition come from Kiparsky's work. A phonological rule is opaque if there are surface forms that either look like they should have undergone that rule but didn't, or surface forms that did undergo that rule but look like they couldn't have. Those two cases of underapplication and overapplication correspond approximately to two kinds of rule ordering in standard phonology, that is, counterfeeding ordering and counterbleeding ordering, respectively. These kinds are schematically exemplified in (16).

(15) Opacity (Kiparsky 1973 : 79)

A process P of the form A → B / C ___ D is opaque to the extent that there are phonetic forms in the language having either (i) A in the environment C___D, or (ii) B in environments other than C___D.

(16) a. Type (i): underapplication of counterfeeding opacity

underlying	/CAE/
A → B/__D	_____
E → D/__#	CAD
surface	CAD

b. Type (ii): overapplication of counterbleeding opacity

underlying	/CAD/
A → B/__D	CBD
D → E/__#	CBE
surface	CBE

In (16a), the rule changing A to B in effect applies too early in the derivation, before the environment D has been created. The result is not surface-true. In the other kind of opacity exemplified in (16b), a phonological process applies and then a later rule wipes out the conditions that made it applicable. As a result, non-surface-apparent structure emerges.

A typical example of underapplication comes from *s*-deletion and hiatus resolution in Korean. The so-called *s*-irregular verbs and adjectives undergo the deletion of stem-final *s* when followed by a vowel, which do contrast with the regular verbs and adjectives.[2] The relevant data are given in (17):

(17) *s*-Deletion and Hiatus Resolution in Korean

a. *s*-regular verbs

us-ta	us-ko	us-əla	'to laugh'
s'is-ta	s'is-ko	s'is-əla	'to wash'
pis-ta	pis-ko	pis-əla	'to comb'
pəs-ta	pəs-ko	pəs-əla	'to undress'

b. verbs with stem-final vowels

ci-ta	ci-ko	cyəla(*ci-əla)	'to lose'
ca-ta	ca-ko	cala(*ca-ala)	'to sleep'
ka-ta	ka-ko	kala(*ka-ala)	'to go'
na-ta	na-ko	nala(*na-ala)	'to come out'
i-ta	i-ko	yəla(*i-əla)	'to carry on the head'
keu-ta	keu-ko	kewəla(*keu-əla)	'to vomit'

[2] Some dialect such as Kyungsang dialect does not show the *s*-deletion process. The data of this paper are basically from Standard Seoul Korean.

c. *s*-irregular verbs

cis-ta	cis-ko	ci-əla(*cyəla)	'to build'
cas-ta	cas-ko	ca-ala(*cala)	'to spin out'
pus-ta	pus-ko	pu-əla(*pwəla)	'to pour'
nas-ta	nas-ko	na-ala(*nala)	'to recover'
is-ta	is-ko	i-əla(*yəla)	'to connect'
cəs-ta	cəs-ko	cə-əla(*cəla)	'to stir'

Stem-final *s* in regular verbs remains intact when followed by vowel-initial suffixes, and so there occurs no vowel hiatus as seen in (17a). On the other hand, when the vowel-ending verbs are followed by the vowel-initial suffixes, there arises some vowel hiatus resolution by glide formation or vowel elision[3] as shown in (17b). But this kind of vowel hiatus resolution does not apply to *s*-irregular verbs like (17c), where the final *s* is deleted before a suffix-initial vowel and feeds the environment under which some vowel hiatus resolution may effect a change.

Within the operational serialism framework, this difference can be captured by rule ordering, that is, ordering hiatus resolution before *s*-deletion. The derivations are below:

(18) /cis-əla/ 'to build' /ci-əla/ 'to lose'

+s-DEL		
———	cyəla	vowel hiatus resolution
ci	——	*s*-deletion
[ci-əla]	[cyəla]	output

Here the crucial ordering is required, that is, vowel hiatus resolution precedes *s*-deletion, which is counterfeeding order. The reordering conditions proposed in Kiparsky(1968) that feeding order tends to be maximized and bleeding order tends to be minimized predict the direction of reordering correctly in most cases. Still, a number of examples have turned up where these conditions are inadequate. The interaction of *s*-deletion and hiatus resolution in Korean is another example against this general rule ordering directionality. In addition, it is not clear what kind of cognitive evidence

[3] There is some disagreement whether the vowel elision and glide formation are accompanied by compensatory lengthening. There seems to be no vowel length distinction among most young speakers. This is beyond the scope of this paper.

there is for any intermediary representation.

Looking one level deeper down, however, we can observe that VV sequence is avoided on the surface only if they are also adjacent in the input form; if the stem-final vowel is a derived one through the deletion of the consonant, VV sequence is tolerated on the surface. Such a rule conspiracy is found in one language after another, but derivational theory does not capture this point directly. One way to cope with this problem within the derivational theory is to introduce the global rule with a global condition, which says that VV hiaus is not allowed in Korean provided that VV sequence does not arise as a consequence of the consonant deletion. While descriptively attractive in this case, such global conditions are theoretically undesirable because they significantly increase the power of potential grammar. It would be preferable to impose a more general condition.

The opacity cases above also pose challenges for standard OT, which assumes a monostratal single step from underlying to surface form. Intermediate levels of derivations are excluded by OT, under its most straightforward interpretation. Thus, to handle the distinction between the behaviors of underlying features and those of derived features, there seems to require an approach to the study of opacity from different angles. One possibility, vigorously pursued in the work of McCarthy(1995) and further explored by several other researchers including Ito/Mester(1997), Karvonen/Sherman(1997) and Katayama(1998) to name a few, is to construct a new device 'Sympathy.'

In order to explain this kind of opacity within OT as well, McCarthy(1998) suggests that the optimal output form needs to be chosen not from the correspondence relationship with the input but from the correspondence relationship with the sympathetic candidate (which is noted by the symbol ♧). The sympathetic candidate is chosen by faithfulness to the input; it is the most harmonic candidate that obeys some designated faithfulness constraint, called selector (which is noted by the symbol ☆). Consider the effect of adding the sympathetic candidate and sympathetic constraint:

(19) *s*-irregular verbs: /cis-əla/ → [ciəla] 'to build'

/cis-əla/	*s	♧O-Faith	*VV	☆Max-IO
Opaque ☞ a. ciəla		*	*	*
Sympathetic ♧ b. cisəla	*!			
Transparent c. cyəla		**!		*

Here the most harmonic candidate that obeys ☆Max-IO is ♧*cisəla*. It obeys the selector because no segments have been deleted. The sympathetic faithfulness constraint, here designated by ♧O-Faith, evaluates candidates for similarity to the sympathetic candidate. The actual output form *ciəla* (19a) with hiatus maintenance is more similar to ♧*cisəla* than the transparent candidate **cyəla* with hiatus resolution is. Obviously ♧*cisəla* is maximally similar to itself, and so it performs perfectly on ♧O-Faith, but it is not optimal because of its fatal **s* violation.

In the case of *s*-regular verbs where **s* is irrelevant, the sympathetic candidate itself turns out to be the winner. Tableau (20) shows this situation:

(20) *s*-regular verbs: /us-əla/ → [usəla] 'to laugh'

/us-əla/	~~*s~~	♧O-Faith	*VV	☆Max-IO
a. uəla		*	*	*
☞♧ b. usəla				
c. wəla		**!		*

From this we can infer that no effects of sympathy are possible if the actual output form obeys the selector constraint, because in that case the selector and normal harmonic evaluation will converge on the same candidate and ♧O-Faith will be vacuously satisfied by the optimal candidate.

To make a complete picture together with the above two cases, let us consider the case where the heteromorphemic two vowels are underlyingly adjacent, which results in the transparency effect:

(21) vowel-ending stems: /ci-əla/ → [cyəla] 'to lose'

/ci-əla/	*VV	Dep-IO	*ComplexOnset
a. ciəla	*!		
☞ b. cyəla			*
c. ci□əla		*!	

To summarize, the opacity problem shown by *s*-irregular verbs seems to be solved by introducing the sympathetic candidate and sympathetic constraint into the standard OT. But the fundamental problem in terms of optimality theoretic explanation is similar to the one encountered by the sequential approach, since sympathy simulates sequentialism. Sympathy approach abandons the condition that well-formedness constraints are exclusively output representation motivated, and so exclusively stated over output representations. So the attempt to preserve the gist of the sequentialist account by means of sympathy fares little better than derivational analyses. For sympathy theory to be workable, the problem of limiting the constraints responsible for selecting sympathy candidates is to be solved as well. Sympathy theory, in spite of its claim to provide a general solution to all of opacity, falls short of achieving this goal, and holds little promise as far as further insight into opaque interactions is concerned. This appears to be sufficient grounds to look for an explanation elsewhere.

4. Paradigm Strength in Opaque Cases

A more substantive account of the puzzling asymmetry between the underlying VV clash and the derived VV clash can be possible within the paradigm principle. Compare *s*-irregular and vowel-final stems, repeated from (17):

(22) a. *s*-final irregular verbs
{cis-ta, cis-ko, ci-əla(*cyəla)} 'to build'
{is-ta, is-ko, i-əla(*yəla)} 'to connect'
{cas-ta, cas-ko, ca-ala(*cala)} 'to spin out'
b. vowel-final regular verbs
{ci-ta, ci-ko, cyəla(*ci-əla)} 'to lose'

{i-ta, i-ko, yəla(*i-əla)} 'to carry on the head'
{ca-ta, ca-ko, cala(*ca-ala)} 'to sleep'

As we have seen in the previous section, the opaque forms violating *VV emerge in the *s*-irregular verbs, where VV sequence is a derived one from the prior rule application. Such opaque relationships can be found in any language as well. Now we must try to discover if they serve any purpose. One answer here is that opaque relationships help to preserve underlying contrasts. Recall that in the transparent relationship the underlying contrast between *s*-final stem and vowel-final stem is lost and lead to homophony (**cyəla* 'to build' vs. *cyəla* 'to lose'), while in the opaque relationship this underlying contrast is preserved in the form of hiatus resolution and hiatus maintenance contrast (*ciəla* 'to build' vs *cyəla* 'to lose').

Counterfeeding ordering for opacity reduces surface ambiguity, i.e., it increases the recoverability of the underlying forms. Recoverability relation between underlying and surface representations allows the grammar to motivate distinct phonologies from the normal pattern. Whether the hiatus phenomenon is resolved or not is a feature that marks or characterizes *s*-irregular verbs and thereby helps to distinguish them from regular counterparts.

In this respect, the preservation of underlying contrasts can play a much more direct role in controlling the application of a particular phonological rule. I call it 'paradigm stability.' Notable is the fact that there is a strong tendency of identity relationships among the morphologically related output forms, thus keeping consistent stability. Opacity, or underapplication and overapplication of phonology, can be said to be due to paradigm stability: the domination of well-formedness constraints by paradigm stability strength. On this functional ground, some morphological categories put up a stronger resistance to phonological changes which eliminate their morphological distinctions on the surface, and thus their underlying forms are more recoverable by the retention of lexical identity.

In the above case, VV sequence derived from consonant deletion resists hiatus resolution at the expense of violating phonological well-formedness constraint. Here morphologically deleted but vestigial consonant interrupts the adjacency condition of VV, and so stem-final vowel is opaque for the vowel hiatus resolution, thus keeping its mother paradigm identity and paradigm stability with the underlying difference reflected in the surface patterns.

Obviously a language can function as a communication system only if semantically or morphologically distinct forms are in general realized as phonologically distinct. We can therefore attribute the widespread existence of opaque relationships as functioning to maintain underlying semantic and morphological contrasts in the surface patterns as well. To recapitulate, the forms [ci-əla] 'to build', [i-əla] 'to connect', and [ca-ala] 'to spin out' in *s*-irregular verbs violate *VV to avoid misunderstanding, that is, to carry clear meaning by a distinctive pronunciation.

The interesting data which show another paradigm effect is that there are some dialectal variations which deviate from the standard pattern: *p*-irregular verbs /nup-ə/ 'to lie down' and /kup-ə/ 'to bake' respectively are pronounced as [nubə] and [kubə], rather than [nuwə] and [kuwə]; *t*-irregular verb /tit-ə/ 'to listen' as [tidə] rather than [tirə]; *s*-irregular verb /pus-ə/ 'to pour' and /cəs-ə/ 'to stir' as [pusə] and [cəsə] respectively without *s*-deletion, which is contrary to what is expected in the normal irregular conjugations. This variation implies that there is a principle requiring paradigmatically related forms to be phonologically as similar as possible. In other words, the pressure of allomorphy reduction and paradigm regularization is predominantly operative to the extent that it causes no meaning clash, which was originally introduced into the generative tradition by Kiparsky(1972).

Kenstowicz(1996) developed a constraint of Uniform Exponence that evaluates sets of morphologically related words for segmental and prosodic similarity.

(23) Uniform Exponence: minimize the differences in the realization of a lexical item (morpheme, stem, affix, word.)

We can account for the dialectal variations straightly if the speakers of those dialects rank stem paradigm uniformity above other constraints. In this case, it is more important to keep stem uniformity than to observe the morphological subcategorization constraints of *p, *t, and *s, so far as there is no misunderstanding resulting from the meaning clash. The reason for uniform exponence can be found in functionalism: the uniform realization of a morpheme is easier to learn than several different forms of the same morpheme.

The preference for uniform paradigms of sharing contextually invariant morphemes is confirmed by Steriade(1996) once again. She proposes a

Paradigm Uniformity condition, which promotes invariance of some sound property within a given paradigm:

(24) Paradigm Uniformity: All surface realizations of μ, where μ is the morpheme shared by the members of paradigm x, must have identical values for property P.

The degree of phonological invariance of shared morphemes stands in direct relation to the paradigm's productivity or frequency: the productive paradigm shows less contextual variability than the unproductive paradigm. The above-mentioned verbs such as /nup-ta/, /kup-ta/, /tit-ta/, /pus-ta/, and etc. are highly productive and frequently used words among others. We can predict the general directionality of this regularization on the basis of paradigm uniformity, which can be an independently motivated alternative solution without reference to the mechanism of rule reordering or constraint reranking.

However, we can observe apparent counterexamples to the paradigm regularization. Consider vowel hiatus phenomena of consonant-irregular verbs in the informal speech style:

(25)	informal form	formal form	
/cis-ta/	[cyəla]	[ciəla]	'to build'
/pus-ta/	[pwəla]	[puəla]	'to pour'

It may be possible to explain about formal and informal speech contrast in optimality theoretic framework: in formal speech, paradigm strength is higher that *VV; in informal speech, phonological well-formedness constraint is higher than paradigm preservation strength. This type of explanation is, however, circular or stipulative. The circularity stems from the fact that we distinguished between formal and informal speeches by reranking the constraints.

We can find the alternative to this stipulation in the communicative nature of language. People are using language in order to communicate and this produces a need for efficiency which leads to the tensive trading relation between the ease of production and ease of perception. In formal situation, it is more important that there should be less confusion on the part of the hearer and articulate speech is highly valued. The maximal distinctness cannot be obtained when a sound blends into the surrounding

sounds too much and its distinctive qualities become difficult to hear. Thus for the speaker to avoid being understood, faithfulness-related constraints are ranked higher than wellformedness-related ones. In informal situation, on the other hand, it is just the other way round, as long as there is no danger of meaning clash between paradigms.

5. Conclusion

The functional analysis of hiatus resolution and hiatus maintenance asymmetry in the phonologically identical environments which we presented in this paper will lead to the following conclusions. Although the opacity problem in the derived environments apparently issues a severe challenge to both derivational theory and optimality theory, there is in fact a functionalism-based counterpart to them: paradigm strength. Hiatus maintenance is closely linked to the paradigm principles that regulate the overall uniform paradigmatic pattern.

The transparency effects observed in morphologically and phonologically derived environments can be accounted for by locally conjoining the faithfulness constraint and the well-formedness constraint. In morphologically derived environments, the violation of alignment constraint activates the relevant phonology; in phonologically derived environments, the violation of feature identity constraint does the job, thus resulting in the emergence of the transparent unmarked output. On the other hand, in nonderived environments without any prior morphological or phonological rule application, the faithfulness constraint is always satisfied, and so the locally-conjoined constraint has no force. In this case, lower-ranked well-formedness constraint is decisive in choosing the optimal output. Here we can see the blocking effect of relevant phonology.

The opacity effects of underapplication and overapplication can be handled more insightfully within a paradigmatic approach. Paradigm strength including paradigm stability, paradigm economy, and paradigm regularization, is an independent factor in phonology, and this cannot be wholly reducible to formal properties of rules or constraints and their relations. Whereas previous studies have relied crucially on the ordering or ranking relations to predict the correct form, it is no longer possible to predict whether a given phonological form is well-formed on the basis of the grammar alone; we also need to know the whole paradigm in which the form in question is

supposed to fit.

In this respect, it is certainly significant that paradigm-based perspective still claims our attention. This paper is another attempt to explain the opaque interactions among processes in terms of paradigm strength. In conclusion, a complete theory of phonology should account for the way in which phonological representations can be related to each other, thus optimalizing the grammar. It is my belief that continued studies will strengthen the empirical basis of phonology.

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