

A Harmonic Serialism Analysis of Velar Softening in English*

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Chung, Chin-Wan. "A Harmonic Serialism Analysis of Velar Softening in English." *Studies in English Language & Literature* 45.4 (2019): 277-300. This paper deals with velar softening occurring between base-final velar stops and non-low front vowels which initiate the process triggering suffixes in English. We adopt a mixed type of theory with derivation and constraints in order to explain examples which require both simple and multiple mapping between input and output. It is argued that velar softening is motivated by a markedness constraint, which bans a sequence of velar stops plus non-low front vowels across a morpheme boundary. The simple velar softening case, which results in [s] and [dʒ], is explained by ranking a specific marked constraint over a general markedness constraint. The procedural approach applies to opaque and diphthongization examples. The opaque case is explained by assuming that there is a word-final mid-front vowel /e/, which triggers the process and is deleted. This type of non-surface apparent opacity needs a step-by-step account. The latter case is related to the verb-forming suffix initiating with /t/, which is diphthongized in the output when it is stressed. This is explained by proposing a constraint calling for well-formed foot structure. Thus, the current approach can explain both simple and complex cases of English velar softening. (Chonbuk National University)

Key Words: Velar softening, Harmonic serialism, Procedural approach, Constraints, Ranking

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I. Introduction

Segmental changes often occur across a morpheme boundary such as in palatalization, spirantization, and velar softening. One common factor we can observe from them is that a base-final segment is affected by a suffix-initial segment. The other factor is that base final segments undergo changes and the resulting segments generally have similar place features or are changed into an identical segment. In palatalization(Chomsky and Halle, 1968; Rubach, 1984; Halle and Mohanan, 1985; Kreidler, 1992; Park, 2012; Chung, 2015), the /t/ changes into [ʃ] and the /d/ into [ʒ] as in *invent~invention* and *divide~division* in a general palatalization environment. On the other hand, the /t/ and /d/ are converted into [s] in spirantization(Chomsky and Halle, 1968; Kreidler, 1992; Harris, 1994) as in *delicate~delicacy* and *allude~allusive*. However, such segmental change patterns found in palatalization and spirantization are not observed in velar softening. The voiceless velar stop changes into [s] while the voiced counterpart does not change into [z] but into [dʒ] in English. In addition to the difference in their place feature, they are also different in their manner feature: fricative and affricate. Thus, velar softening does not show a type of parallelism in the resulting segments observed in palatalization and spirantization. Furthermore, there are some velar softening examples that seemingly show a case of overapplication. That is, a segment undergoes a process without having any overt environment for velar softening. For example, the base-final /k/ in *produ/k/* is realized as [s] in *produ[s]* in which there is no apparent output trigger of the process. This segmental change is opaque and it is dubbed non-surface apparent case of opacity(McCarthy, 1998). Nonetheless, velar softening and the two morpho-phonological processes such as palatalization and spirantization show an identical aspect of undergoing weakening from the sonority perspective.

Thus, the goal of this study is to look into the examples of velar softening again and provide an alternative analysis by delving into the following issues. Firstly, what

is the motivation of velar softening? Secondly, why do we have non-parallel resulting segments of velar softening? Thirdly, how can we deal with the examples of non-surface apparent opacity in velar softening? Fourthly, can we provide a unified account of velar softening?

It is argued in the study that the process is triggered by a marked constraint and the resulting segments are the best choices for the grammar which are selected by the interaction of co-occurrence restrictions. At the same time, the data of opacity can be explained by utilizing a theory which adopts a consistent constraint ranking of the constraint-based theory (Prince and Smolenky, 1993, 2004; McCarthy and Prince, 1995) and derivation mode of the rule-based generative grammar (Chomsky and Halle, 1968). By applying this hybrid-type of Harmonic Serialism (McCarthy, 2008, 2010, 2011), we could provide a unified account, which can explain both regular and seemingly opaque velar softening examples in English.

The study is structured as follows. Section two presents the examples of velar softening with their description. Section three reviews former studies along with their analytic problems. Section four presents a new alternative account whose approach is different from those of the previous studies. The summary and the implication wrap up the study in Section five.

II. Data Presentation

In this section, we present the data for velar softening which are divided into three sub-groups. The first group consists of a base-final voiceless velar stop followed by vowel initial noun and verb forming suffixes. The second group is composed of a base ending in a voiced velar stop plus noun, verb, and adjective forming suffixes. The final group of examples are formed with bases ending in a voiced or voiceless velar stop which are followed by the mid front unround vowel /*ɛ*/ underlyingly (Chomsky and Halle, 1968: 220).

The first type of examples is given in (1) where the base final /k/ is realized as [s] when followed by noun and verb forming suffixes initiating with /ɪ/. We assume that the vowel in {-ize} is underlyingly /ɪ/ but it is diphthongized due to metrical reason in the output, which will be discussed in Section 4. Based on the change from /k/ to [s], we assume that a velar stop plus /ɪ/ sequence across a morpheme boundary is not desirable in English. Thus, changing from /k/ to [s] seems to be motivated by the following vowel across the morpheme boundary.

(1) [k]~[s] alternations

electri/k/	electri[s]ity	'electricity'
logi/k/	logi[s]ize	'logicize'
physi/k/al	physi[s]ist	'physicist'
criti/k/	criti[s]ism	'criticism'
medi/k/al	medi[s]ine	'medicine'
publi/k/	publi[s]ize	'publicize'
opa/k/ue	opa[s]ify	'opacify'

Unlike the examples in (1), when a base ends in /g/ and it is followed by noun, adjective, and verb forming suffixes beginning with /ɪ/, the voiced velar stop changes into [dʒ]. We also ascribe the trigger of velar softening in (2) to an unwanted sequence of /g+ɪ/ across the morpheme boundary. From the description of the examples in (1) and (2), we can assume that velar stops in English change into [s] and [dʒ] when followed by derivational suffixes starting with /ɪ/ mentioned above. However, we should eliminate the adjective forming {-y} and {-ive} from the triggers of velar softening. This is because the former does not motivate velar softening when affixed to bases ending in /k/ and /g/ as in *silk*→*silky*, *milk*→*milky*, *bulk*→*bulky*, *bag*→*baggy*, *bug*→*buggy*, and *zigzag*→*zigzaggy*. At the same time, the latter cannot be the trigger of velar softening because we cannot find examples in which base-final /g/ is followed by an adjective forming {-ive} suffix in English. Thus, it implies that suffixes themselves require certain base-final segments as hinted by Fabb (1988).

(2) [g]~[dʒ] alternations

analo/g/ue	analo[dʒ]y	'analogy'
prodi[g]al	prodi[dʒ]y	'prodigy'
dialo[g]ue	dialo[dʒ]ize	'dialogize'
pedago[g]ue	pedago[dʒ]ic	'pedagogic'
ri[g]or	ri[dʒ]id	'rigid'
fun[g]ous	fun[dʒ]icide	'fungicide'
apolo[g]ue	apolo[dʒ]ist	'apologist'

There is yet another type of velar softening examples where the velar stops are base final segments but they undergo velar softening realized as [s] and [dʒ]. As shown by the examples in (3), all the bases end in velar stops before the presumed underlying vowel /ε/, which triggers velar softening in English. Without the putative suffix /ε/ (Chomsky and Halle, 1968: 220), we cannot explain velar softening in (3). The trigger of velar softening is deleted in the output because English words do not end in [ε]. If velar stops are not followed by [ε], they are realized as they are as shown by the examples in the final column.

(3) Word-final [k]~[s] and [g]~[dʒ] alternations

produ/k+ε/	produ[s+ε]	produ[s]	cf. produ[k]tion
redu/k+ε/	redu[s+ε]	redu[s]	cf. redu[k]tion
introdu/k+ε/	introdu[s+ε]	introdu[s]	cf. introdu[k]tion
indu/k+ε/	indu[s+ε]	indu[s]	cf. indu[k]tion
alle/g+ε/	alle[dʒ+ε]	alle[dʒ]	cf. alle[g]ation
pur/g+ε/	pur[dʒ+ε]	pur[dʒ]	cf. pur[g]atory
obli/g+ε/	obli[dʒ+ε]	obli[dʒ]	cf. obli[g]atory

Considering the examples from (1) to (3), we can argue that segmental sequences of velar stops and non-low front vowels such as /ɪ/ or /ε/ of noun, adjective, or verb forming suffixes are not allowed and these motivate velar softening in English. So velar softening is a strategy to avoid an unwanted segmental sequence in the output. In the following section, we review previous studies on velar softening and discuss their problems before we propose an alternative account.

III. Previous Studies

In this section, we review former studies which are framed in rules (Chomsky and Halle, 1968) and constraints and their ranking (Prince and Smolenky, 1993, 2004; McCarthy and Prince, 1995). Based on rules and their ordering, Chomsky and Halle (1968: 224) propose the following velar softening rule:

(4) Velar softening rule

$$\begin{pmatrix} -\text{cont} \\ -\text{ant} \\ +\text{deriv} \\ <-\text{voice}> \end{pmatrix} \rightarrow \begin{pmatrix} +\text{cor} \\ +\text{stri} \\ <+\text{ant}> \end{pmatrix} / \text{---} \begin{pmatrix} -\text{low} \\ -\text{back} \\ \text{V} \end{pmatrix}$$

The given rule in (4) says that velar stops become non-stop segments with [+strident] feature specification when followed by non-low front vowels. That is, velar softening is phonologically predictable. The given rule can explain the examples provided in (1), (2), and (3). For the examples in (3), they add the following e-Elision rule in (5).

(5) $e \rightarrow \emptyset / \text{---}[-\text{seg}]$ (Chomsky and Halle, 1968: 147)

The rule in (5) should be ordered after the application of (4) to explain the final output of the examples in (3). However, the proposed rule does not provide any reason why velar stops should undergo such featural changes when followed by non-low front vowels in English. Another problem is that the given rule does not explain why we have non-identical pattern of velar softening results in English.

Framed in constraint-based theory, Lee(2004) proposes that more than one allomorph is present in the input and an appropriate allomorph is selected by the given constraint ranking. The proposed analysis by Lee indicates that the selection of right allomorph is not predictable in the output. Due to this limit, he argues for the multiple allomorphs in the input. The constraints used in the analysis and their

ranking are given in (6).

- (6) a. Ident-IO(F): Output correspondents of an input [ɣF] segments are also [ɣF].
 b. *[a_{back}][-a_{back}]: Horizontal tongue movement from onset to peak should not occur in direct opposite direction.
 c. Word Final Non-release (WFN): Word final consonants should not be released.
 d. Ranking: Ident-IO(F) ≫ *[a_{back}][-a_{back}] ≫ WFN

Since Ident-IO(F) is undominated, there should not be any change in feature specifications between correspondents. The undominated status of Ident-IO(F) implies that there are no feature changes in output segments or there is no velar softening in the output. This is because the appropriate allomorph is chosen by the constraint ranking so alternations in segments are not allowed in the analysis. The following constraint tables show how the given constraint ranking selects the correct allomorph in the output.

(7) A. critic

criti{k,s}	Ident-IO(F)	*[a _{back}][-a _{back}]	WFN
☞ a. criti[k]			
b. criti[s]			*!
c. criti[t]	*!		

B. criticism

criti{k,s}ism	Ident-IO(F)	*[a _{back}][-a _{back}]	WFN
a. criti[k]ism		*!	
☞ b. criti[s]ism			
c. criti[t]ism	*!		

As shown in (7A-B), the proposed constraint and their ranking look succinct and can explain the data in (1) and (2). However, the analysis is unable to account for the examples in (3) because the given constraint ranking selects *produ[t]* and *redu[k]* as optimal instead of actual optimal forms *produ[s]e* and *redu[s]e*. This is because *[a_{back}][-a_{back}] does not play any role and it is trivially satisfied by all

the examples in (3). Thus, without the assumption of putative underlying vowel /*ɛ*/, the examples in (3) cannot be explained. The fact that the putative underlying vowel /*ɛ*/ is deleted after it triggers velar softening as proposed in a rule-based approach (Chomsky and Halle, 1968) indicates that input to output simple mapping approach in the constraint-based analysis is unable to handle the examples in (3).

Radomski (2010) proposes an analysis of velar softening by changing trigger of the process from Lee's (2004) featural co-occurrence and WFN to alignment constraints, which subcategorize base final segments. However, Radomski employs Lee's Ident-IO(F). The following alignment constraints play an important role in selecting a correct allomorph in the output.

- (8) a. Align(I): Align suffix /I/ with the right edge of a base that ends in [+delayed release] consonants. (/I/ = {-ity, -ist, -ism, -ine, -ize, -y, ic(ide), -ent})
- b. Align(A): Align suffix /A/ with the right edge of a base that ends in [-delayed release] consonants. (/A/ = {-ate, -al, -ous,})
- c. Ranking: Ident-IO(F) \gg Align(I), Align(A)

Align(I) calls for the proper align of the vowel initial suffixes listed in (8a) with fricatives and affricates. On the other hand, Align(A) demands that suffixes in (8b) align base final segments with obstruent stops. The given constraint ranking in (8c) can explain velar softening examples in (1) and (2) as illustrated by the following table.

(9) publicize

publi{k,s}ize	Ident-IO(F)	Align(I)	Align(A)
a. publi[k]ize		*!	
b. publi[s]ize			
c. publi[t]ize	*!	*	

The optimal candidate in (9) is (b) which does not violate any given constraints. Since Ident-IO(F) is highest ranking constraint, it does not permit any featural change of input consonants in the output, which leads to the elimination of candidate (c). The analysis implies that velar softening is phonologically

unpredictable because the selection of the optimal form is implemented by morphologically-motivated alignment constraints and the given allomorphs in the input, which are almost identical to those of Lee(2004). However, the same problem arises as it did in the analysis by Lee (2004). That is, the proposed account cannot explain the examples in (3) because the suffixes listed in Radomski do not include the putative underlying suffix /*ɛ*/. If there is no base-final underlying vowel in *produ*/k/, the ranking in (9) will choose *produ*[s] and *produ*[k] as optimal. Thus, the actual optimal form cannot be distinguished from the incorrect output. It should be noted that the correct optimal form is not the result of selectional process imposed by alignment constraints but rather a random choice, which should not be permitted in theoretical analyses.

Contrary to Lee's and Radomski's analysis, Lee(2018) argues that velar softening is phonologically predictable. To explain the examples, Lee proposes two important featural alignment constraints.

(10) Featural Alignment Constraints (=Align-Suffix_{*i*})

- a. Align (Suffix_{*i*}, L, [coronal], R) (=Align-to-[cor])
Align suffix_{*i*} to stem-final coronals.
- b. Align (Suffix_{*i*}, L, [+delayed release], R) (=Align-to-[d.r.])
Align suffix_{*i*} to stem-final [+delayed release] consonants.

The two alignment constraints reflect restrictions levied on base-final segments by suffixes (Fabb, 1988; cf. Lee, 2010). That is, derivational suffixes select segmental sequences of base elements. In the alignment constraints, the Suffix_{*i*} includes several suffixes beginning with /*ɪ*/ and /*ay*/ such as in {-ic}, {-ist}, {-icide}, {-ity}, {-ine}, {-ism}, {-ize}, {-ile}, and {-i_{Noun}}. Thus, two alignment constraints specify the phonological environment for velar softening in English.

Concerning the ranking of the alignment constraints, Lee argues that Align-Suffix_{*i*} should be ranked lower than Ident(lab), and Ident(cor) ∩ Ident(del rel). This is because labial consonants in English do not undergo any featural changes when

suffixed by the suffix_{*i*} such as in *syllab-ic*, *Arab-ize*, *pulp-ify*, and *reviv-ify* (Lee, 2018: 394). At the same time, the complex Ident(cor)∩Ident(del rel) constraint (Cap-junction: Lee, 2013) is a type of conjoined constraint which is only satisfied if both identities are satisfied. If, however, one of the constraint is violated, the constraint is violated. Thus, the complex constraint selects the best of the best. Lee argues that the combined constraint is necessary for the /k/ to be realized as [s] in the output as required by (10b). Thus, the Align-Suffix_{*i*} constraint is ranked between the combined constraint and the component constraints of the combined constraint.

- (11) Ranking of Align-Suffix_{*i*} (Lee, 2018: 394)
Ident(lab), Ident(cor)∩Ident(del rel) ≫ Align-Suffix_{*i*} ≫
Ident(dor), Ident(cor), Ident(del rel).....

In order to explain underlying /č/ in *church* and its derived form *church-ism*, Lee proposes Faith(č) and *č, which are ranked Faith(č) ≫ *č but the higher ranked Faith(č) does not have any ranking with Align-Suffix_{*i*}. The following tables show how the given constraints can explain the change from /k/ to [s] and underlying /č/ to [č].

- (12) i. chur/č/ → chur[č]ism

chur/č/+ism	Align-Suffix _{<i>i</i>}	Faith(č)	*č
☞ a. chur[č]ism			*
b. chur[s]ism		*!	
c. chur[k]ism	*Align-to-[cor]		

- ii. criti/k/ → criti[s]ism

criti/k/+ism	Align-Suffix _{<i>i</i>}	Faith(č)	*č
a. criti[č]ism			*!
☞ b. criti[s]ism			
c. criti[k]ism	*Align-to-[cor]! *Align-to-[d.r.]		
d. criti[t]ism	*Align-to-[d.r.]!		

The two additional constraints such as Faith(č) and *č can explain velar softening from /k/ to [s]. Lee adds that the realization of /k/ to [s] is a case of the Emergence of the Unmarked because alveolar [s] is less marked than alveo-palatal [č].

In order to explain the examples in (3), Lee(2018) adopts the analytic strategy employed in Lee(2004) who uses multiple underlying allomorphs. For the analysis, Lee proposes Align-[cor](=Final(cor), *j, and *s and they are ranked Final(cor) » *j, *s. Final(cor) demands that prosodic word final consonants be coronal. The two segmental markedness constraints do not allow the occurrence of [j] and [s] in the output. As shown by the following tables, the correct allomorphs are selected by the given constraint ranking.

(13) i. pur[dʒ]e

pur{dʒ,g}	Final(cor)	*j	*s
a. pur[g]e	*!		
☞ b. pur[dʒ]e		*	

ii. pur[g]atory

pur{dʒ,g}atory	Final(cor)	*j	*s
☞ a. pur[g]atory			
b. pur[dʒ]atory		*!	

iii. produ[s]e

produ{k,s}	Final(cor)	*j	*s
a. produ[k]e	*!		
☞ b. produ[s]e			*

iv. produ[k]+tion

produ{k,s}+tion	Final(cor)	*j	*s
☞ a. produ[k]tion			
b. produ[s]tion			*!

As we have seen so far, the analysis proposed by Lee(2018) seems to explain the examples from (1) to (3) and the analysis partially predict velar softening in English. However, there are problems in the account. The first problem is that if velar

softening is phonologically predictable, the vowel initial suffixes of the suffix, should share a certain feature specifications which trigger the process but the vowels /i/ and /ay/ do not seem to form a common feature group. The second problem is that the Align-to-[d.r.] should be substantiated by another constraint which can eliminate sonorant segments in the output. The third problem is that there seem to be two approaches in the analysis: one approach does not allow multiple allomorphs while the other allows them. Thus, the second approach implies the unpredictable nature of velar softening as we observed in Lee's (2004) and Radomski's (2010) analysis.

In this section, we reviewed several previous studies on velar softening in English and found out that each former analysis had its own insights in dealing with the data but there are some unsolved issues. Thus, we adopt some ideas from the former studies and propose an alternative account for velar softening in the next section.

IV. An Alternative Analysis

In this section, we provide an account of velar softening, which is based on the assumption that velar softening is phonologically predictable (Chomsky and Halle, 1968; Lee, 2018). Thus, we adopt concepts from both Chomsky and Halle(1968) and Lee(2018) but we do not utilize rules and simple input-to-output mapping of constraint-based approach(Prince and Smolensky, 1993, 2004; McCarthy and Prince, 1995) but a procedural constraint-based theoretical framework, a Harmonic Serialism(McCarthy, 2008, 2010, 2011). This is because some of the velar softening examples need to be handled by steps of evaluation.

With respect to a group of vowel initial suffixes that motivate velar softening, we include noun-forming {-i}, {-ity}, {-ine}, {-ism}, {-ist}, and {-icide}; verb-forming {-ify}, {-ize}, and {-e}; adjective-forming {-ic} and {-id}. These suffixes begin with an initial vowel /i/. We dub such suffixes 'VelSof suffixes' in the study. We assume

that the initial vowel of {-ize} is underlyingly /ɪ/ but it is diphthongized when it is stressed in the output. We exclude an adjective forming {-ile} from the suffixes because the word *fragile* is not composed of *frag+ile* but the word is back-formed from *fragility*. In addition to the /ɪ/, we also assume that front vowel /ɛ/ is underlyingly present in the examples given in (3): *produ*/k+ɛ/ → *produ*[sɛ] → *produ*[s], which will eventually be deleted after it motivates the velar softening. Thus, we argue that velar stops and suffix-initial non-low front vowels [ɪ, ɛ] across the morpheme boundary are not allowed in English.

Concerning the base-final velar stops, it is argued that targets of process are restricted by the suffixes mentioned above because the elements of bases to which suffixes are affixed can be constrained by the requirement from suffixes. This indicates that attachment of suffixes is not implemented haphazardly but it is conducted according to the demands called for by suffixes (Fabb, 1988; Spencer, 1992; Plag, 1999; Kang, 2000). In order to explain velar softening examples, we propose following constraints.

(14) Constraints for velar softening

- a. *VP-V_{NLF}: Velar plosives and non-low front vowels of noun, verb, and adjective forming suffixes across a morpheme boundary are not allowed.
- b. Ident[*Son/Lar*]: Input and output corresponding consonants are identical in their sonorant and laryngeal specifications.
- c. Sib_{-NLF}V: Non-low front vowels of suffixes prefer to have preceding sibilants.
- d. *Sib+ɪ/ɛ: Sequences of sibilants and suffix initial non-low front vowels are not permitted.
- e. Ident-I → O(+ant ∪ +cor): Input consonants from bilabial to palatal place features are faithfully realized in the output.
- f. *t-I_{Noun}: The base-final alveolar stop /t/ and the noun forming {-y} suffix are not allowed.
- g. Ident[*bk*]: Input and output corresponding consonants are identical in their [back] feature specification.
- h. FtBin: Feet are binary under moraic or syllabic analysis.
- i. *ɛ_{wd}: Word-final [ɛ] is not allowed.

*VP_{NLF}V calls for prohibition of base final velar plosives /k, g/ followed by suffix initial VelSof suffixes. This markedness constraint motivates velar softening in English and is undominated. This constraint, however, does not specify how to avoid such an undesirable sequence.

Ident[*Son/Lar*] restricts a range of changes in velar plosives when they change into other segments to avoid the violation of *VP_{NLF}V. The constraint allows changes in velar stops except for sonorant and laryngeal specification. So the velar stops may change into fricatives or affricates, which have higher sonority than plosives and such changes are in line with the velar softening. However, the fricatives and affricates should maintain the identical laryngeal feature, which implies that change into sonorants are prohibited due to Ident-[*Son/Lar*]. This constraint is ranked very high in the analysis and is equally ranked with *VP_{NLF}V.

Sib_{NLF}V states that non-low front vowels of VelSof suffixes prefer to have preceding sibilants. This is a general constraint which leads base-final velar plosives into sibilants before initial vowels of VelSof suffixes. This can be viewed as fronting of place of velar stops before non-low front vowels, which induces a natural transition of an onset segment to a nucleus across the morpheme boundary. On the other hand, the constraint may reflect an idea from Lee(2004) who proposes *[aback][*-aback*] requiring natural tongue movement from onset to nucleus. While this place change occurs over a morpheme boundary, a similar but lower-degree of featural change in velar plosives occurs when followed by tauto-morphemic front vowels /ɪ/ such as in *keep*[*kɪp*] and *ski*[*sɪl*] where [*ɪ*] signals fronting of the tongue position (Wolfram and Johnson, 2003; cf. Lee, 2018). This type of fronting of velar plosives also occurs in Polish when they are followed by front vowels: *menk-a* ‘torment’ → *men-ɸiɕ* ‘to torment’ and *rog-ek* → *rodɕ-ek* ‘horn’ (Spencer, 1996; Łubowicz, 2002). Thus, based on these examples, velar softening of English is results of fronting of velar plosives when followed by front vowels across the morpheme boundary. This fronting also can be construed as weakening of velar stops by becoming [s] or [dʒ] which has higher sonority than that of velar stops.

This general change is counterbalanced by $*\text{Sib}+1/\epsilon$, which dominates $\text{Sib}_{\text{-NLF}}\text{V}$ because the former bans several sequences of sibilants plus $[\text{I}, \epsilon]$ in the output such as $*\text{z}+1/\epsilon$, $*\text{ʃ}+1/\epsilon$, $*\text{ʒ}+1/\epsilon$, and $*\text{ʝ}+1/\epsilon$ in which the prevocalic sibilants are derived ones. On the other hand, the latter allows all combinations of sibilants plus $1/\epsilon$. The sibilants $[\text{z}, \text{ʃ}, \text{ʒ}, \text{ʝ}]$ do not occur before VelSof suffixes in the output because only $/\text{k}/ \rightarrow [\text{s}]$ and $/\text{g}/ \rightarrow [\text{dʒ}]$ changes appear across a morpheme boundary when followed by VelSof suffixes. Thus, more specific $*\text{Sib}+1/\epsilon$ is ranked over more general $\text{Sib}_{\text{-NLF}}\text{V}$ in the analysis.

Concerning the underlying segments other than derived $[\text{s}]$ or $[\text{dʒ}]$ from $/\text{k}/$ or $/\text{g}/$, they should be realized as they are in the output. The faithful realization of underlying segments is guaranteed by $\text{Ident-I} \rightarrow \text{O}(+\text{ant} \cup +\text{cor})$. This is a type of conjoined constraint (Crowhurst and Hewitt, 1997; Crowhurst, 2011) and the concept of ‘direction’ is adopted from Pater(1999, 2004) who proposes that ‘direction’ indicate the faithful mapping of input features on a corresponding segment in the output. The element $(+\text{ant} \cup +\text{cor})$ denotes $+\text{ant}$ or $+\text{cor}$ so that it implies $(+\text{ant})$ or $(+\text{cor})$ and $((+\text{ant}) \text{ or } (+\text{cor}))$. It is represented as constraint evaluation(Lee, 2013: 153):

(15) Disjunctive combination (CUP-junction)

	$[\text{X} \cup \text{Y}]$	X	Y
a.	✓	✓	✓
b.	✓	*	✓
c.	✓	✓	*
d.	*!	*	*

As shown in (15), the constraint demands that the base-final segments from bilabial to palatal place of articulation in the input faithfully be realized in the output. If this constraint is in action, only velar plosives will be excluded from this requirement. So only base-final $/\text{k}/$ and $/\text{g}/$ are subject to change in the output. In reality, all the input consonants from bilabial to palatal place of articulation are generally realized as they are in the output but there is a minor problem here. The problem is related

to a base-final /t/ and the noun-forming suffix {-y}. The alveolar stop /t/ should be realized [t] when followed by VelSof suffixes but it is realized as [s] only before a noun forming {-y} violating Ident-I→O(+ant∪+cor). This is because the noun-forming {-y} also can trigger spirantization when it is preceded by the base-final alveolar stop as in *delica*/t+ɪ/→*delica*[sɪ], *frequen*/t+ɪ/→*frequen*[sɪ], and *vacan*/t+ɪ/→*vacan*[sɪ] (Chomsky and Halle, 1968; Kreidler, 1992; Bauer, Lieber, and Plag, 2013). In order to suppress the identical realization of /t/ to [t] before the {-y}, we should propose a specific constraint, *t-I_{Noun}. This constraint can exclude [t] from a number of consonants which are secured to be faithfully realized in the output by Ident-I→O(+ant∪+cor). From this interaction, we rank *t-I_{Noun} over Ident-I→O(+ant∪+cor). We exclude /d/ from *t-I_{Noun} because base-final /d/ does not become a noun by the affixation of {-y}.

In the analysis, we rank Ident-I→O(+ant∪+cor) over *Sib+ɪ/ε and Sib_{NLF}V because there are some base-final sibilants and they are realized as sibilants before VelSof suffixes as in *bossism*, *trapezist*, *fetishist*, *speechify*, *churchism*, and *strategic*. This ranking relation guarantees the faithful realization of base-final sibilants in the output even before VelSof suffixes.


Ident[bk] checks identical back feature of corresponding consonants and it requires the preservation of [back] feature of velar softening targets. Since base-final velar plosives are supposed to change into [s] or [dʒ], this constraint is violated whenever velar softening applies. So it is ranked lowest in the analysis. Ft-Bin is called for in the analysis because it leads the vowel /ɪ/ into diphthongization in the output as in *publi*/k+ɪz/→*públi*[sàyz]. The output form (*públi*)(sà)z has two feet but the final segment after the second foot is extrametrical (Burzio, 1994). If the vowel in the ultimate syllable is realized as (sɪ)z, the second foot is a degenerate foot and it violates FtBin. Thus, the constraint secures the diphthongization of the vowel in the suffix. This type of examples need to be accounted for by a step-by-step approach because putative underlying vowel of the [ay] in *públi*sàyz is /ɪ/ as in *publi*/k+ɪz/.

The final constraint is *ε]_{wd}. This constraint is motivated to explain the examples


in (3) where the velar softening triggering vowel is deleted after the process (Chomsky and Halle, 1968). This is because the assumed underlying vowel / ϵ / does not occur as the word-final vowel in the output. Thus, without the assumption of putative base-final vowel / ϵ /, it is very difficult to explain the examples in (3). If the base-final presumed vowel is deleted after it triggers velar softening, we observe a non-surface apparent case of opacity in the output where the process seemed to have overapplied without any process motivator (McCarthy, 1998). The proposed constraint plays an important role in the analysis but is not ranked highly because there are words that end in vowels in English. We rank it equally with Ft-Bin, which is ranked lower than Sib_{NLF}V.

Based on the constraints and their interaction reflected in ranking, we first provide an example in which the base-final /k/ becomes [s]. In the following tables, we only include relevant constraints for the data. We also do not mark stress unless it is critical in the analysis.

(16) a. Step 1

criti/k+i/sm	*VP-V _{NLF}	Id[<i>Son/Lar</i>]	*Sib+i/ ϵ	Sib _{NLF} V	Id[bk]
criti[k+i]sm	*!			*	
criti[t+i]sm				*!	*
 criti[s+i]sm					*
criti[j+i]sm			*!		*
criti[ʒ+i]sm			*!		*

b. Step 2

criti[s+i]sm	*VP-V _{NLF}	Id[<i>Son/Lar</i>]	*Sib+i/ ϵ	Sib _{NLF} V	Id[bk]
 criti[s+i]sm					

As shown in Step 1, the first candidate preserves input /k/ in the output, violating *VP-V_{NLF}, which leads the candidate to be eliminated. The second candidate, which changes input /k/ to the unmarked place [t] is also edged out by Sib_{NLF}V. Thus, changing from a plosive to another plosive is futile in that it does not achieve softening of the plosive. On the other hand, final two candidates properly change /k/

into fricatives fulfilling raising of the plosive sonority in the output. However, they are suboptimal because [ʃ] and [ʒ] before VelSof suffixes are not allowed in English. The local optimal form *criti[s+ɪ]sm* only incurs a violation of the lowest-ranking Id[bk], and now it becomes the input in the second step. The candidate in Step 2 is identical to the input, which is called convergence and the candidate satisfies all the given constraints, becoming the ultimate optimal form.

In the next tables, we show softening of /g/ to [dʒ] and diphthogization of the input vowel in the output, which is metrically motivated. In the table below, we only use phonetic symbols for the base-final consonant and initial vowel of VelSof suffixes.

(17) a. Step 1

dialo/g+ɪ/ze	*VP-V _{NLF}	Id[Son/Lar]	*Sib+ɪ/ε	Sib _{NLF} V	FtBin
di(álo)(gɪ)ze	*!			*	*
di(álo)(zi)ze			*!		*
di(álo)(ʒi)ze			*!		*
di(álo)(ʃi)ze		*!	*		*
☞ di(álo)(dʒi)ze					*

b. Step 2

di(álo)(dʒi)ze	*VP-V _{NLF}	Id[Son/Lar]	*Sib+ɪ/ε	Sib _{NLF} V	FtBin
di(álo)(dʒi)ze					*!
☞ di(álo)(dʒəy)ze					

c. Step 3

di(álo)(dʒəy)ze	*VP-V _{NLF}	Id[Son/Lar]	*Sib+ɪ/ε	Sib _{NLF} V	FtBin
☞ di(álo)(dʒəy)ze					

In (17), the expected result of velar softening for /g/ is [z] if and only if there is a parallel pattern of velar softening considering the change from /k/ to [s]. But this is not the case in Step 1 where the /g/→[z] change is ruled out by *Sib+ɪ/ε. So there is only one option for the input base-final /g/ to select in Step 1, which is the [dʒ] among the sibilants. The local optimal form, however, still violates the

lowest-ranking FtBin because there is only one mora in the second foot while the another potential mora to be projected by [z] is not the option due to its extrametricality. In Step 2, the simple vowel is diphthongized to meet the requirement of FtBin as shown by the second local optimal form. This form eventually becomes the final output in Step 3 where convergence is achieved.

Next, we show the evaluation tables illustrate how the examples in (3) can be accounted for by the step by step processes.

(18) a. Step 1

produ[k+ε/	*VP-V _{NLF}	*Sib+I/ε	Sib _{NLF} V	*ε] _{wd}
produ[k+ε]	*!		*	*
produ[j+ε]		*!		*
produ[tʃ+ε]		*!		*
☞ produ[s+ε]				*

b. Step 2

produ[s+ε]	*VP-V _{NLF}	*Sib+I/ε	Sib _{NLF} V	*ε] _{wd}
produ[s+ε]				*!
produ[s]				

c. Step 3

produ[s]	*VP-V _{NLF}	*Sib+I/ε	Sib _{NLF} V	*ε] _{wd}
produ[s]				

As shown in (18), it will be difficult to deal with this non-surface apparent opacity data without the assumed underlying vowel /ε/ to motivate velar softening. Even though it is not ranked high in the analysis, it plays a critical role in explaining the examples in (3). Without such an assumption, the given examples will be cases of absolute neutralization in the coda position. However, such neutralization cases are not observed in English. So far we presented procedural account of velar softening examples from (1) to (3).

Now the question we should ask is that whether the given constraint for velar softening can deal with the examples that do not have base-final velar plosives. The

given constraints and their ranking can account for the examples which are not related to velar softening. We first demonstrate an example that ends in /ʃ/ as in *church*+{-ism}.

(19) a. Step 1

chur/ʃ ⁺ i/sm	*VP- V _{NLF}	Id [Son/Lar]	Id-I→O (+A ∪ +C)	*Sib+ <i>i</i> /ε	Sib- NLFV
☞ chur/ʃ ⁺ i/sm				*	
chur/s ⁺ i/sm			*!		
chur/ʃ ⁺ i/sm			*!	*	
chur/t ⁺ i/sm			*!		*

The examples with no base-final velar plosives do not need to undergo steps to select the optimal form because all consonants except for the base-final consonants /k, g, t/ are faithfully realized in the output. The /t/ in /k, g, t/ is the one that is selected which is influenced by the noun-forming {-y} suffix. As shown in (19), the first candidate, which is identical to the input, is selected as optimal since convergence is achieved in Step 1. For the example with the base-final /t/, it should undergo modification because the /t+*i*/ sequence is filtered out by *t-I_{Noun}, which is illustrated by the following tables.

(20) a. Step 1

delica/t ⁺ i/	*VP- V _{NLF}	*t-I _{Noun}	Id-I→O (+A ∪ +C)	*Sib+ <i>i</i> /ε	Sib- NLFV
delica/t ⁺ i/		*!			
delica/ʃ ⁺ i/			*	*!	
delica/k ⁺ i/	*!			*	
☞ delica/s ⁺ i/			*		

b. Step 2

delica/s ⁺ i/	*VP- V _{NLF}	*t-I _{Noun}	Id-I→O (+A ∪ +C)	*Sib+ <i>i</i> /ε	Sib- NLFV
☞ delica/s ⁺ i/					

The high-ranking $*t\text{-I}_{\text{Noun}}$ edges out the first candidate with the [tɪ] sequence even though it maintains the base-final segment /t/ in the output satisfying Ident-I→O(+ant∪+cor). However, since $*t\text{-I}_{\text{Noun}}$ dominates Ident-I→O(+ant∪+cor), the effort of preserving base-final segments except for /k, g/ is obscured in the output. On the contrary, when a base-final segment is /t/ and is followed by VelSof suffixes excluding the noun-forming {-y}, the /t/ is faithfully realized in the output as demonstrated in (21).

(21) a. Step 1

ar/tɪ/st	*VP-V _{NLF}	*t-I _{Noun}	Id-I→O (+A∪+C)	*Sib+ɪ/ε	Sib- NLFV
ar[tɪ]st					*
ar[kɪ]st	*!		*		*
ar[sɪ]st			*!		
ar[tʃɪ]st			*!	*	

The given constraint selects the first candidate as optimal in Step 1 and it is the ultimate optimal form because convergence is accomplished here. So far we have seen that the proposed constraints and their ranking could explain both velar softening and other examples that are not related to velar softening. The constraint ranking we have employed so far is provided in (22).

(22) $*VP\text{-}V_{\text{NLF}}, \text{Ident}[\text{Son}/\text{Lar}], *t\text{-I}_{\text{Noun}} \gg \text{Ident-I} \rightarrow \text{O}(\text{+ant} \cup \text{+cor}) \gg *Sib+\text{ɪ}/\epsilon \gg Sib\text{-}NLFV \gg \text{FtBin}, *[\epsilon]_{\text{wd}}$

V. Conclusion

In this study, we provided a unified account based on a hybrid-type of theory, which allows derivation-like steps but candidates in each step are evaluated by a consistent constraint ranking. We adopted this type of theory instead input-to-output

simple mapping of constraint-based analysis because there are some examples that we had to assume an underlying vowel, which triggers velar softening first and is deleted later. Such group of examples presented in (3) shows non-surface apparent case of opacity, which poses an analytic problem for the classic simple input-to-output mapping constraint-based theory. Another reason we employed this theory is to explain diphthongization, which was motivated by metrical reason to satisfy FtBin.

This type of analysis has some advantage over a rule-based and a constraint-based approach in that the former does not provide justifiable reasons why certain rules are proposed. On the other hand, the latter cannot provide an account for the examples in (3), which cannot be explained by simple mapping of optimality or correspondence theory. However, the account proposed in this study could explain the examples given from (1) to (3) and could provide reasons why there should be /k/→[s] and /g/→[dʒ] changes in English.

There are several points we can draw from the current analysis. Firstly, the non-typical pattern found in velar softening [s] and [dʒ] instead of [s] and [z] or [ʃ] and [dʒ] comes from the language-internal reason. Normally the [z+ɪ] sequence occurs when the vowel is an adjective-forming class 2 suffix as in *jazz*→*jazzy*, *bronze*→*bronzy*, and *snooze*→*snoozy*. So the sequence does not occur before VelSof suffixes. The sequence [tʃ+ɪ] does not occur before VelSof suffixes but it occurs before the adjective forming class 2 suffix {-y} as in *itch*→*itchy*, *patch*→*patchy*, and *beach*→*beachy*. Secondly, velar softening in English is phonologically predictable because the process can be construed as fronting of velar place of articulation and weakening of plosives into sibilants just like spirantization in English. Thirdly, the fact that general target of velar softening is base-final velar plosives implies asymmetrical implementation of position such as onset vs coda even if the base-final velar stops become onsets when followed by vowel initial suffixes.

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