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Silent onsets? An optimality-theoretic approach to French *h aspiré* words[1]

This paper reexamines one of the classical problems of French phonology: the phenomenon of *h aspiré* words (Fouché 1959, Klein 1963, Rothe 1978, Encrevé 1988). These vowel initial items display a special behavior with respect to typical phonological processes of French, such as *enchaînement*, *liaison*, and *élision*. Based on the analysis of experimental data we investigate the phonetic realizations of these items and propose an optimality-theoretic (OT) approach in order to account for this phenomenon as well as for the variation encountered in our data.

The paper is organized as follows: We start with an overview of the relevant facts from a rather descriptive point of view (section 1) before presenting the data analyzed for the present study (section 2). While section 3 reviews selected non OT approaches to French *h aspiré* words, section 4 goes into the problem of variation from an optimality-theoretic perspective: We give an overview of the proposals under discussion before putting forward our own account that largely relies on the model of Stochastic OT developed by Boersma/Hayes (2001). Section 5, finally, offers some concluding remarks.

1 The phenomenon

One of the characteristics of French phonology lies within the strong tendency to create regular CV sequences and to avoid hiatus (V.V) through the application of phonological processes such as *enchaînement* (syllabification of a fixed final consonant into the empty onset position of the following word, 1.a), *liaison* (surfacing of a latent final consonant into the onset position of the following word, 2.a) and *élision* (deletion of certain vowels in prevocalic position, 3.a). All these processes have in common that they create onsets for vowel-initial words (that would otherwise violate the high-ranked constraint ONSET), but at the same time they mask the left edges of these words by a consonantal element. There is, however, a group of words that – despite of their (semi-)vocalic beginning – do not provoke any of these processes and thus rather behave like consonant-initial words (1.b,c, 2.b,c, 3.b,c). Many of them are of Germanic origin (e.g. *HAUNIPA > *honte* 'shame') and until the 16th century they were pronounced with an initial glottal fricative [h] (Thurot 1881: 391f) which is still reflected in their orthography. This is the reason for the term '*h aspiré* words' used to refer to this group, although other members derive from different sources and do

[1] Earlier versions of this paper have been presented and discussed at several occasions, among others at *Phonetik und Phonologie 1*, Potsdam 2004, at *OCP2* and at the PFC conference *Phonological variation: the case of French*, both in Tromsø, Norway, 2005. We would like to thank all our colleagues for their helpful feedback and comments. Special thanks go to Bill Barry (Saarbrücken) for his support in the analysis of the sound files and to Brechtje Post (Cambridge) and Maria Selig (Regensburg) who thoroughly reviewed the prefinal version of our text. The usual disclaimers apply.

not necessarily display an *h* in their written form (e.g. *le onze* 'the (number) eleven' [lə.õz], < lat. UNDECIM).

(1)	a.	*sept amis*	/sɛt/	+	/ami/	→	[sɛ.tami][2]	+*enchaînement*
		'seven friends'	C		V		CV.CV	
	b.	*sept garçons*	/sɛt/	+	/gaʁsõ/	→	[sɛt.gaʁsõ]	–*enchaînement*
		'seven boys'	C		C		C.C	
	c.	*sept Hongrois*	/sɛt/	+	/õgʁwa/	→	[sɛt.õgʁwa]	–*enchaînement*
		'seven Hungarians'	C		V		C.V	
(2)	a.	*les amis*	/le(z)/	+	/ami/	→	[le.zami]	+*liaison*
		'the friends'	CV		V		CV.CV	
	b.	*les garçons*	/le(z)/	+	/gaʁsõ/	→	[le.gaʁsõ]	–*liaison*
		'the boys'	CV		C		CV.CV	
	c.	*les Hongrois*	/le(z)/	+	/õgʁwa/	→	[le.õgʁwa]	–*liaison*
		'the Hungarians'	CV		V		CV.V	
(3)	a.	*l'abeille*	/la/	+	/abɛj/	→	[la.bɛj]	+*élision*
		'the bee'	CV		V		CV.CV	
	b.	*la fille*	/la/	+	/fij/	→	[la.fij]	–*élision*
		'the girl'	CV		C		CV.CV	
	c.	*la hausse*	/la/	+	/os/	→	[la.os]	–*élision*
		'the rise'	CV		V		CV.V	

While *h aspiré* words behave like consonant-initial words in the processes illustrated in (1) to (3), the prosodic process shown in (4) – the surfacing of a latent schwa /(ə)/ – applies exclusively to this group.

(4)	a.	*une abeille*	/yn(ə)/	+	/abɛj/	→	[y.na.bɛj]	–surfacing /(ə)/
		'a bee'	VC		V		CV	
	b.	*une souris*	/yn(ə)/	+	/suʁi/	→	[yn.suʁi]	–surfacing /(ə)/
		'a mouse'	VC		C		C.C	
	c.	*une hausse*	/yn(ə)/	+	/os/	→	[y.nə.os]	+surfacing /(ə)/
		'a rise'	VC		V		V.V	

The facts mentioned so far provide strong evidence for the assumption that the left edge of *h aspiré* words is granted special protection. This protection, however, inevitably yields an increase of syllabic structures that are rather dispreferred in French: While hiatus (V.V as in 2.c [le.õgʁwa], 3.c [la.os], 4.c [ynə.os]) only violates ONSET, the constellation C.V (1.c [sɛt.õgʁwa]) additionally entails a transgression of NOCODA. Such a local conjunction (Smolensky 1993, Tranel / Del Gobbo 2002) or conjoint violation of ONSET&NOCODA is

[2] The notation of underlying forms is simplified and does not entail any theoretical assumptions concerning issues other than the problem addressed here. Syllable boundaries are indicated only at the site under discussion.

problematic in its phonetic realization as will be demonstrated in the following section. One strategy to avoid these constellations simply consists in not treating *h aspiré* words as such (5.b), yielding pronunciations that are rather associated with informal speech styles.

(5) a. *les haricots / quels haricots !* /le(z)/kɛl(z) aʁiko/ → [le.aʁiko]/[kɛl.aʁiko]
'the beans' / 'what beans!'

b. *les haricots / quels haricots !* /le(z)/kɛl(z) aʁiko/ → [le.zaʁiko]/[kɛl.zaʁiko]

While some *h aspiré* words seem to lose their special protection, being increasingly treated as regular vowel initial words, other items, such as the numerals and letter words given in (6), insistently retain their special status. There are even new *h aspiré* words emerging from abbreviations (7) and language games such as *verlan* (8).

(6) *le huit* [lə.ɥit] 'the (number) eight', *le onze* [lə.õz] 'the (number) eleven', *la une* [la.yn] 'the (number) one / front page', *le R* [lə.ɛʁ] 'the (letter) R'

(7) *la SNCF* [la.ɛsɛnseɛf] (*Société nationale des chemins de fer*) 'national railway society', *le RER* [lə.ɛʁəɛʁ] (*Réseau Express Régional*) 'local train network', *les HLM* [le.aʃɛlɛm] (*Habitations à Loyer Modéré*) 'state-subsidized apartments'

(8) *deux oufs* [dø.uf] (verlan form of *deux fous*) 'tow madmen' (Plénat 1995: 104)

2 Data

As, on the whole, *h aspiré* words display a rather low frequency in the French lexicon, they accordingly do not appear very often in spontaneous speech. In order to get reliable data allowing for a systematic comparison of the speakers' strategies for dealing with these items we conducted an experiment in May 2004 with 12 native speakers of French (exchange students at the University of Osnabrück, Germany).[3] The task, camouflaged as a combined word finding and reading speed test, consisted in responding as fast as possible to a total of 48 visual, mainly written stimuli that appeared on the screen in the same pseudo-randomized order. Subjects directed the pace of the test by hitting the spacebar after reading or verbalizing each stimulus. These included 16 instances of (written) *h aspiré*

[3] We also scrutinized the recordings that we made within the context of the PFC project (*Phonologie du Français Contemporain*; see Durand et al. 2002 and http://www.projet-pfc.net) in February/March 2002 in Lacaune (Tarn, Southern France), but there were only few relevant data: *le hasard* 'the coincidence' from the fictitious newspaper article that all our 13 speakers realized with a surfacing schwa yielding the hiatus pronunciation required by the norm [lə.azaʁ] (V.V), plus three occurrences of *h aspiré* words in the transcribed parts of the interviews: *une haie de buis* [ynə.ɛdəbɥi] 'a box-hedge', realized with a surfacing schwa as required by the norm (as in 4.c) and two occurrences of *Hongrie* 'Hungary' and *hongroise* 'Hungarian (f.)', respectively, pronounced by one and the same speaker, but displaying variation insofar as *en Hongrie* 'in Hungary' is realized without *enchaînement*, yielding the output form [ɑ̃.õgʁi] (as in 2.c), whereas *hongroise* in *d'origine hongroise* 'of Hungarian origin' is treated as a regular vowel initial word, its left edge consequently being masked through application of *enchaînement* [dɔʁiʒi.nõgʁwazə] (as in 5.b). Given the sparse results these data will not be considered any further in this paper.

words that appeared in all relevant contexts (following a fixed consonant, as in 9.a, a latent consonant, as in 9.b, or a fixed consonant plus latent schwa, as in 9.c).

(9)	a.	*sept Hongrois* 'seven Hungarians'	/sɛt ɔ̃gʁwa/	(fixed C)
	b.	*tout Hongrois* 'every Hungarian'	/tu(t) ɔ̃gʁwa/	(latent C)
	c.	*une hausse* 'a rise'	/yn(ə) os/	(fixed C + latent schwa)

The recordings were transferred from DAT recorder to computer, transformed into wav sound files, and submitted to an acoustic investigation using Praat speech analysis software. Our attention focussed on the length and nature of the interval between the final segment of the preceding item and the initial vowel of the *h aspiré* word: We measured the span between the release of the consonant and the beginning of the vocal cord vibrations or the eventual interruption of the vibrations in the case of a preceding vowel or voiced consonant. Furthermore, we examined the spectral structure of the intervals. The acoustic analyses were constantly checked against our auditory impressions.

The results can be summarized as follows. One group of speakers simply treats a given *h aspiré* word like a usual vowel initial one: These subjects do not leave any interval between the two segments in question (10.c) or they produce only a very small one (10.a and b, less than 50 ms), thus yielding the impression that the preceding (latent or fixed) consonant is syllabified into the onset position of the *h aspiré* word.[4]

(10)	a.	*sept Hongrois*	[sɛ.tɔ̃gʁwa]	(4/12 speakers)
	b.	*tout Hongrois*	[tu.tɔ̃gʁwa]	(4/12 speakers)
	c.	*une hausse*	[y.nos]	(1/12 speakers)

The other group does treat the relevant items as *h aspiré* words: Following a fixed coda consonant, the beginning of the vocal cord vibrations is crucially delayed, thus leaving a pause between the preceding coda consonant and the initial vowel, which is occasionally characterized by the phenomenon of creaky voice. Void in some cases, the pause between the two words is often filled with phonetic material caused by constrictions of the glottis and/or a glottal stop – sounds that in French are usually limited to cases of special emphasis. Concerning the stimulus *sept Hongrois*, the duration of the pause is between 80-200 ms.

(11)		*sept Hongrois*	[sɛt.ˌʔɔ̃gʁwa]/[sɛt. ʔɔ̃g-]/[sɛt.ˌʔɔ̃g-]/[sɛt.ˌɔ̃g-]…	(8/12)

Speakers thus tend to create some sort of 'silent' onset position in order to avoid the C.V constellation that violates both the NOCODA and the ONSET constraint. In our data such silent onsets also appear as a strategy to avoid the (less problematic) hiatus, i.e. after a preceding vowel as in *tout Hongrois* (12.b; pause 70-160 ms), although the constellation V.V is generally tolerated in French and even regarded as the correct pronunciation in this case (12.a).

(12)	a.	*tout Hongrois*	[tu.ɔ̃gʁwa]	(3/12)
	b.	*tout Hongrois*	[tu.ˌʔɔ̃gʁwa]/[tu. ʔɔ̃g-]/[tu.ˌɔ̃g-]/[tu.ˌɔ̃g-]…	(5/12)

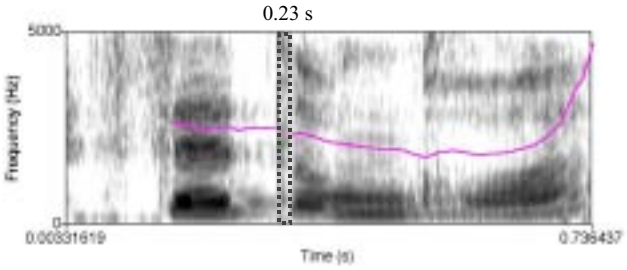
[4] Note that this holds as well for *quel héros !* 'what a hero!' which, against Tranel's (1995) prediction, is pronounced [kɛ.leʁo] by 6 speakers (= 50%).

Silent onsets are even created when the underlying form displays a floating schwa that is supposed to surface in order to avoid the problematic C.V constellation yielding the normative hiatus pronunciation *une hausse* [ynə.os] (13.a). Concerning this stimulus the inserted pause is between 40-155 ms when schwa surfaces (13.b) and between 75-150 ms when no schwa is pronounced (13.c).

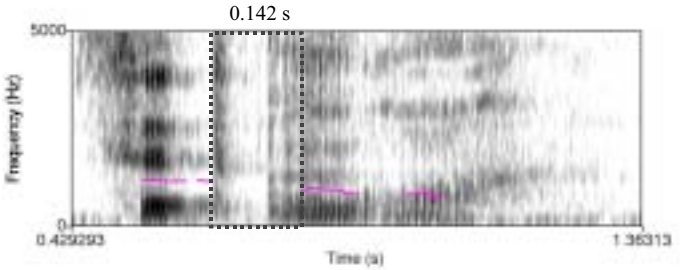
(13) a. *une hausse* [ynə.os] (3/12)
b. *une hausse* [ynə.̰ʔos]/[ynə.̰ʔo̰s]/… (3/12)
c. *une hausse* [yn.̰ʔos]/[yn.̰ʔo̰s]/… (6/12)

The following spectrograms exemplify three different pronunciations of *sept Hongrois*, first treated as regular vowel initial word (14.a), then displaying delayed onsets, a rather 'silent' one in (14.b), and one filled with creaky noise caused by glottal constrictions in (14.c). The dotted lined box marks the span between the release burst of the plosive and the beginning of the vowel (equivalent to the interruption of the F0 curve).

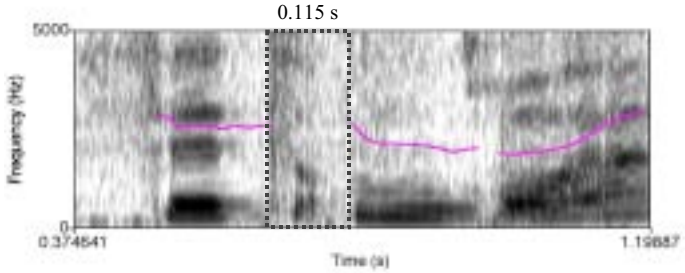
(14) a. *sept Hongrois* not treated a an *h aspiré* word [sɛ.tɔ̃gʁwa] (speaker YT)



b. *sept Hongrois* treated a an *h aspiré* word [sɛt. ʔɔ̃gʁwa] (speaker AB)



c. *sept Hongrois* treated a an *h aspiré* word [sɛt.̰ʔɔ̃gʁwa] (speaker BP)



Before elaborating our own OT account we give a short survey of non OT approaches to *h aspiré* words.

3 Non OT approaches to *h aspiré* words

The various attempts that have been made in order to capture the phenomenon of *h aspiré* words are similar insofar as they all rely on a certain kind of lexical marking of the elements concerned. However, the approaches differ in assuming that either a more or less abstract underlying segment at the beginning of the items in question or some inherent structural feature is claimed to be responsible for their special behavior. Scholars belonging to the first group are, among others, Bally (1944: 164) and Klein (1963: 27) who assume a consonantal phoneme zero, Schane (1968: 7f) who proposes an underlying initial glottal fricative /h/, Dell (1985: 261f) who departs from an underlying initial glottal stop /ʔ/ and, finally, Pagliano (2003: 638ff), who adopts Dell's proposal and integrates it into an analysis casted in terms of Charm and Government Phonology (see below for details). One of the representatives of the second line of research is Rothe (1978: 103) for whom *h aspiré* words display a special feature attributing the relevant items to the masculine /lə/ or the feminine /la/ declension rather than to the /l/ declension vowel initial words usually belong to.[5]

Within autosegmental phonology, certain particularities in the skeletal positions of *h aspiré* words and the resulting syllable structures are responsible for the special behavior of the items in question: According to Durand (1986) *h aspiré* words are characterized by word initial empty skeletal slots. Encrevé (1988: 196ff) assumes that they possess an initial skeletal slot that is not filled with melodic material but linked to a syllabic constituent, and that consequently their onset positions are empty but not null. De Jong (1990) presumes that the items in question have no initial skeletal point at all and accordingly lack an onset position. Charette (1991: 89f) adopts Dell's proposal that *h aspiré* words should be represented as items with an initial constituent dominating a skeletal point but no segmental material and integrates this view into the framework of Government Phonology. Her approach is comparable to Tranel's (1995) assumption of *h aspiré* words as so-called 'syllable islands' that are blocked for certain phonological processes; a necessary prerequisite for these accounts is, once again, diacritic marking of the relevant items in the lexicon.

A recent proposal that relies on both the assumption of an underlying initial consonantal segment /ʔ/ and the concept of special skeletal positions has been put forward by Pagliano (2003: 634-46). Closely following Scheer/Ségéral's (2001: 117f) claim that the combined surfacing of schwa and glottal stop at the beginning of *h aspiré* words is restricted to cases of emphasis, she develops a model in which an additional pair of skeletal positions (CV) is inserted into the structure only in case of emphasis, thus allowing for the association of both an (epenthetic) schwa and the underlying glottal stop.[6] From this point of view empha-

[5] From this point of view the situation in French would be comparable to Latin where the type of declension class cannot necessarily be inferred from the morphological shape of the noun.

[6] Without this insertion of additional skeletal positions through emphasis only one of the two elements, i.e. either schwa or the glottal stop can surface because of the particular government relations assumed within the Charm and Government model. For further details concerning this

sis is translated by inserting a glottal stop before an initial vowel and, if a glottal stop is already present (i.e. in *h aspiré* words), by inserting a schwa before the (surfacing) segment. Referring to our data Pagliano would claim that there are only two neutral realizations for *une hausse*, either with a surfacing schwa ([ynə.os], as in 13.a) or with a glottal stop ([yn.ʔos], as in 13.c), whereas the pronunciations given in (13.b) that display both features would be restricted to emphatic use.[7] However, the author's judgment concerning the status of a given form as emphatic or not seems to rely more on her native speaker's intuition than on systematic investigation of empirical data. The data we collected do not provide any ground for attributing the combined surfacing of schwa and glottal stop before *h aspiré* words exclusively to emphasis.[8] Until now there seems to be no reliable data supporting the proposal put forward by Pagliano (2003), and we consequently abstain from integrating pragmatic features such as emphasis in the following account.

4 OT account

To our knowledge Tranel / Del Gobbo's (2002) paper is the only recent study that explicitly addresses the problem of *h aspiré* words from an OT perspective.[9] In order to capture the fact that the left edge of *h aspiré* words is granted special protection the authors adopt word specific alignment constraints such as ALIGN-L(*hausse*, σ) militating against the syllabification of (latent or fixed) consonants into the onset position of the relevant item as happens in the case of *liaison* and *enchaînement*. Such an approach, however, crucially challenges the basic OT assumption of the general universality of constraints: A constraint that can exclusively be violated by one and only one lexical item belonging to the lexicon of a certain language, e.g. the French word *hausse*, can hardly be claimed to be universal in the sense that it should be part of the grammar of all languages.

Instead of adopting word-specific constraints that attribute the special behavior of the items concerned to the grammar we propose to pursue a lexicalist approach. In order to account for the phonetic cues we observed at the left edge of *h aspiré* words (glottal stop,

framework see the basic papers by Kaye/Lowenstamm/Vergnaud (1985, 1990) and the relevant chapters in Pagliano (2003).

[7] It should be pointed out that for Pagliano (2003: 635f) all pre-*h aspiré* schwas are epenthetic, even those corresponding to a feminine morpheme as in *grosse housse* [gʁosə.us] 'thick bedspread'. Furthermore she assumes – contra Dell (1985: 186) – that schwa epenthesis can apply in contexts such as *quel hêtre* 'what a beech' yielding [kɛ.ləɛtʁ(ə)], an adequate output form claimed to be on a par with [kɛl.ʔɛtʁ(ə)]. If so, there should be occurrences of epenthetic schwa in utterances like *sept Hongrois* or *quel héros*, yielding output forms such as [sɛtə.ɔ̃gʁwa] or [kɛlə.eʁo] that are, however, unattested in our data.

[8] Even if we assumed that some of our speakers used their 'emphatic speech register' in the experiment, there would be hardly an explanation for the fact that the same speakers used the emphatic pronunciation with one stimulus and a neutral one with others.

[9] Tranel (1996: 442-446) gives a first sketch of how *h aspiré* words could be treated in an OT framework, positing with ALIGN-LEFT » ONSET a special ranking – and consequently an extra grammar – for this group of words (vs. ONSET » ALIGN-LEFT otherwise). Tranel (2000) and Féry (2003) thoroughly address the different aspects of *liaison* and analyze the resulting syllable structures but exclude *h aspiré* words.

pause usually filled with glottal constrictions, creaky vocalic onset, etc.), we assume an underlying initial segment informally symbolized as /ʔ̲/ that embraces all these surface realizations and is responsible for the special behavior of the items in question. This analysis accounts for the temporal dimension of the delay, which is best captured by the assumption of an underlying consonantal segment.[10] We thus take up the pre OT accounts discussed in section 3 specifying the assumed segment according to the phonetic cues encountered in our data.

As the non-treatment of *h aspiré* words as such cannot systematically be interpreted as a function of a certain speech style, the segment /ʔ̲/ is assumed to be absent from the input of speakers who treat them just like usual vowel initial words, e.g. pronounce *Hongrois* or *hausse* with *liaison* and *enchaînement* as in the examples from our data given in (10). For speakers who switch between these two main realizations, we admit double input forms, e.g. /ʔ̲ɔ̃gʁwa/ and /ɔ̃gʁwa/, from which they choose according to certain pragmatic requirements. The main dimension of variation encountered in the data – i.e. treatment as an *h aspiré* or as a usual vowel initial word – thus constitutes a case of so-called pseudo-optionality (Müller 2003, Anttila 2002): it is kept out of the grammar and left to the lexicon, in sharp contrast to the proposal put forward by Tranel / del Gobbo (2002).[11]

In order to account for the output forms resulting from the speakers' different strategies to deal with input forms containing an initial segment /ʔ̲/ we propose an OT account largely based on Boersma's (1999) and Boersma/Hayes' (2001) concept of stochastic OT. Let us first turn to the constraints necessary for dealing with the forms close to the requirements of the norm. Concerning the constellation C.V yielded by the combination of an item displaying a fixed consonant in coda position and an *h aspiré* word, we need a specification of the general ALIGN-L(EFT) constraint stipulating that the left edges of grammatical words coincide with the left edges of prosodic words (15.a). Furthermore, a MAX constraint (15.b) and a markedness constraint banning glottal stops (15.c) are required:

(15) a. ALIGN(ʔ̲): The left edge of a lexical item beginning with /ʔ̲/ matches the onset of its first syllable.
b. MAX(ʔ̲): /ʔ̲/ in the input is represented in the output.
c. *ʔ: No [ʔ] in the output.

Given the fact that ALIGN(ʔ̲) occupies a high position in the constraint hierarchy the form [sɛ.tɔ̃gʁwa] is ranked out in tableau (16.a). If, on the other hand, the input lacks the initial segment /ʔ̲/, an output containing any of the phonetic cues of a silent onset is ruled out by DEP-IO (16.b).

[10] To proceed on the more abstract assumption of an underlying void is farther away from surface realizations and unnecessarily complicates the analysis.

[11] Another possible solution can be seen in assuming that initial /ʔ̲/ becomes a floating segment whenever a given *h aspiré* word loses its specific left edge protection. This would suggest extending the idea of a floating segment to all vowel initial words. Such a generalized beginning with /(ʔ̲)/ would also account for the fact that regular vowel initial words can be realized with a glottal stop in emphatic contexts, e.g. *c'est incroyable !* [setʔɛ̃krwajabl] (Pagliano 2003: 621). For reasons of space this approach will not be discussed any further here.

(16) a. *sept Hongrois* (fixed C + *h aspiré* word)

	/sɛt ʔ͡ɔ̃gʁwa/	ALIGN(ʔ͡)	*ʔ	MAX(ʔ͡)
☞	sɛt.͡ʔɔ̃gʁwa		*	
	sɛ.tɔ̃gʁwa	*!		*

b. *sept Hongrois* (fixed C + vowel initial word)

	/sɛt ɔ̃gʁwa/	DEP-IO	ALIGN(ʔ͡)	*ʔ	MAX(ʔ͡)
	sɛt.͡ʔɔ̃gʁwa	*!		*	
☞	sɛ.tɔ̃gʁwa				

Let us now turn to the constellation V.V that results from an *h aspiré* word immediately preceded by an item containing a final latent consonant. In order to account for this pattern, we need to split up the constraint militating against glottal stops (15.c) into one constraint that bans this segment in intervocalic position (17.a) and one that bans it in between consonant and vowel (17.b). In addition, we adopt Tranel's (1996) AIF constraint (17.c):

(17) a. *VʔV: No [ʔ] between vowels.
b. *CʔV: No [ʔ] between a consonant and a vowel.
c. AIF: Avoid integrating floaters.

The form [tu.tɔ̃gʁwa] does not respect the special left edge protection typical for *h aspiré* words and is consequently ruled out because of its ALIGN(ʔ͡) violation. The second candidate [tu.͡ʔɔ̃gʁwa] displays a silent onset despite of the fact that the hiatus (V.V) resulting from the non-integration of the floating segment /(t)/ is generally tolerated in French; surfacing of /ʔ͡/ between two vocalic segments thus constitutes an additional structural effort (violation of *VʔV).

(18) *tout Hongrois* (latent C + *h aspiré* word)

	/tu(t) ʔ͡ɔ̃gʁwa/	ALIGN(ʔ͡)	*VʔV	MAX(ʔ͡)	AIF
☞	tu.ɔ̃gʁwa			*	
	tu.͡ʔɔ̃gʁwa		*!		
	tu.tɔ̃gʁwa	*!		*	*

Whenever an *h aspiré* word is preceded by an item ending in a latent schwa as in *une hausse* the realization of this floating segment corresponds to the norm ([ynə.os]). In order to account for the surface constellation ə.V we assume a constraint requiring the integration of this vocalic element before words with protected left edges, i.e. before underlying /ʔ͡/:[12]

(19) MAX(ə)/_ʔ͡: A floating schwa is integrated before /ʔ͡/.

The relevant tableau is given in (20):

[12] See Boersma (2004) for a different proposal.

(20) *une hausse* (latent schwa + *h aspiré* word)

	/yn(ə) ʔ̲os/	ALIGN(ʔ̲)	MAX(ə)/_ʔ̲	*VʔV	*CʔV	MAX(ʔ̲)
☞	ynə.os					*
	ynə.˽ʔos			*!		
	yn.˽ʔos		*!		*	
	y.nos	*!	*			*

However, the data presented in section 2 do not only display the kind of variation that can be attributed to different input forms (tableaus 16.a vs. 16.b), but are also characterized by differing strategies of dealing with forms that contain an underlying initial segment /ʔ̲/. We thus have to account for output forms other than those corresponding to the norm (and emerging as the winning candidates from the evaluation processes depicted in the tableaus 16.a, 18, and 20, respectively): Concerning *tout Hongrois* three speakers pronounced [tu.ɔ̃gʁwa] as required by the norm, whereas five participants realized a delayed onset ([tu.˽ʔɔ̃gʁwa]). As for *une hausse* there are even three different ways of dealing with the special protection of the word's left edge: three speakers chose the hiatus solution [ynə.os], two speakers realized an additional silent onset yielding [ynə.˽ʔos], and, finally, six participants left the floating schwa unrealized and assured the left edge protection through silent onset only ([yn.˽ʔos]). As already pointed out in the previous section we do not assume that these slightly differing variants can be attributed in an unambiguous way to different pragmatic contexts. We thus need a model that allows for deriving distinct output forms from one and the same grammar. A relevant proposal concerning this matter comes from Reynolds/Nagy (1994) who define one or more constraints as floating with respect to an otherwise fixed hierarchy. Applying this concept to our data we would need MAX(ʔ̲) as a floating constraint for the case of *tout Hongrois* (21), whereas the various output forms of *une hausse* would require a second floating constraint, MAX(ə)/_ʔ̲, that in contrast to the first one moves downwards in the hierarchy (22).

(21) a. ☞ [tu.ɔ̃gʁwa] ALIGN(ʔ̲) » *VʔV » MAX(ʔ̲) » *AIF
b. ☞ [tu.˽ʔɔ̃gʁwa] ALIGN(ʔ̲) » MAX(ʔ̲) » *VʔV » *AIF

(22) a. ☞ [ynə.os] ALIGN(ʔ̲) » MAX(ə)/_ʔ̲ » *VʔV » *CʔV » MAX(ʔ̲)
b. ☞ [ynə.˽ʔos] ALIGN(ʔ̲) » MAX(ə)/_ʔ̲ » MAX(ʔ̲) » *VʔV » *CʔV
c. ☞ [yn.˽ʔos] ALIGN(ʔ̲) » MAX(ʔ̲) » *VʔV » *CʔV » MAX(ə)/_ʔ̲

In order to account for the variation observed we thus have to assume different floating constraints that are promoted and lowered in the hierarchy, respectively. In addition, there are no means to express the relevant frequencies of the forms. A proposal that allows for such frequency predictions comes from Anttila (1997, 2002) who suggests a model of so-called Stratified Grammars (StratG). Such a grammar consists of several strata of constraints that are internally unranked, but strictly ranked with respect to each other. Consequently multiple rankings can be derived from one and the same grammar. Adopting this approach for the analysis of our data we would have to assume the grammar given in (23) displaying a stratum that contains the constraints *VʔV and MAX(ʔ̲).

(23) ALIGN(ʔ̲) » { MAX(ʔ̲}, *VʔV } » …

The following two tableaus can be derived from (23):

(24) *tout Hongrois* (latent C + *h aspiré* word)

	/tu(t) ʔ̲ɔ̃gʁwa/	ALIGN(ʔ̲)	*VʔV (stratum)	MAX(ʔ̲) (stratum)	…
☞	tu.ɔ̃gʁwa			*	
	tu.˷ʔɔ̃gʁwa		*!		
	/tu(t) ʔ̲ɔ̃gʁwa/	ALIGN(ʔ̲)	MAX(ʔ̲)	*VʔV	…
	tu.ɔ̃gʁwa		*!		
☞	tu.˷ʔɔ̃gʁwa			*	

The frequency prediction resulting from a grammar with a stratum containing two constraints is necessarily 50 % per each output form. In order to account for the different realizations of *une hausse* we have to add two more constraints to the stratum yielding the grammar sketched in (25):

(25) ALIGN(ʔ̲) » { MAX(ʔ̲), *CʔV, *VʔV, MAX(ə)/_ʔ̲ } » …

In (26) we give an example for one of the 24 tableaus that can be derived from the ranking in (25).

(26) *une hausse* (latent schwa + *h aspiré* word)

	/yn(ə) ʔ̲os/	ALIGN(ʔ̲)	MAX(ə)/_ʔ̲ (stratum)	*VʔV (stratum)	*CʔV (stratum)	MAX(ʔ̲) (stratum)	…
☞	ynə.os					*	
	ynə.˷ʔos			*!			
	yn.˷ʔos		*!		*		

(… and 23 tableaus more)

The StratG prediction resulting from the ranking given in (25) is 41.7 % for the forms [ynə.os] and [ynə.˷ʔos], respectively, both being the winning candidate in 10 out of the 24 possible tableaus, and 16.7 % for the form without surfacing schwa ([yn.˷ʔos]) that comes out winning in 4 of the 24 possible tableaus.

Another proposal for an OT grammar that allows for frequency predictions has been made by Boersma (1999) and Boersma/Hayes (2001). In contrast to Anttila's model where such predictions result from the arithmetic proportions determined by the number of constraints contained in a given stratum and the relevant violations, the model developed by Boersma/Hayes is explicitly based on real frequencies and integrates them through stochastic computation into the OT grammar (henceforth StochG). The central assumption of such a StochG model is a continuous ranking scale, on which the constraints occupy fixed ranking values located at more or less distance from one to another. At evaluation time a small amount of noise (according to the standard deviation of 2.0) is added, and the resulting actual ranking values determine the selection points which are relevant for the position of each constraint in a given tableau. As repeated evaluations yield slightly different selection points, a constraint's position on the scale varies around the fixed ranking value. Constraints are thus associated with ranges of values and not with fixed points, and these ranges

may overlap to different degrees. The more two neighboring constraints overlap, the higher is the probability that their selection points cross for a given evaluation, the actual tableau thus displaying a reversed ranking. Learnability is achieved by the so-called Gradual Learning Algorithm (GLA), which is fed with learning data and effects the appropriate changes in the ranking values.[13] Variation is thus accounted for by presenting the data under consideration in their relative frequencies.

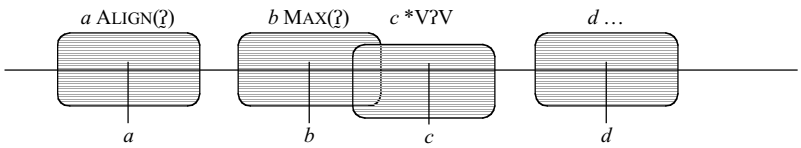
After feeding the GLA with the frequencies of *tout Hongrois* realized as [tu.ˌʔɔ̃gʁwa] (5/12 speakers) and [tu.ɔ̃gʁwa] (3/12 speakers), a few thousand applications result in the following stochastic ranking values for the relevant constraints (27.a) and in the respective distributions of output forms (27.b).

(27) a. Stochastic ranking
MAX(ʔ) 100.5
*VʔV 99.5

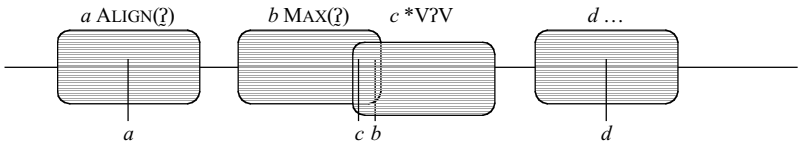
b. Output distribution
[tu.ˌʔɔ̃gʁwa] 63.2 %
[tu.ɔ̃gʁwa] 36.8 %

The constraint hierarchies that can be derived from (27.a) are sketched below: (28.a) represents the common result where MAX(ʔ) dominates *VʔV and [tu.ˌʔɔ̃gʁwa] comes out winning, (28.b) represents the less common result with the reverse ranking and [tu.ɔ̃gʁwa] as the winning form.

(28) a. Common result: [tu.ˌʔɔ̃gʁwa] (63.2 %)
ALIGN(ʔ) » MAX(ʔ) » *VʔV » …



b. Less common result: [tu.ɔ̃gʁwa] (36.8 %)
ALIGN(ʔ) » *VʔV » MAX(ʔ) » …



The predicted output distribution for the variation in *une hausse* and the stochastic ranking of the relevant constraints is given in (29):

[13] The required computations can be made with the software Praat in which the GLA is integrated.

(29) a. Stochastic ranking

*V?V	101.1
MAX(ʔ)	100.5
*C?V	98.3
MAX(ə)/_ʔ	98.3

b. Output distribution

[ynə.os]	27.3 %
[ynə.ˌʔos]	18.7 %
[yn.ˌʔos]	54.1 %

If we finally compare the predictions made by the StratG model with those made by the StochG model the latter fit the frequencies displayed in the data much better than the former:

(30)

output forms	our data	StratG prediction	StochG prediction
[tu.ɔ̃gʁwa]	37.5 %	50.0 %	36.8 %
[tu.ˌʔɔ̃gʁwa]	62.5 %	50.0 %	63.2 %
[ynə.os]	27.3 %	41.7 %	27.3 %
[ynə.ˌʔos]	18.2 %	41.7 %	18.7 %
[yn.ˌʔos]	54.5 %	16.7 %	54.1 %

While the StratG approach does not allow for an adequate modeling of the empirical data, the output distribution calculated by the frequency based StochG approach does. This follows from the fact that in Boersma/Hayes' model the computation is explicitly based on the frequency distribution found in the relevant data whereas Anttila's model relies on purely arithmetic proportions and does not take into account any empirical frequencies.[14] It thus seems to be pure coincidence that Anttila's (1997) computations match the frequencies found in his corpus of Finnish genitive forms quite well.

5 Concluding remarks

French *h aspiré* words and the variation they entail constitute a challenge for phonological theory. As a special type of vowel initial words their main characteristic consists in a protected onset position which is blocked for the syllabification of preceding (fixed or latent) consonants, while preceding latent schwas are supposed to surface. The phonetic cues found in our data exhibit a more or less void but clearly perceptible pause that is eventually followed by a glottal stop and/or a creaky vocalic onset. In order to account for these cues we proposed an underlying initial segment /ʔ/, distinguishing *h aspiré* words from regular

[14] It should be emphasized that the frequency predictions made by StochG entirely result from statistic projections based on the data the algorithm is fed with. The relevant computations thus represent a modeling of the data distribution rather than a prediction concerning the dynamics of language change.

vowel initial words. But speakers do not always treat *h aspiré* words as such, and these items then behave like usual vowel initial words. To take care of this divergence, we suggested different input forms and a double input for speakers who switch between the two forms. One of the main dimensions of variation found in the data, i.e. the treatment of an item as an *h aspiré* or as a regular vowel initial word, is thus accounted for by different lexical entries starting with /ʔ̲V/ vs. /V/. Variation within the group of *h aspiré* words is determined by the context: While silent onsets are always found when the preceding word ends in a fixed consonant – including the cases in which a schwa does not surface – (thus always yielding C.ʔ̲V), additional silent onsets optionally occur when the *h aspiré* word is preceded by a regular vowel (yielding V.ʔ̲V) or by a surfacing schwa (yielding ə.ʔ̲V). As has been shown in section 4 this kind of variation that cannot be attributed to different lexical entries or different pragmatic contexts is best accounted for by means of a Stochastic Grammar model that replaces the fixed or partly fixed hierarchy by the concept of overlapping constraints.

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