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## Prosodic anchoring in Basque cluster simplification

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Consonant cluster simplification in Basque depends on the prosodic domain. Simplification across morpheme boundaries is obligatory while simplification across word boundaries is optional. Moreover, strident-affricate clusters inside words are simplified by deaffrication, while phrase-internally such a mapping is not observed. Depending on the variety, clusters may be avoided by simplification or vowel epenthesis. Previous OT-based analyses of Basque clusters posited that the aforementioned phenomena are triggered by an output requirement that stops must be followed by vowels (Côté 1999; 2000). The empirical argument in favor of this view is that stops and affricates before a pause are also avoided. Importantly, a repair strategy is less likely to be applied phrase-finally than phrase-internally. In order to account for the aforementioned asymmetries, positional markedness constraints relativized to prosodic boundaries were invoked. The goal of this paper is to construct a uniform OT grammar that accounts for stop deletion, affricate spirantization, deaffrication, spirant coalescence, voiced stop lenition as well as voice assimilation. Two conspiracies are identified: against non-prevocalic stops and against adjacent stridents. It is argued that prosodic anchoring as the locus of the asymmetries in the application of the listed processes is superior to the positional markedness approach. In a probabilistic grammar, the former yields satisfactory results while the latter generates unattested outputs. From the theoretical side, the anchoring model posits one driver for each conspiracy. The positional markedness model, on the other hand, has no formal device of expressing the conspiracies since a different markedness constraint triggers simplification word-internally, phrase-internally and phrase-finally.

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## 1 Introduction

Consonant cluster phonotactics exhibits considerable asymmetry across different domains. For instance, in Cairene and Iraqi Arabic (Broselow 1980; 1992; Selkirk 1981; Wiltshire 1994; 1998; 2003), consonants must be adjacent to vowels phrase-internally (Côté 2000: §5.3.1). This requirement is satisfied via vowel epenthesis, e.g., /katab-t ma-ktuub/ → [katabitmaktuub] ‘I wrote a letter’ in Iraqi Arabic and /katabt gawaab/ → [katabtigawaab] ‘you (m.) wrote a letter’ in Cairene Arabic (Côté 2000: 275). Phrase-initially, epenthesis is optional in Iraqi and obligatory in Cairene; phrase-finally, on the other hand, the process is obligatory in Iraqi, while it does not apply in Cairene. In order to account for such asymmetries in Optimality Theory (OT; Prince & Smolensky 2004; McCarthy & Prince 1995), Côté (2000) proposes a set of perceptually motivated markedness constraints requiring that consonants must be adjacent to/followed by vowels across different prosodic domains, as summarized in (1).

- (1) Conditional licensing constraints (Côté 2000: 269–270)

$$C|_i \leftrightarrow V$$

A consonant that is next to a boundary *i* is adjacent to a vowel.

$$C|_i \rightarrow V$$

A consonant that is next to a boundary *i* is followed by a vowel.

$$C]_i \leftrightarrow V$$

A consonant that is followed by a boundary *i* is adjacent to a vowel.

$$C]_i \rightarrow V$$

A consonant that is followed by a boundary *i* is followed by a vowel.

$${}_i[C \leftrightarrow V$$

A consonant that is preceded by a boundary *i* is adjacent to a vowel.

$${}_i[C \rightarrow V$$

A consonant that is preceded by a boundary *i* is followed by a vowel.

The crucial ranking that distinguishes Cairene from Iraqi Arabic with respect to vowel epenthesis concerns the constraints DEP<sub>V</sub>, C]<sub>p</sub> ↔ V and <sub>p</sub>[C ↔ V, where P stand for phonological phrase.<sup>1</sup> In Cairene, the ranking <sub>p</sub>[C ↔ V >> DEP<sub>V</sub> >> C]<sub>p</sub> ↔ V ensures phrase-initial epenthesis and no epenthesis phrase-finally. In Iraqi, on the other hand, C]<sub>p</sub> ↔ V >> {DEP<sub>V</sub>, <sub>p</sub>[C ↔ V} ensures obligatory epenthesis phrase-finally; phrase-initially, epenthesis is optional and hence DEP<sub>V</sub> is optionally ranked above or below <sub>p</sub>[C ↔ V (Côté 2000: 277-278).

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<sup>1</sup> Côté distinguishes domains such as prosodic word, phonological phrase, intonational phrase and utterance (Côté 2000: 272). In the case of Cairene and Iraqi Arabic, utterance level is diagnosed as the relevant domain. However, since it is not crucial for the analysis presented in the ensuing sections, I simplify matters and limit the domains to Word (W) and Phrase (P).

This article discusses processes affecting consonant clusters in Basque with an aim of constructing a uniform OT grammar that accounts for stop deletion, affricate spirantization, deaffrication, spirant coalescence, voiced stop lenition as well as voice assimilation. Crucially, the aforementioned phenomena are not homogeneous across different domains. It is argued that the model based on the licensing constraints proposed by Côté (2000) yields better results when anchoring is used instead of positional markedness. Specifically, the positional markedness constraints outlined in (1) are abandoned in favor of the anchoring constraints relativized to various domains. As a result, the locus of the asymmetric application of processes across different domains is the input-output faithfulness. This is advantageous from the theoretical perspective as it expresses two active conspiracies: against non-prevocalic stops and against adjacent stridents. The proposed model is also successful when it comes to probabilistic constraint ranking. When the competing models are fed into Gradual Learning Algorithm (GLA; Boersma 1997), the constraint set including positional markedness generates a significant number of unattested outputs.

Section 2 gives a brief background regarding the data and the linguistic situation of Basque as well as the core theoretical assumptions. The latter part of this section outlines the general discussion on positional markedness and positional faithfulness in OT. Sections 3.1 and 3.2 develop an OT analysis of stop deletion and affricate spirantization as well as strident dissimilation and coalescence, respectively. It is shown that anchoring yields better results than positional markedness when it comes to probabilistic constraint ranking in GLA. Additionally, the positional faithfulness approach successfully expresses the identified conspiracy. Section 3.3 considers a different strategy of avoiding non-prevocalic stops in Basque, i.e., vowel epenthesis, analyzed in Côté (1999; 2000). The model advocated in this article is able to account for the data equally well as Côté's (2000) model. Section 3.4 gives a sketch of an analysis that incorporates voiced stop lenition and voice assimilation into the proposed model. Section 4 offers the main conclusions.

## 2 Background

### 2.1 Data

The data used in this paper are drawn from the existing literature as well as my fieldwork conducted in June of 2023 in Biscay (Getxo, Lekeitio) and Navarre (Goizueta), Basque Country. Most of the fieldwork data exemplify processes described in the literature (Hualde 1988; 1991; Hualde & Bilbao 1992; Hualde *et al.* 1994; Côté 1999; 2000; Hualde *et al.* 2010; Hualde *et al.* 2019). Importantly, the presented data confirm some underreported cases regarding the behavior of strident clusters (see Section 3.2). Unless clearly indicated otherwise in a dataset, the data come from the fieldwork. Most of the presented IPA transcriptions have been confirmed by inspecting the spectrograms and waveforms. Example spectrograms generated in Praat (Boersma & Weenink 2024) are given in the Appendix.

Basque exhibits a considerable dialectal variation. However, most of the processes discussed in this article are common to the majority of varieties. Therefore, in the ensuing sections, unless indicated otherwise, the term “Basque” is used to denote the aforementioned dialects spoken in Biscay and Navarre. Since the paper does not aim to compare these varieties, individual examples are not associated with specific dialects.

## 2.2 Core assumptions

In the ensuing analysis, apart from the general framework of Optimality Theory (OT; Prince & Smolensky 2004; McCarthy & Prince 1995), it is assumed that affricates are specified as [–continuant, +strident] (Jakobson *et al.* 1952). The discussion regarding the advantages and disadvantages of the alternative views, among which the most prominent is the non-linear complex segment approach (Lombardi 1990), where affricates are specified for both [+continuant] and [–continuant], is beyond the scope of this article (see LaCharité 1993; Rubach 1994; Clements 1999; Krajewska 2010). It is also assumed that phonological features are organized hierarchically on autosegmental tiers (Clements 1985; Sagey 1986). Finally, by the logic of autosegmental phonology, we are employing the MAX/DEP-feature theory in the analysis (Lombardi 1995; 1998; LaMontagne & Rice 1995; Causely 1996; Walker 1997; Pater 1999).

## 2.3 Positional markedness and positional faithfulness

Classic OT (Prince & Smolensky 2004; McCarthy & Prince 1995) has a well-known problem with expressing the directionality of processes. For instance, some languages require that VC<sub>1</sub>C<sub>2</sub>V clusters be simplified to VCV. The preserved member of the cluster, however, is almost unequivocally C<sub>2</sub> (Wilson 2001; though see Lamont 2015; 2016 for morphologically conditioned simplification). Classic OT is unable to generate this asymmetry since the constraints responsible for the mapping VCCV → VCV do not distinguish between C<sub>1</sub> and C<sub>2</sub>. To illustrate this point, let us assume that simplification is driven by \*CC (*no clusters*). The competing faithfulness constraint is MAXC (*do not delete*). \*CC is satisfied by the deletion of either of the consonants. MAXC, on the other hand, equally penalizes the deletion of C<sub>1</sub> and C<sub>2</sub>. As a result, under the ranking \*CC > > MAXC, VC<sub>1</sub>V and VC<sub>2</sub>V tie.

In response to such issues, two basic theories are invoked: positional markedness (Itô 1988; Zoll 1997; Steriade 1997) and positional faithfulness (Beckman 1997; 1998; 1999; Casali 1997; Lombardi 1999). The debate whether one is superior to the other and/or whether both are necessary has not been entirely resolved (e.g., Lombardi 2001; Beckman 2004; Rubach 2008; Zhang 2020 for an overview). In the schematic example of VCCV simplification, VC<sub>1</sub>C<sub>2</sub>V → VC<sub>2</sub>V may be a result of either a high-ranked positional faithfulness constraint protecting prevocalic segments (e.g., MaxC<sub>prev</sub>), or a positional markedness constraint militating against coda consonants (e.g., CodaCond). While the former analysis is readily carried out in a parallel framework, the latter necessitates a serial approach (McCarthy 2008).

Apart from the directionality of mappings, generic faithfulness and markedness constraints are unable to distinguish between stem-level, word-level and phrase-level processes (e.g., see Lexical Phonology; Kiparsky 1982; Rubach & Booij 1987) without abandoning a strictly parallel one-step OT model (cf. Derivational/Stratal OT; Rubach 1997; Kiparsky 1997). Many aspects of these domain-driven asymmetries can be captured by positional markedness and/or positional faithfulness relativized to different prosodic boundaries. The current paper shows two disadvantages of the positional markedness approach in the analysis of Basque cluster simplification: one theoretical and one empirical. Although the proposed constraint set involves anchoring constraints, which are not a classic example of positional faithfulness constraints, they still invoke the faithfulness rather than the markedness of constituents associated with specific structures. Therefore, in this sense, anchoring falls within the category of positional faithfulness.

### 3 Basque consonant clusters in OT

#### 3.1 Stop deletion and affricate spirantization

Consider the data in (2) regarding stop deletion in Basque across morpheme and word boundaries.

(2) Stop deletion<sup>2</sup>

- |    |                                  |       |                                 |
|----|----------------------------------|-------|---------------------------------|
| a. | <i>/bat + naka/</i> <sup>3</sup> | → [n] | ‘one by one’ (Hualde 1988: 380) |
|    | <i>/bat + na/</i>                | → [n] | ‘one apiece’ (Trask 2008: 40)   |
| b. | <i>zenbai[t t]okitan</i>         | ~ [t] | ‘in some places’                |
|    | <i>bos[t p]ertsona</i>           | ~ [p] | ‘five people’                   |
|    | <i>Tomase[k t]ourroa</i>         | ~ [t] | ‘proper name’                   |
|    | <i>interne[t n]ola</i>           | ~ [n] | ‘how Internet (has been)’       |
|    | <i>ufada[k n]eurtu</i>           | ~ [n] | ‘gusts measured’                |
|    | <i>agentee[k m]adrilgo</i>       | ~ [m] | ‘agents (from) Madrid (Police)’ |
| c. | <i>senbe[t s]aharra</i>          | ~ [s] | ‘how many old people’           |
|    | <i>batzu[k s]ublimatzen</i>      | ~ [s] | ‘sublimating some’              |
|    | <i>zaurituetati[k s]ortzi</i>    | ~ [s] | ‘eight out of (ten) wounded’    |
|    | <i>zenbai[t ʃ]ehetasun</i>       | ~ [ʃ] | ‘some details’                  |
|    | <i>Trueba[k ʃ]axatuta</i>        | ~ [ʃ] | ‘encouraged by Trueba’          |
|    | <i>Interne[t x]aio</i>           | ~ [x] | ‘Internet born’                 |
|    | <i>hainba[t x]ende</i>           | ~ [x] | ‘various people’                |

<sup>2</sup> Since the reduction processes discussed in this paper hinge upon segmental adjacency as well as the features [-continuant] and [+strident], I simplify the transcription, ignoring the apical-laminal distinction for the alveolar fricatives and affricates (Hualde 2003: §2.1.1) as well as allophonic palatalization of stops in Lekeitio Basque (Hualde *et al.* 1994: 13). Apical-laminal contrast is lost in some varieties of Basque (Hualde 2003: 17). The specific place of articulation of these segments, however, does not influence the analysis.

<sup>3</sup> Examples of the synchronic alternation at morpheme boundaries are scarce. This is due to the fact that almost no roots/prefixes end in oral stops in Basque.

<i>ba</i> [t x] <i>auna</i>	~ [x]	‘one (moment) sir’
<i>alaba</i> [k x] <i>aio</i>	~ [x]	‘daughters born’
<i>ikaslea</i> [k x] <i>auna</i>	~ [x]	‘disciples (saw) the Lord’

The data in (2a) exemplify obligatory deletion of plosives before non-continuant segments across morpheme boundaries. In (2b) and (2c), word-final stops are optionally deleted before the following consonant-initial word (see also Hualde 1988; 1991; Hualde & Bilbao 1992).<sup>4</sup>

Past research treats the changes in (2a) and (2b) either as a dissimilation effect working against adjacent non-continuants (Hualde 1988; 1991) or as an effect of a Coda Condition against coda stops (Artiagoitia 1993). The former approach is insufficient since it does not account for the data in (2c), where stops are deleted before continuants. The latter, on the other hand, creates complications in accounting for word-final stops not followed by consonants, e.g., *ba*[t] ‘one’, which are not deleted (see Côté 2000 for a critique of the syllabic approach).

The mappings in (2) may be analyzed in OT as an interaction of a markedness constraint militating against non-prevocalic stops (Côté 2000) with MAXC and a positional faithfulness constraint, MAXC<sub>PREV</sub>, listed in (3).

(3) OT constraints

T → V (Côté 2000)

A [-continuant] segment is followed by a vowel.

MAXC

An input consonant must have an output correspondent.

MAXC<sub>PREV</sub>

An input prevocalic consonant must have an output correspondent.

The markedness constraint T → V requires that non-continuants must be followed by vowels. The rationale for this constraint comes from the license-by-cue approach (Steriade 1999), where perceptual salience plays a pivotal role. Specifically, prevocalic stops have stronger phonetic cues than non-prevocalic stops (Jun 1995; 2004; Steriade 1999). As a result, the drive to avoid low salience may trigger various processes that conspire against relatively weak segments.

Consider the evaluations in (4) for /bat + naka/ → [banaka] ‘one by one’, /bost p̄ert̄sona/ → [bosp̄ert̄sona] ‘five people’, /suretsat sormena/ → [suretsasormena] ‘creativity for you’ and /bat/ → [bat] ‘one’.

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<sup>4</sup> A reviewer points out that there are more options regarding the mappings in (2b), e.g. lack of plosion /k t/ → [kʰt], which may result in consonant lengthening for homorganic clusters, such as /t t/ → [t:] (Hualde *et al.* 2019: §6). In the current analysis, lack of plosion and lengthening are not phonologically relevant as they correspond to the phonological sequences of two stops, where two time slots are preserved on the surface. Consequently, such outputs do not violate MAXC and violate the markedness constraint T → V given in (3). Since these examples do not create problems for the proposed analysis, I do not include them for clarity (for an analysis where lack of plosion is phonologically relevant, see McCarthy 2011).

(4) Non-continuant simplification<sup>5</sup>

<i>Input</i>	<i>Output</i>	MAXC <sub>PREV</sub>	T → V	MAXC
(i) bat + naka	a. batnaka		*!	
	b. $\text{ba}^{\text{H}}\text{naka}$			*
	c. bataka	*!		*
(ii) bost pert̄sona	a. bost pert̄sona		*!	
	b. $\text{bos}^{\text{H}}\text{pert̄sona}$			*
	c. bost ert̄sona	*!		*
(iii) suretsat sormena	a. suretsat sormena		*!	
	b. $\text{suretsa}^{\text{H}}\text{sormena}$			*
	c. suretsat ormena	*!		*
(iv) bat	a. $\text{bat}^{\text{H}}$		*!	
	b. $\text{ba}^{\text{H}}$			*

There are two problems with the ranking argument in (4). First, it fails to derive the attested output in (4iv). This is because the driver, T → V, makes no distinction between preconsonantal and phrase-final stops. Therefore, the ranking T → V >> MAXC predicts that preconsonantal stops and phrase-final stops are avoided to the same extent. This is an undesired result since plain stops at the end of utterances are not deleted: /bat/ → [bat], not \*[ba]. Second, simplification across morpheme boundaries is obligatory, while simplification across word boundaries is optional. Therefore, in the latter case there is a possibility of reranking T → V below the faithfulness constraints. Such a demotion, however, proves problematic for the obligatory status of simplification across morpheme boundaries, e.g., /bat + naka/ → [banaka], not \*[batnaka]. In other words, the model in (4) does not predict any discrepancies between stem-level and phrase-level processes and both must be either obligatory or optional.

In order to salvage the analysis, we may employ a set of prosodically conditioned constraints referencing different prosodic boundaries, as proposed in Côté (2000). Accordingly, T → V may be relativized word (W) or phrase (P) boundary, as summarized in (5).<sup>6</sup>

## (5) Conditional licensing constraints (Côté 2000)

$$T]_{\emptyset} \rightarrow V$$

A [-continuant] segment that is followed by no boundary is followed by a vowel.

<sup>5</sup> Candidates such as [bas] (not included in the evaluation) are rejected by an undominated DEP[+strid]. Indeed, there are no examples in Basque that would exhibit an insertion of this feature.

<sup>6</sup> Actually, Côté distinguishes domains such as prosodic word, phonological phrase, intonational phrase and utterance (Côté 2000: 272). I simplify matters since it does not influence the present analysis.

$T]_w \rightarrow V$

A [-continuant] segment that is followed by a word boundary is followed by a vowel.

$T]_p \rightarrow V$

A [-continuant] segment that is followed by a phrase boundary is followed by a vowel.

As argued by Côté (2000), simplification is stronger the lower the boundary. This relation is expressed in OT by a universal ranking  $T]_{\emptyset} \rightarrow V \gg T]_w \rightarrow V \gg T]_p \rightarrow V$ . With the licensing constraints in the picture, phrase-final stops are no longer in danger of being eliminated on a par with morpheme and word-final stops, as shown in (6).

(6) Non-continuant simplification – revised

<i>Input</i>	<i>Output</i>	$MAXC_{PREV}$	$T]_{\emptyset} \rightarrow V$	$T]_w \rightarrow V$	$MAXC$	$T]_p \rightarrow V$
(i) bat + naka	a. batnaka		*!			
	b. $\text{[b̥]}$ banaka					
	c. bataka	*!			*	
(ii) bat paratu	a. bat paratu			*!		
	b. $\text{[p̥]}$ ba paratu				*	
	c. bat aratu	*!			*	
(iii) bat	a. $\text{[p̥]}$ bat					*
	b. ba				*!	

In (6i) and (6ii), simplification is observed since the licensing constraints requiring that stops at no/word boundaries must be followed by vowels outrank the faithfulness constraints. In contrast, no simplification is generated in (6iii), where  $MAXC$  is ranked above the driver,  $T]_p \rightarrow V$ .

The split of the licensing constraints also resolves the problem with the optionality of simplification in different domains. While  $T]_{\emptyset} \rightarrow V$  must be categorically ranked above  $MAXC$ ,  $T]_w \rightarrow V$  can be ranked either above or below  $MAXC$ , which yields optional simplification across word boundaries, as shown in (7). Since deletion is not observed at the end of Ps,  $MAXC$  must always dominate  $T]_p \rightarrow V$ .

(7) Optionality of deletion

(i) Deletion

<i>Input</i>	<i>Output</i>	$T]_{\emptyset} \rightarrow V$	$T]_w \rightarrow V$	$MAXC$
bat + naka	a. batnaka	*!		
	b. $\text{[b̥]}$ banaka			*
bat paratu	a. bat paratu		*!	
	b. $\text{[p̥]}$ ba paratu			*

## (ii) No deletion

Input	Output	$T]_{\emptyset} \rightarrow V$	MAXC	$T]_w \rightarrow V$
bat + naka	a. batnaka	*!		
	b. $\text{ba} \text{ naka}$		*	
bat paratu	a. $\text{bat} \text{ paratu}$			*
	b. ba paratu		*!	

Let us now consider the data regarding the behavior of affricates in similar contexts, given in (8).

## (8) Spirantization of affricates

- a.  $/\widehat{\text{ots}} + \text{tu}/ \rightarrow [\text{st}]$  ‘to become cold’ (Hualde 1988: 380)  
 $/\widehat{\text{its}} + \text{tegi}/ \rightarrow [\text{st}]$  ‘dictionary’ (Hualde 1988: 380)
- b.  $\text{Ari}[\widehat{\text{ts}} \text{ t}] \text{rueba} \sim [\text{s t}]$  ‘proper name’  
 $\text{abera}[\widehat{\text{ts}} \text{ t}] \text{onto} \sim [\text{s t}]$  ‘rich fool’  
 $\text{hankamo}[\widehat{\text{ts}} \text{ x}] \text{aio} \sim [\text{s x}]$  ‘born lame’
- c.  $\text{har}[\widehat{\text{ts}} \text{ j}] \text{akintxua} \sim [\text{s j}]$  ‘wise bear’  
 $\text{Arkai}[\widehat{\text{ts}} \text{ l}] \text{andeta} \sim [\text{s l}]$  ‘proper name’  
 $\text{Ari}[\widehat{\text{ts}}] \sim [\text{s}]$  ‘proper name’  
 $\text{bali}[\widehat{\text{ts}}] \sim [\text{s}]$  ‘if’

In (8a), affricates undergo obligatory spirantization before non-continuants across morpheme boundaries. Across word boundaries, spirantization is optional in the same phonological context, as shown in (8b). Finally, the data in (8c) document that the relevant context may also include continuant consonants or a pause (see also Hualde 1988; 1991; Hualde & Bilbao 1992; Hualde *et al.* 1994).

In order to account for spirantization, we need an additional constraint militating against the deletion of the feature  $[-\text{continuant}]$ ,  $\text{MAX}[-\text{con}]$ . As shown in (9), the ranking argument developed so far with this additional constraint successfully generates the attested mappings.

## (9) Spirantization

Input	Output	$\text{MAXC}_{\text{PREV}}$	$T]_{\emptyset} \rightarrow V$	MAXC	$T]_w \rightarrow V$	$T]_p \rightarrow V$	$\text{MAX}[-\text{con}]$
(i) $\widehat{\text{ots}} + \text{tu}$	a. $\widehat{\text{otstu}}$		*!				
	b. $\text{ostu}$						*
	c. $\text{otu}$			*!			*
	d. $\widehat{\text{otsu}}$	*!		*			*

<i>Input</i>	<i>Output</i>	MAXC <sub>PREV</sub>	T] <sub>∅</sub> → V	MAXC	T] <sub>W</sub> → V	T] <sub>P</sub> → V	MAX[-con]
(ii) $\widehat{\text{ots}}$ bat	a. $\widehat{\text{ots}}$ bat				*!		
	b. $\text{os}$ bat						*
	c. o bat			*!			*
	d. $\widehat{\text{ots}}$ at	*!		*			*
(iii) $\widehat{\text{ots}}$	a. $\widehat{\text{ots}}$					*!	
	b. $\text{os}$						*
	c. o			*!			*

With a low-ranked MAX[-con], spirantization is observed whenever an affricate is not followed by a vowel. Since spirantization is optional at the end of Ws and Ps, (9i) and (9ii), MAX[-con] may be promoted over T]<sub>P</sub> → V or T]<sub>W</sub> → V. This creates an effect similar to (7).

There are two problems with the analysis in (9). First, the model based on relativized markedness does not yield satisfactory results when tested using Gradual Learning Algorithm (GLA; Boersma 1997), as shown below. Second, the split of the driver C → V into (at least) three constraints effectively splits the process into three separate processes, thus obscuring the conspiracy against non-prevocalic [-continuant] segments.

Consider the results of a GLA model (run in OTSoft; Hayes *et al.* 2013) based on mock input frequencies (possible vs. impossible outputs) given in (10). Notice that such a model incorrectly predicts that phrase-final deletion of plosives applies on a par with phrase-final spirantization. Specifically, it does not distinguish between /arits/ → [aris] ‘proper name’ and /bat/ → [bat] ‘one’ (not \*[ba]).

(10) Cluster simplification in GLA – conditional licensing

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
-t + n-	-tn-	0	0.001
	-n-	1	0.999
	-t-	0	0
$\widehat{\text{ts}}$ + t-	$\widehat{\text{tst}}$ -	0	0
	-st-	1	1
	-t-	0	0
	$\widehat{\text{ts}}$ -	0	0
-t p-	-t p-	0.5	0.561
	-p-	0.5	0.439
	-t-	0	0

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
$\widehat{-ts} \ t-$	$\widehat{-tst-}$	0.5	0.392
	$-s \ t-$	0.5	0.608
	$-t-$	0	0
	$\widehat{-ts-}$	0	0
$-t$	$-t$	1	0.798
	$-\emptyset$	0	0.202
$\widehat{-ts}$	$\widehat{-ts}$	0.5	0.635
	$-s$	0.5	0.365
	$-\emptyset$	0	0

The ranking values found by GLA based on the inputs given in (10) are listed in (11).

(11) Incorrect ranking values – conditional licensing

<i>Constraint</i>	<i>Ranking value</i>
$T]_{\emptyset} \rightarrow V$	106
$MAXC_{PREV}$	104
$T]_w \rightarrow V$	97
$MAXC$	97
$MAX[-con]$	97
$T]_p \rightarrow V$	96

The model summarized in (10) and (11) incorrectly predicts stop deletion at the end of phrases. This is due to the fact that  $MAXC$  and  $MAX[-con]$  are ranked similarly, too close to  $T]_p \rightarrow V$ . As a result,  $T]_p \rightarrow V$  may outrank both faithfulness constraints, generating the unattested  $/-t/ \rightarrow *[-\emptyset]$ .

A solution to both the theoretical and the empirical problem with the analysis outlined above entails shifting the weight of the asymmetry from positional markedness to positional faithfulness. In the ensuing analysis, we are going to employ a set of anchoring constraints that regulate the input-output correspondence between morphological and prosodic edges, as defined in (12).

(12) Anchoring (McCarthy & Prince 1995: 123)

$\{LEFT/RIGHT\}$ -ANCHOR( $S_1, S_2$ )

Any element at the designated periphery of  $S_1$  has a correspondent at the designated periphery of  $S_2$ .

The constraint in (12) is a template for a family of anchoring constraints. The relevant domains for the data in (2) include morphological roots and affixes under the umbrella term Morpheme in the position of  $S_1$  as well as the prosodic domains of Word and Phrase in the position of  $S_2$  (for a more fine-grained prosodic hierarchy, see Côté 2000). Since Morpheme will be common for all anchoring constraints used in the ensuing analysis, we are going to introduce the abbreviations in (13).

(13) Relevant anchoring constraints

{LEFT}-ANCHOR(Morpheme, Word) = ANCHL<sub>W</sub>

{RIGHT}-ANCHOR(Morpheme, Word) = ANCHR<sub>W</sub>

{LEFT}-ANCHOR(Morpheme, Phrase) = ANCHL<sub>P</sub>

{RIGHT}-ANCHOR(Morpheme, Phrase) = ANCHR<sub>P</sub>

Consider the evaluation in (14), which includes the same input-output pairs as the evaluation in (4). To save space, only the relevant segments are listed.

(14) Non-continuant simplification – anchoring<sup>7</sup>

<i>Input</i>	<i>Output</i>	ANCHR <sub>P</sub>	T → V	ANCHR <sub>W</sub>	MAXC
(i) -t + n-	a. -tn-		*!		
	b. $\mathbb{E}$ -n-				*
(ii) -t p-	a. -t p-		*!		
	b. $\mathbb{E}$ -p-			*	*
(iii) -t s-	a. -t s-		*!		
	b. $\mathbb{E}$ -s-			*	*
(iv) -t	a. $\mathbb{E}$ -t		*		
	b. -∅	*!		*	*

The tableaux in (14) generate the attested outputs. In (14i), deletion is obligatory due to the ranking  $T \rightarrow V \gg \text{MAXC}$ . In (14ii) and (14iii), deletion is observed under the ranking  $T \rightarrow V \gg \text{ANCHR}_W$ . However, this ranking may be optionally reversed, yielding no simplification phrase-internally. Finally, phrase-final deletion is banned by an undominated ANCHR<sub>P</sub> and candidate (14iv-a) is the only possible output. Deletion of prevocalic consonants is barred by an undominated MAX<sub>PREV</sub> (not included in the evaluation).<sup>7</sup>

<sup>7</sup> For clarity, in all tableaux only the relevant violations of the anchoring constraints are marked.

In order to account for spirantization in OT, the anchoring constraints in (13), which refer to segmental correspondence, are expanded to encompass individual autosegmental constituents. Consequently, the set in (15) emerges.

(15) Autosegmental anchoring

- {LEFT}-ANCHOR[-continuant](Morpheme, Word) = ANCHL[-con]<sub>w</sub>  
 {RIGHT}-ANCHOR[-continuant](Morpheme, Word) = ANCHR[-con]<sub>w</sub>  
 {LEFT}-ANCHOR[-continuant](Morpheme, Phrase) = ANCHL[-con]<sub>p</sub>  
 {RIGHT}-ANCHOR[-continuant](Morpheme, Phrase) = ANCHR[-con]<sub>p</sub>

The constraints in (15) are a logical extension of the autosegmental correspondence on the one hand and the strength of boundary effects on the other. Consider the evaluations in (16) (relevant segments only). The constraints ANCHR[-con]<sub>w</sub> and ANCHR[-con]<sub>p</sub> are collapsed under a single entry ANCHR[-con]<sub>w/p</sub>.

(16) Spirantization

<i>Input</i>	<i>Output</i>	ANCHR <sub>p</sub>	T→V	ANCHR[-con] <sub>w/p</sub>	ANCHR <sub>w</sub>	MAX[-con]	MAXC
(i) $\widehat{-ts} + t-$	a. $\widehat{-fst-}$		*!				
	b. $\text{[s]} \widehat{-st-}$					*	
	c. $-t-$					*	*!
(ii) $\widehat{-ts} t-$	a. $\widehat{-ts} t-$		*!				
	b. $\text{[s]} \widehat{-s} t-$			*		*	
	c. $-t-$			*	*!	*	*
(iii) $\widehat{-ts}$	a. $\widehat{-ts}$		*!				
	b. $\text{[s]} \widehat{-s}$			*		*	
	c. $-\emptyset$	*!		*	*	*	*

In (16i), the spirantizing candidate, (16i-b), is preferred over the faithful candidate, (16i-a), due to the ranking  $T \rightarrow V \gg \text{MAX}[-\text{con}]$ . Candidate (16i-c), which deletes the entire affricate, is rejected since it gratuitously violates MAXC. Spirantization across word boundaries in (16ii) is governed by the ranking of  $T \rightarrow V$  *vis-à-vis* ANCHR[-con]<sub>w</sub>. If the licensing constraint outranks the anchoring constraint, spirantization is observed. Otherwise, the faithful candidate emerges victorious. Finally, phrase-finally in (16iii), spirantization applies under the ranking  $T \rightarrow V \gg \text{ANCHR}[-\text{con}]_p$ . In all cases, deletion of prevocalic segments is prohibited by an undominated MAXC<sub>PREV</sub> (not listed).

The ranking argument in (16) generates the attested outputs when it comes to plain stops, as shown in (17).

(17) Deletion

<i>Input</i>	<i>Output</i>	ANCHR <sub>p</sub>	T→V	ANCHR[-con] <sub>w/p</sub>	ANCHR <sub>w</sub>	MAX[-con]	MAXC
(i) -t + n-	a. -tn-		*!				
	b. $\text{☞}$ -n-					*	*
(ii) -t p-	a. -t p-		*!				
	b. $\text{☞}$ -p-			*	*	*	*
(iii) -t	a. $\text{☞}$ -t		*				
	b. -∅	*!		*	*	*	*

In (17i), deletion is obligatory. In (17ii), deletion depends on the ranking of the licensing constraint and ANCHR[-con]<sub>w</sub> and/or ANCHR<sub>w</sub>. Finally, phrase-final deletion is categorically banned by a high-ranked ANCHR<sub>p</sub>.

The upshot of the ranking argument presented in (17) is that it reflects a true cross-domain conspiracy driven by the requirement that non-continuants must be followed by a vowel. It also yields promising results when it comes to probabilistic constraint ranking, which is particularly insightful with regard to the obligatory vs. optional nature of processes in different domains. Consider the results of a GLA model based on mock probabilities (possible vs. impossible outputs), given in (18).

(18) Cluster simplification in GLA – anchoring

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
-t + n-	-tn-	0	0.005
	-n-	1	0.995
	-t-	0	0
$\widehat{-ts} + t-$	$\widehat{-tst}$	0	0
	-st-	1	1
	-t-	0	0
	$\widehat{-ts}$	0	0
-t p-	-t p-	0.5	0.478
	-p-	0.5	0.522
	-t-	0	0

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
$\widehat{-ts} t-$	$\widehat{-tst-}$	0.5	0.478
	$-s t-$	0.5	0.522
	$-t-$	0	0
	$\widehat{-ts-}$	0	0
$-t$	$-t$	1	0.996
	$-\emptyset$	0	0.004
$\widehat{-ts}$	$\widehat{-ts}$	0.5	0.478
	$-s$	0.5	0.522
	$-\emptyset$	0	0

The ranking values found in this model are given in (19).

(19) Ranking values – anchoring

<i>Constraint</i>	<i>Ranking value</i>
$ANCHR_p$	110
$MAXC_{PREV}$	110
$T \rightarrow V$	103
$ANCHR[-con]_w$	103
$MAXC$	96
$MAX[-con]$	93
$ANCHR_w$	88

As visible in (18), the proposed constraint set is able to generate the input values without generating any unattested outputs in a probabilistic grammar. Comparing the model based on anchoring in (18) and the model based on conditional licensing in (10), it is evident that the former more accurately reflects the input values.<sup>8</sup>

### 3.2 Strident dissimilation and coalescence

Strident clusters constitute a special case of cluster simplification. Even though in Section 3.1 we have established that affricates are spirantized in the non-prevocalic position, a different result is

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<sup>8</sup> When it comes to the data presented in this section, similar results are achieved by employing a feature markedness constraint militating against the feature [-continuant], \*[-con], instead of the licensing constraint  $T \rightarrow V$ . The problem with this alternative approach is that in some dialects of Basque, non-prevocalic stops are avoided by means of vowel insertion (Côté 1999; 2000; see Section 2.4). An interaction of \*[-con] with positional faithfulness is unable to account for this strategy. Conversely, a single licensing constraint  $T \rightarrow V$  is satisfied by both vowel insertion and consonant deletion. This further unifies the conspiracy under a single driver.

observed when it comes to affricate-fricative and affricate-affricate clusters. Additionally, strident clusters straddling morpheme boundaries undergo dissimilation without deletion, which does not occur across word boundaries. Finally, fricative-fricative clusters undergo degemination. Consider the data in (20).<sup>9</sup>

(20) Simplification of strident clusters

- |    |   |                             |                      |
|----|---|-----------------------------|----------------------|
| a. | /ikus + $\widehat{\text{tsen}}$ /                                       | → [st] <sup>10</sup>        | ‘see’ (imperf.)      |
|    | /eros + $\widehat{\text{tsen}}$ /                                       | → [st]                      | ‘but’ (imperf.)      |
| b. | <i>hor</i> [ $\widehat{\text{ts}}$ s] <i>uriak</i>                      | ~ [ $\widehat{\text{ts}}$ ] | ‘white teeth’        |
|    | <i>har</i> [ $\widehat{\text{ts}}$ s] <i>uria</i>                       | ~ [ $\widehat{\text{ts}}$ ] | ‘white bear’         |
|    | <i>har</i> [ $\widehat{\text{ts}}$ s] <i>antua</i>                      | ~ [ $\widehat{\text{ts}}$ ] | ‘holy bear’          |
|    | <i>Zarau</i> [ $\widehat{\text{ts}}$ s] <i>eigarren</i>                 | ~ [ $\widehat{\text{ts}}$ ] | ‘Zarautz (is) sixth’ |
| c. | <i>bali</i> [ $\widehat{\text{t}}$ $\widehat{\text{t}}$ ] <i>ori</i>    | ~ [ $\widehat{\text{t}}$ ]  | ‘if birds’           |
|    | <i>abera</i> [ $\widehat{\text{ts}}$ $\widehat{\text{t}}$ ] <i>ikia</i> | ~ [ $\widehat{\text{t}}$ ]  | ‘small rich person’  |
|    | <i>hi</i> [ $\widehat{\text{ts}}$ $\widehat{\text{t}}$ ] <i>ikia</i>    | ~ [ $\widehat{\text{t}}$ ]  | ‘small word’         |
| d. | <i>e</i> [s s] <i>ara</i>   | ~ [s] <sup>11</sup>         | ‘you are not’        |
|    | <i>e</i> [s s] <i>uen</i>   | ~ [s]                       | ‘he did not’         |
|    | <i>indarre</i> [s s] <i>artu</i>  | ~ [s]                       | ‘enter by force’     |

The data in (20a) exemplify dissimilation of fricative-affricate clusters across morpheme boundaries, where the affricate loses the feature [+strident] in the output. As shown in (20b), affricate-fricative clusters across word boundaries are optionally simplified to a single affricate. Clusters of two affricates across word boundaries, (20c), are also optionally simplified to a single affricate, which preserves the place of articulation of the prevocalic segment. Finally, (20d) exhibits an optional simplification of fricative-fricative clusters (see also Hualde 1991: §5.3, §5.6; Hualde & Bilbao 1992: 20–21; Hualde *et al.* 1994: 33).

The data in (20) are problematic for the ranking argument developed in Section 3.1. First, recall that the final ranking generating the attested outputs of stop deletion and affricate spirantization involves a high-ranked  $\text{MAXC}_{\text{PREV}}$ . This, in turn, predicts that clusters in (20b) should simplify

<sup>9</sup> These phenomena are found in the dialects of Getxo and Lekeitio. I have not observed strident dissimilation in Goizueta Basque. This topic requires further research.

<sup>10</sup> A reviewer suggests that the changes in (20a) may be analyzed as allomorphy of the imperfective suffix, which surfaces as [ten] or [ $\widehat{\text{tsen}}$ ], depending on the root. Such an analysis is supported by the fact that there exist suffixes, such as *-tzat* ‘prolative’, that do not undergo deaffrication, e.g., *aberats-tzat* ‘as wealthy’, not \**aberastat*. This approach does not influence the current analysis in that it also relies on a bias against adjacent strident segments. The selection of the imperfective allomorph is conditioned phonologically, where [ten] is attached to roots ending in stridents and [ $\widehat{\text{tsen}}$ ] to roots ending in non-stridents. Such an outcome is impossible without the constraint OCP[+strid]. An exception to this rule are stems ending in *-n*, e.g., *eman* ‘give’ – *ematen* (imperf.).

<sup>11</sup> The reviewers point out that sequences of two fricatives of which one belongs to the negative particle *ez* undergo affrication in central and eastern dialects, e.g., *e*[ $\widehat{\text{ts}}$ ]*uen* ‘he did not’. This is clearly exceptional behavior since no other morphosyntactic contexts participate in this process and hence it is not included in the analysis (Hualde 2003: 23).

by deleting the non-prevocalic segment,  $/\widehat{ts} s-/ \rightarrow *[-s-]$ . Second, the markedness constraint employed in the analysis so far,  $T \rightarrow V$ , is unable to drive the changes in (20a). Specifically, a requirement that stops (or even consonants in general) must be followed by vowels is not relevant in the mapping  $/-s + \widehat{ts}-/ \rightarrow [-st-]$ .

The patterns in (20), especially (20a), call for a driver militating against adjacent strident segments,  $OCP[+strid]$ . We must also consider additional output candidates that would not violate the high-ranked  $MAXC_{PREV}$ . Specifically, a mapping  $/\widehat{ts} s/ \rightarrow [\widehat{ts}]$  in OT may be interpreted as segmental deletion,  $/\widehat{ts}_1 s_2/ \rightarrow [\widehat{ts}_1]$ , or segmental merger,  $/\widehat{ts}_1 s_2/ \rightarrow [\widehat{ts}_{1,2}]$ . In the latter case, the two input segments correspond to a single output segment. A constraint militating against coalescence is  $UNIFORMITY$  ( $UNIF$ ; McCarthy & Prince 1995).<sup>12</sup> The asymmetry between word-internal and phrase-internal simplification is accounted for by the anchoring constraints targeting the feature  $[+strident]$ ,  $ANCH[+strid]$ , which are analogous to the anchoring constraints targeting the feature  $[-continuant]$  in (15) of Section 3.1. The tableaux in (21) do not include candidates deleting prevocalic segments; I also assume a high-ranked  $MAX(Place)_{PREV}$ , which assures that prevocalic place features are preserved in the output, thus eliminating mappings such as  $/-\widehat{ts}_1 \widehat{tj}_2-/ \rightarrow [-\widehat{ts}_{1,2}-]$ . The constraints  $ANCHL[+strid]_W$  and  $ANCHR[+strid]_W$  are collapsed under a single entry.

(21) Strident simplification

<i>Input</i>	<i>Output</i>	$ANCHL/R[+strid]_W$	$OCP[+strid]$	$UNIF$	$ANCHR[-con]_W$	$MAXC$
(i) $-\widehat{s}_1 + \widehat{ts}_2-$	a. $-\widehat{s}_1 \widehat{ts}_2-$		*!			
	b. $-\widehat{s}_1 t_2-$					
	c. $-\widehat{ts}_2-$					*!
	d. $-\widehat{ts}_{1,2}-$			*!		
	e. $-\widehat{s}_{1,2}-$			*!		
(ii) $-\widehat{ts}_1 s_2-$	a. $-\widehat{ts}_1 s_2-$		*!			
	b. $-\widehat{ts}_{1,2}-$			*		
	c. $-\widehat{s}_{1,2}-$			*	*!	
(iii) $-\widehat{ts}_1 \widehat{tj}_2-$	a. $-\widehat{ts}_1 \widehat{tj}_2-$		*!			
	b. $-\widehat{tj}_{1,2}-$			*		
	c. $-\widehat{tj}_2-$	*!			*	*
	d. $-\widehat{s}_1 t_2-$	*!			*	

<sup>12</sup> From the perspective of the theory, there is no reason why a mapping such as  $/A B/ \rightarrow [B]$  should not be analyzed as segmental merger,  $/A1 B2/ \rightarrow [B1,2]$ , rather than deletion,  $/A1 B2/ \rightarrow [B2]$ . The featural makeup of both  $[B1,2]$  and  $[B2]$  is identical and hence the argument for one interpretation or the other is formal rather than empirical (Wheeler 2005). Second, Basque exhibits both synchronic and diachronic arguments that coalescence is part of its grammar (Hualde *et al.* 1994: 32; Egurtzegi 2013: 164).

<i>Input</i>	<i>Output</i>	ANCHL/R[ <i>strid</i> ] <sub>W</sub>	OCP[ + <i>strid</i> ]	UNIF	ANCHR[– <i>con</i> ] <sub>W</sub>	MAXC
(iv) $-s_1 s_2-$	a. $-s_1 s_2-$		*!			
	b. $-s_{1,2}-$			*		
	c. $-s_2-$	*!				*

In (21i), the only possible winner is candidate (21i-b), which violates a low-ranked MAX[–con] (not listed). In (21ii), (21iii) and (21iv), optional simplification is carried out by the ranking OCP[ + *strid*] >> UNIF. The reverse ranking yields no simplification, which is also attested. A high-ranked anchoring constraint militating against the deletion of the feature [+ *strident*] at word boundaries generates the asymmetry between word-internal and phrase-internal simplification. Accordingly, an affricate following a strident segment becomes a plosive only at the stem level, (21i), but not across word boundaries, (21iii).

To conclude this section, let us examine the predictions of GLA for the dataset discussed so far using mock frequencies. Since we are considering coalescing candidates, such candidates are also included for the phenomena analyzed in Section 3.1. In (22), I omit outputs that delete prevocalic segments/Place features (they have been included in the actual model as they affect the final ranking).

(22) GLA – deletion, coalescence and dissimilation

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
$-t_1 + n_2-$	$-t_1 n_2-$	0	0.007
	$-n_2-$	1	0.993
	$-n_{1,2}-$	0	0
$-\widehat{ts}_1 + t_2-$	$-\widehat{ts}_1 t_2-$	0	0
	$-s_1 t_2-$	1	1
	$-t_2-$	0	0
	$-\widehat{ts}_{1,2}-$	0	0
$-t_1 p_2-$	$-t_1 p_2-$	0.5	0.489
	$-p_2-$	0.5	0.508
	$-p_{1,2}-$	0	0
$-\widehat{ts}_1 t_2-$	$-\widehat{ts}_1 t_2-$	0.5	0.472
	$-s_1 t_2-$	0.5	0.526
	$-t_2-$	0	0
	$-t_{1,2}-$	0	0
	$-\widehat{ts}_{1,2}-$	0	0.002

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
-t	-t	1	0.993
	-∅	0	0.007
$\widehat{-ts}$	$\widehat{-ts}$	0.67	0.500
	-s	0.33	0.500
	-∅	0	0
$s_1 + \widehat{ts}_2$	$-s_1 \widehat{ts}_2^-$	0	0.005
	$-s_1 t_2^-$	1	0.990
	$\widehat{-ts}_2^-$	0	0
	$\widehat{-ts}_{1,2}^-$	0	0.005
	$-s_{1,2}^-$	0	0
$\widehat{-ts}_1 s_2^-$	$\widehat{-ts}_1 s_2^-$	0.5	0.509
	$-s_2^-$	0	0
	$-s_{1,2}^-$	0	0
	$\widehat{-ts}_1^-$	0	0.002
	$\widehat{-ts}_{1,2}^-$	0.5	0.488
$\widehat{-ts}_1 \widehat{tj}_2^-$	$\widehat{-ts}_1 \widehat{tj}_2^-$	0.5	0.508
	$-s_1 t_2^-$	0	0.003
	$\widehat{-tj}_2^-$	0	0.002
	$\widehat{-tj}_{1,2}^-$	0.5	0.487
	$\widehat{-ts}_{1,2}^-$	0	0
$-s_1 s_2^-$	$-s_1 s_2^-$	0.5	0.511
	$-s_2^-$	0	0.002
	$-s_{1,2}^-$	0.5	0.488

The ranking found in the model is given in (23).

(23) Ranking values – deletion, coalescence and dissimilation

<i>Constraint</i>	<i>Ranking value</i>
ANCHR[strid] <sub>w</sub>	116
ANCHL[strid] <sub>w</sub>	115
MaxC <sub>prev</sub>	110
ANCHR <sub>p</sub>	110
UNIF	109

<i>Constraint</i>	<i>Ranking value</i>
OCP[ +strid]	109
MAX(Place) <sub>PreV</sub>	104
T → V	103
ANCHR[-con] <sub>w</sub>	103
MAX[ +strid]	102
ANCHR[strid] <sub>p</sub>	100
ANCHR[-con] <sub>p</sub>	100
ANCHR <sub>w</sub>	99
MAXC	96
MAX[-con]	80

The ranking values in (23) do not reflect the hierarchy proposed by Côté (2000), where phrase-internal processes are more likely than phrase-final processes. Specifically, some of the anchoring constraints targeting phrase-final constituents are ranked below the anchoring constraints targeting the same constituents phrase-internally, e.g., ANCHR[strid]<sub>w</sub> significantly outranks ANCHR[strid]<sub>p</sub>. This might be due to the mock nature of the model. The goal of the presented GLA models is to test whether the proposed constraint set can theoretically generate all and only attested outputs in a single probabilistic evaluation. Therefore, the quantity of mappings as well as almost categorical frequencies do not reflect the actual grammar. Importantly, the same GLA model with established *a priori* rankings (ANCH<sub>p</sub> >> ANCH<sub>w</sub>) also yields satisfactory results, reflecting the input frequencies in the generated frequencies. This means that the proposed constraint set has a potential of accounting for the real corpus data. Quantitative evaluation of the model, however, falls beyond the scope of this paper.

The GLA model in (23) also attests to the existence of two conspiracies governing cluster simplification in Basque. When considered within a single grammar, the simplification of clusters involving two strident segments is triggered by OCP[ +strid], while the remainder of cluster simplification is driven by T → V.

The competing positional markedness model proves inferior also when strident clusters are included, as shown in (24).

(24) GLA – deletion, coalescence and dissimilation – conditional licensing

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
-t <sub>1</sub> + n <sub>2</sub> -	-t <sub>1</sub> n <sub>2</sub> -	0	0
	-n <sub>2</sub> -	1	0.984
	-n <sub>1,2</sub> -	0	0.016

<i>Input</i>	<i>Output</i>	<i>Input Freq.</i>	<i>Generated Freq.</i>
$\widehat{-ts_1 + t_2}$	$\widehat{-ts_1 t_2}$	0	0
	$-s_1 t_2$	1	1
	$-t_2$	0	0
	$\widehat{-ts_{1,2}}$	0	0
$-t_1 p_2$	$-t_1 p_2$	0.5	0.742
	$-p_2$	0.5	0.258
	$-p_{1,2}$	0	0.001
$\widehat{-ts_1 t_2}$	$\widehat{-ts_1 t_2}$	0.5	0.192
	$-s_1 t_2$	0.5	0.808
	$-t_2$	0	0
	$-t_{1,2}$	0	0
	$\widehat{-ts_{1,2}}$	0	0
$-t$	$-t$	1	0.957
	$-\emptyset$	0	0.043
$\widehat{-ts}$	$\widehat{-ts}$	0.67	0.559
	$-s$	0.33	0.441
	$-\emptyset$	0	0
$s_1 + \widehat{ts_2}$	$-s_1 \widehat{ts_2}$	0	0.44
	$-s_1 t_2$	1	0.22
	$\widehat{-ts_2}$	0	0
	$\widehat{-ts_{1,2}}$	0	0.34
	$-s_{1,2}$	0	0
$\widehat{-ts_1 s_2}$	$\widehat{-ts_1 s_2}$	0.5	0.443
	$-s_2$	0	0.220
	$-s_{1,2}$	0	0
	$\widehat{-ts_{1,2}}$	0.5	0.338
$\widehat{-ts_1 \widehat{tj_2}}$	$\widehat{-ts_1 \widehat{tj_2}}$	0.5	0.442
	$-s_1 t_2$	0	0.220
	$\widehat{-tj_2}$	0	0
	$\widehat{-tj_{1,2}}$	0.5	0.338
	$\widehat{-ts_{1,2}}$	0	0
$-s_1 s_2$	$-s_1 s_2$	0.5	0.443
	$-s_2$	0	0.219
	$-s_{1,2}$	0.5	0.338

The ranking found for this model is given in (25).<sup>13</sup>

(25) Ranking values – deletion, coalescence and dissimilation – conditional licensing<sup>13</sup>

<i>Constraint</i>	<i>Ranking value</i>
$T]_{\emptyset} \rightarrow V$	110
MAX[ +strid]	106
UNIF	106
OCP[ +strid]	105
MAXC <sub>PREV</sub>	102
MAX(Place) <sub>PREV</sub>	100
MAXC	99
$T]_w \rightarrow V$	98
MAX[-con]	95
$T]_p \rightarrow V$	95

It is clear that the results in (24) are not satisfactory. While phrase-final deletion is no longer a problem, the constraint set in (25) generates some unattested mappings when it comes to strident clusters. Specifically, the asymmetry between word-internal and phrase-internal simplification is not captured. The model incorrectly predicts optional simplification across morpheme boundaries, with  $/-s + \widehat{ts}/$  yielding three possible outputs:  $*[-s_1 \widehat{ts}_2-]$ ,  $[-s_1 t_2-]$  and  $*[-\widehat{ts}_{1,2}-]$ . Additionally, it incorrectly predicts word-initial deaffrication,  $/-\widehat{ts}_1 \widehat{t}_2-/ \sim *[-s_1 t_2-]$  as well as word-final affricate deletion,  $/-\widehat{ts}_1 s_2-/ \rightarrow *[-s_2-]$ . The principal issue with the constraints employed in (24) is that they are unable to distinguish between edge and non-edge stridents. The analysis may be salvaged by employing the relevant anchoring constraints targeting strident segments (ANCHOR[strid]). However, such an operation seems to create a redundancy from the perspective of the model based on anchoring alone, which yields satisfactory results by using anchoring without the additional set of conditional licensing.

The following subsection verifies the predictions of the positional faithfulness model with regards to vowel epenthesis, another strategy of avoiding non-prevocalic stops in some dialects of Basque.

### 3.3 Vowel epenthesis

As discussed in Côté (1999; 2000), Ondarroa Basque exhibits *a*-insertion instead of consonant deletion in clusters, which constitutes a different strategy of avoiding non-prevocalic stops. Consider the data in (26) adduced in Côté (2000).

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<sup>13</sup> Relativizing OCP[ +strid] to different prosodic domains yields almost identical, unsatisfactory, results.

(26) Vowel epenthesis (Côté 2000: 313–314)<sup>14</sup>

a.	/eskats + tʃo/	→ [ekatsatʃo]	‘kitchen’ (dim.)
	/kokot + tʃo/	→ [kokotatʃo]	‘neck’ (dim.)
b.	/eskats bat/	~ [eskatsabat] ~ [eskasbat]	‘a kitchen’
	/kokot bat/	~ [kokotabat]	‘a neck’
c.	/eskats/	~ [eskats]	‘kitchen’
	/kokot/	~ [kokot]	‘neck’

Similarly as in the case of cluster simplification discussed in the preceding sections, vowel insertion across morpheme boundaries, (26a), is obligatory. Phrase-internally, (26b), epenthesis is optional and fully faithful clusters may also emerge. Phrase-finally, (26c), stops and affricates are mapped faithfully, although epenthesis may marginally occur.

Côté (2000) successfully analyzes the mappings in (26) using positional markedness constraints relativized to prosodic boundaries (see (1), Section 1). However, since positional markedness proves problematic for the mappings outlined in Sections 3.1 and 3.2, the question remains whether the analysis advocated in the current paper yields satisfactory results when it comes to epenthesis. Consider the evaluation of the mappings in (26) given in (27) under the constraint set proposed in the preceding sections. The constraint DEP-*a* militates against *a*-insertion (after Côté 2000). Wiggly lines denote optional reranking; ANCHR<sub>p</sub> and ANCHR<sub>w</sub> are abbreviated to ANCHR<sub>p/w</sub> to save space.

## (27) Epenthesis

<i>Input</i>	<i>Output</i>	ANCHR [-con] <sub>p</sub>	T→V	ANCHR [-con] <sub>w</sub>	MAXC	MAX [-con]	ANCHR <sub>p/w</sub>	DEP- <i>a</i>
(i) -ts + tʃ-	a. -tstʃ-		*!					
	b.  -tsatʃ-							*
	c. -stʃ-					*!		
(ii) -t + tʃ-	a. -ttʃ-		*!					
	b.  -tatʃ-							*
	c. -tʃ-				*!	*		
(iii) -ts b-	a.  -ts b-		*!					
	b.  -tsa b-			*			*	*
	c.  -s b-			*			*!	

<sup>14</sup> This is not the entire dataset analyzed by Côté (2000), who also considers mappings that exemplify the effects of the avoidance of non-prevocalic fricatives. Since this output requirement is not observed in the dialects analyzed in this paper, I focus on the conspiracy against non-prevocalic stops.

<i>Input</i>	<i>Output</i>	ANCHR [-con] <sub>p</sub>	T→V	ANCHR [-con] <sub>w</sub>	MAXC	MAX [-con]	ANCHR <sub>p/w</sub>	DEP-a
(iv) -t b-	a. $\text{[t̥]}-t b-$		*!					
	b. $\text{[t̥]}-ta b-$			*			*	*
	c. - b-			*	*!	*	*	
(v) -ts̃	a. $\text{[t̥]}-ts̃$		*					
	b. ?-ts̃a	*!		*			**	*
	c. -s	*!		*		*		
	d. -∅	*!		*	*	*	**	
(vi) -t	a. $\text{[t̥]}-t$		*					
	b. ?-ta	*!		*			**	*
	c. -∅	*!		*	*	*	**	

The ranking argument in (27) generates all and only attested outputs. MAX[-con] may be optionally ranked below ANCHR<sub>p/w</sub> in order to generate affricate spirantization instead of vowel epenthesis in (27iii). The ranking T → V >> ANCHR[-con]<sub>w</sub> assures the avoidance of non-prevocalic stops phrase-internally; the reverse ranking yields the fully faithful outputs in (27iii) and (27iv). Finally, phrase-final faithfulness is guaranteed by a high-ranked ANCHR[-con]<sub>p</sub>. Marginal epenthesis is possible after the promotion of T → V to an undominated position.

### 3.4 Voiced stop lenition and voice assimilation

The final processes to be considered are voiced stop lenition and voice assimilation. These processes may interact with stop deletion as well as affricate spirantization and hence must be included in the uniform model. It is shown that such interaction is not problematic for the proposed constraint set in parallel OT. The analysis presented in this section includes the most frequent mappings and hence does not constitute an exhaustive account of voicing effects in Basque.

In Basque, voiced stops are in complementary distribution with their non-strident continuant counterparts, as shown in (28). The former surface before non-continuant or a pause, (28)b; the latter surface when preceded by a [+continuant] segment, (28)a.<sup>15</sup>

(28) Voiced stop lenition (Hualde 1991: 100)

- a. [aβere] ‘cattle’ [arβi] ‘turnip’ [dezβerðin] ‘uneven’  
 [aðar] ‘horn’ [arði] ‘sheep’ [ezðuin] ‘unworthy’  
 [layun] ‘friend’ [arɣi] ‘light’ [dezɣoɣo] ‘reluctance’

<sup>15</sup> Voiced stop lenition may depend on various factors, such as speech style or tempo (Saadah 2011). I do not include these details in the analysis and instead focus on the process interaction.

- b. [embora] ‘trunk’      [beri] ‘new’  
       [mendi] ‘mountain’ [dore] ‘tower’  
       [anjo] ‘of there’    [gori] ‘red’

Voiced stop lenition is active across word boundaries (Hualde 2003: §2.1.4.6). Accordingly, word-initial stops undergo lenition when preceded by vowels or continuant consonants, e.g., *ze[r d]a* → [r ð] ‘what is’.

Another relevant process affecting consonant clusters in Basque is voice assimilation, exemplified in (29).

(29) Voice assimilation

- poze[s b]ete*      → [z β]      ‘filled with joy’  
*e[s d]akit*        → [z ð]/[s t] ‘I don’t know’  
*gainditzea[s g]ain* → [z γ]      ‘in addition to passing’

Based on the data in (29) we can formulate a generalization that voiceless fricatives become voiced before voiced obstruents. An alternative strategy of assimilation is progressive devoicing; however, it is far less common and it is predominantly found with the negative particle [es], e.g., *e[s d]ago* → [s t] ‘there is no’. Voice assimilation effects are also observed for stops, e.g., *du[t b]este* → [ð β] ‘have another’; however, since deletion of preconsonantal stops is a prevalent phenomenon in Basque, stop voicing may be less frequent than fricative voicing (Hualde *et al.* 2019: §6.2). Progressive devoicing of stops, on the other hand, is predominantly found word-internally, e.g., *bat + batean* > *ba[p]atean* ‘suddenly’.

Lenition and voice assimilation interact with stop deletion and affricate spirantization discussed in the preceding sections, as documented by the data in (30).

(30) Process interaction

- a. *bat da*                ~ [ð]      ‘is one’  
       *bizirik dagoen*    ~ [ð]      ‘alive (is)’  
       *hasieratik bertatik* ~ [β]      ‘from the beginning’  
       *guztiak bezalaxe* ~ [β]      ‘like all’
- b. *ho[ts̄ b]at*            ~ [z β]    ‘a cold’  
       *zuhai[ts̄ b]atzuk*    ~ [z β]    ‘some trees’  
       *hi[ts̄ b]at*             ~ [z β]    ‘a word’  
       *Ekai[ts̄ g]oikoetxea* ~ [z γ]    ‘proper name’  
       *hi[ts̄ g]ehiago*      ~ [z γ]    ‘more words’

The fact that voiced stops become [+continuant] when preceded by [+continuant] segments in (30) may be attributed to a markedness constraint LENITION (LEN), banning sequences of continuants followed by voiced oral stops (cf. Broś 2018 for Spanish lenition in OT). The voicing

effects in (29) and (30b), on the other hand, may be analyzed in terms of an additional output requirement that adjacent consonants must agree in voicing, AGREE[±vc] (Lombardi 1999). The competing faithfulness constraint is MAX[±vc]. The asymmetry between word-internal and phrase-internal assimilation effects is captured by anchoring constraints targeting edge [±voice] features. Finally, we need to include an inventory constraint militating against non-strident fricatives in order to distinguish between stop lenition and stop deletion. Consider the evaluation in (31).

(31) Lenition and voice assimilation

Input	Output	T→V	ANCHR [-con] <sub>w</sub>	ANCHL [+vc] <sub>w</sub>	LEN	AGREE [±vc]	MAX [-vc]	MAX [-con]	*[+con, -strid]	MAXC
(i) -t + b-	a. -t b-	*!				*				
	b. -b-				*!		*	*		*
	c. [ɸ]-p-							*		*
	d. -β-						*!	**	*	*
(ii) -t b-	a. ([ɸ])-t b-	*!				*				
	b. -b-		*		*!		*	*		*
	c. -p-		*	*!				*		*
	d. ([ɸ])-ð β-		*				*	**	**!	
	e. [ɸ]-β-		*				*	**	*	*
(iii) -ts b-	a. ([ɸ])-ts b-	*!				*				
	b. -ts p-	*!		*						
	c. -z b-		*		*!		*	*		
	d. [ɸ]-z β-		*				*	**	*	
	e. -s β-		*			*!		**	*	
	f. -s p-		*	*!				*		
(iv) -s b-	a. -s b-				*!	*				
	b. [ɸ]-z β-						*	*	*	
	c. -s p-			*!						

Simplification across morpheme boundaries in (31i) preserves the feature [-voice] on the surface. Effectively, candidate (31i-c) does not violate MAX[-vc] as this feature is realized in the output. As established in Section 3.1, the choice between cluster simplification and the fully faithful outputs in (31ii) and (31iii) is carried out by the probabilistic ranking of T → V and ANCHR[-con]<sub>w</sub>. The candidates preserving the quality of the underlying voiced stops after simplification,

(31ii-b) and (31iii-c), are eliminated by LEN in favor of candidates (31ii-d)/(31ii-e) and (31iii-d), which exhibit lenition. The remaining candidates, (31ii-c) as well as (31iii-e) and (31iii-f), are excluded by ANCHL[+vc]<sub>w</sub> or AGREE[±vc]. Regressive voice assimilation *cum* lenition in fricative-stop clusters, (31iv-b), is due to the interaction of ANCHL[+vc]<sub>w</sub>, LEN and AGREE[±vc] with the lower-ranked faithfulness constraints.

It is evident that Basque exhibits voice assimilation, but not at all cost. Such assimilation does not yield voiced affricates (due to inventory restrictions; Hualde 1991) and tends to preserve the feature [+voice] rather than [-voice] (at least in fricatives; see Hualde & Bilbao 1992). Furthermore, AGREE[±vc] does not trigger cluster simplification, but only the voicing effects. This is a desired result in regards to the too-many-solutions problem (Steriade 2009): from the perspective of language typology, deletion is not a strategy of satisfying the requirements of voice assimilation.

The voicing effects as well as lenition found in Basque entail some additional mappings (e.g., Hualde *et al.* 2019). However, the intricacies of this topic merit a separate in-depth analysis. Further research is needed to account for the complexity of these data in OT.

## 4 Summary and conclusions

Basque cluster simplification exhibits two conspiracies: against non-prevocalic stops and against adjacent stridents. Different strategies of satisfying the former involve stop deletion, affricate spirantization and vowel epenthesis, depending on the dialect. The latter requirement is principally satisfied by deaffrication and coalescence. In both conspiracies, prosodic domains play a crucial role in the application of simplification/epenthesis. Non-prevocalic stops are obligatorily avoided word-internally and optionally avoided phrase-internally and phrase-finally, with phrase-final deletion of plosives being banned by higher-ranked faithfulness constraints. Similarly, strident clusters are categorically prohibited word-internally and optionally elsewhere. An additional asymmetry with respect to strident-affricate clusters is the choice of the strategy of satisfying OCP[+strid]: deaffrication is only possible word-internally.

It has been shown that an analysis based on morphology-prosody anchoring is superior to previous analyses employing positional markedness. The former is able to generate all and only attested outputs within a single probabilistic OT evaluation. The latter, on the other hand, is unable to capture the asymmetries between different domains within a unified grammar. Additionally, the use of a set of positional markedness constraints relativized to different prosodic domains obscures the conspiracy. On this view, word-internal, phrase-internal and phrase-final simplification/epenthesis are formally different processes since they are driven by different markedness constraints. The formal account of conspiracies has been one of the arguments against rule-based phonology and in favor of OT (e.g., McCarthy 2002). The model based on

anchoring constraints, on the other hand, unifies the two conspiracies under their respective drivers: non-prevocalic stops are penalized by  $T \rightarrow V$ , while adjacent stridents are penalized by OCP[+strid]. The rate of application as well as the choice of the strategy depends on the faithfulness constraints, especially from the ANCHOR family. Finally, it has been shown that the proposed constraint set is able to account for two additional processes affecting consonant clusters in Basque: voiced stop lenition and voice assimilation, which interact with stop deletion and affricate spirantization.

There are two outstanding issues that fall beyond the scope of the current paper. First, the hypothesis of  $T \rightarrow V$  being the driver of stop deletion entails that stops are equally deleted before continuant and non-continuant segments phrase-internally. If there is a significant asymmetry regarding the rate of deletion in these contexts, a single driver is most likely insufficient to account for the data. Second, the presented GLA models serve to illustrate the predictions of a unified probabilistic grammar using almost categorical frequencies and a limited set of inputs. The question remains whether these models would be able to successfully account for the real corpus data.

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## Abbreviations

OT = Optimality Theory, GLA = Gradual Learning Algorithm, W = Word, P = Phrase, [ $\pm$  con] = [ $\pm$  continuant], [ $\pm$  strid] = [ $\pm$  strident], [ $\pm$  vc] = [ $\pm$  voice], PreV = prevocalic, ANCH = ANCHOR, L = left, R = right, UNIF = UNIFORMITY, LEN = LENITION

## Supplementary Files

Appendix: spectrograms and waveforms of the selected examples. DOI: <https://doi.org/10.16995/glossa.25098.s1>

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## Competing interests

The author has no competing interests to declare.

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