Coda neutralization: Against purely phonetic constraints

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1. Introduction

The neutralization of the laryngeal features of a consonant that is not directly followed by a vowel is a common process cross-linguistically. Laryngeal neutralization in this position has a clear phonetic cause: laryngeal features are not salient unless they are immediately followed by a vowel. Since laryngeal neutralization has a phonetic cause, it seems reasonable to characterize it directly in phonetic terms, without positing any additional layer of phonological abstraction. However, a phonetic explanation is not sufficient to account for all cases of laryngeal neutralization. For example, in Korean, laryngeal neutralization occurs in a non-neutralizing phonetic environment; in Nisgha, laryngeal neutralization occurs only in the reduplicant, although the phonetic environment for neutralization is found in both the reduplicant and the base.

Although phonetics is the major factor leading to the development of these types of restrictions on laryngeal features, I argue that a phonetic account is not adequate for all such restrictions. Abstract phonological constraints and representations are necessary. Hence, two types of neutralization are possible: (i) phonetic neutralization, which results directly from the lack of saliency of cues and occurs in every instance of the neutralizing environment; and (ii) abstract phonological neutralization, which may occur where the neutralizing environment is absent (as will be demonstrated for Korean), and may fail to occur in every instance of the neutralizing environment (as will be demonstrated for Nisgha).

2. Korean

2.1 Laryngeal neutralization

Korean aspirated and 'tense' obstruents surface as plain obstruents word-finally (see (1)) and before another consonant (see (2)). Aspirated obstruents are characterized here with the feature [+spread glottis] ([sg]), and tense obstruents with [+constricted glottis] ([cg]). Plain obstruents and neutralized obstruents have neither of these features.

(1) Word-final neutralization of laryngeal features (C.-W. Kim 1979 and K.-H. Kim 1987)

		Input	Phonetic form	
a.	$t^h \rightarrow t$	nat^h	nat	'a piece'
b.	$\check{c}^h \rightarrow t$	$na\check{c}^h$	nat	'a face'
c.	s' → t	nas'-	nat	'was born'
d.	t → t	nat	nat	'a grain'

(2) Preconsonantal neutralization of laryngeal features (C.-W. Kim 1979 and K.-H. Kim 1987)

		Input	Neutralized form	Phonetic form	
a.	$k^h \rightarrow k$	puək^h + e	puək^{h}e	puək^{h}e	'in the kitchen'
		puək^h + to	puəkto	puəkt'o	'the kitchen also'
b.	k' → k	sək' + əra	sək'əra	sək'əra	'mix!'
		sək' + ta	səkta	səkt'a	'to mix'
c.	k → k	mək + əra	məkəra	məgəra	'eat!'
		mək + ta	məkta	məkt'a	'to eat'

Phonetic facts about the realization of Korean laryngeal features help to explain why they are neutralized in word-final and preconsonantal positions. The acoustic cues to the laryngeal features of a Korean obstruent are dependent on the onset of voicing following the obstruent. Han and Weitzman (1970) found for Korean that voice onset time is perceptually important for distinguishing aspirated from plain stops. Two factors involving voice onset proved perceptually important for distinguishing tense from plain stops: (i) the value of the fundamental frequency at voice onset (high for tense stops, lower for plain stops) and (ii) the rate of the build-up in intensity of voicing after voice onset (rapid for tense stops, slower for plain stops).

If there is no onset of voicing immediately following an obstruent, then the cues to the laryngeal features of that obstruent are not salient. Korean laryngeal features are neutralized exactly where the phonetic facts about their realization predict that they should be neutralized.

The approach to feature licensing of Steriade (1994, 1995) could directly capture the Korean facts presented so far. Briefly put, the licensing of a feature F is expressed in terms of the acoustic cues to F, and not in terms of the prosodic position to which F is associated. Hence, F is not licensed wherever the cues to F are weak. In the Korean case, laryngeal features are not licensed wherever they are not immediately followed by the onset of voicing.

(3) Licensing by Cue (Steriade (1995))
'The only relevant factor in neutralization for F is the availability of cues to F in different contexts.'

An advantage of a Licensing by Cue analysis of Korean is that the cause and environments for neutralization are stated directly, with no extra layers of abstraction. However, a phonetic account of Korean laryngeal neutralization cannot be maintained if the interaction of laryngeal neutralization with obstruent voicing in compounds is to be accounted for.

2.2 Obstruent voicing

Korean plain obstruents are phonetically voiced when they are preceded by any voiced sound and followed by a vowel or a glide (see (4)). Plain obstruents are voiceless word-finally (*nat* → *nat* 'a grain' (1d)), before another consonant (*mək-ta* → *məkta* 'to eat' (2c)), and word-initially (*puək^h-e* → *puək^{h}e* 'in the kitchen' (2a)). Aspirated and tense obstruents are never phonetically voiced (see (5)).

(4) Plain stops: phonetically voiced (C.-W. Kim 1979 and K.-H. Kim 1987)

	Input	Phonetic form	
a.	sap + i	sabi	'a shovel (subj.)'
b.	sin + pal	sinbal	'foot-wear, shoes'
c.	pan + tal	pandal	'half-moon'
d.	si + ča	siǰa	'mayor'
e.	ne + si + kyə	nesigyə	'about 4 o'clock'

(5) Aspirated and tense stops: not phonetically voiced (C.-W. Kim 1979 and K.-H. Kim 1987)

	Phonetic form	
a.	kip^{h}um	'dignity'
b.	sont^{h}op	'a fingernail'
c.	manč^{h}an	'dinner'
d.	čok^{h}a	'a nephew'
e.	ap'a	'daddy'
f.	ut'uk	'aloft'
g.	kač'a	'a fake'
h.	čak'u	'frequently'

As we have seen so far for Korean, the presence or absence of a vowel following an obstruent seems to be important in determining two facts: (i) whether the underlying laryngeal features of the obstruent are realized and (ii) whether the obstruent is phonetically voiced.

In most circumstances, a single obstruent can not satisfy the conditions for both laryngeal neutralization and obstruent voicing. However, there is one environment in which the conditions for neutralization and voicing are met simultaneously. The laryngeal features of the final obstruent of the lefthand member of a compound are neutralized; neutralization in this position takes place even if the second member of the compound is vowel-initial (e.g. *puək^h* + *an* → *puəkan*, **puək^{h}an* 'inside the kitchen'). These facts can be explained by the phonetic analysis outlined above if the final consonant of the lefthand member of the compound is *not* considered to be phonetically followed by a vowel.

However, there is reason to believe that this position *is* phonetically followed by a vowel. If the righthand member of the compound is vowel-initial, the final obstruent of the lefthand member is phonetically voiced (see (6)). Recall that Korean consonants must be followed by a vowel or glide in order to be phonetically voiced.

(6) Compounds and neutralization (C.-W. Kim 1979)

	Input	Phonetic form	
a.	⟦ puək^h ⟧ + ⟦ an ⟧	puəgan (*puək^{h}an)	'inside the kitchen'
b.	⟦ ap^h ⟧ + ⟦ ərin ⟧	abərin (*ap^{h}ərin)	'the gentleman ahead'
c.	⟦ nač^h ⟧ + ⟦ insaŋ ⟧	nadinsaŋ	'facial impression'
d.	⟦ pat^h ⟧ + ⟦ wi ⟧	padwi (*pat^{h}wi)	'top of the garden'

We have arrived at a paradox for a phonetic account of the Korean laryngeal neutralization and voicing facts: a single obstruent must be considered to be both followed by a vowel (it's voiced) and not followed by a vowel (its laryngeal features are neutralized).

The solution proposed here is that neutralization and voicing are not both properly characterized as phonetic. Voicing *is* phonetic: it occurs wherever its phonetic environment is met. Laryngeal neutralization, on the other hand, is not phonetic, since it occurs in environments in which the phonetic conditioning factors do not obtain.

We have seen that neutralization occurs before a consonant and word-finally. I assume that Korean word-final consonants are syllabified as codas. Since Korean has no word-initial or word-final consonant clusters, I assume that in a C_1C_2 sequence, C_1 is syllabified as a coda (and C_2 as an onset). The environment for Korean laryngeal neutralization, then, is *coda position*.

Obstruent voicing is not sensitive to syllable structure. If an obstruent that has no laryngeal features is preceded by a voiced sound and followed by a vowel or glide, it is voiced, regardless of its status as coda or onset.

I claim that Korean syllabification respects the morphological word (MWd) edges of compounds. That is, a single syllable may not contain phonological material from more than one MWd. The final consonant of the lefthand member of a compound is always syllabified as a coda, and never as the onset to the initial syllable of the righthand member of the compound. For example, ⟦*puək^h*⟧ + ⟦*an*⟧ 'inside the kitchen' is syllabified ⟦*puəg*⟧.⟦*an*⟧, not *⟦*puə.g*⟧⟦*an*⟧. Syllable edges are marked by ".", MWd edges are marked by "⟦ ⟧", and other morphological edges are marked by "[ ]".

I now turn to an analysis of Korean laryngeal neutralization in Optimality Theory.

2.3 OT Analysis

The restrictions against laryngeal features in the coda are expressed with the constraints *CODA([sg]) and *CODA([cg]) in (7). There is no evidence for the ranking of these two constraints in Korean; I abbreviate the two constraints together as *CODA(L).

(7) *CODA(L)

a. *CODA([sg])
[spread glottis] is not associated to a coda.

b. *CODA([cg])
[constricted glottis] is not associated to a coda.

These constraints do not reflect the phonetics of the restriction on laryngeal features. This is appropriate, since Korean laryngeal neutralization is not in a one-to-one relation with its phonetic causes.

The Faithfulness constraint IDENT-IO(F) prohibits featural differences between input and output:

(8) IDENT-IO(F) (McCarthy and Prince (1995, 16))
Output correspondents of an input [γF] segment are also [γF].

Since input laryngeal features may be absent from output in order to satisfy *CODA(L), *CODA(L) dominates IDENT-IO(F).

The ONSET constraint simply requires that syllables have onsets:

(9) ONSET (Prince and Smolensky (1993))
Syllables must have onsets.

The restrictions on the alignment of syllables and morphological edges discussed above are expressed with the following alignment constraints:

(10) ALIGN(MWd,R,σ,R) (see McCarthy and Prince (1993))
Align the right edge of every morphological word with the right edge of a syllable.

(11) ALIGN(M,R,σ,R) (see McCarthy and Prince (1993))
Align the right edge of every morpheme with the right edge of a syllable.

ALIGN(MWd,R,σ,R) requires alignment of syllable edges and MWd edges, while ALIGN(M,R,σ,R) requires alignment of syllable edges and all types of morphological edges. The specific ALIGN(MWd,R,σ,R) is ranked over the general ALIGN(M,R,σ,R); otherwise the effects of the specific constraint would not be observable (see Prince and Smolensky (1993) on Panini's Theorem).

ALIGN(MWd,R,σ,R) dominates *CODA(L) and ONSET: a syllable may not cross a MWd edge in order to avoid a violation of *CODA(L) or ONSET. ONSET dominates ALIGN(M,R,σ,R), since other types of morphological edges may be crossed in order to provide an onset to a syllable (e.g. ⟦ [puə.k^h][e] ⟧ 'in the kitchen').

These subrankings taken together produce three possible total rankings, given in (12). Ranking (12a) is assumed for the remainder of the analysis.

(12) Possible total rankings:

a. ALIGN(MWd,R,σ,R) » { ONSET, *CODA([sg]) } » { IDENT-IO(F), ALIGN(M,R,σ,R) }

b. ALIGN(MWd,R,σ,R) » *CODA([sg]) » { IDENT-IO(F), ONSET } » ALIGN(M,R,σ,R)

c. ALIGN(MWd,R,σ,R) » ONSET » { ALIGN(M,R,σ,R), *CODA([sg]) } » IDENT-IO(F)

In tableau (13), no candidate violates ALIGN(MWd,R,σ,R), since no syllable crosses an MWd edge. Other morphological edges are strictly aligned with syllable edges in candidates (13c) and (13d) (avoiding violation of ALIGN(M,R,σ,R)), but both contain an onsetless syllable, and so are eliminated by ONSET. Candidates (13a) and (13b) avoid violating ONSET by allowing misalignment of syllable and morpheme edges. The input feature [sg] is missing from the output in candidate (13b), incurring a fatal violation of IDENT-IO(F). Hence, candidate (13a), which violates only low-ranked ALIGN(M,R,σ,R), is optimal.

(13) ⟦ [puəkʰ] + [e] ⟧ → ⟦ [puə.kʰ][e] ⟧ 'in the kitchen'

Input: ⟦ [puəkʰ] [e] ⟧ | [sg]	ALIGN (MWd,R,σ,R)	ONSET	*CODA ([sg])	IDENT-IO(F)	ALIGN (M,R,σ,R)
☞ a. ⟦ [puə.kʰ] [e] ⟧ | [sg]					*
b. ⟦ [puə.k] [e] ⟧				*!	*
c. ⟦ [puəkʰ] . [e] ⟧ | [sg]		*!	*		
d. ⟦ [puək] . [e] ⟧		*!		*	

In tableau (14), MWd edges and syllable edges are not well-aligned in candidates (14a) and (14b), incurring a fatal violation of ALIGN(MWd,R,σ,R) for each. The well-aligned (14c) and (14d) each incur one ONSET violation. *CODA(L) eliminates (14c), in which [sg] is associated to a coda, in favor of (14d), the optimal candidate.

(14) ⟦puək^h⟧ + ⟦an⟧ → ⟦puək⟧.⟦an⟧ (→ puəgan) 'inside the kitchen'

Input: ⟦puək^h⟧⟦an⟧ [sg]	ALIGN (MWd,R,σ,R)	ONSET	*CODA ([sg])	IDENT-IO(F)	ALIGN (M,R,σ,R)
a. ⟦puə.k^h⟧⟦an⟧ [sg]	*!				*
b. ⟦puə.k⟧⟦an⟧	*!			*	*
c. ⟦puək^h⟧.⟦an⟧ [sg]		*	*!		
☞ d. ⟦puək⟧.⟦an⟧		*		*	

The crucial difference in the behavior of Korean compounds and non-compounds with respect to laryngeal neutralization is syllabification. Syllable structure must respect the MWd edges of compounds, but is not required to respect other morphological edges. Laryngeal neutralization is sensitive to syllable structure; consequently, its environment is indirectly determined by MWd edges.

Again, a purely phonetic analysis of Korean laryngeal neutralization has no explanation for why the laryngeal features of the final consonant of the lefthand member of a compound are not realized. Since this consonant is phonetically followed by a vowel, the features should be realized.

Another case of laryngeal neutralization is found in Nisgha, a Tsimshian language of British Columbia. Here, the restrictions on laryngeal features are (phonetically arbitrarily) more stringent in the reduplicant than in the base.

3. Nisgha

In Nisgha, glottalization is neutralized in the coda of the reduplicant, but not in the coda elsewhere (see (15)). Again it appears that laryngeal features are neutralized wherever they are not phonetically followed by a vowel. However, glottalized consonants regularly appear before other consonants in the base (see (16)); it is only in the reduplicant that laryngeal features are neutralized. Nisgha laryngeal neutralization is not amenable to a purely phonetic analysis: it is mysterious why a phonetic restriction should be more strictly enforced in one morphological category (reduplicant) than in another (base).

A phonological analysis along the lines of the Korean analysis above is developed below. Nisgha laryngeal neutralization is an instance of the emergence of the unmarked (Mc-

Carthy and Prince (1994)): the effects of *CODA(L) are felt in the reduplicant, but not in the language as a whole.

(15) Neutralization of glottalization in the coda of the reduplicant (Shaw (1987))

a.	tim-tám'	'to press'
b.	qan-qín'	'to chew'
c.	t^s'il-t^s'ál'	'face; pair of eyes'
d.	haw-(h)áw'	'to stop, go home'
e.	hat-hít'	'to stick'
f.	has-hát^s'	'to bite'

(16) Preconsonantal glottalization (Shaw (1987))

a.	túk^w'łinχ	'to drown, suffocate'
b.	łux^w-łú:t'x^w	'to cherish (stg/so)'
c.	łi-m'ó:l'-tk^w	'to be wrapped'
d.	t'is-t'ú:t^s'-k^w	'to be black'

The constraint against [constricted glottis] associated to a coda presented in the Korean analysis applies to Nisgha as well:

(17) *CODA([cg]) (= (7b))
[constricted glottis] is not associated to a coda.

IDENT-RB(F) prohibits featural differences between reduplicant and base:

(18) IDENT-RB(F) (McCarthy and Prince (1995, 16))
Reduplicant correspondents of a base [γF] segment are also [γF].

IDENT-IO(F) (see (8)) dominates *CODA(L): input [cg] may not be absent from the output in order to satisfy *CODA(L). *CODA(L) dominates IDENT-RB(F): base laryngeal features may be absent from the reduplicant in order to satisfy *CODA(L). The total ranking of these constraints is:

(19) Total ranking: IDENT-IO(F) » *CODA([cg]) » IDENT-RB(F)

In tableau (21), input [cg] is missing from the output base in candidates (21b) and (21c); hence, IDENT-IO(F) eliminates them both. Candidate (21a) incurs two violations of *CODA([cg]), one in the base and one in the reduplicant. Candidate (21d) has only one violation of *CODA([cg]), so it is selected as optimal, even though it also violates low-ranking IDENT-RB(F).

(20) RED-tam' → $[tim]_R$-$[tám']_B$ 'to press'

Input: RED-tam' (cg)	IDENT-IO(F)	*CODA([cg])	IDENT-RB(F)
a. tim'-tám' (cg cg)		**!	
b. tim-tám	*!		
c. tim'-tám (cg)	*!	*	*
☞ d. tiḿ-tám' (cg)		*	*

4. Summary

The vowel following a consonant is important in at least three ways to the phonetic saliency of the features of that consonant. As discussed above for Korean, voice onset is important in cuing laryngeal features. The formant transitions from a consonant to a following vowel and release burst are also important cues to consonant features (Malécot (1958), Wang (1959), Lehiste and Shockey (1972), Fujimura, Macchi, and Streeter (1978)). If no vowel follows the consonant, then voice onset and formant transition information is not available, and release burst is not salient (Henderson and Repp (1982), Repp and Lin (1989)).

If there is no vowel following a consonant, then the cues to the laryngeal features of that consonant are not salient; non-salient features are likely to be neutralized. It seems reasonable, then, to state neutralization in phonetic terms, without positing an additional layer of phonological abstraction. Steriade (1994) argues that the phonetic causes of neutralization should be stated directly: 'Why are coda stops frequently neutralized as to place? Because the relevant CV-transitions are missing. [*Not* because the onset licenses something that the coda fails to license]'.

However, neutralization is not always a purely phonetic process; sometimes it must be characterized as an abstract phonological process. Korean laryngeal neutralization is sensitive to syllable structure, which is in turn sensitive to morphological structure; Nisgha laryngeal neutralization arbitrarily occurs only in the reduplicant. The view argued for here is that the lack of saliency of a consonant that is not followed by a vowel is related to, but is not in a one-to-one relationship with, an abstract phonological constraint against features in the coda.

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