Compensatory and opaque vowel lengthening in Harmonic Serialism[1]

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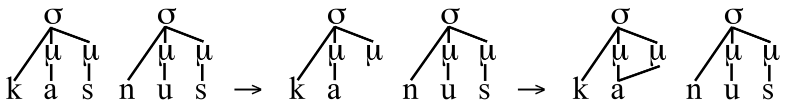
1 Introduction and overview

Classic compensatory lengthening (CL) occurs when a mora-bearing coda consonant is deleted and its mora reassociates with a preceding vowel (Ingria 1980, Steriade 1982, Hock 1986, Wetzels 1986, Hayes 1989, Kavitskaya 2002). In other words, the deleted consonant is replaced by a lengthened vowel. This phenomenon is usually referred to as CL via mora preservation. The derivation in (1) illustrates one case of classic CL in Latin.

(1) /kasnus/ → [kaːnus] 'gray' (Hayes 1989)



The derivation in (1) proceeds as follows. First coda consonants project their own mora because CVC syllables count as heavy in Latin. Then /s/ deletion applies when followed by a [+sonorant, +anterior] segment. Finally the first vowel of the word links to the mora left behind and surfaces as a lengthened vowel. A strong prediction follows from this standard analysis: classic CL is restricted to weight-sensitive languages only when coda consonants are deleted, but not onsets, which are universally weightless (Hayes 1989).[2]

If classic CL is claimed to be a process involving mora preservation, parallel Optimality Theory (POT) fails in selecting the right output forms because the conditions that make weight by position applicable are non-surface-apparent, since the coda consonant is deleted on the surface. That is, deletion of a mora-bearing coda consonant counterbleeds the application of weight by position.[3]

The main goal of this chapter is to argue on the basis of classic CL and opaque vowel lengthening (VL) in favor of Harmonic Serialism (HS), a version of OT where input-output mappings usually require a serial derivation in which harmony is incrementally achieved. I argue that HS derives classic CL and double flop (see discussion below) only if two independently motivated proposals about the gradual nature of GEN are considered together. First, that syllabification is built serially in harmonically improving steps (Jesney 2011, Pater 2012, this volume, Elfner this volume, Elsman this volume), and second that deletion of a coda consonant is a two-step process that begins with debuccalisation (McCarthy 2008b). These theoretical assumptions are also extended to account for opaque interactions between VL and word-final obstruent devoicing in Friulian, as well as a more complex opaque interaction between VL and syllable-final obstruent devoicing, vowel epenthesis, and subsequent resyllabification in Alsatian French.

The remainder of this chapter is organized as follows. It begins with showing that POT is unable to derive classic CL and double flop, which constitute particular cases of opacity by overapplication (section 2). Then it continues by presenting some theoretical background of what recent literature on HS has said about syllabification and deletion processes (section 3). An explanation of the representational system assumed, as well as its implications for the theory of GEN in HS follows (section 4). The HS analysis of classic CL and double flop is presented in section 5. This proposal is extended to cases of opaque VL in Friulian and Alsatian French in section 6. Section 7 includes a brief excursus in which HS is compared with OT with candidate-chains and Stratal OT. Section 8 concludes.

2 Classic compensatory lengthening and double flop in POT

Classic CL is an opaque process in which weight by position overapplies because the condition that makes weight by position applicable is wiped out by the process of coda deletion. In other words, there is no coda consonant in the surface representation that justifies the presence of the second mora associated with the vowel. Using a rule-based rhetoric, deletion of a mora-contributing coda consonant counterbleeds weight by position: first coda consonants project a mora, and deletion, which is the bleeding process, follows. A reverse ordering between these two processes would give the wrong result in any rule-based derivational framework.

A CL output form is harmonically bounded in POT. This is so because the violation marks incurred by the transparent candidate, with deletion but no lengthening, are a proper subset of those incurred by the CL candidate, which cannot win under any permutation of the constraint set. The tableau (2) illustrates this fact with the example from (1). Throughout this paper I use the following notational conventions for candidates: parentheses mark syllable boundaries, a subscript $<_{\mu}>$ stands for a mora linked to the preceding segment, a regular $<\mu>$ stands for a shared mora, and a superscript $<^{\mu}>$ stands for a floating mora.

(2) Classic CL in POT

/kasnus/	WBP	*s[+son, +ant]	DEP-μ	MAX-C
a. → $(ka_{\mu})(nu_{\mu}s_{\mu})$			L	1
b. ☹ $(ka_{\mu\mu})(nu_{\mu}s_{\mu})$			1	1
c. $(ka_{\mu}s_{\mu})(nu_{\mu}s_{\mu})$		1 W	L	L
d. $(ka\mu s)(nu_{\mu}s_{\mu})$	1 W	1 W	L	L

Candidates (a) and (b) are equally unmarked. They vacuously satisfy the top-ranked markedness constraint WEIGHT-BY-POSITION, which assigns one violation mark for every coda consonant that does not project a mora, because there is no coda consonant in the surface that can be evaluated. They also satisfy the phonotactic constraint *s[+sonorant, +anterior], which triggers /s/ deletion. However, although both candidates equally violate the anti-deletion faithfulness constraint MAX-C, candidate (b) incurs one violation of the faithfulness constraint against inserting moras that are not positionally licensed (see Bermúdez-Otero 2001), DEP-μ, as opposed to candidate (a).[4] The problem is that there is no top-ranked markedness constraint that compels the violation of DEP-μ in candidate (b), which is less faithful than candidate (a) without apparent motivation. The last two candidates lose because they violate one or both of the top-ranked markedness constraints.

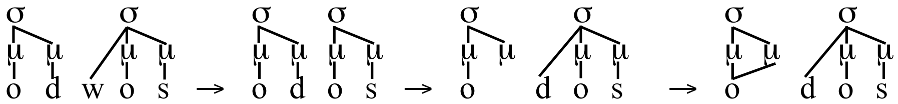
Another classic example of CL extensively discussed in the literature is double flop in Ancient Greek, where CL is triggered by deletion of a segment that is not adjacent to the lengthened vowel (Steriade 1982, Wetzels 1986, Hayes 1989). East Ionic Greek illustrates double flop. As can be seen in (3), a rule of /w/ deletion applied in this dialect. What is interesting in these data is that /w/ deletion only triggers CL if a consonant intervenes between /w/ and the lengthened vowel.

(3) /w/ deletion in East Ionic Greek (Hayes 1989)

*woikos	→	oikos	‘house’
*newos	→	neos	‘new’
*odwos	→	o:dos	‘threshold’

Steriade (1982), Wetzels (1986) and Hayes (1989) showed that this situation could be accounted for by resorting to double flop. A standard derivation of a form like /odwos/ could be as follows. First the word is syllabified as (*od*)(*wos*), where /d/ is assigned a mora because closed syllables count as heavy in Ancient Greek. Then /w/ deletion takes place giving rise to an intermediate representation (*od*)(*os*). This universally ill-formed intermediate syllabification in which a closed syllable precedes an onsetless syllable is fixed by means of resyllabification of /d/, resulting in (*o*)(*dos*) (first flop). Once /d/ has shifted from coda position to onset position, the first vowel links to the mora left behind, giving rise to CL, [(o:)(dos)] (second flop). These facts are represented in the derivation in (4).

(4) /odwos/ → [(o:)(dos)] ‘threshold’ (Hayes 1989)



The following tableau demonstrates again that POT cannot select the opaque double flopped candidate. Candidate (a), the transparent one, is selected because it satisfies DEP-μ, and harmonically bounds candidate (b), the actual output form. Candidate (c), on the one hand, loses because it violates ONSET twice. Candidate (d), on the other hand, is ruled out because it fatally violates the top-ranked markedness constraint against occurrences of /w/, *w. The constraint WEIGHT-BY-POSITION is omitted in tableau (5).

(5) Double flop in POT

/odwos/	*w	ONSET	DEP-μ	MAX-C
a. → $(o_{\mu})(do_{\mu}s_{\mu})$		1	L	1
b. ☹ $(o_{\mu\mu})(do_{\mu}s_{\mu})$		1	1	1
c. $(o_{\mu}d_{\mu})(o_{\mu}s_{\mu})$		2 W	L	1
d. $(o_{\mu}d_{\mu})(wo_{\mu}s_{\mu})$	1 W	1	L	L

In this section it has been shown that a POT analysis of classic CL and double flop as mora preservation processes fails in selecting the actual output forms, in which deletion, or resyllabification triggered by deletion, counterbleeds weight by position. Classic CL and double flop are typical cases of non-surface-apparent linguistic generalizations, which cannot be accommodated within a parallel constraint-based model.

The next section presents some theoretical background in HS with respect to syllabification and deletion processes. It will serve as the basis for further discussion.

3 Theoretical background

POT is mostly concerned with the study of CON. One of its aims is to establish the set of universal, but violable constraints in order to predict phonological patterns, which are the result of factorial typology. Given that in POT input-output mappings are accomplished at once, with intermediate representations excluded, the exact nature of the GEN component of Universal Grammar is irrelevant. Actually GEN is a blind brute force that generates an infinite set of candidates that may differ in many ways with respect to the input. Thus the only source of language variation and language typology is constraint ranking.

In HS, on the contrary, GEN plays a paramount role. It is restrained by a gradualness condition on candidate generation by which candidates only introduce one single modification with respect to the input. Defining gradualness, that is, exploring what it means to introduce a single change at a time is one of the main research interests in HS, a theory which has already been proved to be adequate both in the study of language typology and phonological opacity.[5]

This paper aims to contribute to the study of opacity in HS in the light of classic CL and double flop. When facing the problems posed by classic CL and double flop, two main questions arise within the context of HS: how is syllable structure built by GEN; what is the exact nature of deletion operations? The next subsections briefly explore these questions.

3.1. Syllabification in HS

Two different conceptions are plausible in HS with respect to syllabification. In one of them, rooted in a faithfulness-based definition of gradualness, syllable-building operations are not subject to the gradualness requirement on GEN because a single modification is defined in terms of a single violation of a basic faithfulness constraint (McCarthy 2007a). Given that syllabification is never contrastive in tautomorphemic sequences in a given language, faithfulness constraints protecting syllabification must be excluded from CON (but see Elfner 2006 for arguments in favor of contrastive syllabification). It follows from this that syllabification can be accomplished simultaneously with another single operation without violating gradualness (McCarthy 2008a, 2010, Elfner this volume, Pruitt 2010). As opposed to syllabification, stress assignment does count as a single modification because it can be contrastive. Metrical foot building is thus an unfaithful operation that violates a constraint like IDENT(stress) (McCarthy 2008a) or DEP-PROMINENCE (Elfner this volume).

The other approach to syllabification departs from an operation-based definition of gradualness, in which all prosody-building operations, including syllabification, count as autonomous operations (Jesney 2011, Pater 2012, this volume, Elfner this volume, Elsman this volume). I will call this the operation-based definition of gradualness. Under this view, syllabification cannot coexist with other phonological operations within the same candidate set. I will not discuss whether syllables are built one at a time or whole syllabification is reached in a separate single step because both alternatives make no distinction with respect to classic CL or double flop, although I will make use of Elfner's (this volume) serial syllabification operations to be consistent with previous work. McCarthy (2008a) also discusses this issue and concludes in favor of a model of serial syllabification in which syllables are built one at a time. This topic connects with the 'multiple application problem', which was a controversial issue in the context of rule-based generative phonology in the early 1970's: are phonological rules applied at once at different loci if the structural description is met or do they apply iteratively at different derivational stages?

In this chapter I will argue in favor of the operation-based definition of gradualness, according to which syllabification is subject to the gradualness requirement on GEN.

3.2. Deletion in HS

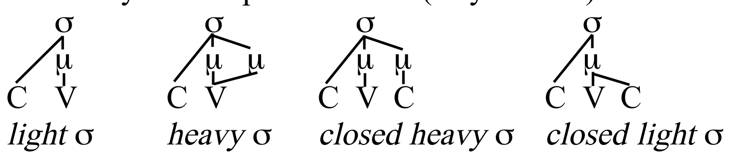
In McCarthy (2008b) a serial theory of consonantal cluster reduction in HS is proposed. Processes of deletion and place assimilation are split into two serially ordered single-step processes. In deletion, the first step is debuccalisation (*i.e.*, deletion of oral place features), which introduces a MAX(place) violation, followed by deletion of the root node, which correlates with a MAX-C violation. In place assimilation, the first step is also debuccalisation, and the second one, insertion of a new association line between the placeless root node and the place feature autosegment associated with the onset consonant, which constitutes a violation of NO-LINK(place). The markedness constraint that triggers debuccalisation is CODA-CONDITION, which prohibits place features from being associated with segments that are parsed in coda position. In a NO-LINK(place)-violating representation, CODA-CONDITION is satisfied because the place feature associated with the coda consonant, which is also associated with the onset, becomes licensed. The main argument in favor of splitting deletion and place assimilation into two separate autosegmental processes comes from the coda/onset asymmetry. The coda/onset asymmetry refers to the fact that codas, but not onsets, are generally affected by deletion and place assimilation processes. A HS derivation of the mapping /patka/ → [pa.ka] is thus as follows: /patka/ → *paH.ka* → [pa.ka], where capital *H* represents a debuccalised, placeless stop consonant. This derivation is gradual and harmonically improving when evaluated by a constraint hierarchy in which CODA-CONDITION dominates HAVE-PLACE and MAX(place), and HAVE-PLACE dominates MAX-C. However, a derivation that results in onset deletion like **/patka/ → *pat.Ha* → [pa.ta] (where ** marks a non-harmonically improving derivation), is harmonically bounded at the first step of the derivation, where it gets stuck. Debuccalisation of the second consonant in *pat.Ha* is not a harmonically improving step under any permutation of the constraint set because *pat.Ha* incurs a superset of the violations incurred by the fully faithful parse of the input *pat.ka*. Both *pat.Ha* and *pat.ka* violate CODA-CONDITION, because there is a coda consonant associated with its own place features, but *pat.Ha* adds violations of HAVE-PLACE and MAX(place). POT, on the contrary, cannot predict the coda/onset asymmetry because both [pa.ka] and [pa.ta] tie under the same assumptions of CON.

4 Representations and GEN operations

4.1. Representational assumptions

I follow Hayes' (1989) moraic theory of syllable structure. Vowels project one mora; onsets are exclusively dominated by the syllable node; long vowels are linked to two moras; and coda consonants are linked to their own mora in languages where closed syllables count as heavy, or share the mora associated with the vowel in languages where closed syllables count as light.[6]

(6) Moraic syllabic representations (Hayes 1989)



With respect to weight sensitivity, in languages where closed syllables count as heavy, the markedness constraint WEIGHT-BY-POSITION dominates the faithfulness constraint against moras that exclusively dominate consonants, *μ/C (Broselow et al. 1997). In languages where closed syllables count as light, the reverse ranking, where *μ/C dominates WEIGHT-BY-POSITION, is observed.

4.2. Syllable-building operations

In Elfner (2009) a serial theory of syllabification in HS is proposed, based on a set of three basic syllable formation operations, listed in (7).

(7) Syllable formation operations (Elfner 2009)

(i) Project syllable: from a segment *x*, create a syllable (x), where *x* can be either moraic, (x_μ), or not, (x).

(ii) Adjunction: given a syllable (x_μ) or (x), adjoin a segment *y*, where *y* can be moraic or not, to the right (coda adjunction) or to the left (onset adjunction).

(iii) Core syllabification: from segments *x* and *y*, create a binary syllable (xy_μ), where *x* is the dependent and *y* the moraic head.

Another operation that will be relevant to this analysis is resyllabification. I assume that this operation is accomplished at once as a separate step (*i.e.*, as a delinking-cum-association single-step process), and is not correlated with any violation of a faithfulness constraint (see McCarthy 2008a for arguments in favor of considering resyllabification an operation that co-occurs with syncope).

With respect to epenthesis, I also follow Elfner (2009) in that vowel epenthesis is an operation triggered by the satisfaction of a markedness constraint against moraless syllables, SYLLABLE-HEAD. First an unsyllabifiable consonant projects its own degenerate syllable, because PARSE-SEGMENT dominates SYLLABLE-HEAD. Then a moraic vowel is inserted in order to fix that minor syllable because SYLLABLE-HEAD dominates DEP-V.[7]

5 Classic compensatory lengthening and double flop in HS

Tableaux (8-12) illustrate that a harmonically improving derivation towards classic CL is possible if syllabification is gradual and deletion counts as a two-step process.

At the first step of the derivation, the candidate in which a core syllable has been projected, (CV_μ)C, is selected as the most harmonic candidate because this is the only operation that maximally satisfies PARSE-SEGMENT.

(8) Step 1: core syllabification

/CVC/	PARSE-SEG	MAX(place)	HAVE-PLACE
a. → (CV_μ)C	1		
b. C(V_μ)C	2 W		
c. CVC	3 W		
d. CVH	3 W	1 W	1 W

At the second step, candidate (a) in tableau (9) satisfies PARSE-SEGMENT because of the adjunction of the last consonant to the already existing syllable, ($CV_\mu C_\mu$).[8] At this step, the transparent candidate with complete deletion is not a possible GEN-generated candidate because deletion is a two-step process. Opacity is then the result. The constraint PARSE-SEGMENT can also be satisfied by inserting a mora link between the last consonant and the mora headed by the vowel, as candidate (b) illustrates, but this possibility is ruled out because of the activity of WEIGHT-BY-POSITION. The fully faithful candidate (c), and candidate (d), which shows debuccalisation, are ruled out because they fatally violate the top-ranked constraint PARSE-SEGMENT.

(9) Step 2: coda adjunction

/$(\text{CV}_\mu)\text{C}$/	Parse-Seg	WbP	μ/C	Coda-Cond	Max (place)	Have-Place
a. → $(\text{CV}_\mu\text{C}_\mu)$			1	1		
b. $(\text{CV}\mu\text{C})$		1 W	L	1		
c. $(\text{CV}_\mu)\text{C}$	1 W		L	L		
d. $(\text{CV}_\mu)\text{H}$	1 W		L	L	1 W	1 W

It is at the third step of the derivation when debuccalisation applies, $(\text{CV}_\mu\text{H}_\mu)$. Candidate (a) is more harmonic than candidate (b) in tableau (10) because it satisfies Coda-Condition by deleting the place features associated with the coda consonant.

(10) Step 3: debuccalisation

/$(\text{CV}_\mu\text{C}_\mu)$/	Coda-Cond	Max(place)	Have-Place
a. → $(\text{CV}_\mu\text{H}_\mu)$		1	1
b. $(\text{CV}_\mu\text{C}_\mu)$	1 W	L	L

At step 4, deletion of the root node takes place because Have-Place dominates Max-C and a markedness constraint against moras that are not linked to any segment, *Floatingμ. (Recall that superscript $<^\mu>$ represents a floating mora.)

(11) Step 4: deletion

/$(\text{CV}_\mu\text{H}_\mu)$/	Have-Place	Max-C	*Floatingμ
a. → $(\text{CV}_\mu{}^\mu)$		1	1
b. $(\text{CV}_\mu\text{H}_\mu)$	1 W	L	L

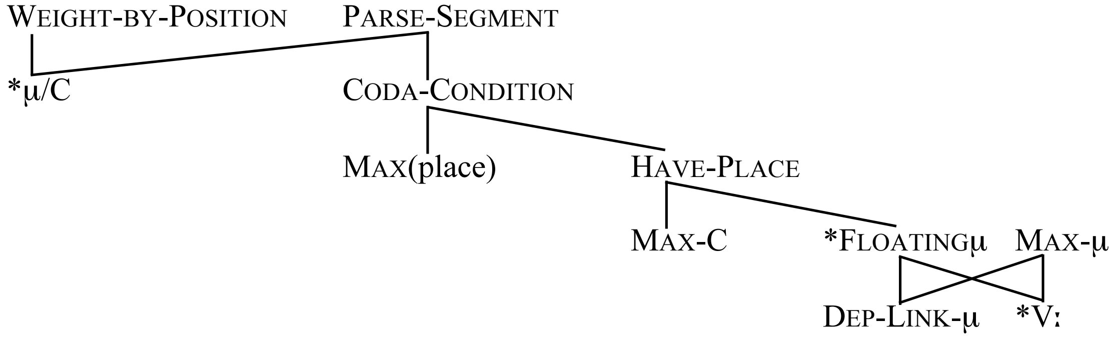
At the fifth step of the derivation, two operations are at play. Deletion of the floating mora is excluded because of the higher ranked position of Max-μ. Inserting a mora link is the most harmonic operation because *Floatingμ is satisfied, and only low-ranked Dep-Link-μ is violated. This is why candidate (a) in (12) emerges as the optimal candidate. Convergence is reached at the next step of the derivation, omitted here, where Max-μ and *Floatingμ also dominate the markedness constraint against long vowels, *V:.

(12) Step 5: lengthening

/$(\text{CV}_\mu{}^\mu)$/	Max-μ	*Floatingμ	Dep-Link-μ	*V:
a. → $(\text{CV}_{\mu\mu})$			1	1
b. $(\text{CV}_\mu{}^\mu)$		1 W	L	L
c. (CV_μ)	1 W		L	L

The ranking arguments that derive classic CL in HS if syllabification is gradual and deletion counts as a two-step process appear as a Hasse diagram in (13).

(13) Hasse diagram for classic CL



With respect to double flop, a HS derivation for the East Ionic Greek form /odwos/ would be as follows: /odwos/ → … → $(o_{\mu}d_{\mu})(wo_{\mu}s_{\mu})$ → $(o_{\mu}d_{\mu})(o_{\mu}s_{\mu})$ → $(o_{\mu}{}^{\mu})(do_{\mu}s_{\mu})$ → $(o_{\mu\mu})(do_{\mu}s_{\mu})$. Here I treat deletion as a one-step process for the sake of clarity. Notice that in double flop serial syllabification is enough to capture the CL facts. Once PARSE-SEGMENT is satisfied, the word is syllabified as $(o_{\mu}d_{\mu})(wo_{\mu}s_{\mu})$, given that a rising intersyllabic contact is preferable to a complex onset. This syllabification pattern could be derived from a ranking in which *COMPLEX-ONSET outranks CONTACT. At that stage of the derivation the coda consonant /d/ has projected its own mora because of the top-ranked constraint WEIGHT-BY-POSITION. Later on /w/ deletion applies, yielding $(o_{\mu}d_{\mu})(o_{\mu}s_{\mu})$, because the markedness constraint *w outranks MAX-C. When /w/ deletion has applied, ONSET can be minimally satisfied if the coda consonant /d/ is resyllabified, $(o_{\mu}{}^{\mu})(do_{\mu}s_{\mu})$. This operation leaves a floating mora that will be reassociated with the first vowel, $(o_{\mu\mu})(do_{\mu}s_{\mu})$.

If syllabification coexisted with the candidate showing deletion and deletion was considered a single step process, the wrong result would be predicted. In this hypothetical scenario, the first generated set of candidates would contain the transparent candidate $(o_{\mu})(do_{\mu}s_{\mu})$, with /w/ deletion and unmarked syllabification. This candidate vacuously satisfies the top-ranked constraint WEIGHT-BY-POSITION and minimally violates ONSET and DEP-μ. For this reason it harmonically bounds the desired candidate in which /d/ is syllabified in coda position and has projected a mora, $(o_{\mu}d_{\mu})(o_{\mu}s_{\mu})$, as can be seen in (14).

(14) Step 1: syllabification not subject to gradualness

/odwos/	WBP	ONSET
a. → $(o_{\mu})(do_{\mu}s_{\mu})$		L 1
b. ☹ $(o_{\mu}d_{\mu})(o_{\mu}s_{\mu})$		2

Following the rationale of McCarthy (2007b), I have demonstrated that this particular case of counterbleeding opacity can be accounted for in HS if GEN operations are able to be decomposable into more primitive operations. To deal with CL and double flop, satisfying at once both of the top-ranked markedness constraints involved in the opaque interaction, WEIGHT-BY-POSITION and CODA-CONDITION, must be blocked. The theory of gradual syllabification and deletion as a two-step process confer on HS a myopic nature. In this analysis, HS cannot 'look ahead' to the global minimum of harmonic improvement, which would correspond to the transparent candidate. By allowing the satisfaction of WEIGHT-BY-POSITION to happen first, opacity is evaded. If deletion must be preceded by debuccalisation, then complete deletion is not a possible generated candidate at the derivational step where only WEIGHT-BY-POSITION can be satisfied. The strategy of simulating ordering relations with constraint ranking by looking closely at the nature of GEN is the strategy to follow in order to accommodate counterbleeding opacity in HS.[9]

In the next section, I will also argue that opaque VL in Friulian and Alsatian French can only be accommodated in HS if syllabification is gradual, meaning that it is able to precede final obstruent devoicing.

6 Opaque VL in Friulian and Alsatian French

An HS analysis of opaque VL in two romance varieties, Friulian[10] and Alsatian French[11], is presented in this section. As opposed to classic CL, in these two languages VL is not triggered by deletion of a mora-bearing coda consonant and subsequent association of the vowel with the mora left behind, but by a process of VL that applies before underlying voiced obstruents in coda position are devoiced.

6.1. Friulian

Friulian presents a fully productive synchronic alternation between long and short vowels in some morphologically related words (Hualde 1990).[12] As can be seen in (15), when a stressed vowel precedes an underlying voiced obstruent that surfaces in word-final coda position as a voiceless obstruent due to word-final obstruent devoicing, the vowel is lengthened. However, in the presence of a vowel-initial inflectional or derivational suffix, the vowel remains short and the obstruent faithfully surfaces as voiced. When post-vocalic obstruents are underlyingly voiceless, as can be seen in (16), vowels do not undergo lengthening.

(15) Vowel length alternations in Friulian (Hualde 1990)

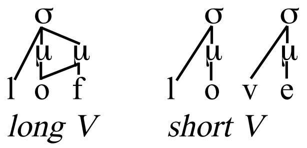
[ˈloːf]	‘wolf.masc’	[ˈlo.ve]	‘wolf.fem’
[ˈfreːt]	‘cold.masc’	[ˈfre.de]	‘cold.fem’
[saˈvuːt]	‘known.masc’	[sa.ˈvu.de]	‘known.fem’
[fiˈniːt]	‘finished.masc’	[fi.ˈni.de]	‘finished.fem’
[ˈnaːf]	‘ship’	[na.vi.ˈgaː][13]	‘to navigate’
[faˈmoːs]	‘famous.masc’	[fa.ˈmo.ze]	‘famous.fem’
[ˈlaːk]	‘lake’	[la.ˈgu.ne]	‘lagoon’

(16) Non-alternating forms in Friulian (Hualde 1990)

[ˈskrit]	‘written.masc’	[ˈskri.te]	‘written.fem’
[ˈfat]	‘made.masc’	[ˈfa.te]	‘made.fem’
[ˈmat]	‘crazy.masc’	[ˈma.te]	‘crazy.fem’
[ˈpak]	‘package’	[pa.ˈkut]	‘package.dim’
[ˈklap]	‘stone’	[kla.pa.ˈdaː]	‘to stone’

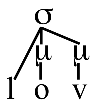
I interpret VL in Friulian as a sonority-related mora-sharing process (see Zec 2003, Montreuil 2010 for the same process in Lorraine French, Iosad 2012 for a POT analysis of Friulian based on a substance-free phonology approach). In (17) the output moraic representations of the pair [ˈloːf] ~ [ˈlo.ve] are illustrated. VL is represented as a mora-sharing configuration, where the vowel is doubly linked to its own mora and to the extra mora associated with the coda consonant. When the root-final voiced consonant is syllabified in onset position due to the presence of a vowel-initial inflectional or derivational suffix, the vowel is not lengthened because onsets do not contribute to syllabic weight.

(17) Surface representation of the pair [ˈloːf] ~ [ˈlo.ve]



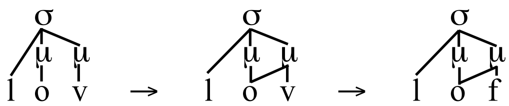
I propose that VL is triggered by the satisfaction of Weight-by-Position and the markedness constraint *μHead/Obstruent$_{[+\text{voice}]}$, a more specific version of *μ/C, which militates against voiced obstruents that are mora heads. The representation in (18) violates *μHead/Obstruent$_{[+\text{voice}]}$, although it satisfies Weight-by-Position.

(18) *μHead/Obstruent$_{[+\text{voice}]}$-violating representation



In (19) I show the derivation of the mapping /lov/ → [loːf], which is discussed below.

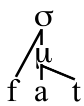
(19) Derivation of the mapping /lov/ → [loːf]



In the first representation in (19), Weight-by-Position is satisfied, resulting in a *μHead/Obstruent$_{[+\text{voice}]}$-violating configuration, meaning that the former constraint dominates the latter. Then *μHead/Obstruent$_{[+\text{voice}]}$ is satisfied by means of adding a link between the vowel and the mora already associated with the voiced obstruent, meaning that *μHead/Obstruent$_{[+\text{voice}]}$ dominates Dep-Link-μ. Finally the voiced consonant undergoes word-final obstruent devoicing. The last representation in (19) does not violate the constraint *μHead/Obstruent$_{[-\text{voice}]}$, the counterpart constraint of *μHead/Obstruent$_{[+\text{voice}]}$, because the mora linked to the consonant is licensed by being also linked to the vowel. The second representation in (19) does not violate *μHead/Obstruent$_{[+\text{voice}]}$ for the same reason.

Following Hualde (1990), I assume that voiceless obstruents are not weight contributing. I therefore interpret the lack of VL in the left column in (16) as the result of the constraint ranking *μHead/Obstruent$_{[-\text{voice}]}$ » Weight-by-Position. A weightless voiceless coda is thus represented as in (20). Lengthening is then blocked in inputs like /fat/ because there is only one mora to start with.

(20) Weightless coda



The most interesting aspect of the data presented so far is that VL, as triggered by the presence of an underlying voiced coda consonant, becomes a non-surface-apparent generalization due to word-final obstruent devoicing. The data in the left column in (15) exemplify cases of overapplication of VL because at the surface there is no voiced coda consonant, which is the triggering environment for VL, due to the interaction of word-final obstruent devoicing. Word-final obstruent devoicing thus counterbleeds VL. I will argue below that these facts can only be accounted for in HS if gradual syllabification is assumed.

In order to derive VL before underlying voiced coda consonants in POT, the constraint Weight-by-Position should dominate Dep-Link-μ, as can be seen in tableau (21). (Recall that a regular <μ> represents a doubly linked mora).

(21) VL in POT

/lov/	WbP	Dep-Link-μ
a. → (lo$_{\mu}$μf)		1
b. (loμf)	1 W	L

However, as can be seen in tableau (22), a reverse ordering between Weight-by-Position and Dep-Link-μ would be needed in order to account for the absence of VL when the coda consonant is voiceless in the underlying representation. This ranking paradox is a strong argument against a POT analysis of opaque VL in Friulian.

(22) VL in POT (ranking paradox)

/fat/	WbP	Dep-Link-μ
a. → (fa$_{\mu}$μt)	L	1 W
b. ☹ (faμt)	1	

As opposed to POT, HS with gradual syllabification can account for the vowel length alternations in (15) and the lack of VL in (16) with the same ranking.

(23) Partial ranking for Friulian
*μHead/Obstruent$_{[-\text{voice}]}$ » Weight-by-Position » *μHead/Obstruent$_{[+\text{voice}]}$ » Dep-Link-μ

To begin the analysis, let's first take the input /lov/. Core syllabification is the most harmonic candidate at step 1, as shown in all previous examples. At the second step of the derivation, the voiced consonant following the vowel is adjoined to the existing syllable as a mora-bearing coda, as candidate (a) in tableau (24) shows. The selection of candidate (a) instead of candidate (b) derives from a crucial ranking, in which Weight-by-Position outranks *μHead/Obstruent$_{[+\text{voice}]}$. Candidate (c) fatally violates the top-ranked constraint Parse-Segment.

(24) Step 2: coda adjunction

/(lo$_{\mu}$)v/	Parse-Seg	WbP	*μHead/Obs$_{[+\text{voice}]}$	*VcdObs/Coda
a. → (lo$_{\mu}$v$_{\mu}$)			1	1
b. (loμv)		1 W	L	1
c. (lo$_{\mu}$)v	1 W		L	L

In a theory of HS in which syllabification coexists with word-final obstruent devoicing, the first set of candidates of /lov/ includes a candidate (loμf), preventing /lov/ from mapping to an intermediate form (lo$_{\mu}$v$_{\mu}$) in which the underlying voiced obstruent projects its own mora, which is the source of VL. Parallel syllabification must therefore be discarded.

At the third step of the derivation, lengthening takes place. Candidate (b) is eliminated because it violates *μHead/Obstruent$_{[+\text{voice}]}$. Candidate (c), with devoicing, fatally violates the top-ranked constraint *μHead/Obstruent$_{[-\text{voice}]}$, which must dominate Weight-by-Position, and thus dominates *μHead/Obstruent$_{[+\text{voice}]}$ by transitivity. Candidate (a) is the optimal candidate, in which the vowel links to the second mora, because it satisfies *μHead/Obstruent$_{[+\text{voice}]}$ at the expense of violating the low-ranked constraint Dep-Link-μ.

(25) Step 3: lengthening

/(lo$_\mu$v$_\mu$)/	*μHead/Obs$_{[-\text{voice}]}$	*μHead/Obs$_{[+\text{voice}]}$	Dep-Link-μ	*VcdObs/Coda
a. → (lo$_\mu$μv)			1	1
b. (lo$_\mu$v$_\mu$)		1 W	L	1
c. (lo$_\mu$f$_\mu$)	1 W		L	L

Devoicing applies at the next step of the derivation, omitted here. The positional markedness constraint *VoicedObstruent/Coda (Prince and Smolensky 1993/2004) dominating Ident(voice) is responsible for that. Notice that when devoicing has the chance to apply after lengthening, the top-ranked markedness constraint *μHead/Obstruent$_{[-\text{voice}]}$ is vacuously satisfied because the mora linked to the voiceless obstruent is also linked to the vowel.[14]

Let's take now the input /fat/. After applying core syllabification at step 1, the underlying voiceless obstruent adjoins to the previously built syllable as a weightless coda at step 2 because of the ranking *μHead/Obstruent$_{[-\text{voice}]}$ » Weight-by-Position, as can be seen in (26).

(26) Step 2: coda adjunction

/(fa$_\mu$)t/	*μHead/Obs$_{[-\text{voice}]}$	WbP
a. → (faμt)		1
b. (fa$_\mu$t$_\mu$)	1 W	L

At the next step of the derivation lengthening has no chance to apply and the derivation gets stuck because no harmonic improvement is possible.

The ranking arguments that derive opaque VL in Friulian appear as a Hasse diagram in (27).

(27) Hasse diagram for Friulian

*μHead/Obs$_{[-\text{voice}]}$ Parse-Segment

Weight-by-Position *VcdObs/Coda

*μHead/Obs$_{[+\text{voice}]}$ Ident(voice)

Dep-Link-μ *VoicedObstruent

In this subsection it has been demonstrated that overapplication of VL in Friulian is straightforwardly accounted for in HS because syllabification, VL (*i.e.*, link insertion) and word-final obstruent devoicing must apply at different derivational steps given gradualness.

6.2. Alsatian French

In Alsatian French, root-final stop plus lateral sequences, which show a rising sonority profile, are repaired by means of word-medial schwa epenthesis: /sikl/ → [ˈsi.kəl] 'cycle'; /kupl/ → [ˈku.pəl] 'couple' (Montreuil 2010). The interesting data come from root-final /bl/

clusters. I assume that in Alsatian French, as in Friulian, the source of vowel length is the mora projected by a voiced coda consonant.

Syllable-final obstruent devoicing applies in Alsatian French, giving rise to the opaque mapping /tabl/ → [(ˈtaː)(pəl)] ‘table’, where syllable-final obstruent devoicing counterbleeds VL. As Montreuil (2010) points out, epenthesis also needs to follow devoicing. If epenthesis were to precede devoicing, there would be no reason to devoice the obstruent since the stop would be syllabified in onset position, and devoicing only applies in coda position, yielding transparent *[(ˈta)(bəl)]. This double counterbleeding ordering relation between VL and devoicing, on the one hand, and devoicing and epenthesis, on the other hand, is exemplified in (28).

(28) Rule-based derivation (Montreuil 2010)

input:	/tabl/
vowel lengthening	(taːb)l
counterbleeds	
devoicing	(taːp)l
counterbleeds	
epenthesis	(taːp)(əl)
feeds	
resyllabification	[(ˈtaː)(pəl)]

The same ranking that has been proposed for opaque VL in Friulian also applies in Alsatian French. However, some additional constraints must be included in order to account for schwa epenthesis (see 4.2). PARSE-SEGMENT must dominate SYLLABLE-HEAD in order for GEN to build a degenerate, moraless syllable, and SYLLABLE-HEAD must outrank DEP-V because the minor syllable is fixed by means of schwa epenthesis.

The HS derivation of the input /tabl/ is then as follows: /tabl/ → (ta$_{\mu}$)bl → (ta$_{\mu}$b$_{\mu}$)l → (ta$_{\mu}$b$_{\mu}$)(l) → (ta$_{\mu}$μb)(l) → (ta$_{\mu}$μp)(l) → (ta$_{\mu}$μp)(ə$_{\mu}$l$_{\mu}$) → (ta$_{\mu\mu}$)(pə$_{\mu}$l$_{\mu}$). The harmonic improvement tableau in (29) illustrates this derivation by showing the winning candidates at each derivational step. For the sake of clarity, only the constraints that are violated by the winning candidates are included in (29).

(29) Harmonic improvement tableau for Alsatian French

/tabl/	PARSE-SEG	SYLL-HEAD	*μHEAD/OBS$_{[+voice]}$	DEP-V	ONSET	*VCDOBS/CODA]$_\sigma$	DEP-LINK-μ	ID (vc)	*VCDOBS
Step 1 (ta$_{\mu}$)bl	2!								1
Step 2 (ta$_{\mu}$b$_{\mu}$)l	1!		1			1			1
Step 3 (ta$_{\mu}$b$_{\mu}$)(l)		1	1(!)			1(!)			1
Step 4 (ta$_{\mu}$μb)(l)		1				1!	1		1
Step 5 (ta$_{\mu}$μp)(l)		1!						1	
Step 6 (ta$_{\mu}$μp)(ə$_{\mu}$l$_{\mu}$)				1(!)	1(!)				
Step 7 (ta$_{\mu\mu}$)(pə$_{\mu}$l$_{\mu}$)									
Step 8 (ta$_{\mu\mu}$)(pə$_{\mu}$l$_{\mu}$)									

At the first step of the derivation, core syllabification applies. This is the most harmonic operation because the winning candidate minimally violates the top-ranked constraint PARSE-SEGMENT. Then /b/ is adjoined to the previously existing syllable as a weighted coda, and the top-ranked constraint WEIGHT-BY-POSITION is satisfied, not included in (29). At the third step, /l/ must be parsed as a degenerate, moraless syllable because PARSE-SEGMENT dominates SYLLABLE-HEAD. The markedness constraint against mora-bearing voiced coda consonants *μHEAD/OBS$_{[+voice]}$ is then satisfied by means of inserting a mora link between the vowel and the mora headed by the voiced coda consonant. At the next step, syllable-final obstruent devoicing applies because the positional markedness constraint *VOICEDOBSTRUENT/CODA]$_\sigma$ dominates IDENT(voice). At the next step SYLLABLE-HEAD is satisfied by means of word-medial schwa epenthesis. At the seventh step resyllabification applies and ONSET is satisfied. Finally the derivation converges and the actual opaque output [(ta$_{\mu\mu}$)(pə$_{\mu}$l)], with lengthening, devoicing, and schwa epenthesis, is obtained.

7 Derivational constrained-based alternatives

Apart from HS, other derivational versions of OT could in principle accommodate classic CL and opaque VL, namely OT with candidate-chains (OT-CC, McCarthy 2007) and Stratal OT (Kiparsky 2000, Bermúdez-Otero in preparation).

On the one hand, opaque VL in Lorraine French, which mirrors the Friulian data discussed here, and opaque VL in Alsatian French have been analyzed in OT-CC in Montreuil (2010). Classic CL has also been analyzed in OT-CC in Shaw (2009).[15] On the other hand, in Kiparsky (2010) a Stratal OT account of non-classic compensatory lengthening in Finnish and Samothraki Greek is presented, in which the trigger of VL is not the loss of a coda consonant. It is not the purpose of this paper to review all these proposals, but to show very briefly that classic CL and the type of opaque VL discussed so far find a more simple treatment in HS.

OT-CC needs PRECEDENCE constraints to deal with opacity. This type of metaconstraint forces a particular ordering among faithfulness violations between two consecutive members of a candidate chain. In Montreuil's (2010) OT-CC analysis of Lorraine and Alsatian French, PRECEDENCE constraints forcing lengthening to apply before devoicing and devoicing before schwa epenthesis are needed. One could argue against PRECEDENCE constraints based on its *ad hoc* character. Why should a PRECEDENCE constraint state that an A faithfulness violation must precede a B faithfulness violation and not the other way around? In other words, one should be skeptical about their stipulative character, the same way extrinsic rule ordering was seen as an undesirable artifact in rule-based phonology.

Regarding Stratal OT, classic CL could be easily accounted for because, although EVAL applies in parallel, ranking permutation is allowed at each morphological stratum. In order to derive classic CL, MAX must outrank NO-CODA at the stem-level phonology in order to select the candidate in which weight by position has applied. At the word-level phonology, the reverse ranking is needed, in which NO-CODA dominates MAX. The main problem with this kind of analysis is that, in many cases, no morphology at all is involved in classic CL or in the case of opaque VL in Alsatian French, in which lengthening applies in monomorphemic words.

In HS neither PRECEDENCE constraints nor ranking permutation are needed. Classic CL, double flop and opaque VL are just a natural consequence of the intrinsic derivational nature of the theory imposed by the gradualness requirement on GEN.

8 Conclusions

Classic CL challenges POT because the conditions that make weight by position applicable are non-surface-apparent; deletion of a mora-bearing coda consonant counterbleeds the application of weight by position. In this chapter I have argued in favor of HS, a version of OT in which input-output mappings usually require a serial derivation in which harmony is incrementally achieved. It has been shown that HS derives classic CL and double flop only if two independently motivated proposals about the gradual nature of GEN are considered together. Namely, that syllabification is built serially in harmonically improving steps (Jesney 2011, Pater 2012, this volume, Elfner this volume, Elsman this volume) and that deletion of a coda consonant is a two-step process that begins with debuccalisation (McCarthy 2008b). These theoretical assumptions have also been extended to account for opaque interactions between VL and final obstruent devoicing in Friulian and Alsatian French, which also require syllable formation operations to apply before final devoicing and schwa epenthesis.

The contribution of this paper has been twofold. From an empirical point of view, it has been demonstrated that HS is able to accommodate particular cases of counterbleeding opacity in which syllabification is involved. From an internal theoretical perspective, the proposed analyses have given additional support to two hypotheses about the gradual nature of GEN that have been proposed in recent literature on HS for independent reasons: serial syllabification and deletion as a two-step process.

Notes

[1] This research has been supported by a Rubicon postdoctoral fellowship (446-11-022) from the Netherlands Organization for Scientific Research. I am grateful to Joan Mascaró, John J. McCarthy, Joe Pater and one anonymous reviewer for helpful comments.

[2] See Topintzi (2006) for cases of CL triggered by onset deletion.

[3] In Sprouse (1997) the opacity problem is avoided because inputs are enriched with prosodic information. Other alternatives, which do not go beyond the basic assumptions of POT, are found in Hermans (2001) and Topintzi (2006), in which classic CL is argued to be

a non-mora preservation process. Campos-Astorkiza (2011) also argues against a mora-preservation approach to CL based on perceptual similarity.

[4] Bermúdez-Otero's (2001) revised formulation of DEP-μ avoids penalizing weight by position and coda adjunction, which, as opposed to vowel lengthening or gemination, are basic syllabification operations. According to Bermúdez-Otero (2001), "a non-syllabic segment α is positionally μ-licensed by a mora μ if, and only if, (a) α does not have an input correspondent linked to a mora, and (b) α is immediately dominated only by μ." Bermúdez-Otero (2001):7. See also Campos-Astorkiza (2004) for a discussion of the proper formulation of DEP-μ.

[5] Given the same assumptions about CON, the typological predictions of HS have been shown to be more restrictive than those derived from POT (McCarthy 2007b, 2008a, b, 2010, 2011, Pruitt 2010, Jesney 2011, Kimper 2011, Elfner this volume). This restrictiveness is a natural consequence of gradualness, which confers to HS the property of local optimality or the impossibility to 'look ahead' towards global optimality. If a mapping /A/ → [C] requires an intermediate form *B* in HS given gradualness, but there is no plausible universal constraint in CON favoring *B* over /A/, or there is one but the necessary ranking to get *B* from /A/ contradicts known constraint rankings in a given language, then [C] is not a possible output derived from /A/, even though [C] is globally more harmonic than /A/. This is different in POT, where the relative harmony between *B* and /A/ or [C] does not matter and the mapping /A/ → [C] can be obtained just if [C] is more harmonic than /A/. Under these circumstances, when the mapping /A/ → [C] is unattested, the explanatory power of HS is superior to that of POT (McCarthy 2010).

[6] See Rosenthall and van der Hulst (1999) for a different approach to weightless coda cosonants, according to which they adjoin directly to the syllable node.

[7] See also Moore-Cantwell (this volume) for a theory of epenthesis in HS that solves a too-many-solutions problem in POT.

[8] One anonymous reviewer points out that this analysis assumes that mora insertion is a free operation that accompanies consonant adjunction and asks whether the analysis predicts moras to be inserted at any point in the derivation, regardless of what other changes are being performed at that point. The answer is no. One specific reason for assuming that mora insertion comes for free only when core syllables are projected or consonants are adjoined to already existing syllables is the fact that these operations are basic syllabification operations that do not violate DEP-μ, according to Bermúdez-Otero's (2001) reformulation of this faithfulness constraint based on positional licensing. The same anonymous reviewer points out the asymmetry I assume between consonant deletion as a two-step process and vowel insertion as a single-step process. I agree the insertion of a segment could also be the result of two operations: first insertion of a root node and then insertion of subsegmental features. This paper, however, assumes vowel insertion to be accomplished at a single step because this issue is tangential to the cases of opacity addressed here. Moreover, although insertion of a vowel requires one violation of DEP-V, it does not constitute a violation of DEP-μ because the inserted mora is positionally-licensed, *i.e.*, headed by the syllable nucleus.

[9] Counterfeeding opacity, on the contrary, seems harder to account for in HS (McCarthy 2000).

[10] Friulian belongs to the Rhaeto-Romance subfamily of Romance languages and is spoken in the Friuli region of northeastern Italy.

[11] Alsatian French must not be confused with Alsatian, a Low Alemannic German dialect spoken also in Alsace, a region of northeastern France.

[12] Long vowels in Friulian are not only the result of a predictable VL process. Long vowels are also phonemic. See Prieto (1992) for a diachronic study of the origin of underlying long vowels in Friulian.

[13] The source of world-final long vowels in infinitives is the diachronic loss of the infinitive morph /r/, which triggered classic CL. This specific case of classic CL in infinitive forms is synchronically opaque (*i.e.*, it became lexicalized) because /r/ does not surface under any circumstance in Modern Friulian (Paolo Roseano p.c.).

[14] One anonymous reviewer suggests an alternative analysis in which VL is interpreted not as a mora-sharing process triggered by the satisfaction of *μHEAD/OBSTRUENT$_{[+\text{voice}]}$, but instead by a process of delinking, after word-final obstruent devoicing, of the mora associated to the devoiced obstruent as a way to satisfy *μHEAD/OBSTRUENT$_{[-\text{voice}]}$, which dominates WEIGHT-BY-POSITION and MAX-LINK-μ. This delinking operation leaves the mora afloat, which reassociates with the preceding vowel in order to satisfy *FLOATINGμ. The HS derivation would be as follows: $(\text{lo}_{\mu})\text{v} \rightarrow (\text{lo}_{\mu}\text{v}_{\mu}) \rightarrow (\text{lo}_{\mu}\text{f}_{\mu}) \rightarrow (\text{lo}_{\mu}{}^{\mu}\text{f}) \rightarrow (\text{lo}_{\mu\mu}\text{f})$. This interpretation of the facts is parallel to the rule-based derivational analysis defended in Hualde (1990), in which devoicing automatically triggers delinking, which is the source of VL. This analysis seems at first sight empirically correct. The only drawback I can see in this account has to do with the consequences of delinking regarding the syllabic affiliation of the devoiced obstruent. If the devoiced coda obstruent is parsed into the syllable by means of being linked to a mora, once delinking applies there is no reason to believe that syllabic affiliation is still preserved. This situation would prevent the candidate showing delinking from winning because of the top-ranked position of PARSE-SEGMENT.

[15] In Shaw (2009) it is argued that OT-CC makes a more restricted prediction regarding the languages that allow classic CL, which are presumably those that, apart from being sensitive to weight, also undergo the process of closed syllable lengthening. This statement follows from the fact that, according to Shaw (2009), GEN does not produce stray elements, meaning that before deleting a mora-bearing coda consonant, the vowel must be linked to the mora headed by the coda, the source of closed syllable lengthening. This way, the path towards vowel lengthening is said to start with lengthening, and then followed by deletion. It is not clear to me why a classic derivation that starts with deletion is not possible in OT-CC. In fact, the floating mora is not 'produced' by GEN as a stray element if deletion precedes lengthening, but is just the natural consequence of coda deletion. If a markedness constraint such as *FLOATINGμ is included in CON, there is no reason to discard a constraint-based derivation of CL in OT-CC that starts with deletion.

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