

The Posteriorization of Palato-Alveolar Fricatives in Quebec French: An Effort-Based Approach

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Abstract: Recent developments in phonology offer promising avenues for analysing posteriorization of palato-alveolar fricatives in Quebec French (QF). I will provide a formal phonological account grounded in Optimality Theory (Prince & Smolensky, 2004). Posteriorization in QF is relevant for several issues that are currently debated, especially within functionally oriented approaches to phonology: ease of articulation (e.g. Kirchner 1998, 2004; Hayes, 1999), dispersion theory (e.g. Flemming 1995), and systemic contrast (e.g. Padgett 2003). I will examine three approaches that could be suitable to explain the phenomenon: a symmetry approach inspired by Hull (1960), a perceptual distinctiveness of contrasts approach based on Flemming's (1995) dispersion theory, and an effort-based approach inspired by Kirchner (1998, 2004). My analysis will be developed with the effort-based approach using a floating constraint (Reynolds 1994) that will be crucially unranked to allow variation in the output (See Anttila 2002 for a review of variation in OT).

Keywords: posteriorization, debuccalization, palato-alveolar/alveo-palatal fricatives, Quebec French

1. Introduction

In Quebec French (QF) the palato-alveolar fricatives /ʃ ʒ/ are sometimes produced with a more posterior articulation, as exemplified in (1). According to Charbonneau (1957) and Hull (1960, 1966), the segments [h] and [ɦ] are the most frequent variants of this articulation.

(1)	French word	Translation	Phonological representation	Result of posteriorization
a.	<i>manger</i>	'to eat'	/mãʒe/	[mãɦe]
b.	<i>marcher</i>	'to walk'	/marʃe/	[marɦe]
c.	<i>jupe</i>	'skirt'	/ʒyp/	[ɦɥp]

The numerous allophonic variants of these phonemes gave rise to a rich nomenclature for the phenomenon among which we find the terms aspiration (Vinay 1973, Hansen 1988, Bittner 1995), spirantization¹ (Charbonneau 1957),

¹ Spirantization does not seem to be an appropriate term for this process and Charbonneau does not explain why he uses it. Bittner (1995) suggests that he might have approached the phenomenon with a definition of spirant *à la* Martinet (1956). Martinet's view was that spirant is a more vocalic and lax articulation than the common fricative.

velarization (Holder 1972), and mellowing (Brent 1971, Walker 1984). Debuccalization is also a possible term since the phonemes seem to undergo a process in which they lose their oral articulation to keep only a glottal component. In fact, in many languages, phenomena like the one that occurs in QF are called debuccalization. The difference here is that some of the allophonic variants retain an oral component; therefore, I will not adopt this term. Finally, lenition is another term that could be proposed. However, I prefer to restrict its use to that of a metaterm that includes other phenomena like debuccalization, spirantization, voicing, etc. This sort of posteriorization should nevertheless be considered a type of lenition because it corresponds to a reduction in the degree of constriction.

The phenomenon is spread around in a somewhat unpredictable fashion throughout the province of Quebec, Ontario (Holder 1972, Hull 1966), and New-Brunswick, in Louisiana (Hull, 1966) and in certain areas of western France (Charbonneau 1957, Chidaine 1967, Vinay 1973). Concerning Quebec, Hansen (1988) points out that there is no place where French speakers posteriorize systematically; that is, the process is always variable. Posteriorization tends to be more common in rural areas than in urban ones (Charbonneau, 1957) and for people of lower economic class rather than people belonging to the middle and superior classes (Hansen 1988). Concerning the education factor, people who received only an elementary education posteriorize generally more than those who received a secondary or post-secondary education. Finally, men posteriorize three times more than women. Strangely, even if posteriorization is stigmatized in QF (Hull 1966, Morgan 1975), only people from the lowest socio-economic class have a lower rate of posteriorization when they attempt to speak in a more formal register (Hansen 1988).²

Apart from the work of Charbonneau (1957), posteriorization has not been the focus of any in depth phonological analysis. I propose to undertake this task here using the recent progress in phonology to shed a new light into the complexity of

² A note of caution about Hansen's (1988) conclusions should be given here. Her study is based on the pronunciation of eight speakers only, with 100 tokens of /ʒ/ from each of them. It is possible that a study including more speakers and more tokens would be able to show a finer distinction between the social groups. Also a study of more stylistic contexts on more subjects with more tokens might be able to show a stylistic effect in all of the social groups.

the phenomenon. I start by re-examining the allophones of posteriorization and their distribution. Then, I will discuss three approaches that could potentially account for the phenomenon and finally, I will propose an analysis using an effort-based approach inspired by Kirchner (1998, 2004).

2. Re-examination of the data

I will first look at the different allophones of the phonemes /ʒ ʒ/ that lead to the rich nomenclature for the phenomenon. Then, I will examine their phonological and morphological distribution in an attempt to establish patterns. My observations will lead to the conclusion that we cannot determine precise and systematic contexts for posteriorization. However, tendencies clearly emerge as it appears to be more or less productive in different phonological environments.

2.1 Allophonic variants

For the phoneme /ʒ/, we can count a great variety of allophones proposed by different authors in addition to the standard allophone [ʒ]. We can separate the authors into two major groups: those who mention only the most widespread posteriorized variant [ɸ] (Hull 1960, Vinay 1973, Walker 1984) and those who also recognize other posteriorized variants (Charbonneau 1957, Brent 1971, Morgan 1975). This last group acknowledge a variant situated between [ʒ] and [ɸ] that I will note as [ʒ^h]. Charbonneau (1957) describes it as a partially voiceless [ʒ] followed by [ɸ] whereas Brent (1971) and Morgan (1975) talk about double constriction. Finally, Morgan (1975) adds that there may be various intermediate articulation between the three variants already proposed [ʒ...ʒ^h...ɸ] while Charbonneau (1957) is more specific about those variants. He mentions that it can be partially devoiced word-initially [ʒ^h] and word-finally [ʒ^h]. He further presents a voiceless velar fricative [x] as a variant for /ʒ/ even though it was present in very low frequency in his subjects. Finally, he presents a nasal [ɸ] as a separate allophone, but since the only example he provides is preceding a nasal vowel, I will consider that the nasal feature spreads onto the consonant as a result of coarticulation.

There is less information about the allophones of /ʃ/, because it has not been the focus of special attention like /ʒ/. Hull (1960) and Morgan (1975) count the voiceless glottal fricative [h] amongst the variants of /ʃ/ whereas Vinay (1973) and Walker (1984) argue that its posteriorized variant is still in contrast with the *h*

aspire that is sometimes pronounced as [h] in a few regions in Quebec. They therefore give the voiceless velar [x] as the posteriorized form for /ʃ/. Hull (1960) and Brent (1971) also mention this variant, but it is clearly not the only posteriorized form of /ʃ/ for them. Finally, Brent (1971) proposes [ʃ^x] as an intermediate variant between [ʃ x]. Morgan (1975) follows with [ʃ^h] as an intermediate variant between [ʃ] and [h]. He also adds there may be other intermediate articulations between the allophones [ʃ...ʃ^h...h]. Again, they both talk about double constriction for the intermediate variant [ʃ^h].

Here is a summary of the allophonic variants by phoneme and author:

Table 1 - The allophones of /ʒ/ and /ʃ/ according to different authors³

Variants →	/ʒ/						/ʃ/			
Authors ↓	[ʒ]	[ʒ̠]/[ʒ̠ʰ]	[ʒ ^h]/[ʒ ^{h̥}]	[x]	[h]	[h̥]	[ʃ]	[ʃ ^h]	[x]	[h]
Charbonneau (1957)	x	x	x	x	x	x				
Hull (1960)	x				x		x		x	x
Brent (1971)	x		x		x		x	x	x	
Morgan (1975)	x	...	x	...	x		x	x	...	x
Vinay (1973)	x				x		x		x	
Walker (1984)	x				x		x		x	

Definitely, there is no agreement amongst authors as to what the posteriorized variants of the palato-alveolar fricatives are in French.⁴ Three factors may be relevant in explaining this heterogeneity: the acoustic variability present in [ʃ ʒ], the segmental context in which /ʃ ʒ/ occurs, and possibly regional variation. Bittner (1995) says that when describing the posteriorization of palato-alveolar fricatives in French, it is a problem to determine its allophones because of the already existing variability in the production of the standard [ʃ ʒ]. This can easily translate into variability in the output to posteriorization as well. As will be described in more detail in the following section, posteriorization is a context-

³ The three dots indicate possible intermediate values, and the dark cells indicate that the author has not investigated this phoneme. The dotted line indicates that the variant is not a completely separate allophone.

⁴ As a reviewer noted, different authors can also have different judgments about the same sounds and this can be reflected in the transcription of fine phonetic details. It was the case here, but for purposes of comparison, an attempt was made at grouping similar allophones together by paying close attention to the written descriptions provided by the authors. Therefore, table 1 actually shows less variation than there probably is in reality.

dependent process. There are reasons to believe that the different variants of posteriorization are also context-dependent. For example, a given allophone may be excluded from certain configurations (Charbonneau 1957, Morgan 1975). As a result, in any given context; the variation observed may not be as great as suggested in Table 1. This issue, however, is beyond the scope of this paper and is left for future research. Finally, there may be regional differences as well, since authors describe the phenomenon as observed in different geographical areas, but these differences have yet to be investigated.

2.2 Phonological contexts

The only available studies which have looked into phonological environments were concerned with the posteriorization of /ʒ/ solely. However, they allow us to get a general idea of which contexts are favourable to the posteriorization of /ʃ/.

Charbonneau (1957) notes that word-finally, the allophone [f̥] is absent, but it does not exclude the presence of other variants (2a). In word-initial position, it is attested and the presence of posterior [ɑ] increases the occurrence of posteriorization (2b more productive than 2c). Word-medially, [f̥] appears at a similar rate.⁵ However, in this position, [f̥] has also been seen in company of vowels such as /i ɔ ã/⁶ and the presence of [ɑ] does not have as much influence as word-initially (2 d-f).

(2)	French word	Translation	Phonological representation	Result of posteriorization
a.	<i>tige</i>	‘stem’ or ‘rod’	/tiʒ/	[tʰiʒ̠]
b.	<i>Jacques</i>	‘Jack’	/ʒɑk/	[f̥ɑk]
c.	<i>gérer</i>	‘to manage’	/ʒere/	[f̥ere]
d.	<i>magique</i>	‘magic’	/maʒik/	[maf̥ik]
e.	<i>édraçonner</i> ⁷	‘to remove the sucker from a plant’	/edraʒɔne/	[edraf̥ɔne]
f.	<i>régenter</i>	‘to domineer over’	/reʒãte/	[ref̥ãte]

⁵ Precise quantitative data were not made available in Charbonneau’s study.

⁶ Charbonneau does not specify the position of these vowels relative to /ʒ/.

⁷ This example is taken from Charbonneau (1957). This word does not exist in dictionaries, it is a construction from the word *drageon* ‘sucker’ and appropriate affixes. It might not be very common today, but in 1957, it probably was, especially in L’Assomption where agriculture is omnipresent.

Finally, Charbonneau (1957) remarks that, in intervocalic position, one can find the most systematic variation between allophones. Hansen (1988) obtained similar results concerning the productivity of posteriorization depending on the position of /ʒ/ in the word. Data extracted from her work and presented in table 2 shows that a context V_V favours posteriorization more than a context _V, V_ or _C, C_. In turn, these last contexts are more favourable to the phenomenon compared to a C_C context. Her results also show that the posteriorization rate increases between identical vowels compared to different vowels. She also examined the importance of the phonological environment (C vs. V) in the preceding and following contexts. A careful analysis of the data she provides suggests that vowels favour posteriorization more than consonant and that the following context has a greater influence on posteriorization.

Table 2 – Contextual productivity of posteriorization

Note concerning token selection	Contexts		Number of occurrences / total of tokens	Percentage of occurrence
Any morphological context	V_V		70/367	19%
Only word-medially		V _x _V _x	18/37	49%
		V _x _V _y	22/77	29%
A vowel only on one side in any morphological context	_V,V_		37/367	10%
At least a vowel on one side in any morphological context		V_	93/659	14%
		_V	84/442	19%
A consonant only on one side in any morphological context	_C,C_		35/363	10%
At least a consonant on one side in any morphological context		C_	11/103	11%
		_C	28/356	8%
Any morphological context	C_C		2/48	4%

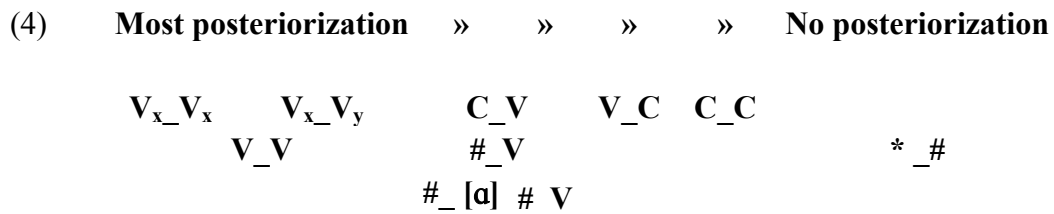
When ranking these contexts according to their productivity, we obtain: _V » V_ » C_ » _C. This suggests the following ranking of the phonological environment, from most productive to least productive: V_V » C_V » V_C » C_C. Although she does not provide detailed rankings, a careful look at the data presented in

figure 5 of her article allowed me to obtain the following: V_V (19% - 70/367) » C_V (16% - 9/54) » V_C (8% - 23/291) » C_C (4% - 2/48).⁸

Here is a summary of the important generalizations made in this section:

- (3) a. The variant [h] never occurs word-finally. (*_#)
(Charbonneau 1957)
- b. Word-initially, it is more frequent when the following vowel is a posterior /a/. (#_[a] » #_V)
(Charbonneau 1957)
- c. It is in word-medially, in intervocalic position that posteriorization is favoured the most. However, in such a context, the influence of the posterior /a/ is not as strong compared to other vowels. (V_V » #_V)
- d. Hansen (1988) notes that surrounding vowels seemed to favour posteriorization more than consonants. (V_V » C_V » V_C » C_C)
- e. Also, Hansen (1988) notes that identical vowels favour posteriorization more than different ones. (V_x_V_x » V_x_V_y)
- f. The following context has more importance the preceding one.

It is now possible to organize these generalizations in a hierarchy of most to least productive contexts.



Note that the generalization presented here are only used to reflect the tendencies discussed by different authors, namely that the more open the flanking segments, the more posteriorization there is. A less detailed ranking (e.g. V_V » {C, #}_V,

⁸ The differences between percentages are small and Hansen does not provide any statistical analysis for her data. Therefore, we don't know if those differences are significant. Note however that the ranking between C_V and V_C that I propose here is not crucial to my analysis.

V_C » C_C » _#) as well as a non-ranking of certain contexts (e.g. C_V vs. V_C) would not affect the outcome of the analysis.

2.3 The grammatical category and the position of /ʒ/ in the word

Hansen⁹ finds that the grammatical category of the word as well as the position of /ʒ/ at word boundary vs. word-medially affects the likelihood of posteriorization. She distinguishes the following contexts: the pronoun *je* ‘I’, adverbs (e.g. *toujours* ‘always’, *aujourd’hui* ‘today’, *déjà* ‘already’), and /ʒ/ word-medially in intervocalic position. However, she notes that there are two categories of speakers who posteriorize palato-alveolar fricatives. The first group, which seems to include half of her speakers¹⁰, has a lower posteriorization rate. These speakers posteriorize mainly *je* (4% - 10/252), followed by /ʒ/ word-medially in intervocalic position (2% - 1/49), and finally adverbs (0% - 0/58). For this group, it is initial /ʒ/ followed by a morphological boundary that favours aspiration the most: "*...le pronom je précédé d'une voyelle et suivi d'un verbe à voyelle favorise plus l'aspiration que le même contexte phonologique sans frontière morphologique*" (Hansen 1988: 192) For example, *j'aimais* ‘I loved’ is more productive than *jamais* ‘never’. The second group, which is composed of the rest of her speakers who have a high posteriorization rate, prefers the reverse order: adverbs (62% - 33/53), then /ʒ/ word-medially in intervocalic position (60% - 39/65), and finally, *je* (18% - 42/229).

No statistical analysis has been carried to verify if these percentages are significant, but Hansen is aware of the important variation between speakers, and suggests that putting the second most favourable context of both groups on top of productivity hierarchy might better reflect reality. Both groups have word-medial contexts in intervocalic position as their second most favourable context. This type of favourable context is explained by two facts. First, vowels favour posteriorization more than consonants (see section 2.2). Second, a word-initial

⁹ She studied only the phoneme /ʒ/.

¹⁰ It is unclear how many speakers are in each group. She does not give an explicit number, but if we refer to figure 2 of her article, half of her speakers qualify for each group based on her criterion. She grouped those who posteriorize 10% and more of the times in one group and those who posteriorize less than 10% of the time in the other group.

and word-final position discourages posteriorization compared to a word-medial /ʒ/.¹¹ The context in (5a) is more productive than the one in (5b) or (5c).

(5)	French word	Translation	Phonological representation	Result of posteriorization
	a. <i>agent</i>	‘agent’	/aʒã/	[aɦã]
	b. <i>Jean</i>	‘John’	/ʒã/	[ɦã]
	c. <i>fromage</i>	‘cheese’	/frɔmaz/	[frɔmaz] ¹²

Unfortunately, beyond the description of the phenomenon, no real attempt to provide an explanation or a formal analysis for this variation has been made, except for Brent (1971), who provides transformational rules, and Hull (1960), who sketches a hypothesis.

3. Three possible approaches

Here, I will quickly explore three explanatory approaches that could be adopted to account for the phonological tendencies that condition posteriorization of palato-alveolar fricatives in QF. First, in section 3.1, I will present Hull's (1960) hypothesis referring to the symmetry of the segment inventory. Then in 3.2, I will look at dispersion theory developed by Flemming (1995) in the OT framework. Finally in 3.3, I will explore an effort-based articulatory approach inspired by Kirchner (1998). This last approach will be adopted for the analysis in section 4 because articulation appears to be a key factor, the only one, which correctly accounts for the observed contextual tendencies.

3.1 Hull (1960) – Symmetry of the consonant inventory

Hull (1960: 22) argues that the whole consonantal system in QF is “not really economical,”¹³ especially if we look at stops compared to fricatives. The labial

¹¹ Hansen talks about morphological boundaries. However, a morphological boundary can also include a verb+suffix boundary. She does not provide any statistics for the productivity of posteriorization in this context, but it is likely that the boundary does not inhibit the phenomenon in this case as words like *mang+er* ‘to eat’, *chang+er* ‘to change’, *couch+er* ‘to lay down’, *juch+er* ‘to go to roost, to perch’ are very commonly posteriorized and yet the palato-alveolars in them are followed by a morphological boundary.

¹² In section 3.2, I have discussed Charbonneau’s claim that posteriorization to [ɦ] does not occur word-finally.

and dento-alveolar oral stops have one nasal and two fricative counterparts. However, the dorsal stops have only a nasal counterpart since /ʒ ʒ/ are coronal. According to Hull (1960), posteriorization increases the symmetry in the consonant system by getting rid of the distinction between dento-alveolars and palato-alveolars. Nowadays, in terms of distinctive features, this translates into the elimination of the feature [anterior], which, in its modern definition found for example in Kenstowicz (1994), is used only to distinguish between the front and back coronal consonants.¹⁴

Table 4 – Phoneme inventory of QF

Place →		Labial	Coronal		Dorsal	Laryngeal
Manner ↓			Dento-alveolar	Palato-alveolar		
Oral stops	Voiceless	p	t		k	
	Voiced	b	d		g	
Nasal stops		m	n		ɲ ¹⁵	
Fricatives	Voiceless	f	s	ʃ	([x])	([h])
	Voiced	v	z	ʒ		[ɦ]
Liquids	Central		(r) ¹⁶		(ʁ)	
	Lateral		l			

However, it is not so clear if posteriorization represents a real economy. It remains to be seen whether the addition of [h ɦ] would require a new feature or whether a single feature may oppose dorsals and laryngeals together from coronals and labials. Hull's (1960) hypothesis fails to explain why the process

¹³ His terminology is borrowed from Martinet (1955).

¹⁴ as opposed to its traditional SPE definition (Chomsky & Halle 1968), according to which all segments are specified for [ant].

¹⁵ The phoneme /ɲ/ is realised as [ɲ] at the end of a syllable in QF (Côté 2005).

¹⁶ The rhotic has several dorsal and coronal variants in QF. These are not relevant in the present discussion.

does not apply systematically to all occurrences of /ʃ ʒ/ and why this need for symmetry does not seem to be consistent across phonological contexts.

3.2 Flemming (1995) – Dispersion Theory

An approach like that of Flemming (1995) could also be useful in explaining the posteriorization process. Flemming explores the perceptual side of the conflict between perception and production in speech. To do so, he observes whole segment inventories and argues that phonological contrasts are dependant on three functional goals (Flemming 1995: 3):

- (7) a. Maximize the number of contrasts
- b. Maximize the distinctiveness of contrasts
- c. Minimize articulatory effort

These goals are transposed into constraints that conflict with each other in an OT framework. Balancing these requirements in different languages with different constraints rankings will give rise to different contrast inventories.

In QF, we can hypothesize that posteriorization serves to increase the distinctiveness of the contrast between /s z/ and the more back pair of fricatives /ʃ ʒ/. To confirm this, we would need to compare the acoustic distinctiveness of the contrast between the pair [s z]–[ʃ ʒ] and pairs like [s z]–[x] and [s z]–[h ɦ] to see whether these last two pairs offer better perceptual distinctiveness. However, even if posteriorization is shown to enhance the perceptual contrast between the two pairs of fricatives, this approach, like Hull's (1960), fails to take into account the contextual tendencies discussed earlier and does not attempt to explain why the process is not systematic. If posteriorization serves to enhance the distinctiveness of contrast between two phonemes, we expect that it will apply preferentially in contexts where this contrast is perceptually weakened, i.e. in contexts where the consonants do not benefit from optimal perceptual cues (for example between two consonants). Wright (2004) explains that the best syllable pattern for the perception of acoustic cues is the CVCV pattern, while the pattern C+glide+V+glide+C is not as optimal, and word-final and preconsonantal consonants are worst sequences. Yet, it is precisely in the most salient context,

between two vowels, that posteriorization is the most productive in QF. So the contextual tendencies observed do not seem to support a perceptual motivation for the posteriorization process. I will therefore explore a different approach, based on articulatory effort, to try explaining those tendencies.

3.3 Kirchner (1998) – An Effort-based approach

We will now turn to an effort-based approach inspired from Kirchner's (1998) approach to consonant lenition. He argues that

lenition patterns are expressed in terms of conflicts between the effort minimization constraint, LAZY, on the one hand, and on the other hand a class of lenition-blocking constraints. The lenition-blocking constraints in turn are divisible into 'faithfulness' constraints (penalizing divergence from identity between underlying representation and corresponding surface form), and 'fortition' constraints (which serve to enhance the salience and robustness of perceptual distinctions. (Kirchner 1998: 27)

(8) LAZY: Minimize articulatory effort. (Kirchner 1998: 39)

Earlier, in section 2.2, the different phonological contexts that are more or less productive for the phenomenon were inventoried and organized in a hierarchy of most productive to least productive contexts. The ranking of those contexts points towards the hypothesis that the phenomenon occurs to ease coarticulation. Therefore, an effort-based approach will be adopted here. As Kirchner (2004: 315) says: "The more open the flanking segments, the greater the displacement (hence effort) required to achieve a given degree of consonantal constriction." If we look at flanking segments in QF, it is exactly what we observe. There is a correlation between the productivity of posteriorization and the openness of the flanking segments: the process is favoured most between two vowels and least between two consonants.

Vowels are pronounced with open articulators. However, the articulation of palato-alveolar fricatives [ʃ ʒ] is quite closed and requires a certain degree of precision. On the other hand, the shape of the vocal tract during the production of

glottal fricatives like [h fi]¹⁷ is highly influenced by surrounding sounds (Keating 1988, as mentioned in Ladefoged & Maddieson, 1996). Therefore, posteriorization can be favoured in this context because it is more economical than to bring articulators close together to pronounce palato-alveolars. This explains why a V_V context favours posteriorization more than any other context be it word-initially (#_V) or when surrounded by a consonant (C_V or V_C) or even two (C_C). This claim is also reinforced by the fact that when the vowels are identical, there is more posteriorization. When posteriorized, the consonant can be produced quickly, without any effort of displacement after the first vowel and there is no need for the speaker to move back the articulators to the same vowel position to pronounce the following one since they did not move for the production of the consonant in the first place. Of course, there are major differences between sequences like [a]_[a] vs. [i]_[i]. There is no doubt that the shape of the vocal tract required for the vowels in a word like [viʃi] *Vichy* ‘a city in France’ is much closer to [ʃ] than in a word like [aʃalɛ] *achaler* ‘to bother’. Almost no displacement, hence effort, is required to move the articulators from [i] to [ʃ] and back to [i]. This is not the case in a sequence like [aʃa]. We could expect further investigations to show a small effect of vowel height in the productivity of posteriorization.

Also, the more consonants there are around the phonemes, the less posteriorization there is (C_V « V_C « C_C). Since the surrounding consonants already require a certain constriction, the palato-alveolar fricatives can be produced with less effort. It was also noted that when the posterior [ɑ] follows a palato-alveolar word-initially, there is more posteriorization than with other vowels. Sequences like [ʃɑ]-[ʒɑ] require more displacement than [ʃ ʒ] followed by a more close vowel like [i y e] between which the articulatory displacement from one segment to the other is smaller. Consequently, posteriorization is relatively more advantageous from the point of view of articulatory effort in the context of [ɑ], the most open vowel, than in the context of other vowels.

¹⁷ The intermediate variants such as [x], [ʃ^h], and [ʒ^h] are not excluded from the analysis; they only occur less frequently and are probably more dependant on the place of articulation of flanking segments. To keep the discussion simple, I will consider only the most natural and most frequent glottal variants [h fi].

The effort-based approach is also supported by the fact that the process specifically targets fricatives. Of course, an approach concerned with the symmetry of the inventory like that of Hull (1960) has the advantage of explaining straightforwardly why only fricatives and not stops are affected. However, there is also a plausible explanation in an effort-based approach. Posteriorization favours fricatives in QF because it would not be as beneficial for stops. The pronunciation of fricatives requires precise movement than that of stops. In fact, Ladefoged & Maddieson (1996: 137) say: “A stop closure will produce more or less the same sound as long as it is complete, irrespective of whether there is firm or light articulatory contact. In a fricative a variation of one millimetre in the position of the target makes a great deal of difference.” This markedness is also reflected in languages which do not have fricatives as part of their consonant inventories, notably most Australian languages (Hamilton 1996). Yet, languages containing fricatives but no stops are unattested. In QF, posteriorization to [h ñ] eliminates the need for articulatory precision¹⁸ required to produce the fricatives /ʒ ʒ/ and to distinguish them from /s z/.

The choice for an effort-based approach can therefore be justified by two main factors: displacement and precision. First, the contextual tendencies favour posteriorization in environments requiring greater displacement. Second, fricatives, the targeted segments, can be considered to require more precise articulatory movement than other type of segments. Posteriorization can be seen as an attempt to reduce the effort cost that greater displacement and precision require.

4. The Analysis

4.1 Markedness constraints

The markedness constraint I use is very similar to Kirchner’s (2004) LAZY constraint except that his also contains information about the segment affected by effort minimization and speech register. He presents his constraints in the format

¹⁸ Since the shape of the vocal tract during the production of glottal fricatives is highly influenced by surrounding sounds (Keating 1988, as mentioned in Ladefoged & Maddieson, 1996), it is to be expected that their production requires less precision

in (9) “where *C* refers to some class of consonant, *K* to some context, and *R* to some rate of speech” (Kirchner 2004: 321).

(9) LAZY (*C*, *K*, *R*)

(10) LAZY (*C*, *K*, *R*) » LAZY (*C'*, *K'*, *R'*) (Kirchner 2004: 321)

The universal ranking in (10) represents the relative effects of the constriction degree, the flanking segments, and the speech rate and register. In the remainder of this section, I explore each of these variables.

For Kirchner (2004), the class of consonant *C* is a more constricted class of consonant than *C'*

(11) LAZY (stops, *K*, *R*) » LAZY (fricatives, *K*, *R*)

Note that he uses these constraints to explain lenition in Florentine Italian. According to him, the higher the degree of consonantal constriction, the more likely lenition is to occur to minimize effort. Therefore he ranks his constraints militating for a less effortful pronunciation of more closed sounds like stops higher than that of more opened sounds like fricatives. If we do this too, we should expect stops to undergo posteriorization before fricatives do in French. It works well in a language where all types of consonants lenite like in Florentine Italian, but this is not the case in QF where posteriorization preferentially affect fricatives rather than stops. I propose the two LAZY constraints in (12), which specify the affected segments, and the ranking in (13), which may be obtained if effort is based not only on displacement, as in Kirchner, but also on precision.

(12) LAZY_{fricatives}: Minimize articulatory effort in fricatives
LAZY_{stops}: Minimize articulatory effort in stops

(13) LAZY_{fricatives} » LAZY_{stops}

To simplify the presentation of the analysis, the specifications in the constraints in (12) will be omitted in the tableaux. The $LAZY_{stops}$ constraint will be ranked too low to affect the output and trigger the lenition of stops.

In Kirchner's (2004) analysis, the flanking segments favour lenition when they are more open. He presents the context K as a more open context than the context K' . It is also the case in QF. The contexts favouring posteriorization discussed in 2.2 can be translated in a set of LAZY constraints (15), which follow the general format in (14).

(14) $LAZY(X_Y)$: minimize articulatory effort from one segment to the next in context X_Y .

- | | | | | |
|------|----|------------------|----|------------------|
| (15) | a. | $LAZY(V_x_V_x)$ | e. | $LAZY(C_C)$ |
| | b. | $LAZY(V_x_V_y)$ | f. | $LAZY(\#_ [a])$ |
| | c. | $LAZY(C_V)$ | g. | $LAZY(\#_V)$ |
| | d. | $LAZY(V_C)$ | h. | $LAZY(_ \#)$ |

Those are ranked in (16). The ranking can be considered universal since it follows from Kirchner's statement about the fact that the displacement effort required to pronounce a sound depends on the openness of flanking segments.

- (16) Ranking of LAZY constraints¹⁹
 $LAZY(V_x_V_x) \gg LAZY(V_x_V_y) \gg LAZY(C_V) , LAZY(\#_ [a]) \gg$
 $LAZY(\#_V) \gg LAZY(V_C) \gg LAZY(C_C) \gg LAZY(_ \#)$

To have a better idea of the way the variables work within the constraints, here is what we would obtain if we were to present constraints with information about the type of segments that posteriorize.

- (17) Ranking of LAZY constraints
 $LAZY(\text{fricatives}, V_x_V_x) \gg LAZY(\text{fricatives}, V_x_V_y) \gg (\dots)$
 $LAZY(\text{stops}, V_x_V_x) \gg LAZY(\text{stops}, V_x_V_y) \dots$

¹⁹ The information about posteriorization in QF does not allow us to determine if a context C_V is more or less productive than a context $\#_ [a]$. Therefore I have ranked the context C_V at the same level as $\#_ [a]$.

Finally, Kirchner (2004) has information that allows him to conclude that the faster the speech rate and the lower the speech register, the more lenition there is. He formalizes this in his analysis with the variable *R*. A speaker employs a faster or more casual speech in a register *R* than in a register *R'*. This ranking allows more lenition in the lower registers than in the higher ones. However, in the case at hand, I do not have enough detailed information about the stylistic factor to include it in the analysis in the way he does. Moreover, taking the variation between registers into account has a major inconvenience because registers are not finite. Therefore, using this variable poses an important computational problem because it creates a potentially infinite number of constraints. Also, including registers in the constraints creates a tool that is so powerful that it risks over predicting. Solutions to this problem could be the object of further investigations, but I will leave the matter aside for now as it is not in the scope of this research.

4.2 Faithfulness constraints

Fortition constraints will not be used in this analysis because the faithfulness constraints, which interact with LAZY constraints, are sufficient to favour the preservation of input material.

- (18) MAX-IO: A segment present in the input must have a correspondent in the output.
- DEP-IO A segment in present in the output must have a correspondent in the input.
- IDENT-IO (continuant): A continuant feature present in the input must have a correspondent in the output.
- IDENT-IO (voice): A voicing feature present in the input must have a correspondent in the output.
- IDENT-IO (anterior): An anterior feature present in the input must have a correspondent in the output.
- IDENT-IO (strident): A strident feature present in the input must have a correspondent in the output.

These constraints will militate for the preservation of the input. IDENT-IO (strident) is the faithfulness constraint violated by posteriorization. I will discuss its interaction in more detail in section 4.3. MAX-IO, DEP-IO, IDENT-IO

(continuant), IDENT-IO (voice), and IDENT-IO (anterior) will be ranked the highest in the hierarchy of constraints because they are never violated. IDENT-IO (continuant) militates against a change in manner of articulation. It is ranked high to reflect the fact that in QF stops do not become fricatives and vice versa. Also, note that IDENT-IO (voice) has been included in the analysis to require preservation of the voicing feature in the posteriorized segments. However, if advanced acoustic studies were to prove that preservation of voicing is not so important when there is posteriorization, the constraint could be demoted. In fact, it is possible that this depends on the phonological context or varies from speaker to speaker. Finally, IDENT-IO (anterior) serves to distinguish between front coronal fricatives /s z/ ([+anterior]) and back coronal fricatives /ʃ ʒ/ ([-anterior]). My analysis uses Chomsky & Halle's (1968) definition for the feature [anterior] as opposed to Kenstowicz's (1994). This means that all segments are specified for [anterior]: labials and dento-alveolar coronals are [+anterior], and palato-alveolar coronals, velars, pharyngeals, etc. are [-anterior]. Therefore, if a front (dento-alveolar) coronal fricative undergoes any posteriorization process and loses its [+anterior] feature, the constraint will be violated. On the other hand, if a [-anterior] segment is posteriorized, its feature will remain the same, and the constraint will not be violated. Tableau 1 shows how the faithfulness constraints are unranked and undominated, except for IDENT-IO (strident) which will be discussed in the next section.

Tableau 1

<i>assis</i> 'seated' /asi/	MAX-IO	DEP-IO	IDENT-IO (continuant)	IDENT-IO (voice)	IDENT-IO (anterior)	IDENT-IO (strident)
↗ [asi]						
[ai]	*!					
[aki]			*!			
[afi]				*!	*	*
[aʃi]					*!	
[afi]						*!
[ahi]					*!	*

4.3 Constraint interaction

The faithfulness constraints are left undominated and are followed by the markedness constraints, i.e. the LAZY constraints. These are always ranked in the same order relative to each other, but the floating constraint IDENT-IO (strident) can vary position between them, as in Reynolds (1994). This is necessary to generate the observed variation. IDENT-IO (strident) is ranked randomly in this range at utterance time. The likelihood that IDENT-IO outranks a lower LAZY constraint is greater than the likelihood that it outranks a higher one. This accounts for the relative likelihood of application of posteriorization in different segmental contexts. If IDENT-IO (strident) is ranked at the very top, with the other faithfulness constraints, no posteriorization is allowed (tableau 2). If it is below LAZY (V_x_V_x), but dominates (LAZY (V_x_V_y)), then posteriorization will be allowed only in contexts where the flanking segments are identical (Tableau 3).

Tableau 2

<i>achaler</i> 'to bother' /afale/	IDENT-IO (strident)	LAZY (V _x _V _x)	LAZY (V _x _V _y)
↻ [afale]		*	
[ahale]	*!		

Tableau 3

<i>achaler</i> 'to bother' /afale/	LAZY (V _x _V _x)	IDENT-IO (strident)	LAZY (V _x _V _y)
[afale]	*!		
↻ [ahale]		*	

This ranking can vary between and within speakers allowing for a certain degree of variation, but always favouring more open flanking segments first, and then other contexts in order of their productivity. Tableau 4 shows a context that is slightly less productive than identical flanking vowels, that is between non-identical vowels. At the lower end of the LAZY hierarchy, IDENT-IO (strident) will almost always outrank a constraint like LAZY (_#) since posteriorization rarely or never occurs in this context.

Tableau 4

<i>achève</i> 'to put the finishing touch, to be almost done' /aʃɛv/	LAZY (V _x _V _x)	LAZY (V _x _V _y)	IDENT-IO (strident)
[aʃɛv]		*!	
↻ [ahɛv]			*

Tableau 5 gives more examples of how such an analysis could account for some variation allowing posteriorization in some contexts and no posteriorization in other contexts for a certain speaker at one point in time. Posteriorization is predicted to occur in all contexts above IDENT-IO (strident) (example a-e), and it is blocked in all contexts below IDENT-IO (strident) (examples f-g). It is not clear at this point whether the floating range of IDENT-IO (strident) is the same for all speakers and whether it is the case that some speakers never posteriorize in some contexts, in which case the corresponding LAZY constraints will be ranked below the floating range of IDENT-IO (strident).

		LAZY (V _x _V _x)	LAZY (V _x _V _y)	LAZY (C_V)	LAZY (#_[a])	LAZY (#_V)	IDENT-IO (strident)	LAZY (V_C)	LAZY (C_C)	LAZY (_#)
a. (V _x _V _x)	<i>achaler</i> 'to bother'	/aʃale/								
		[aʃale]	*!							
	↻ [ahale]						*			
b. (V _x _V _y)	<i>sagesse</i> 'wisdom'	/saʒes/								
		[saʒes]		*!						
	↻ [safes]						*			
c. (C_V)	<i>marcher</i> 'to walk'	/marʃe/								
		[marʃe]			*!					
	↻ [marhe]						*			

example like in tableaux 3 and never in the less productive contexts. It is instead very likely that the floating constraint varies position in the ranking of a speaker at different times. This random variation within and between speakers will result in the floating constraint always favouring the most productive contexts when allowing posteriorization. Further research could also show that the sociolinguistic factors influencing the process have an influence on the placement of the floating faithfulness constraint between the ranked markedness ones.

An analysis taking registers into account as in Kirchner (2004) was not possible since we do not know enough about the sociolinguistic factors causing the process to take place sometimes and be avoided some other times. As mentioned earlier, social class, level of education, sex, and word frequency are relevant factors, but further research is needed to clarify their contribution to the process. Also, the problems created by over generation and over prediction in Kirchner's approach would need to be addressed. This should therefore be taken as an analysis of structural factors influencing the process rather than of the sociolinguistic factors.

More recent field research focusing specifically and solely on posteriorization in QF is now needed to clarify the productivity of the process in the contexts that have been left unexplored so far. Articulatory imaging could also be used to confirm details concerning the differences in displacement and precision for the production of the posteriorized variants compared to the standard ones.

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