

Canadian French Vowel Harmony

A dissertation presented by

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to

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This thesis provides a phonological, psycholinguistic and phonetic description of vowel harmony in Canadian French (CF), as well as a theoretical account of the phenomenon showing that the CF facts may only be accounted for in derivational frameworks that include the notion of ‘cycle.’ CF [ATR] vowel harmony is regressive, optional, and parasitic on the feature [+high]. CF [ATR] harmony involves spreading of a [-ATR] feature from a final [+high] vowel in a closed syllable to other [+high] vowels within the same word that are in non-final open syllables (e.g. [f i . lɪp] or [fɪ . lɪp] are both acceptable variants for ‘Phillip’). The thesis describes and explains the four key attributes of harmony in this language:

- 1) There is inter-speaker (and possibly intra-speaker) variation with respect to whether harmony is applied locally and/or iteratively. Variation with respect to these parameters leads to the existence of three patterns of harmony, as evidenced by words of more than two syllables. There is the local non-iterative pattern, e.g. [i . lɪ . sɪt] (‘illicit’), the non-local pattern, e.g. [ɪ . li . sɪt] and the ‘across-the-board’ pattern [ɪ . lɪ . sɪt].
- 2) As shown in 1), there exists a pattern of non-local harmony, in which the target vowel is separated from the trigger by another [+high] vowel.
- 3) Harmony is counterbled by a process of ‘pre-fricative tensing,’ which leads to opaque allophony.
- 4) Harmony applies cyclically, but is then counterbled by another ‘open-syllable tensing’ process, which results in another case of opacity. For example, harmony can apply in a word like [mɪ . zɪk] (‘music’), but if we concatenate a resyllabifying suffix like [aɪ], we obtain [mɪ . zɪ . kaɪ] (‘musical’). The initial [+high] vowel can be [-ATR], since harmony applied in the stem, but the resyllabified trigger must be [+ATR], by an open syllable tensing rule.

The thesis makes the following claim: CF vowel harmony shows very compellingly that models of the phonological component must include mechanisms accounting for non-local relations, derivational opacity and the interaction between phonology and morphology.

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*À Jean-Marc Poliquin,
mon grand-père, mon compagnon.*

今迄は罪もあたらぬ昼寝哉
- 小林一茶

факты- вещь упрямая
-владимир ленин

Chapter 1: Introduction

1 Topics

The focus of this thesis is as narrow as its general interest is broad. The general goal is to describe the behaviour of three [+high] vowel phonemes in Canadian French (CF):

/i, y, u/. CF [+high] vowels differ from their European French counterparts in each having a tense and a lax allophone, whose distribution is governed by entirely predictable processes. The distribution of these allophones is in part determined by vowel harmony. Vowel harmony in this language is an optional process whereby non-word-final [+high] vowels can share the lax quality of the word-final [+high] vowel if the word-final [+high] vowel is lax. Generally speaking, a word-final [+high] vowel is lax in this language if it is in a closed syllable.

CF vowel harmony is characterised by variation among speakers in how the process is applied. Broadly, there are three patterns of harmony attested in this language: some speakers will harmonise all [+high] vowels in a word; others will only harmonise the [+high] vowel that is strictly adjacent to the final [+high] vowel, and yet others will harmonise only the initial vowel. My account and documentation of this language-internal typology is an important theoretical contribution in and of itself, since it is the first complete one of its kind for CF. What is more, some of these patterns are cross-linguistically unusual, which increases the range of patterns that a theory of vowel harmony must predict. Yet this is by no means the most important contribution of the thesis. Vowel harmony in this language interacts with other phonological processes, which results in two cases of *opacity*. Opacity has been at the forefront of recent phonological literature, since its very existence is at odds with the dominant theoretical framework assumed by phonologists today: Optimality

Theory (OT). The main theoretical contribution of this dissertation will be to show that all proposed OT-based solutions to this problem make erroneous predictions when it comes to CF. What I propose should not be seen as a critique of OT itself, but rather as a contribution to the argument that any theory of phonology should model three key generalisations: 1) phonological processes appear to apply in a non-simultaneous fashion, 2) phonological processes can apply in a specific order, and 3) phonological processes interact with morphology. The main contribution of CF data to these ideas is to provide some very compelling and clear reasons as to why they should be held at all. Many of these ideas contradict the founding principles of OT. Nevertheless, the CF data do not bear on OT's fundamental *raison d'être*, which is to tie in a theory of typological markedness with a theory of phonological computation. As I see it, this goal is still desirable, but it should not be pursued without consideration for what I believe are fundamental generalisations about phonological processes.

I will now expand on several key concepts introduced in these opening paragraphs. First of all: the language. French in Canada is spoken by approximately 7 million people¹. It differs from European standard and non-standard varieties in many respects. CF is the modern descendent of the language spoken by French colonists who settled the St. Lawrence valley during the 17th and 18th centuries. Since Canadian and European speakers have not been in regular contact since then, both varieties of French now differ on many levels. CF has retained many lexical items and 'turns of phrase' judged archaic by European ears. For example, European speakers would associate the term <jaser> ([ʒɑ. zɛ] 'to chat'), or introducing the future tense with <mais que> (lit. 'but that' = 'when'; <Mais qu'j'irai> = 'When I will go') with the language of a 16th century author like François Rabelais, that is, if those terms are known at all by average European Francophones of today. Phonological

¹ Based on the most recent census by the Canadian federal government: www.statcan.ca.

differences also abound. CF dialects² all affricate coronal stops before [+high] front vowels: [t^si] ‘little,’ [d^zi] ‘say,’ [t^sy] ‘you’ [d^zy] ‘some, partitive.’ The rule is applied even in standard CF as heard in the media, whereas similar processes found in European French are associated with non-standard varieties. But vowels present what is perhaps the most striking difference, and they are the focus of a large percentage of the CF phonological literature.

Like all language, the varieties of French spoken in Canada are inherently variable, and a number of dialects can be differentiated on the basis of certain characteristics. Very broadly, the French-speaking community in Canada can be divided into two main dialects. There is what I will call Acadian French, spoken roughly in the Maritime provinces³, which lacks the dialectal features investigated in this thesis, e.g. no lax [+high] vowels⁴. In the second dialect area, I include all other dialects of French spoken in Canada. This broad dialect area is characterised by having [+high] vowel tense and lax allophones, distributed in roughly similar patterns, and potentially, harmony. This is the dialect I refer to as ‘Canadian French,’ which is spoken by the vast majority of French-speaking Canadians. By excluding Acadian French, my choice of designation is perhaps a bit too broad. The dialect is usually known in the literature as ‘Quebec French,’ or ‘Québécois.’ ‘Canadian French’ and ‘Quebec French’ have the same referent. I will not deny that my choice of terminology is somewhat politically motivated. The term ‘Quebec French’ is correct, inasmuch as it designates the dialect of French spoken in Quebec, but it reinforces the misconception that this dialect is only spoken in Quebec. As a French-speaking Ontarian, I find the term excluding. Naturally, the French spoken in Ontario differs in some respects from the one spoken in

² Affrication is not found in Acadian dialects. See discussion below.

³ Acadian French is mainly spoken in the provinces of New Brunswick, Nova Scotia and Prince Edward Island, but also has speakers of related dialects in parts of the Gaspésie peninsula and the Magdalen Islands (Quebec), as well as in certain communities on the west coast of Newfoundland.

⁴ Acadian French’s lack of lax [+high] vowels does not make it more similar to European French in any other way. Intuitively, Acadian French and European French are vastly different in many other aspects.

Quebec, but to my knowledge, they do not differ with respect to the dialectal features relevant to this thesis. I acknowledge that my choice of terminology is perhaps too inclusive, since it implies that all dialects of French spoken in Canada share the features I discuss. My choice is also simply dictated by habit; I have grown up referring to my dialect as ‘français canadien’ not ‘français québécois.’ Old habits die hard.

What all dialects of CF, or what I call ‘CF,’ share is a vowel inventory in which [-low] vowels can be tense or lax. I will also refer to ‘tense’ and ‘lax’ as [+ATR] and [-ATR] respectively. I will use these terms interchangeably, ‘tense’ and ‘lax’ being more descriptive in nature, while [+ATR] and [-ATR] are more technical. The [ATR] quality of [-low] vowels is totally predictable in the case of [+high] vowels, which do not contrast for [ATR]. Mid vowels contrast for [ATR], but the contrast has a low functional load. This is due to the phonemicisation of what used to be [ATR] allophony. As a result, the distribution of [±ATR] variants of mid vowels is partially predictable but not entirely so. This is the subject of a rich and complicated literature⁵. I will not be discussing these facts here. The predictable distribution of [+high] vowels is complicated enough to warrant a dissertation. For the record though, I assume CF has the following surface vowel inventory (these include allophonic variants, which are in boldface)⁶:

(1) *CF surface vowel inventory*

	[high]	[low]	[back]	[round]	[ATR]	[nasal]	[long]
i	+	-	-	-	+	-	-
ɪ	+	-	-	-	-	-	-

⁵ See, among others, Brent (1971), Gendron (1966), Dulong & Bergeron (1980), Dumas (1978b, 1981), Dumas *et al.* (1986), Dumas & Boulanger (1982), Légaré (1978a, b), Léon (1968), Reighard (1979, 1986), McLaughlin (1986a) and Walker (1984) for specialised accounts, as well as Dumas (1987) and Ostiguy & Tousignant (1993) for a more informal review.

⁶ The table includes the feature [long]. This is essentially for notational convenience, the aspect of CF phonology I consider does not address the representational issue of length.

y	+	-	-	+	+	-	-
ɣ	+	-	-	+	-	-	-
u	+	-	+	+	+	-	-
ʊ	+	-	+	+	-	-	-
e	-	-	-	-	+	-	-
ɛ	-	-	-	-	-	-	-
ɛː	-	-	-	-	-	-	+
ø	-	-	-	+	+	-	-
œ	-	-	-	+	-	-	-
o	-	-	+	+	+	-	-
ɔ	-	-	+	+	-	-	-
a	-	+	-	-	-	-	-
ɑ	-	+	+	-	-	-	-
ẽ	-	-	-	-	-	+	-
œ̃	-	-	-	+	-	+	-
õ	-	-	+	+	-	+	-
ã	-	+	-	-	-	+	-

The distribution of [+high] tense and lax allophones is determined either prosodically, or harmonically. In closed syllables, [+high] vowels are lax. This is obligatory in word-final syllables, but optional if the syllable is non-final. Either way, the generalisation is only true if the syllable is closed by a consonant other than a voiced fricative: /v, z, ʒ, ʁ/. When a

syllable is closed by a voiced fricative, preceding [+high] nuclei must be tense (in addition to being long). Compare the following sets of words in (2):

(2) a. *Closed syllable laxing*

pə.t ^s i	‘small, masc.’	e.lɪt	‘elite’
bɛ.ni	‘blessed, masc.’	a.pɪk	‘steep, adj.’
kɤy	‘raw, masc.’	a.nɪl	‘cancel’
dɛ.by	‘beginning’	aɤ.bɪst	‘bush’
dɛ.gu	‘disgust’	e.kɤl	‘crumble, v.’
ɤa.bɤu	‘scold’	e.gut	‘drain, v.’

b. *Pre-fricative tensing*

vɪf	‘lively, masc.’
gɤi:v	‘thrush’
su.mɪs	‘submit, subj. pres.’
e.gli:z	‘church’
fɪs	‘do, make, subj. imp.’
t ^s i:ʒ	‘stem’
flɔ.ɤɪs	‘flower, subj. pres.’
e.kɤi:ɤ	‘to write’

These examples show that the tense or lax quality of [+high] vowels can be determined prosodically, that is, according to the open or closed nature of syllables. If a [+high] vowel is in a closed syllable, it is lax, unless that syllable is closed by a voiced fricative. In open syllables, [+high] vowels are tense. The distribution of tense and lax allophones can also be determined harmonically, that is, by vowel harmony, if the conditions for vowel harmony are met. A [+high] vowel in a non-final open syllable can be lax by harmony if the final vowel in the same word is [+high] and lax. A final [+high] vowel will only be lax if it is in a closed syllable. If there is no [+high, -ATR] final vowel, a non-final [+high] vowel cannot be lax. Compare the following sets of words; I remind the reader that harmony is optional in this language:

(3) a. *Non-final laxing by harmony*

fɪ.lɪp	pr. name
mɪ.nɪt	‘minute’
dʒɪ.sʊt	‘dissolved, fem.’
st ^s ɪ.pɪd	‘stupid’
mɪ.kɪs	‘mucus’
t ^s ɪ.mʊʃ	‘fly paper’
pʊ.ɪt	‘rotten, fem.’
kʊ.t ^s ɪm	‘custom’
ʃʊ.kɔʊt	‘sauerkraut’

b. *Obligatory tensing of non-final [+high] vowels in non-harmonic context.*

mi.tɛn	‘mitten’	*mɪ.tɛn
si.gʌɪ	‘cigar’	*sɪ.gʌɪ
gi.dɔ̃	‘handlebars’	*gɪ.dɔ̃
ʒy.mɛl	‘binoculars’	*ʒɪ.mɛl
ky.lɔt	‘culotte’	*kɪ.lɔt
fɛy.gal	‘frugal’	*fɛɪ.gal
bu.tɔ̃	‘button’	*bʊ.tɔ̃
gu.lo	‘bottleneck’	*gʊ.lo
ku.te	‘to cost’	*kʊ.te

Vowels in (3)a show that non-final [+high] vowels can be lax when the final vowel is [+high] and lax. If the final vowel is [-high], non-final [+high] vowels cannot be lax; see (3)b. Because harmony is optional, speakers’ opinions vary as to which words can be harmonised, but there is a very strong consensus that there exists an asymmetry between the

words in (3)a and the words in (3)b, those in which harmony is possible and those in which non-final laxing is disallowed.

Vowel harmony is a very well-studied phonological phenomenon (see Nevins (2004) for a complete review, or Van der Hulst and Van de Weijer (1995) for a brief description). Vowel harmony is a phonological process occurring in a very wide variety of languages, which involves vowels in a given domain (e.g. a word) sharing a given feature, called the ‘harmonic feature.’ Across languages, vowel harmony systems vary according to five characteristics listed here:

- a) the subset of vowels that ‘participate’ in the harmony process, that is, the vowels that trigger it (‘triggers’) and the vowels that undergo it (‘targets’),
- b) the subset of vowels that are neutral to the process, and whether or not neutral vowels are ‘opaque’ or ‘transparent,’ that is, whether or not medial neutral vowels block spreading of the harmonic feature,
- c) the domain in which harmony must operate,
- d) the direction of application (left-to-right or right-to-left) and finally,
- e) the harmonic feature itself (e.g. [back], [+round], [ATR], etc.).

CF vowel harmony can be briefly described using these five characteristics:

- Triggers: [+high] vowels (in closed final syllables)
- Targets: [+high] vowels (in open non-final syllables)
- Neutral vowels: [-high] vowels, (whether or not they block harmony depends on the speakers parametrisation for locality).
- Domain: The word
- Direction: Always applies left of the trigger.
- Harmonic feature: [-ATR] (lax).

CF harmony has received some attention in the literature but not in full detail, see Dumas (1976, 1981, 1987), Déchaîne (1991), Baronian (2001) and van Oostendorp (1995). This dissertation constitutes the first in-depth study of harmony in this language. The existence of this phenomenon is mainly discussed using disyllabic examples like in (3)a. Dumas (1987) does mention briefly that there exists variation among speakers when it comes to trisyllabic examples, that is, words of three syllables whose three nuclei are [+high], e.g.

[i . l i . s i t] ‘illicit.’ Dumas attests that some speakers will lax all potential targets in the word ([ɪ . l ɪ . s i t]), while other will only lax the first from the left ([ɪ . l i . s i t]), and others will only lax the target that is closest to the trigger ([i . l ɪ . s i t]). Dumas attempts to sketch out what might determine this variation sociolinguistically. Dumas tentatively proposes that the variation may be regional, but is not committed to this theory. This dissertation is the first work in which variation in CF harmony is systematically documented and accounted for. I will show in the next chapter that Dumas’s observation is correct; there exists variation in this respect. I will also show however that the variation does not appear sociolinguistically based. Variation was found among speakers of the same region (Montreal) and age group, with similar education profiles. All speakers apply harmony, but their preferred harmony patterns differ with respect iterativity and adjacency. Why should there be variation on this point? I propose, following Nevins (2004), that this is a case of *nanovariation*. I show that the vast majority of words in which harmony can apply are disyllabics. Disyllabics like *Philippe* are not informative as to whether harmony in this language is iterative or local. Words with more than one potential target are extremely few in number, numbering less than 100, and are also relatively infrequent. I propose that because of this, speakers are provided little to no information in their primary linguistic data on how to set their iterativity and locality parameters. As a result, each speaker sets them differently, leading to variation. The variation in CF is interesting because it displays two important characteristics: a) speakers are consistent in their preferences, suggesting that their grammars show some probabilistic stability, and b) the variation is constrained, though

speakers may set their parameters differently, the range of predicted patterns is limited, and these limits are attested empirically. It is data from tetrasyllabics with only [+high] nuclei (e.g. [si.mi.li.t^sɥd] ‘similarity’) that suggest that variation is constrained. Though tetrasyllabics can show seven logically possible patterns of harmony, only three are attested. These three are the same as those found for trisyllabics, mentioned above: across-board [s_ɪ.m_ɪ.l_ɪ.t^sɥd], non-local harmony [s_ɪ.mi.li.t^sɥd] and adjacent non-iterative harmony [si.mi.l_ɪ.t^sɥd].

The first major contribution of this dissertation is to show that, though speakers’ behaviour is variable, it is systematic. For instance, I show that there is a correlation between speakers’ preference for non-local harmony and their treatment of medial neutral vowels. In vowel harmony systems of the world, medial neutral vowels, that is, neutral vowels located between the trigger and target of harmony, can either block the spreading of the harmonic feature (in which case we say the neutral vowels are ‘opaque’ as in Yoruba, see Archangeli & Pulleyblank 1994), or be ‘transparent’ to the harmony, in which case the neutral vowels do not block spreading of the harmonic feature from the trigger to the target (as in Wolof, again, see Archangeli & Pulleyblank 1994). Among those speakers of CF that show a consistent preference for the non-local pattern, all of them treat neutral vowels as transparent. Targets can undergo harmony, even if they are separated from the trigger by a neutral vowel (e.g. [ɪ.ne.d^zɪt] ‘unpublished, fem.’). Intuitively, this should be expected. If harmony can apply non-locally, then it should apply across any type of vowel. Conversely, speakers who have a consistent preference for the adjacent non-iterative pattern do not accept harmony in a word like *[ɪ.ne.d^zɪt]. Neutral vowels for these speakers are opaque. Again, the generalisation is intuitively expected, and appears supported by the CF data.

The second major contribution of the dissertation has to do with *opacity*⁷. Kiparsky (1982: 75) provides the following rule-based definition:

(4) *Definition of opacity*

“A rule $A \rightarrow B / C_D$ is opaque to the extent that there are surface representations of the form

(i) A in environment C_D

or (ii) B in environment other than C_D.”

Opacity is found wherever a given phonological process is found to underapply as in case (4)(i), or has overapplied, as in case (4)(ii). There are two types of opacity that involve harmony in CF. The first type arises from the interaction of vowel harmony with ‘pre-fricative tensing.’ As mentioned above, [+high] vowels in final syllables closed by a voiced fricative must be tense. If the interaction between these processes were transparent, we would expect harmony not to apply in words where the final [+high] has undergone pre-fricative tensing. If a [+high] vowel has undergone pre-fricative tensing, then it is [+ATR], is not a trigger for harmony. Yet in a word like [mɪ . sɪ : v] (‘letter’), the initial [+high] vowel can be [-ATR]: ✓[mɪ . sɪ : v]. There is thus an asymmetry between words like ✓[mɪ . sɪ : v] and words like *[mɪ . tɛn] (✓[mɪ . tɛn] ‘mitten’). Neither has the conditioning environment on the surface, but [mɪ . sɪ : v], has a [+high] vowel that has undergone pre-fricative tensing. I propose that vowel harmony applies before pre-fricative tensing. This yields the following derivation:

⁷ Generally speaking, in the remainder of this work, ‘opacity’ refers to ‘derivational opacity.’ The opaque status of neutral vowels will be referred to as ‘opaqueness.’

(5) *Informal derivation of ‘missive’-type opacity*

UR	/mɪsɪv/	
Laxing Rule	mɪ . SɪV	} Feeding order
Harmony Rule	mɪ . SɪV	
Pre-fricative Tensing Rule	mɪ . sɪv	} Counterbleeding order
Lengthening Rule	mɪ . sɪ : v	
SR	[mɪ . sɪ : v]	

As indicated in this derivation, vowel harmony and pre-fricative tensing are in counterbleeding order, which leads to opacity. Harmony in this case overapplies. Opacity can be easily derived in a rule-based framework, which is the approach that I adopt to account for all the facts in this dissertation. Opacity is an important issue in recent phonological literature, because Optimality Theory (OT; Prince & Smolensky 1993/2004), the dominant model of phonology in use today, is biased towards transparent input/output relationships. This type of opacity has important consequences not only for OT, but also for many of its later modifications. I will show in chapter 5 that many amended versions of OT that aim to account for opacity effects cannot account for those found in CF. The main contribution of this data point is to show that a theory of phonology must crucially include derivations.

There is also a second type of opacity in CF that arises from the interaction of vowel harmony and open-syllable tensing. If we take a stem like [my . zɪk] ('music'), harmony can be applied so that we obtain [m_Y . zɪk]. If we add a suffix to this stem, the final vowel can be resyllabified so that it is in an open syllable. As a result, the stem-final syllable must be tense: *[m_Y . zɪ . kaɪ], ✓[m_Y . zi . kaɪ]. Notice however, that the stem-initial vowel can still be lax. Though harmony cannot apply, there is no final [+high, -ATR] vowel. Again, harmony overapplies. I account for these facts by assuming that harmony applies regularly before suffixation. The resyllabification instigated by suffixation causes the application of an open-syllable tensing rule that renders vowel harmony opaque, by obscuring its original conditioning environment. I propose that the open-syllable tensing rule does not apply to the stem-initial vowel because it has not undergone resyllabification. This is predicted by the Strict Cycle Condition (see Mascaró 1976, Halle 1978). Again, these facts are very important for the assessment of OT-based theories that aim to account for opacity. I show that none of them can, because they do not model rule interactions of this type as rules do, and also, they do not assume this sort of interaction with morphology. I propose that a theory of phonology that is complete models both of these aspects.

This dissertation is strongly focused on providing a thorough investigation and solid account for all of the CF facts, yet my argument about what a theory crucially includes is also based on cross-linguistic evidence. The harmony pattern exhibited by CF is not cross-linguistically common, but finds an exact, if not an identical counterpart in Javanese, documented in Dudas (1976) and Schlindwein (1988). Central Javanese also exhibits a case of opacity that is almost identical to the one involving suffixation and resyllabification in CF, providing strong ground for my argument concerning the interaction of phonological rules with morphological processes. Palestinian Arabic, as described in Shahin (2002), also exhibits post-velar harmony that closely resembles the CF case; I will briefly compare the two. My analysis of the CF facts also includes some important comparisons between the harmony patterns

attested in this language, and those attested in West African languages, most notably Wolof and Yoruba. Chapter 4 also includes a comparative discussion of CF vowel harmony and metaphony, as it occurs in dialects of Southern Italian and dialects of Spanish spoken in the Asturias region of Spain (Pasiego and Tudanca Montañés).

2 Overview

This section provides a very general chapter-by-chapter overview of the dissertation. More detailed overviews, going section by section, are provided at the beginning of each chapter.

Chapter 2 and 3 provide the empirical basis for the theoretical claims made in later chapters. The first chapter describes CF vowel harmony and related phenomena in detail and presents evidence for constrained variation as concerns tri- and tetrasyllabic words, as well as words involving neutral medial vowels. The chapter shows that there are three patterns of harmony in CF, and that speakers vary with respect to which pattern they prefer. Speaker preferences are determined on the basis of judgment task data. Speakers were tested on their opinions regarding the naturalness of different pronunciations. Results show that, though speakers are divided as to their preferences, they are consistent in those preferences across different types of words. Speakers are consistent in their preferences, but almost never prefer one given pattern to the total exclusion of others. In other words, they consistently might give higher ratings to a certain pattern, but other patterns are never completely rejected. I interpret these data to say that speakers probably display probabilistic preferences for a given pattern, which probably translates as intra-speaker variation in production, with a bias for a single pattern. The interpretation that is important to my argument is that preference for a given pattern across speakers merely indicates that this pattern is possible for a certain type of word. In other words, there exists at least one grammar that can generate it. Chapter 2 also provides some production task data to describe the phonetic qualities of tense and lax vowels in CF. In

addition, chapter 2 provides accounts for the causes of variation in CF harmony; I propose that variation is due to the underdetermined analysis of primary linguistic data.

Chapter 3 is also empirical in nature, since it also presents judgment task data concerning the opaque patterns described above. The main contribution of chapter 3 is to show that these opaque patterns are productive; they extend to nonce and low frequency words. Showing the productivity of opaque patterns is very important to the later theoretical arguments that I make. It has been argued in recent literature (Sanders 2003; Mielke *et al.* 2003) that apparent opacity effects may not be a problem for OT. These authors make the strong prediction that all apparent opacity effects are unproductive or can be accounted for transparently. This chapter argues that all transparent accounts for these patterns cannot be maintained, and that they are synchronically productive, thus falsifying their claim. This is a strong argument that opacity effects are indeed relevant to a theory of phonological computation.

Chapter 4 provides a thorough account of all the CF facts presented in chapters 2 and 3. The account I propose is couched in Lexical Phonology (Kiparsky 1982a, 1985). Lexical Phonology is a rule-based framework, which assumes that the phonological component is divided into different levels, which correspond to specific levels of morpho-syntactic building. I propose a theory by which all and only the attested patterns of CF vowel harmony can be derived. My proposal is based on the crucial assumption that rules can apply directionally instead of simultaneously, and that the application of the vowel harmony rule is conditioned by two bivalent parameters: iterativity and directionality. Opacity facts are accounted for straightforwardly by the ordered and cyclic application of rules, a fundamental assumption of Lexical Phonology.

Chapter 5 is a series of reassessments of OT-based frameworks. I show that classical OT (Prince & Smolensky 1993/2004) cannot account for the full range of CF facts. The main

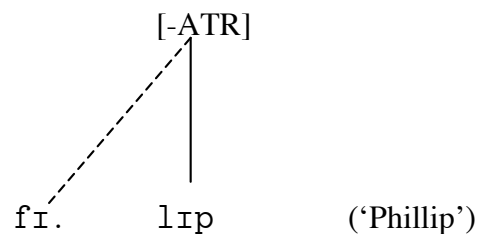
contribution of the chapter is the reassessment of every OT-based framework in the literature that has attempted to account for similar facts, were it non-locality in the application of harmony or opacity/cyclicity facts. I show that some of these frameworks do account for the CF facts in part, but never for the full range of them. The following OT-based frameworks are discussed: classical OT (Prince & Smolensky 1993/2004), ‘Spread,’ ‘Agree,’ and ‘Match’ constraints (Kaun 1995, Bakovic 2000, and McCarthy 2003 respectively, among others), Headed Spans/Optimal Domains (McCarthy 2004, Cole & Kisseberth 1994), Targeted Constraints (Bakovic & Wilson 2001, Wilson 2001, 2003), Sympathy (McCarthy 1999, 2003), OT with Candidate Chains (McCarthy 2006, and forthcoming), Turbidity (Goldrick 2000), and Stratal OT (Kiparsky 2000 and forthcoming; Bermudez-Otero 1999 and forthcoming).

Chapter 2: Variation in Locality and Iterativity

1 Chapter overview

Canadian French (CF) vowel harmony is a type of ‘vowel assimilation’ to call it by a very general term, which, in autosegmental terms, involves spreading of a [-ATR] feature from a final [+high] vowel in a closed syllable to other [+high] vowels in open syllables:

(1) *Autosegmental representation of harmony in a disyllabic word*



CF vowel harmony is harmony of a ‘parasitic’ type: harmony involves spreading of a [-ATR] feature, but the feature may spread iff the trigger and target are [+high]. Triggers are always [+high] vowels that have undergone an obligatory process I call ‘closed syllable laxing.’ CF has three [+high] vowels /ɪ, y, u/, each with a [+ATR] allophone [i, y, u] and a [-ATR] allophone [ɪ, ʏ, ʊ]. In a final closed syllable, [+high] vowels must be [-ATR]. [+high] vowels in open syllables, final or non-final, are [+ATR], unless they have undergone a laxing process targetting [+high] vowels in that position. Vowel harmony is such a process. Though vowel harmony is optional in this language, the distribution of [+high] vowel [±ATR] allophones is entirely predictable. The inventory of CF [+high] vowels is provided here:

(2) *CF [+high] vowel inventory*

	[high]	[back]	[round]	[ATR]
i	+	-	-	+
y	+	-	+	+
u	+	+	+	+
ɪ	+	-	-	-
ʏ	+	-	+	-
ʊ	+	+	+	-

This thesis will provide an analysis of vowel harmony and related phenomena in CF.

Though [ATR] harmony in CF is a well attested phenomenon (Déchaîne 1991, Dumas 1976, 1981, 1987), our knowledge of it is lacking in depth. For now, we know only that what is called ‘harmony’ in this language is certainly a type of ‘vowel assimilation,’ in that it is a process making two (and possibly more) vowels of a certain type share a given feature. But it is unknown whether [-high] vowels, which are neutral, are transparent or opaque to the process⁸. It is also unclear whether all possible targets in a word may undergo harmony if there is more than one target; previous studies have focused mainly harmony on disyllabic words like the one given in (1)⁹. In other words, several questions remain as to how [ATR] harmony in this language compares with other, similar phenomena in other languages. The present chapter aims to answer the more basic of these questions, so as to give a full description of this phenomenon. This will allow us to provide a complete account of CF

⁸ [-high] vowels do not trigger harmony, nor are they targetted by any harmony process. This is certainly true in my dialect, and as far as I know, has not been documented for any dialect of CF.

⁹ Déchaîne does compare harmony in disyllabics with harmony in trisyllabics. Her description of the process and its predictions are reassessed in chapter 3 of this thesis.

harmony, how it relates to other languages, and how these phenomena impact phonological theory.

The main contribution of this chapter is not only to provide a full description of CF harmony, but to describe the systematic variation that exists in this language with respect to harmony.

If we consider trisyllabic words, whose three nuclei are [+high], for example¹⁰, [i . l i . sɪt] ('illicit'), and we know that non-final [+high] vowels in open syllables are potential targets for harmony, we have four potential patterns:

(3) *Possible patterns of harmony in a trisyllabic word*

No harmony	i . l i . sɪt
Across-the-board harmony	<u>i</u> . l <u>i</u> . sɪt
Non-local harmony	<u>i</u> . l i . sɪt
Adjacent non-iterative	i . l <u>i</u> . sɪt

What we discover in the case of trisyllabics is variation among speakers as to which pattern they prefer. Moreover, a speaker rarely prefers one pattern to the total exclusion of all others. What this chapter shows is that inter- and intra-speaker variation is systematic. Though a speaker might not prefer a pattern like 'across-the-board' harmony to the exclusion of the other patterns, this speaker will systematically show a stronger preference for the across-the-board pattern in a tetrasyllabic word. If we think of vowel harmony as being a rule common to all speakers: 'a non-final [+high] vowel in an open syllable is [-ATR], if the final vowel in the word is [+high, -ATR],' but that can be applied in different ways, for example, 'apply iteratively,' or 'apply only to the target most adjacent to the trigger,' and that these conditions on applications are parameters, we might say that speakers do not set their

¹⁰ Unless otherwise indicated, transcriptions of CF words are provided in their standard CF form.

parameters definitively, but probabilistically. In other words, if speaker X has the harmony rule as part of his or her inventory, speaker X might set his or her [\pm iterative] to the ‘+’ value with a 70% probability, and to the ‘-’ value with a 30% probability. This chapter does propose an explanation as to why speakers behave this way with respect to such parameters in this language, but its main purpose is simply to show the systematicity of this variation, and that variation leads to different grammars, all of which must be accounted for. Accounts for these different grammars is the topic of the second part of the dissertation.

Before I provide a section-by-section overview of this chapter, I will provide a few indications on terminology. This chapter describes harmony in four types of words. Three of these four types I will call ‘disyllabics,’ ‘trisyllabics’ and ‘tetrasyllabics.’ These are respectively words of two, three and four syllables whose nuclei I assume are all [+high], and whose non-final nuclei are in open syllables, and whose final nucleus is in a closed syllable. Aside from these three types of words, which are referred to with these specialised terms and an example word, all other types are referred to using an example word only. All types of words and their appellations are provided below:

(4) *Types of words: terminology*

Surface form	Gloss		
fi.lɪp	‘Phillip’	disyllabics	<i>Philippe</i> -type words
i.li.sɪt	‘illicit’	trisyllabics	<i>illicite</i> -type words
si.mi.li.t ^s ɪd	‘similarity’	tetrasyllabics	<i>similitude</i> -type words
i.ne.d ^z ɪt	‘unedited, fem.’	trisyllabics with neutral medial vowel	<i>inédite</i> -type words

mi . d ^z i	‘noon’	disyllabic with identical [+high] vowels and open final syllable	<i>midi</i> -type words
ʒy . li	‘Julie’	disyllabic with non- identical [+high] vowels and open final syllable	<i>Julie</i> -type words
t ^s y . lɪp	‘tulip’	disyllabic with non- identical [+high] vowels and closed final syllable	<i>tulipe</i> -type words
ʒy . ʁi . d ^z ɪk	‘judicial’	trissyllabic with non- identical initial and medial vowels	<i>juridique</i> -type words

Section 2 of this chapter describes the acoustic properties of tense and lax vowels. The section begins by providing duration and formant frequency data of tense and lax [+high] vowels in word-final position. The section argues that, if speakers can hear [±ATR] differences in [+high] vowels in final position, then speakers (and learners) should be able to hear this distinction in non-final vowels, provided that non-final vowels are not significantly shorter than final [+high] vowels. I show that, though non-final [+high] vowels are shorter than final [+high] vowels (especially medial vowels), the difference in duration between non-final and final vowels is not so great that the [±ATR] distinction is lost.

Section 3 introduces the issue of variation with respect to harmony patterns. I propose, based on Nevins (2004), that variation is due to the underdetermined analysis of primary linguistic

data (PLD). Speakers' grammars vary in how they apply the harmony rule. Some allow an iterative application while others do not; some speakers allow non-local harmony while others only apply the rule locally. In the second part of this dissertation, I propose that these grammars differ in their settings for two parameters: iterativity and directionality. I argue in section 3 that the vast majority of PLD consists of disyllabic words, which are uninformative with respect to these parameters. Since learners' analysis is underdetermined by these data, parameters will be set differently from speaker to speaker, resulting in variation. Importantly though, variation is constrained, which is the topic of the next section.

In section 4, I report the results of a judgment task performed by 12 speakers of CF. Speakers were asked to rate the naturalness of pronunciations involving [ATR] differences in their non-final vowels. The experiment finds that speakers can be classified into four groups. The first group, containing only one speaker, has a general dispreference for words featuring harmony, especially tri- and tetrasyllabics. A second group shows a preference for 'across-the-board' harmony, a preference that is maintained in both tri- and tetrasyllabics. The third group prefers the 'non-local' pattern, where only the initial vowel in tri- and tetrasyllabics undergoes harmony. Finally, the fourth group gives strong preference to words where only the target that is most adjacent to the trigger undergoes harmony. The section shows that these preferences are maintained between trisyllabic and tetrasyllabic stimuli. In trisyllabics, the number of attested patterns matches the number of logically possible patterns. In the case of tetrasyllabics, the number of logically possible patterns of harmony is greater than for trisyllabics, but the number of attested patterns stays the same (3), suggesting that the grammar is constrained in some way. The second part of this dissertation proposes that in CF, the vowel harmony rule in CF is not optional at each iteration.

Section 3 also reports that speakers who accept non-local harmony in trisyllabics also allow the initial vowel in *inédite* words to undergo harmony: ✓[ɛ . ne . d^zɪt̚]. Conversely,

speakers who reject [ɪ . l i . sɪt] do not allow harmony in *inédite* words:

*[ɪ . ne . d^zɪt]. These data constitute strong evidence that variations in harmony patterns are partly due to different settings of a locality parameter. Speakers who allow harmony to apply non-locally across a medial [+high] vowel (a perfectly good feature-bearing unit if there is one) should allow it across any vowel, including [-high] vowels. On the other hand, if speakers do not allow harmony to apply non-locally, this should be the case everywhere. Speakers who prefer the across-the-board (ATB) pattern are split according to their judgments about harmony in *inédite* type words. This is the main data point on which the following argument rests: that locality is actually implemented in terms of directionality. CF speakers may apply the harmony rule starting with the immediately adjacent target, or with the target at the left edge of the word. Non-local and adjacent non-iterative apply the harmony rule non-iteratively, but their differences lie in where they start applying the rule within the domain of application (the word). Non-local speakers start on the left, producing a non-local application of harmony: →ɪ . l i . sɪt. Adjacent non-iterative speakers start on the right: i . lɪ . ←sɪt. ATB speakers apply the rule iteratively, but can start on either side, yielding the same output for tri- and tetrasyllabics: starting on the left, →ɪ . →lɪ . sɪt, or starting on the right, ɪ← . lɪ← . sɪt. The hypothesis that iterative speakers can parametrise for directionality of application yields the correct results for *inédite* words. If an iterative speaker starts applying the rule on the left, s/he will output [ɪ . ne . d^zɪt]; if an iterative speaker starts applying the rule on the right, s/he will output [ɪ . ne . d^zɪt].

[ɪ . ne . d^zɪt] will be wrong in the latter case, assuming that the rule scans the consonantal tier, and gives up applying if it does not encounter an appropriate target, i.e. [+high] vowel.

2 Closed syllable laxing

The goal of this thesis is to investigate the quality of non-final [+high] vowels in open syllables. The thesis analyses the quality of such vowels in tri- and tetrasyllabic words containing only [+high] nuclei such as [i . l y . mɪn] ('illuminate') or [sɪ . mi . li . t^sɪd] ('similarity'). We are interested in finding out how many and which non-final vowels undergo harmony, that is, whether they must be tense or lax. The difference is subtle, but it is made even more subtle by the fact that medial vowels in CF tend to be very short because they are unstressed; initial syllables always bear secondary stress (Astésano 2001, Déchaîne 1991, Walker 1984). In fact, in an unstressed position, if a [+high] vowel is flanked by two voiceless consonants, the vowel can be completely elided (Dumas 1981), a phenomenon reminiscent of vowel reduction in Japanese (Akamatsu 2000). The phenomenon is illustrated with a CF example here:

$$(5) \quad /d^z i . f i . s i l / \quad \rightarrow \quad [d^z \text{ɪ} f . s \text{ɪ} l] \text{ 'difficult'}$$

In the example above, vowel deletion causes resyllabification. The initial [+high] vowel can be lax, but it is unclear in this case if laxing is the result of harmony or closed syllable laxing (which is optional in non-final closed syllables, see below). Such words will not be considered in our investigation of harmony.

[+high] vowels that are flanked by at least one voiced consonant are not elided, but can be very short, raising the question of whether or not differences in [ATR] can be distinguished by the learner in this position. It is clear from native speakers' responses that these differences are heard, since they indicate strong and consistent preferences for different patterns of harmony, whose differences are based on the perception of [ATR] differences in medial positions. Non-speakers of CF tend not to hear these differences clearly. The goal of

this section is to show, with the help of acoustic data, that such differences are indeed perceivable by speakers.

2.1 Acoustic properties of word-final lax [+high] vowels

Firstly, I will show the acoustic properties of tense and lax [+high] vowels in final closed syllables, so that we may compare these properties to those of tense and lax [+high] vowels in non-final open syllables. CF vowel harmony is conditioned by what I will call ‘closed syllable laxing.’ In CF, [+high] vowels in final syllables that are closed by a consonant other than a voiced fricative must be [-ATR]. I will use the terms ‘[-ATR]’ and ‘lax’ interchangeably¹¹. The process is obligatory in word-final syllables. It is illustrated by the following examples:

(6) Final closed syllable laxing

	Coda segment	/i/	/y/	/u/
Voiceless stops	/p/	pɪp ‘pipe’	ʒɪp ‘skirt’	lɪp ‘magnifying glass’
	/t/	ɾɪt ‘rite’	ɾɪt pr. name	ɾut ‘road’
	/k/	ʃɪk ‘chic, fancy’	t ^s ɪk ‘ski hat’	buk ‘he-goat’
Voiced stops	/b/	lɪb ¹² ‘free’	t ^s ɪb ‘tube’	tɾub ‘trouble’
	/d/	vɪd ‘empty’	ɾɪd ‘rough’	kud ‘elbow’
	/g/	ʒɪg ‘trad. tap dance’	ɪg pr. name	fug ‘ardour’
Voiceless continuants	/f/	vɪf ‘lively’	tɾɪf ‘truffle’	tuf ‘tuft’

¹¹ I am also assuming that ‘tense’ is equivalent to [+ATR]. See Halle & Clements (1983).

¹² Words like ‘free’ and ‘trouble’ have two syllables underlyingly: /li. bɾə/ and /tɾu. blə/, final schwas are typically deleted in casual speech, and resulting complex codas are simplified. For simplification of consonant clusters in CF see Côté 2000.

	/s/	lɪs 'smooth'	plɪs 'more'	fɛʊs 'fright'
	/ʃ/	nɪʃ 'kennel'	ɛʏʃ 'hive'	duʃ 'shower'
Nasals	/m/	lɪm 'lime'	ɛʏm 'cold, n.'	bʊm 'boom, ono.'
	/n/	mɪn 'mine'	ʏn 'one, fem.'	pʊn pr. name
	/ŋ/	lɪŋ 'line'	ɛə.pʏŋ 'disgust, v.'	no forms
Liquids	/l/	vɪl 'city'	ʒʏl pr. name	bʊl 'ball'

In non-final closed syllables, closed syllable laxing is optional, as illustrated in these examples:

(7) *Optional laxing in closed non-final syllables*

mɪs.tɛ ^j ɛ	'mystery'	mɪs.tɛ ^j ɛ
bɪn.ɛi	'diner'	bɪn.ɛɪ
ɪk.tjo	'ichtyo-'	ɪk.tjo
bʏs.t ^s je	'bustier'	bʏs.t ^s je
bʏl.gʌɛ	'Bulgarian'	bʏl.gʌɛ
e.ɛʏp.sjõ	'eruption'	e.ɛʏp.sjõ
sʊl.ɛi	'drinking spree'	sʊl.ɛɪ
mʊʃ.te	'spotted'	mʊʃ.te
ɛʊm.bɑ	'rhumba'	ɛʊm.bɑ

The 'optionality' of non-final closed syllable laxing is an idealisation somewhat. Whether or not a [+high] vowel can lax in this position in any given word seems to vary with each speaker. For example, I accept laxing in 'ichtyo-' more easily than in 'Bulgarian,' but some speakers have the reverse judgment. What conditions these preferences is not well understood, and lies outside the scope of this thesis. It is not clear if optional laxing can condition harmony of preceding [+high] vowels. The number of forms with the appropriate

conditioning environment are extremely rare, i.e. forms with a closed medial syllable containing a [+high] nucleus, preceded by a [+high] vowel in an open syllable, but followed by a syllable containing a neutral nucleus¹³. It is my prediction that speakers would vary in their acceptance of harmony in such words, though this prediction was not tested due to the rarity of such words. In the discussion that follows, I will assume that only final [+high, -ATR] vowels condition harmony. The obligatory and optional versions of the rule are formalised here:

(8)

a. *Obligatory closed final syllable rule*

$$[+high] \rightarrow [-ATR] / _C(C)\#$$

b. *Optional closed syllable laxing rule*

$$[+high] \rightarrow [-ATR] / _C]_{\sigma} \quad (\text{optional})$$

In final *open* syllables, [+high] vowels must be [+ATR], as illustrated by the following forms:

(9) *Obligatory tensing of [+high] vowels in open syllables*

a . mi	‘friend’	*a . mɪ
pɛ . ji	‘country’	*pɛ . jɪ
ɛʌ . ni	‘hernia’	*ɛʌ . nɪ
sa . ly	‘hi’	*sa . lɪ
tɛ ^j . t ^s y	‘stubborn’	*tɛ ^j . t ^s ɪ
t ^s i . sy	‘cloth’	*t ^s i . sɪ

¹³ There is the added condition that the such forms cannot be morphologically complex e.g. [ɪ . t^sɪl . mā] ‘usefully.’ Such forms do not decide whether harmony is conditioned by non-final [+high] vowels in closed syllables because harmony is possible at the stem level. It is thus possible to assume that the lax [+high] vowels are simply ‘inherited’ from the stem level.

e . gu	‘sewer’	*e . gu
bi . zu	‘kiss’	*bi . zu
ka . ju	‘pebble’	*ka . ju

2.1.1 The duration of tense and lax [+high] vowels

In this section, I will show that non-final [+high] vowels are shorter than final [+high] vowels, but that the difference in duration is not significant enough to warrant the claim that speakers of CF cannot perceive the [ATR] value of non-final [+high] vowels. Tables 1a and 1b compare the average duration of [+high] vowels (lax) in closed final syllables and [+high] (tense) vowels in final open syllables. These data were obtained from five speakers of CF, three females and two males, all from the Montreal area, and all aged between 20 and 35 years old. Speakers were asked to read a carrier sentence containing a target word, whose final syllable had a [+high] nucleus and was either open or closed. The carrier sentence was designed so that the word was neither in initial or final position, and bore the intonational ‘focus’ of the sentence, i.e. had the greatest amplitude. In the case of closed syllables, only syllables closed with a voiceless coronal stop were tested so as to get a uniform comparison (/t/). Each of the [+high] vowels was tested (/i, y, u/). Speakers read one word for each (one word per vowel, three words per speaker). Speakers thus provided 15 [+high] vowels in final closed syllables. Speakers were also asked to read one word per [+high] vowel, where the vowel was in a final open syllable. Words with lax and tense vowels are given in (10)b and c respectively; the carrier sentence is provided in (10)a:

(10)

- a. J’ ai dit X tout de suite.
I have said X right now.

b.

de . bɪt	<débite>	‘output, v.’
de . bɪt	<débute>	‘begins’
de . but	<débout>	‘foil, v.’
c.		
a . bi	<habit>	‘suit’
a . by	<abus>	‘abuse’
a . bu	<à bout>	‘exhausted’

The numbers in the following tables indicate the duration, in milliseconds, of lax vowels in closed final syllables and tense vowels in open final syllables:

		ɪt	ɻt	ʊt	Avg. dur.
Speakers	LPH	60	70	70	67
	ML	70	90	80	80
	GC	70	80	80	77
	KB	70	70	60	67
	PC	80	71	60	70

Table 1a: Duration values (in ms) for lax [+high] in closed final syllables.

		i#	y#	u#	Avg. dur.
Speakers	LPH	90	90	90	90
	ML	72	76	79	76
	GC	81	70	75	75
	KB	70	90	86	82
	PC	77	81	74	77

Table 1b: Duration values (in ms) for tense [+high] vowels in open final syllables.

These numbers show that tense [+high] vowels are somewhat longer for most speakers, but not all. Though there exists a cross-linguistic tendency for tense vowels to be longer (English, German; see Lindau 1970), this correlation is not a necessary attribute of [+ATR] vowels. Unlike Wolof, [ATR] is not a contrastive feature for [+high] vowels in CF, but like Wolof, it seems CF can differentiate between tense and lax qualities without necessarily appealing to length for enhancement of this difference in quality (Ka 1984, 1988). To a

certain extent, the trends in duration illustrated in tables 1a and 1b do reflect the tendency for tense vowels to be longer.

Now, how do these durations compare to the duration of [+high] vowels in non-final positions? This was measured using data from a production task, in which 12 speakers of CF were asked to read a text written in colloquial CF¹⁴. The text featured a dialog between two fictional speakers of CF, which included trisyllabic words with the conditioning environment for harmony. Speakers were asked to read the text aloud into a microphone, and their reading was recorded on a cassette tape. The recording was later digitised into .wav files which could be manipulated in Praat. Four speakers were chosen for this aspect of the study in which non-final [+high] vowels were measured for duration, and F₁ and F₂ values. Four speakers were chosen out of the 12 to represent the four patterns of harmony that are possible for trisyllabics. As mentioned in the introduction to this chapter, trisyllabics can be produced in one of four patterns: without harmony, [i . l y . m I n], represented by speaker BGB; with harmony across the board: [ɪ . l ʏ . m I n], represented by HRZ; with non-local harmony: [ɪ . l y . m I n], represented by MES; and finally, strictly adjacent harmony: [i . l ʏ . m I n], represented by speaker MEA. Speakers are classified as such based on their relative preference for a certain pattern over others. Whether this relative preference is reflected in their production in a consistent manner is uncertain. What is clear, is that we can isolate at least one token for each speaker that does reflect their preferred pattern. These tokens will be used to measure formant values of non-final vowels. This sub-sample of speakers is meant not to predispose the duration of certain vowels to be longer than others because of their tense quality, in the event that a tense quality was strongly correlated with greater duration.

¹⁴ Though CF uses standard orthography in most printed media, colloquial CF is often represented in an unstandardised orthography which represents the language more ‘phonetically.’ Most often included in this orthography is the representation of contractions. These were meant to cue the reader that the text should be read in a certain style of speech. Target words were not spelled in any way suggesting they should be pronounced with harmony; they were represented in standard spelling. A copy of text is provided in the appendix.

In other words, it is possible that, had I chosen a sub-sample made up of non-harmonic and non-local speakers only, that medial vowels would have been longer on average than if the sub-sample included speakers of all patterns.

The following table shows the duration values in milliseconds of initial vowels in the three following words: [sɪ. ʁi. lɪk] ('cyrillic'), [sɪ. ny. sɪt] ('sinusitis') and [pʁi. mi. tɪf] ('primitive'). Duration was measured using Praat software; vowel duration is assumed to correspond to the area of periodicity located between two formant transitions:

Initial	BGB (no harmony)	HRZ (ATB)	MEA (adj. non-iterative)	MES (non-local)
cyrillic	71	74	39	86
sinusite	83	80	69	73
primitif	76	71	86	34
Avg.	76.6666667	75	64.6666667	64.3333333

Table 2: Duration values (in ms) of initial vowels in trisyllabics.

The next table shows duration values for medial vowels in the same three words:

Medial	BGB (no harmony)	HRZ (ATB)	MEA (adj. non-iterative)	MES (non-local)
cyrillic	82	70	76	53
sinusite	94	80	57	76
primitif	60	53	73	58
Avg.	78.6666667	67.6666667	68.6666667	62.3333333

Table 3: Duration values (in ms) of medial vowels in trisyllabics.

If we compare tables 2 and 3 to tables 1a and 1b, we see that, roughly, non-final vowels appear shorter in general. What is interesting though, is that initial vowels, which bear secondary stress, are not longer than medial vowels (which are unstressed) for 2 out of 5 speakers. Astésano (2000: 54), in her detailed description of standard European French (SEF) stress, does say however that duration is one of the most important acoustic cues of

French stress (primary and secondary). These results, though very limited in comparison to Astésano's broader study, seem to suggest that duration is not an acoustic cue for secondary stress that is consistent across speakers. This is perhaps a difference between CF and SEF, which, to my ears at least, have very different intonational contours. I will leave the matter to future investigation.

Though it is true that non-final vowels are probably shorter, and that this average difference is perceivable, the difference is not considerable enough to warrant the claim that non-final vowels are 'not heard' by the learner (provided the vowel is not elided). This is of course assuming that learners have no trouble hearing [ATR] differences in final syllables. We know speakers hear this difference. Anecdotally, if a CF speaker imitates a European French accent, closed final syllable laxing is suppressed.

2.1.2 F₁ and F₂ frequencies of tense and lax [+high] vowels

This section will describe CF [+high] vowels in terms F₁ and F₂ frequencies. This will serve to show that the different patterns of harmony can be clearly differentiated acoustically. Polka, Escudero & Matchett (2002) investigate the formant frequencies of tense and lax final [+high] vowels in CF, and find that lax [+high] vowels have a more 'central' quality than their tense counterparts, which, in terms of formant frequencies, means that tense [+high] vowels are characterised by lower values for F₁, and higher values for F₂¹⁵. Their findings are consistent with the acoustic properties described for vowels involving a greater constriction in the anterior part of the vocal tract (Stevens 1998: 294-299). Stevens (1998) reports that this greater constriction is caused by an upward movement of the tongue body, itself caused by a widening of the pharynx. Stevens also reports, based on Liljencrants & Lindblom (1972), that F₁ and F₂ readings for tense and lax vowels can vary from language to

¹⁵ Polka, Escudero and Matchett (2002) limit their study to [+high] vowels in word final position. This of course only pertains to [+high] front vowels as far as F₂ is concerned. Back [+high] vowels have a much lower F₂.

language. Languages like English, which contrast [+high] vowels for [ATR], tend to show greater differences between F_1 and F_2 readings than languages for which [ATR] differences are allophonic. This is confirmed by the formant readings done for the present study, presented in figure 1 below, which represents F_1 and F_2-F_1 values for [+high] vowels in *final* syllables. The scatter plot is meant to provide a general idea of the acoustic differences between tense and lax [+high] vowels, so that we may show that tense and lax allophones of these vowels can be found in non-final open syllables as well:

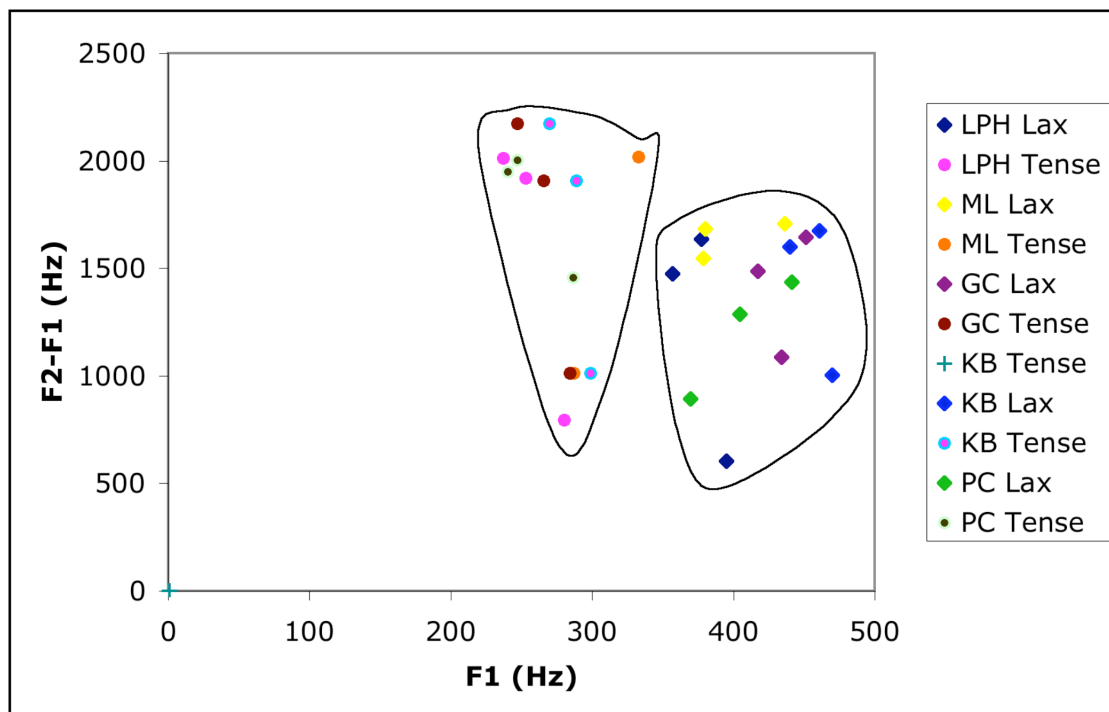


Figure 1: F_1 and F_2-F_1 values for CF [+high] vowels in word-final position (in Hz).

Formant values were measured for [+high] vowels in final position, using the same methods, stimuli and speakers as for tables 1a and 1b in which duration was reported. Frequency values for F_1 and F_2 were measured at three points in each vowel. The first point was defined by the second peak in the acoustic waveform of the vowel, while the third and last point was located on the second to last peak of the waveform. The second point at which formant values were measured corresponded to the mid point between the first and third points.

Formant values represented on the scatter plot represent the values collected at the three points for each vowel, averaged out.

The scatter plot shows that tense and lax vowels in CF pattern consistently with the general observations of Stevens (1998), and the observations of Polka, Escudero and Matchett (2002) for CF. Tense [+high] vowels are spread over a greater range of F_2-F_1 values than their lax counterparts. Moreover, the extremes of the F_2-F_1 range for lax vowels lie within the extremes of the F_2-F_1 range for tense vowels. In other words, the ‘fronter’ of the front tense vowels are more front than the ‘fronter’ lax vowels, while back tense vowels are more back than back lax vowels. Also, lax vowels tend to have a higher F_1 frequency, ranging above the 350 Hz mark. Though the differences between tense and lax [+high] vowels in CF are not considerable, they do appear to pattern with internal consistency; the data points represented in the scatter plot show few to no outliers. Based on these observations, we can assume a ‘rule-of-thumb’ diagnostic for tense and lax [+high] vowels in CF, which I will apply in the evaluation of non-final [+high] vowels. I will assume that a lax [+high] vowel should show an F_1 value over 300-350 Hz, and F_2-F_1 values within the range observed for lax vowels in the scatter plot above.

The following results are collected from the same production as the duration results collected for non-final [+high] vowels in trisyllabics. As discussed in the introduction to this chapter, CF speakers can be classified according to which pattern of harmony they prefer for tri- and tetrasyllabic words. Three patterns of harmony are attested: fully iterative, non-local and adjacent non-iterative harmony. Given that some speakers do not accept harmony, a fourth pattern can be added, which I call the ‘no harmony’ pattern. Again, this classification is based on the results of a judgment task, reported in section 3. Whether the preference that determines this classification is reflected in speakers’ production is unclear, but, conservatively, I will nonetheless assume that speakers can produce the pattern for which they give the highest acceptance rate. All of the speakers produced their preferred pattern at

least once¹⁶, but only four out of 12 speakers produced it for the same token: [sɪ . ny . zɪt] ‘sinusitis,’ thus allowing an exact comparison of the [+high] vowels’ formant values. The purpose of presenting these results is simply to show an objective measure of the variation in quality that non-final [+high] vowels can exhibit in the context of harmony.

The figure below shows F_1 and F_2-F_1 values of the [+high] vowels BGB uttered when reading the word <sinusite> in the production task stimulus. From BGB’s acceptance patterns, I have classified the speaker as one who disprefers any harmony pattern in words of more than two syllables. The speaker did not produce any harmony in this word (or any other, including disyllabics for that matter): [sɪ . ny . zɪt]. Both non-final vowels are thus tense. According to the approximative diagnostic that I assume, we should expect BGB’s non-final [+high] vowels to have a lower F_1 than the final vowel, which for all speakers is lax, and thus has a higher F_1 . We also expect the final lax vowel to be more central, and thus have a lower F_2 . All of these expectations are in fact confirmed:

¹⁶ The ‘preferred patterns’ were determined on the basis of speakers’ responses to the judgment task, whose results are reported in section 4.

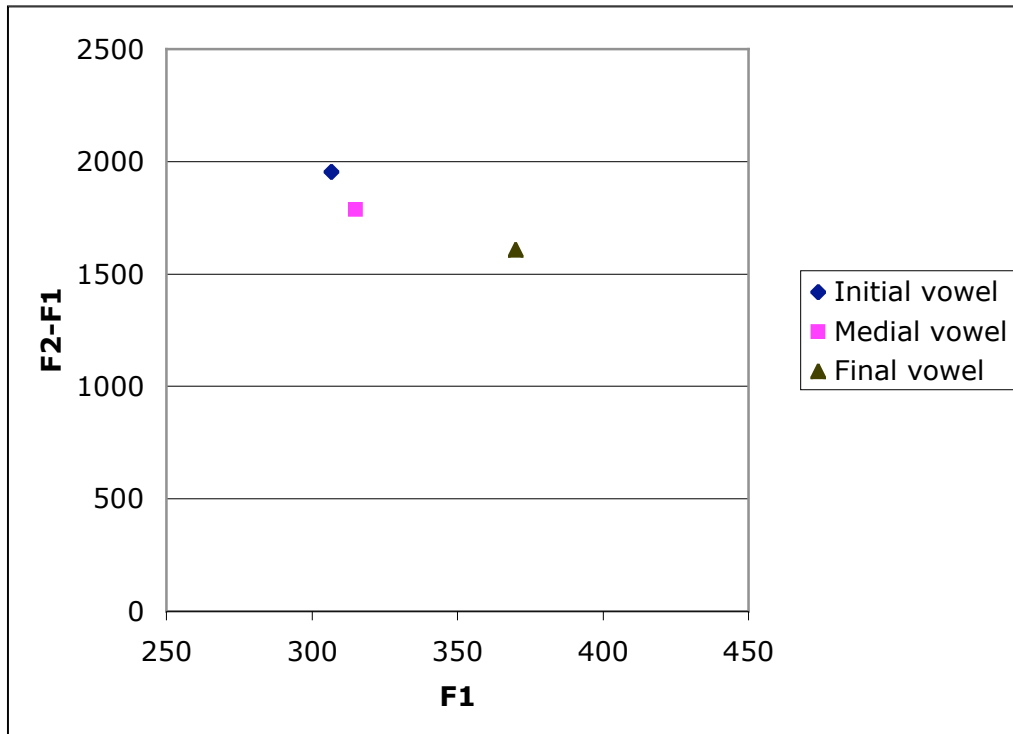


Figure 2: Scatter plot of three [+high] vowels in <sinusite>, as spoken by a non-harmonising speaker (BGB).

We see on the scatter plot that the initial and medial vowels, respectively marked with a lozenge and a square, indeed have an F_1 value below 350 Hz, which is expected of a tense [+high] vowel. In addition, the two non-final vowels have values for F_2 that are higher than those of the lax final vowel.

The next speaker is HRZ, a speaker who shows a consistent preference for the fully iterative pattern, and who produced it for <sinusite>: [sɪ̥.nɪ̥.zɪ̥t]. We thus expect his or her [+high] vowels to be in the same area of the vowel space represented by the scatter plot. This is what we find; all three vowels hover around the 350 Hz mark, and are relatively central, given their F_2 values:

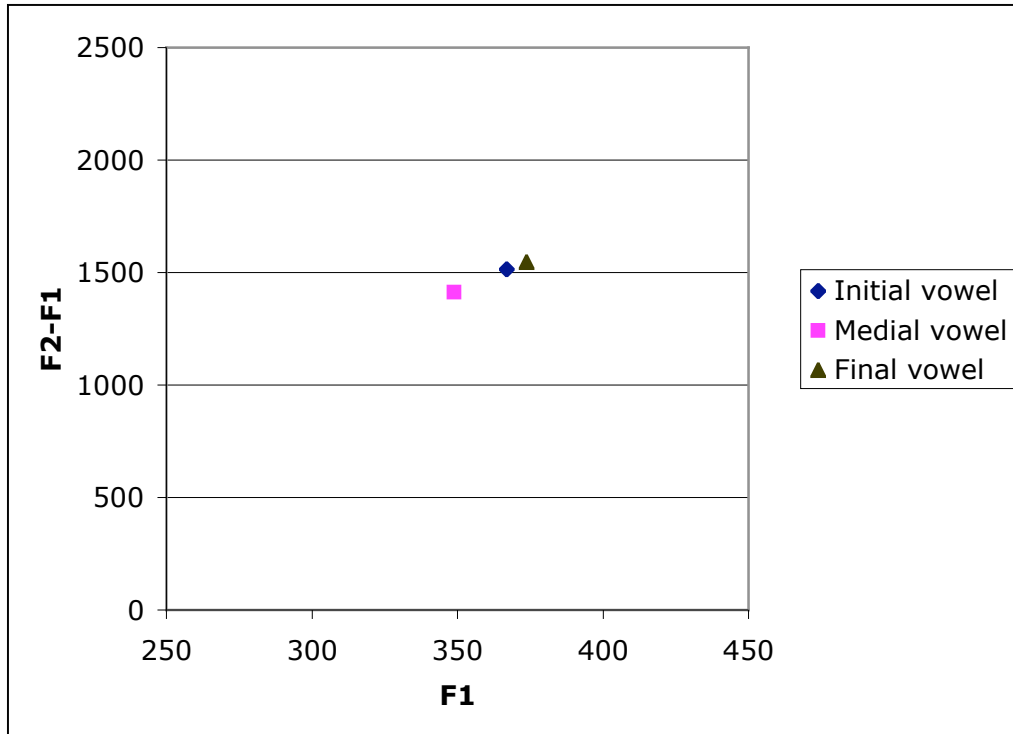


Figure 3: Scatter plot of three [+high] vowels in <sinusite>, as spoken by a fully iterative speaker (HRZ).

In the non-local pattern produced by MES ([sɪ̣ . ny . zɪ̣t]), only the initial vowel is lax, the medial one does not undergo harmony. We thus expect the non-local speaker's initial vowel to pattern like his or her final lax vowel, while the medial vowel should have the characteristics of a tense vowel. This is again shown in the following scatter plot:

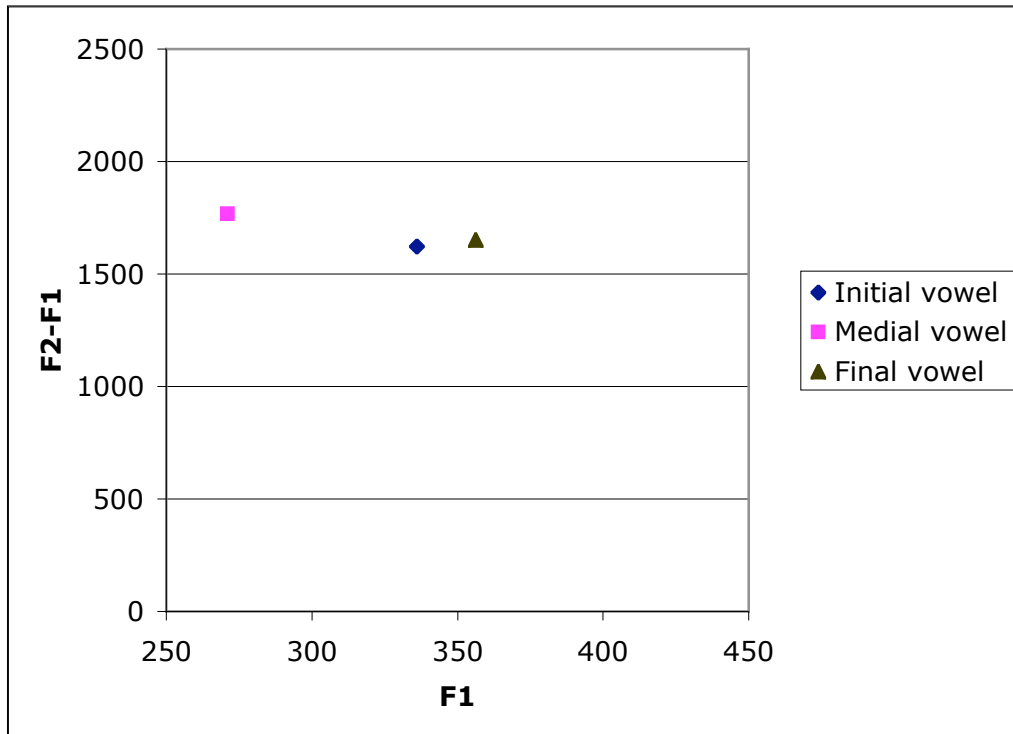


Figure 4: Scatter plot of three [+high] vowels in <sinusite>, as spoken by a non-local speaker (MES).

I am only comparing differences among the four speakers who produced their preferred pattern for *sinusite*, but here I add another scatter plot for the word *primitif* ('primitive') as spoken by another non-local speaker, JFO. Again, we see that the initial and final vowel cluster together, as they are both lax. The medial vowel is tense, and shows a lower F_1 value, which is characteristic:

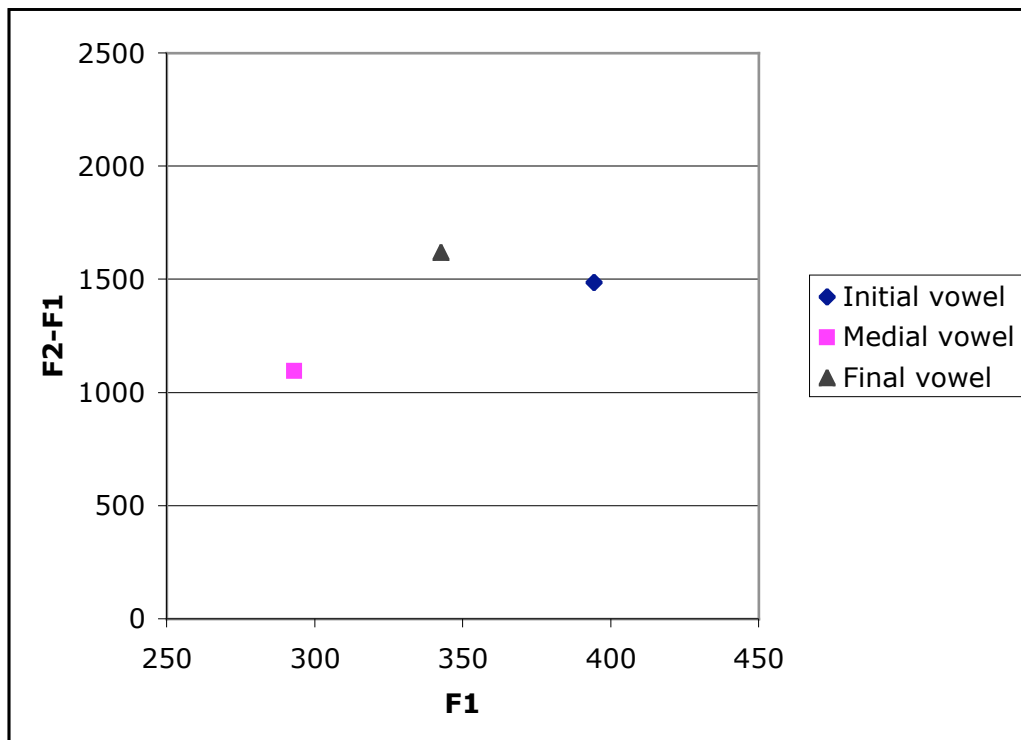


Figure 5: Scatter plot of three [+high] vowels in <primitif>, as spoken by a non-local speaker (JFO).

The opposite result is expected from the local non-iterative speaker, MEA, whose medial vowel should pattern like the lax final vowel, while the initial vowel is tense, and non-central:

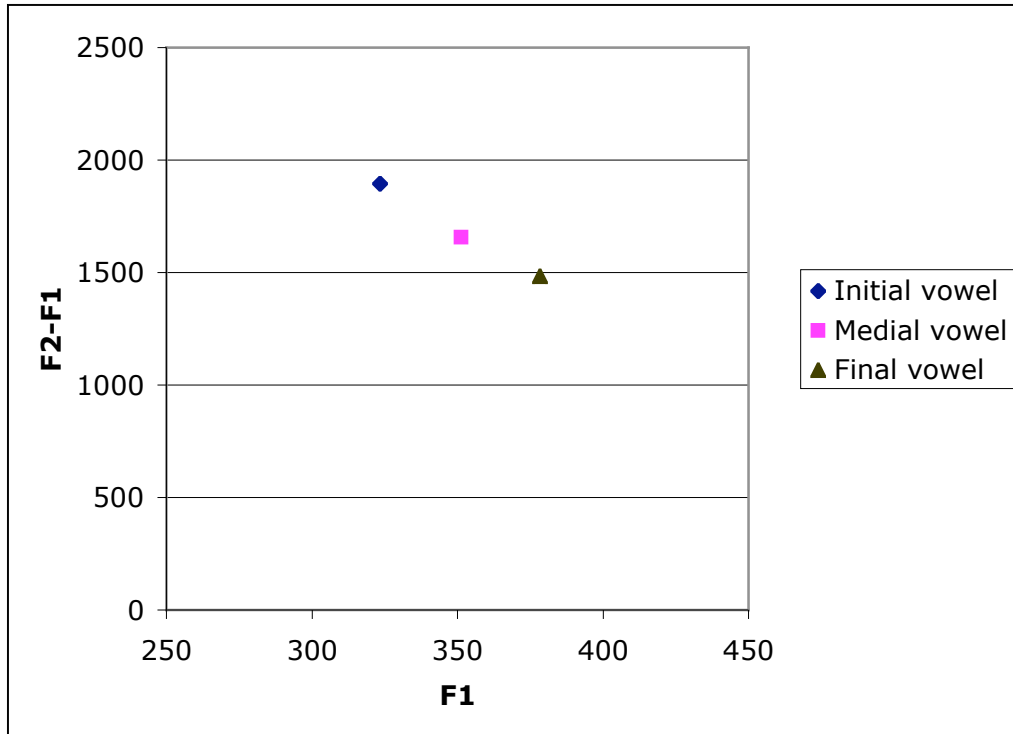


Figure 6: Scatter plot of three [+high] vowels in <sinusite>, as spoken by a local non-iterative speaker (MEA).

Again, the purpose of these data is mainly to illustrate the qualities of non-final [+high] vowels as compared to final [+high] vowels, but also to show that these qualities are perceivable. That being said, a production task is not an ideal tool if we are interested in modelling grammars that can produce a range of harmony patterns. Since harmony is optional, speakers may or may not produce it at all in a given experiment, giving a limited picture of what speakers can and cannot process. In fact, one might argue that, because harmony is associated with a lower register, that speakers are less likely to produce it, if they conceive of the experimental setting as being formal¹⁷. In contrast, a judgment task in which speakers are asked to assess the naturalness of all logically possible harmony patterns is

¹⁷ Informal observations: a) among laypeople, linguists are still believed to be professional prescriptionists, in whose presence language must be ‘proper.’ This is especially true among CF speakers, whose colloquial speech is stigmatised; French Canada has spawned an industry of professional prescriptionists referred to as ‘linguists.’ b) For any experiment, there is a tendency among human subjects to want ‘to do well,’ as if the experiment were a test; this further discourages people from using language associated with a lack of education, even though speakers were explicitly told that casual speech was the object of study.

much more informative because we see which logically possible patterns are systematically dispreferred, thus providing us with clues as to how competence in this respect is constrained. The results of several judgment tasks is reported in section 4.

3 The underdetermined analysis of potentially harmonic words

The results of the judgment tasks explicitly show how variable CF harmony is, but before their results are reported and discussed, I will propose a hypothesis on the causes of this variation. This parenthesis is necessary because the causes of variation highlight the importance of the phenomenon. I will propose that variation is the result of the underdetermined analysis of primary linguistic data (PLD). It is important to emphasise the fact that the variation we are observing here is not ‘sociolinguistic’ in nature. Like any variation, it is the result of different parameter settings, but how one’s parameters are set is not dependent on any external variables of a social nature. One sets one’s parameters essentially at random, but the range of available options is limited. Those limits, I propose, are those of language competence.

Dumas (1987) briefly describes variation in the application of harmony to words of more than two syllables. Though all harmonising speakers of CF agree that harmony is possible in disyllabic words like [fɪ. lɪp], Dumas reports inter-speaker variation when it comes words like <illumine> (standard CF: [i . lɪy . mɪn]). Trisyllabics of this type have more than one potential target, and thus present three logically possible harmonic variants (only harmonic targets are bold and underlined): [ɪ . ly . mɪn , ɪ . lɪy . mɪn , i . ly . mɪn]. According to Dumas, all three patterns are attested. An account of these different patterns and the grammars that can generate them is the topic of this thesis.

For now, the present section offers an explanation for the source of this variation. Variation is explained by the hypothesis that a learner’s knowledge of his or her grammar is

incremental, and reflects a generalisation made on the evidence to which s/he has been exposed to date. This entails that, if presented with new or more evidence, a speaker can very well modify his or her grammar to produce outputs that are different from those produced before encountering new evidence. In other words, parameter setting is entirely contingent on evidence to which the speaker has been exposed. But what if speakers are *never* (or very rarely) presented evidence to set a given parameter one way or another? For example, when a CF learner hears inputs like [fɪ . lɪp], s/he can assume that harmony is a rule in his or her language, but is given no clue whether the harmony rule in the language is iterative or whether or not it applies locally. Given just these two parameters ([±iterative], [±adjacent]), and no positive evidence from the input, three possible behaviours can be expected:

- a) the speaker will set the parameters once and for all but at random, thus resulting in inter-speaker variation but intra-speaker consistency with regards to their outputs; or,
- b) the speaker will set the parameters at random each time they are confronted with a new input, which would result in inter- and intra-speaker variation; or,
- c) the speaker will set the parameters according to a hard-wired default setting.

It goes without saying that any speaker could adopt any of the behaviours above.

Interestingly, the empirical study reported here has found that speaker judgments with respect to different patterns of harmony shows no trend of preference for one given harmony pattern that might act as the output of a default parameter setting. Rather, the study has found that every speaker seems to adopt a ‘mix’ of behaviours a) and b). That is to say, speakers show intra-speaker consistency to the extent that they generally have a consistent preference for a given pattern of harmony. But paradoxically, speakers also show intra-speaker *variation* to the extent that this preference for a pattern is never to the exclusion of other patterns. For this reason, if speakers’ spontaneous speech were monitored, we might

expect a statistically significant use of one pattern over others, but some variation as well. That being said, this sort of data, which was not obtained, is not entirely relevant to the more abstract goals of this study. These goals are to see which patterns are possible, and which are not possible, thus providing clues as to the range of grammars one needs to account for. Thus, if a speaker has a consistent preference for pattern X over pattern Y, this shows that the speaker has a representation of grammar X, and that grammar X is a possible grammar.

This section is largely inspired by the work of Nevins (2004), who has used this theory to explain micro-parametric¹⁸ variations in harmony patterns. The claim rests on the assumption that, if a learner is exposed to data that is underdetermined in nature, i.e. which can be interpreted in different ways, that s/he is able to hypothesise a range of grammars. This range of grammars can be identical in outputting a form O_x , but they may differ with respect to another sort of output O_y . If data of the O_y type is also underdetermined, or statistically rare, speakers will not be exposed to positive evidence that their parameters should be set one way or another. Though all speakers may produce O_x , speakers are expected to produce a range of different outputs O_y ($O_y^1, O_y^2, O_y^3 \dots$ etc.). To my knowledge, the theory does not predict whether we should necessarily find either inter-speaker variation, or intra-speaker variation, or both. All cases are possible. Inter-speaker variation is expected if, though data is underdetermined, a speaker settles on one and only one grammar that will a) output O_x , and b) output O_y in a way that is consistent with the stimulus the speaker believes s/he has been exposed to. Intra-speaker variation is expected if the speaker, in the face of underdetermined data, never ceases to entertain a range of grammars, each of which outputs a different O_y . The speaker in this case will likely switch from one possible grammar to another, and thus produce different outputs.

¹⁸ This phenomenon, which involves variation with respect to the settings of one or more parameters, is called ‘nanovariation’ in Nevins, Poliquin & Perfors (2006) and Poliquin & Nevins (2006). ‘Nanovariation’ is preferred to the term ‘microvariation’ which is reserved for the study of differences among related languages/dialects.

Let us turn to a more concrete example: CF vowel harmony. Vowel harmony in disyllabics is underdetermined with respect to iterativity and adjacency parameters. If we consider data of the *Philippe*-type, one may characterise the non-final vowel in various ways, each of which makes different predictions for words of more than two syllables. Examples of logically possible characterisations are listed below:

(11) *Characterisations of the non-final vowel in Philippe-type words*

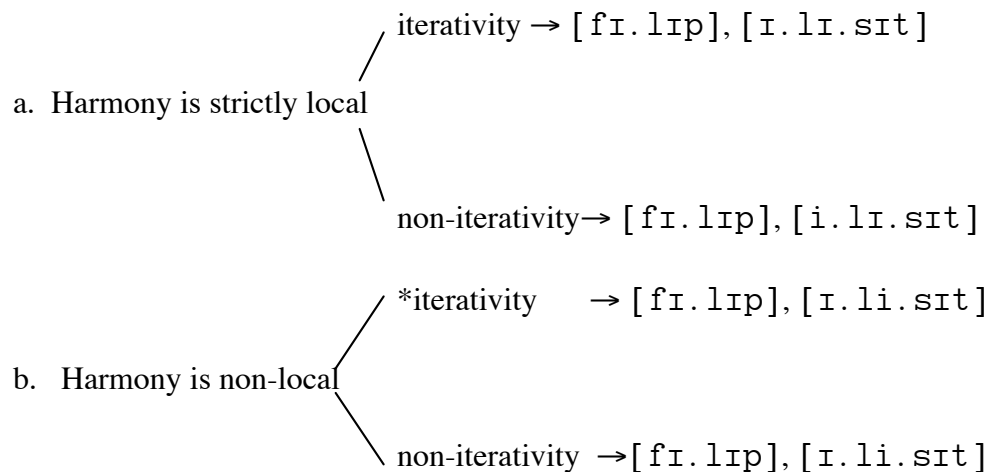
The non-final vowel is. . .

- a. The most adjacent vowel to the trigger.
- b. The leftmost vowel in the word.
- c. The secondarily stressed vowel.

We know that speakers do not entertain option (11)c because they have sufficient evidence from *mitaine*-type words that not all secondarily stressed [+high] vowels may be lax. The output *[mɪ̣ . tɛn] is unattested. As for option (11)a, two different predictions are possible, depending on what the speaker assumes about iterativity. *Philippe*-type words are also underdetermined in this respect. From an output like [fɪ̣ . lɪp], one may assume that all non-final [+high] vowels that are in open syllables may lax provided they are adjacent to a [+high, -ATR] vowel. Or, one may assume that only the vowel that is adjacent to the trigger may lax. Considering that these are two separate grammars, each will predict the same output for a disyllabic input of the *Philippe*-type; each will predict a different output for a trisyllabic input of the *illicite*-type however. The first, which hypothesises iterativity, will select [ɪ̣ . lɪ̣ . sɪt] as the output, while the second, which hypothesises non-iterativity, will select [i . lɪ̣ . sɪt] as the output.

Considering option (11)b, leftmost laxing, will produce a grammar that will select [ɪ . l i . sɪ t] when given a trisyllabic output. In principle, we might consider that there exist two possible grammars based on option (11)b, one with iterativity and the other without. Both however will select the same trisyllabic output, since iterativity would be inapplicable to *illicite*-type inputs in this case anyway; if the leftmost [+high] vowel is laxed, there are no other [+high] vowels to its left to be laxed by iterativity. The (un)predicted grammars are illustrated in the diagram below:

(12) *Predicted grammars*



There remains one crucial factor: if speakers behave variably because *Philippe*-type words are underdetermined, we must assume that trisyllabics of the *illicite*-type are also underdetermined, or insufficient in number to force speakers to parametrise in a stable fashion. In other words, the hypothesis will be verified if we can show that the number of examples of the crucial data point, *illicite*-words, is statistically insignificant in the primary linguistic data (PLD) and in adult speech. Is the stimulus really so limited in this respect?

3.1 How underdetermined is the stimulus?

3.1.1 Child directed speech

3.1.1.1 Using the CHILDES database

To test the hypothesis that the number of *illicite*-type words in the PLD is very low, we must look at child-directed speech. CHILDES (Child Language Data Exchange System; MacWhinney 2000) is a database comprising several corpora of transcriptions of parent-child conversations. The database includes a sub-corpus of conversations in French. By using software provided by the database (CLANX) managers, one can search for which words in child-directed speech are most frequent. ‘Child-directed’ speech only includes the part of transcriptions that corresponds to speech uttered by parents to their children; it excludes child speech. The software provides a list of all words uttered in a given corpus and cites the number of times each word was uttered. The French sub-corpus of CHILDES contains five corpora (representing five different children), which, in total contain 360 transcriptions of child-parent conversations of varying lengths. The total number of different words used in the sub-corpus is 1142. We can thus assume that the French sub-corpus contains a sample of words that is representative of a normal environment in which francophone children might acquire language. By using these 1142 words, we can see, among groups of more or less frequent words, what proportion is made up of words that contain three or more syllables. It should be noted that the sub-corpus focuses only on European French; no such database was available on Canadian French. For these purposes, I will assume that the PLD is the same.

3.1.1.2 Results from the CHILDES database

The following graph depicts the proportion of tri- and tetrasyllabics to di- and monosyllabics in groups of more or less frequent words. The graph includes all tri- and tetrasyllabic words, not only those with a contiguous sequence of [+high] vowels. The leftmost bar in the graph represents the top 10% most frequent words, while the next bar to the right represents the

next 10% most frequent words, this in descending levels of frequency, until the rightmost bar depicts the less frequent words in the sub-corpus:

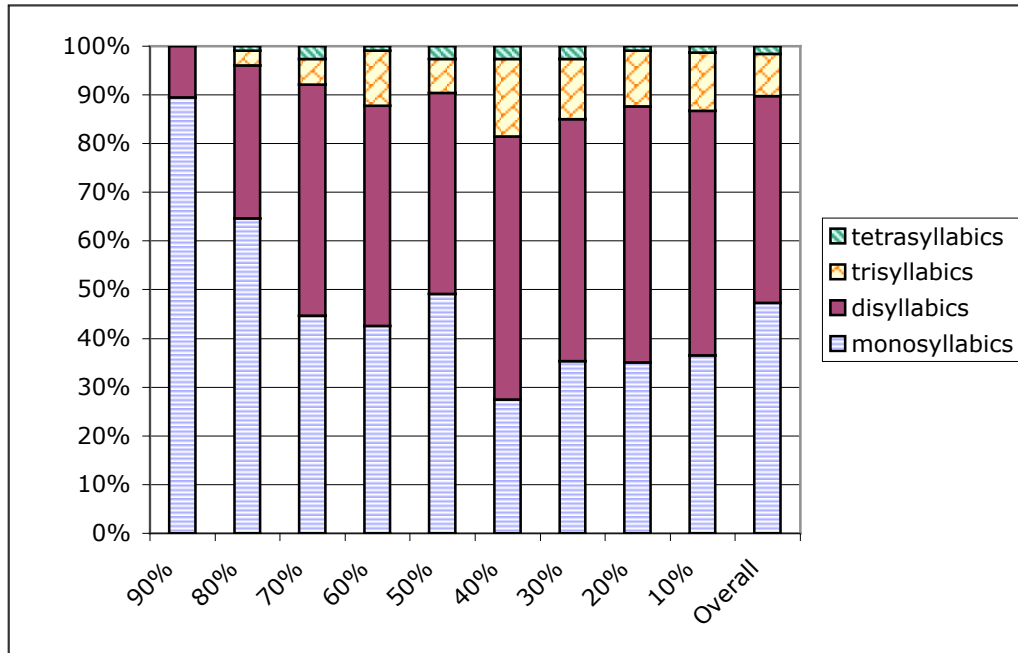


Figure 7: Proportion of tri- and tetrasyllabic words as compared to di- and monosyllabics in more and less frequent words (taken from French sub-corpus of CHILDES database).

We can see from figure 2, that the top 10% most frequent tokens contain no words that have more than two syllables. Overall, words of more than two syllables do not make up more than 10.28% of all words in the sub-corpus. In the top 50% most frequent words, words with more than two syllables make up only 6.74% of the total. It is also important to reiterate that this includes the totality of tri- and tetrasyllabic words, not only those with contiguous sequences of [+high] vowels. These naturally represent an even smaller proportion of these words, if we consider an imaginary corpus that would include all words ever spoken by francophone parents to their children. In the corpus under scrutiny here, not one word among

the tri- and tetrasyllabic words had the proper environment for harmony to occur (e.g. <illumine> or <similitude>).

We can thus conclude that those words that might determine a stable pattern for harmony are effectively absent from child-directed speech. There remains the possibility however, that the generalisations CF speakers make about harmony, and the preferences on which they settle, are determined later in life.

3.1.2 Adult speech

The previous section has shown that the small number of tri- and tetrasyllabic words in PLD is consistent with the hypothesis that CF grammars concerning vowel harmony are unstable. There remains the possibility however that CF speakers settle on their grammars at a later stage in life (e.g. their teenage years). If we can find that tri- and tetrasyllabics form an important part of adult speech, then potentially, speakers may have the opportunity to stabilise their grammars with respect to the iterativity and adjacency parameters. This would leave inter-speaker variation unexplained. This section will show that tri- and tetrasyllabics also form a negligible proportion of adult speech.

The *Lexique* database¹⁹ is a corpus of 133, 433 words made available by the Centre National de Recherche Scientifique (CNRS; Boris New & Christophe Pallier). The corpus will be assumed to be representative of adult speech for the purposes of this study. A simple search of the corpus reveals that mono- and disyllabics constitute approximately 41.6% of the total corpus, while words of more than two syllables make up the majority of words with 58.4%. This might provide the false impression that adult speech data comprises the forms necessary for adults to stabilise their grammars.

¹⁹ www.lexique.org

One must keep in mind that only a small minority of multisyllabic²⁰ words provides crucial data for vowel harmony. Not all multisyllabic words count; only those that provide the conditioning environment for harmony are truly crucial. A search was performed in the database for only those words that contained a contiguous sequence of only [+high] vowels (e.g. *my. zɪk* ‘music,’ or *i. li. sɪt* ‘illicit’). All combinations of [+high] vowels were searched. On a total of 133,433 words in the corpus, the following numbers of relevant multisyllabics were revealed²¹:

	Number	%
Disyllabics	683	0.511%
Trisyllabics	94	0.07%
Tetrasyllabics	8	0.006%

Table 4 Multisyllabics with conditioning environment for vowel harmony in French

The database search reveals that words potentially providing crucial information on vowel harmony to adult speakers (tri- and tetrasyllabics) constitute only 0.08% of the total corpus. What is more, upon hearing this 0.08% of words, speakers may not be exposed to harmony at

²⁰ ‘Multisyllabics’ include words of more than two syllables, not just tri- and tetrasyllabics.

²¹ In these numbers, I include all words in which harmony can potentially apply. Among disyllabics, I count words of more than two syllables whose last two syllables have [+high] vowels: e.g. [dɛ. si. zɪf] ‘decisive.’ These words, like *Philippe*-type words, are also uninformative about locality and iterativity, but harmony can be applied in them. There are 491 disyllabics of the *Philippe* type, and 192 of the *décisif* type. The same goes for trisyllabics. I include among the trisyllabics words of more than three syllables, but whose final three syllables have only [+high] nuclei: e.g. [kɔ̃. tʁi. by. tʁɪf] ‘contributive.’ There are 79 trisyllabics of the *illicite* type and 15 of the *contributif* type. Among these words, I have also included words whose final coda is branching, such as [kɔ̃. my. nɪsm] ‘communism’ and [li. zɪbl] ‘legible.’ The final coda in words like *lisible*, which contains two voiced consonants are always simplified by deletion of the final sonorant: /lizɪbl/ → [li. zɪb], so that the coda is not really branching in this case. For more on cluster simplification in CF, see Côté (2000).

all, given that harmony is optional in CF. Thus, we can still assume that speakers' grammars do not stabilise with respect to harmony for want of sufficient evidence²².

4 Judgment task results on locality parameters

Judgment task results show that CF speakers exhibit seven patterns of behaviour with respect to locality and directionality. Since they are the only such data available for CF, I will assume that the data are sufficiently representative of the general CF-speaking population to draw theories about the principles that underlie their phonological component, and consequently, about the principles that underlie the human faculty for language. That being said, future inquiry into these phenomena may or may not force some modifications to the present analysis.

The data reported in this section are meant to bring an answer to the following questions concerning CF words in which harmony might apply, i.e. words with a [+high, -ATR] vowel in a final closed syllable:

- a) 'if there is more than one target (i.e. a [+high] vowel in an open non-final syllable), how many targets may undergo harmony?'
- b) 'if only one target may undergo harmony, which one, and how far can it be from the trigger?'
- c) 'are [-high] vowels transparent or do they block to the harmony process?'

²² If we measure frequency of tri- and tetrasyllabics in terms of token frequency, it is possible that we may find a small number of tri- and tetrasyllabic tokens that are extremely frequent. If this is the case, then we might expect speakers to be exposed to enough data to set their parameters. The question is, what is the threshold of token frequency that must be crossed by a given token (or set of tokens) to constitute 'enough' evidence for a speaker to set his or her parameters. This is the topic of further investigation. Be that as it may, though there may be a set of tri- and tetrasyllabic tokens that are very frequent, it remains that speakers are exposed to many more disyllabics, whose token frequencies might be equal or greater than that of the hypothetically frequent tri- and tetrasyllabics. The hypothesis of underdetermined stimulus is to be refined on those points in future work.

- d) 'is there a correlation between the acceptance of non-local patterns of harmony and the opaque/transparent status of [-high] vowels?'

Words on which the answers to these questions can be tested are few and far between in the lexicon. Subsection 3 shows that they generally constitute a negligible percentage of the lexicon, and an even smaller percentage of the primary linguistic data (PLD)²³. The answers to these questions thus potentially reveal how the default values of locality parameters are organised in the phonological component. In other words, these rare words provide us with an opportunity to see the "pure" possibilities of what the phonology of these speakers will potentially allow and disallow when existing data does not definitively tell them.

4.1 Judgment task methodology

12 speakers of CF, 8 females and 4 males, all volunteers from the Montreal area, were asked to perform a judgment task. The task consisted of listening to utterances that I pre-recorded on a cassette tape, and indicating a binary choice between natural- and unnatural-sounding utterances on a pre-prepared form. Utterances consisted of single words of different categories with a given pronunciation; words were pronounced in isolation. Words of different categories were randomized, and mixed in with words of other categories used for other tests. Utterances on the recording were elicited one at a time, with a one second interval between them. Each utterance was repeated twice in a row to ensure optimal perception by the subject. Utterances were numbered on the recording, and corresponded to a number on the pre-prepared form beside which subjects saw the words 'yes' or 'no.' During the one second interval separating each utterance on the recording, subjects were to circle if 'yes' the utterance just heard sounded natural, or 'no' if it sounded unnatural.

²³ Due to the relative infrequency of polysyllabic words.

‘Natural’ was defined to speakers beforehand as ‘a pronunciation they would use in their own speech in the context of a casual conversation between two speakers of Canadian French.’

The reason for this is that vowel harmony is suppressible, and in my personal experience, more likely to be so in the context of a formal conversation, or in the context of a conversation between a CF speaker and a speaker of non-Canadian French. The proportion of ‘yes’ answers in a given category is termed the ‘acceptance rate’ of that category, and is assumed to be an indicator of the category’s naturalness. Acceptance rates are represented by a number ranging between 0 and 1.

I personally recorded the stimuli for the experiment for a number of reasons: a) utterances could only be synthesized with great difficulty, and possibly at the cost of making all of them sound unnatural, b) many of the utterances happen to be very unnatural and thus difficult to pronounce so that an untrained speaker might stumble in recording them, thus biasing the experiment; I could train myself to pronounce unnatural utterances in the most neutral fashion, c) though this is not the case for disyllabics, vowels in unstressed syllables are often reduced; again, I trained myself to make each vowel resound clearly.

The following table shows the durations of initial, medial and final vowels in twelve tokens from the stimulus. The twelve tokens from the stimulus represent three different words, each pronounced according to the four different patterns. This is to show that vowel durations in the stimulus were similar to those found in a natural context:

Patterns	Words	Initial	Medial	Final
No harmony	si.ny.zit	107	99	75
No harmony	pri.mi.tif	49	82	70
No harmony	si.ri.lik	83	75	69
Non-local	SI.ny.zIT	70	99	88

Non-local	prɪ.mi.tɪf	75	81	86
Non-local	sɪ.rɪ.lɪk	101	69	64
ATB	sɪ.nɪ.zɪt	88	114	93
ATB	prɪ.mɪ.tɪf	68	79	82
ATB	sɪ.rɪ.lɪk	89	82	78
Adj. non-iter.	sɪ.nɪ.zɪt	59	128	84
Adj. non-iter.	prɪ.mɪ.tɪf	80	71	73
Adj. non-iter.	sɪ.rɪ.lɪk	100	87	82
Avg.		80.75	88.8333333	78.6666667

Table 5: Average durations of [+high] vowels in stimulus trisyllabics

Table 5 shows that the average durations of vowels in the stimulus were longer than in natural speech. This was done on purpose so that speakers might hear the differences in [ATR] more clearly than they might in a natural context. There is a concern that the greater average duration might affect the naturalness of the stimulus forms. Had that been so, one would expect a much higher rate of rejection of non-standard forms (i.e. all harmonic forms). Since speakers gave relatively high acceptance rates to most harmonic forms, I believe the concern is alleviated.

4.2 Results

4.2.1 Harmony in disyllabic words

The purpose of this subsection is to show that 11 out of 12 speakers of CF interviewed for this study show relatively high acceptance rates for non-final laxing in words that have the appropriate for trigger harmony: e.g. fɪ.lɪp ‘Philip.’ Henceforth, I will refer to these words as *Philippe*-type words, or simply, as ‘disyllabics,’ assuming that every nucleus in the word is a [+high] vowel. Examples are provided here (again, a ‘✓’ indicates an accepted pronunciation, which here happens to be the standard):

(13) *Philippe*-type words

fɪ.lɪp pr. name ✓fɪ.lɪp

mɪ . nʏt	‘minute’	✓mi . nʏt
d ^z ɪ . sʊt	‘dissolved, fem.’	✓d ^z i . sʊt
st ^s ʏ . pɪd	‘stupid’	✓st ^s y . pɪd
mʏ . kʏs	‘mucus’	✓my . kʏs
t ^s ʏ . muʃ	‘fly paper’	✓t ^s y . muʃ
pu . ʁɪt	‘rotten, fem.’	✓pu . ʁɪt
ku . t ^s ʏm	‘custom’	✓ku . t ^s ʏm
ʃu . kʁʊt	‘sauerkraut’	✓ʃu . kʁʊt

Naturally, I argue that non-final laxing is due to a harmony process, but is it? And how do we know? This section shows clearly that non-final laxing of [+high] vowels in open syllables is only allowed in *Philippe*-type words, and not anywhere else, for instance, not in words where the final vowel is [-high]: e.g. *mɪ . tɛn ‘mitt.’ I will henceforth refer to these words as *mitaine*-type words, but *not* as ‘disyllabics,’ I reserve the term ‘disyllabics’ for *Philippe*-type words where harmony is allowed. Acceptance rates for disyllabics with non-final laxing are relatively high for all speakers, whereas acceptance rates for non-final laxing in *mitaine*-type words are very low, if not null for almost all speakers.

The following figure shows acceptance rates by speaker for *Philippe*-type words in which the non-final [+high] vowel is [-ATR] (righthand bar), compared to the acceptance rates for the same words, but where the non-final [+high] vowel is [+ATR] (lefthand bar). Speakers are presented in alphabetical order starting from the left. Acceptance rates on the chart are represented as a decimal number between 0 and 1, but I will informally refer to acceptance rates in terms of percentages. Eight words, each with two pronunciations (e.g. [fɪ . lɪp] and [fɪ̣ . lɪp]), constituted the stimuli for this test; with 12 speakers, the total number of answers yielded was 192. The list of words is provided in the appendix.

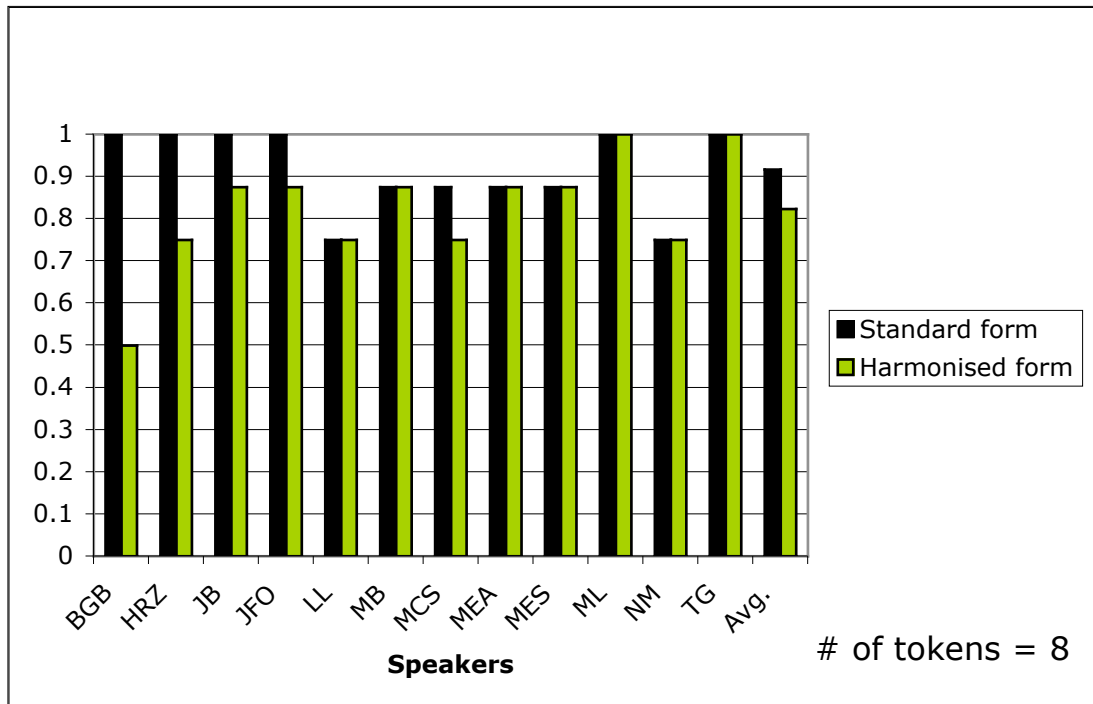


Figure 8: Acceptance rates for non-final laxing in *Philippe*-type words compared to acceptance rates for *Philippe*-type words with [+ATR] non-final [+high] vowel.

It is important here to reiterate the fact that harmony is an optional process in CF (see Dumas 1981, 1987). That being the case, it is expected that acceptance rates should be very high for *Philippe*-words with no harmony, as they represent the standard pronunciation, which all speakers know and speak. This trend is reflected on a speaker by speaker basis as well. 11 out of 12 speakers accept harmony in disyllabics at a rate of 75% or more. The 12th speaker, BGB, accepts harmony in disyllabics at a relatively low rate of 50%, but cannot be said to reject harmony altogether. Furthermore, seven out of 12 speakers have equal acceptance rates for both harmonic and non-harmonic *Philippe*-type words. These acceptance rates do not necessarily equal 100% however. The fact that non-harmonic stimuli can be rejected, even though they are the standard, can be explained by the fact that some words are perhaps more often heard with harmony than otherwise (e.g. *Philippe*, *minute* ‘minute, n.’, *pourrite*

‘rotten, fem.’)²⁴. What makes certain words more or less ‘harmonisable’ is not well understood. The propensity to be harmonic may be correlated with greater frequency in an informal register; though this is perhaps the case, I show in the next chapter that, at least, the opaque harmony pattern is productive in both high and low frequency words²⁵). To my knowledge, the sociolinguistic aspects of this phenomenon have not been studied²⁶, and remain the subject of future investigation. The fact remains however that most speakers give a high acceptance rate for harmonic disyllabics, one that, on average, is not significantly lower than for the standard form.

But is it the case that non-final laxing is only allowed in words with a [+high, -ATR] vowel in a final closed syllable? If not, an analysis of these data as the result of a harmony process is at best difficult. The following figure shows however that, if the final vowel is not a valid trigger, i.e. [-high], non-final laxing is almost unanimously rejected:

²⁴ Some phonetic factors may influence the propensity for a word to exhibit non-final laxing. The presence of a uvular [ʁ], may have centralising influence on the preceding vowel by lowering of F₃ (Marie-Hélène Côté p.c.). These facts, which are also not well understood, were not controlled for in this study. As for the stimuli represented in figures 1 and 2, only one token had this configuration: *pourrite*. Among others see Palestinian Arabic (Shahin 2002) and Aymara (Adelaar 2004) for centralisation or lowering in positions adjacent to post-velar consonants.

²⁵ Relative frequency was not measured for different registers, only within a French language word corpus (Lexique database, www.lexique.org Boris New and Christian Pallier).

²⁶ Dumas (1987) speculates about the geographic distribution of some harmony patterns re: trisyllabics, though they remain speculations. All speakers interviewed for this study were from the greater Montreal area, and still exhibited different preferences for different harmony patterns.

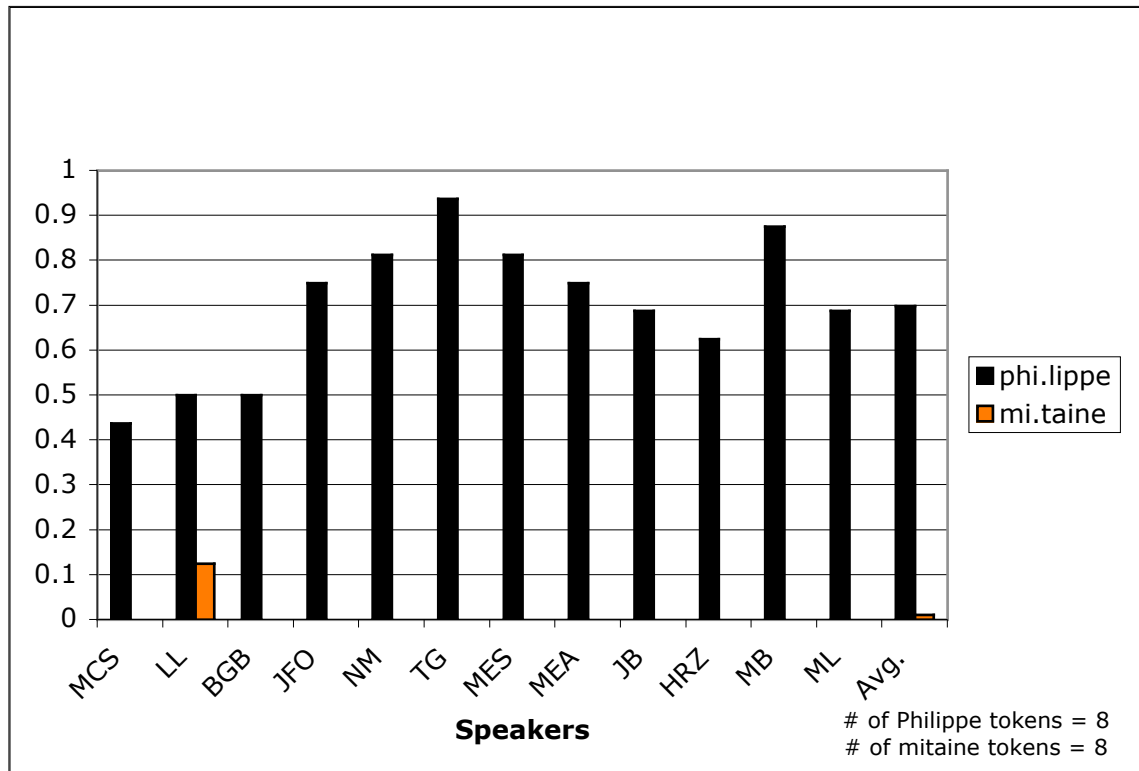


Figure 9: Acceptance rates for non-final laxing in *Philippe*-type words compared to non-final laxing in *mitaine*-type words.

Figure 3 shows very clearly that non-final laxing in *mitaine*-type words is not accepted at all. Only one speaker out of 12 accepted one *mitaine*-type token, which we can attribute perhaps to error, given the universal character of this result. Thus, the presence of a [+high, -ATR] vowel in a final closed syllable is an essential conditioning factor of CF vowel harmony. CF vowel harmony is a ‘parasitic’ case of harmony (Steriade 1981; Cole and Trigo 1988), the term is defined here (Nevins 2004: 121), with F = [-ATR] and G = [+high]:

(14) *Parasitic harmony*

“Harmony for a feature F between segments X and Y applies only if X and Y share the same value for a feature G, $G \neq F$.”

Overall, we can conclude that all speakers of CF agree that non-final laxing is allowed in disyllabics where the final vowel is [+high, -ATR] as a result of final closed syllable laxing.

Given the comparison with *mitaine*-type words, where the latter condition is not found, we can strongly support the hypothesis that non-final laxing in *Philippe*-type words is the result of a harmony process.

4.2.2 Harmony in trisyllabics: variation in locality

The present section deals with what I will refer to as ‘trisyllabics,’ meaning words of three syllables each containing a [+high] nucleus: e.g. /ilymin/ ‘illuminate.’ I will also refer to these words as *illicite*-type words (‘illicit’).

Though CF vowel harmony is attested in Baronian (2001), Déchaîne (1991) and Dumas (1976, 1981, 1987), the process is mostly described using disyllabic words. Trisyllabic words have two non-final [+high] vowels, and thus have two potential targets for harmony. There exists variation across speakers as to whether all targets, or only one target should undergo the harmony. In the case where only one target undergoes harmony, there is also variation as to which of the two targets is [-ATR]. The variation is illustrated with the trisyllabic examples I provide here:

(15)

<i>No harmony</i>	<i>ATB</i>	<i>Non-local</i>	<i>Adjacent non-iterative</i>	
ʒy.βi.d ^z ɪk	ʒ <u>y</u> .β <u>ɪ</u> .d ^z ɪk	ʒ <u>y</u> .βi.d ^z ɪk	ʒy.β <u>ɪ</u> .d ^z ɪk	‘judicial’
si.βi.lɪk	s <u>ɪ</u> .β <u>ɪ</u> .lɪk	s <u>ɪ</u> .βi.lɪk	si.β <u>ɪ</u> .lɪk	‘cyrillic’
ny.tβi.t ^s ɪf	n <u>y</u> .tβ <u>ɪ</u> .t ^s ɪf	n <u>y</u> .tβi.t ^s ɪf	ny.tβ <u>ɪ</u> .t ^s ɪf	‘nutritional’
d ^z i.si.plɪn	d ^z <u>ɪ</u> .s <u>ɪ</u> .plɪn	d ^z <u>ɪ</u> .si.plɪn	d ^z i.s <u>ɪ</u> .plɪn	‘discipline’
li.mu.zɪn	l <u>ɪ</u> .m <u>u</u> .zɪn	l <u>ɪ</u> .mu.zɪn	li.m <u>u</u> .zɪn	‘limousine’

d ^z i.si.mɪl	d ^z <u>ɪ</u> .s <u>ɪ</u> .mɪl	d ^z <u>ɪ</u> .sɪ.mɪl	d ^z i.s <u>ɪ</u> .mɪl	‘dissimulate’
i.ly.mɪn	<u>ɪ</u> .l <u>y</u> .mɪn	<u>ɪ</u> .ly.mɪn	i.l <u>y</u> .mɪn	‘illuminate’

Though this sort of variation is attested in Déchaîne (1991) and Dumas (1987), the present work represents the first systematic study of the phenomenon. As shown in (15), there exist three possible patterns of harmony for trisyllabics, plus the ‘no harmony’ pattern shown in the far left column in (15). The first possible pattern of harmony is what I will refer to as the ‘across-the-board’ pattern (or ‘ATB’), where all non-final [+high] vowels undergo harmony (only the vowels that undergo harmony are underlined): /ɜyɛɪdɪk/ → [ɜy.ɛɪ.d^zɪk]. The second pattern is the ‘non-local’ pattern, where only the leftmost [+high] vowel is [-ATR]: /ɜyɛɪdɪk/ → [ɜy.ɛɪ.d^zɪk]. Finally, the third possibility is to lax only the non-final [+high] vowel that is most adjacent to the trigger: /ɜyɛɪd^zɪk/ → [ɜy.ɛɪ.d^zɪk]. Naturally, there is also the ‘no harmony’ pattern, which is of little concern here. I will show here that all these logical possibilities are empirically attested.

4.2.2.1 ‘Across-the-board’ speakers

Among the 12 speakers interviewed for this study, two of them, speakers JB and HRZ, gave a higher acceptance rate to tokens with the ‘across-the-board’ pattern than to tokens of any other pattern. This is illustrated in the following figure, in which the standard form with no harmony is not represented:

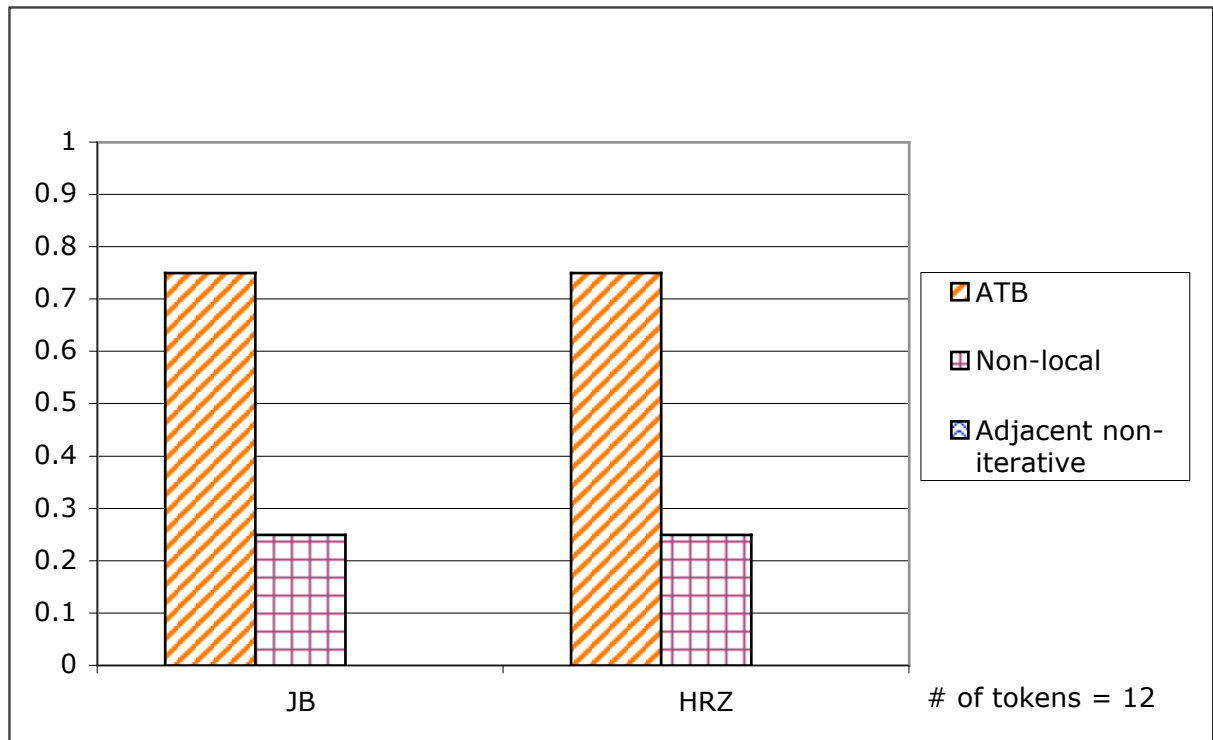


Figure 10: Across-board-speakers JB and HRZ.

Speakers JB and HRZ give an acceptance rate of 75% to trisyllabic tokens with the ATB pattern compared to only 25% for tokens of the non-local pattern²⁷. Tokens exhibiting the adjacent pattern were given an acceptance rate of 0% by both speakers. I will assume that these numbers simply represent speakers' intuitions that a given pattern is more or less natural than others. I make no claim that these represent speakers' probabilistic behaviour in terms of production, that is, whether JB and HRZ produce the ATB pattern 75% of the time, but the non-local pattern 25% of the time. I assume that these speakers' intuition supports the basic claim that the ATB pattern is the product of a possible grammar of CF. This claim is strengthened by the fact that speakers seem to display fairly consistent behaviour across the different forms tested in this study. In other words, JB and HRZ also prefer the ATB pattern when given tetrasyllabic stimuli. Given that JB and HRZ also accept 25% of tokens

²⁷ The adjacent non-iterative pattern does not appear in the figure because it was given a 0% acceptance rate by both speakers.

with non-local harmony, it is possible that these speakers also produce this pattern, and that both patterns are equally natural to them *ceteris paribus*. In this study, we are interested in building an algorithm that will produce this pattern to the exclusion of others, which, in and of itself, is a necessary attempt at idealisation. In the spirit of this idealisation, I will assume that JB and HRZ are ‘across-the-board speakers’ since they prefer this pattern statistically, not only in the case of trisyllabics, but for tetrasyllabics as well.

4.2.2.2 ‘Non-local’ speakers

Three out of 12 speakers gave a higher rate of acceptance to tokens featuring the non-local pattern over other patterns of harmony (excluding the no harmony pattern which is not relevant for our comparison). These speakers are JFO, MES and ML. Their preferences are illustrated in the following figure:

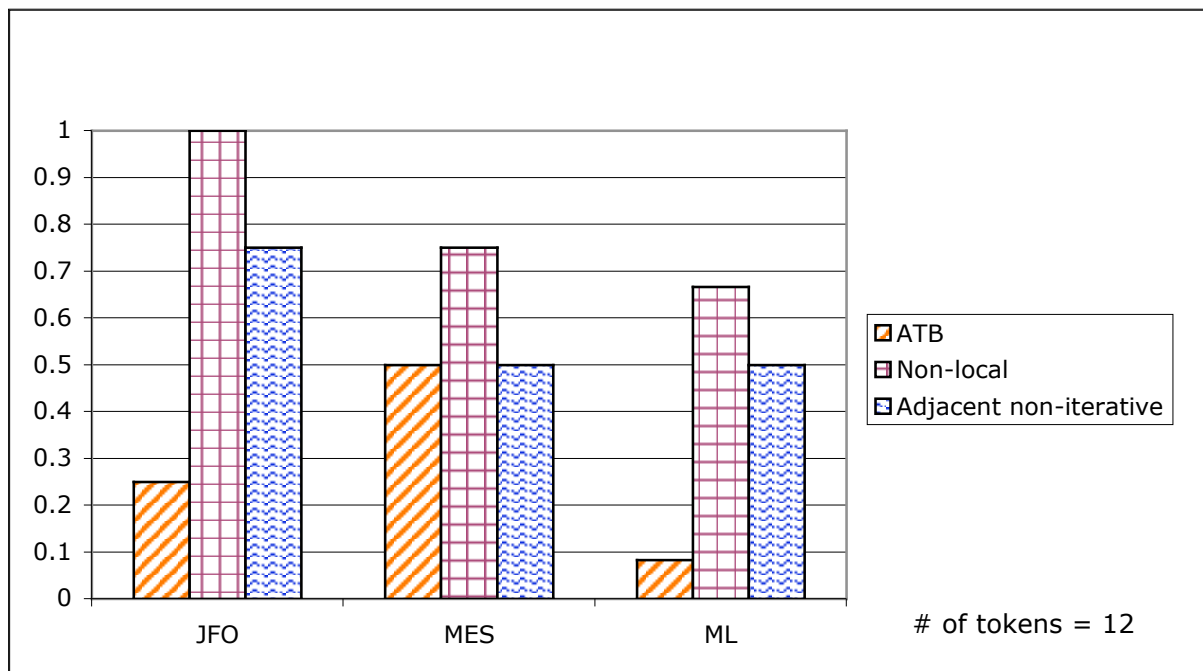
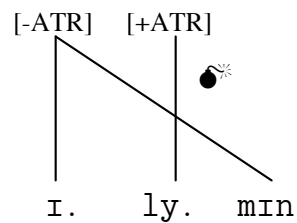


Figure 11: ‘Non-local’ speakers JFO, MES and ML.

What these numbers effectively suggest is that speakers should show some intra-speaker variation in the production of harmony in trisyllabics. That being said, their intuitive preference for a given pattern, a preference that is consistent, allows us to make a solid but basic claim that the non-local pattern is a possible pattern of CF harmony. As a native speaker of CF, my intuitions are that this pattern is preferable to the other patterns in all tested forms. This pattern will be the focus of important theoretical discussion in the second part of this work, as it shows a peculiar configuration. A [+high] vowel assimilates non-locally to another [+high] for [-ATR] across a medial vowel that projects a feature with the opposite value for [ATR]. In autosegmental terms (Goldsmith 1981, 1990), this pattern should be ruled out by the ‘no crossing constraint’ that applies to association lines:

(16)



Autosegmental theory, which assumes that both [-ATR] segments are associated to the same feature, predicts that the non-local pattern is impossible. The question is, are we really still dealing with a case of harmony, or is non-final laxing caused by another process?

One possibility is that the initial [+high] vowel becomes [-ATR] by dissimilation with the following vowel. If this is the case, we predict that, in this dialect, it should not matter whether the final [+high] vowel was [\pm ATR]. In other words, there is no need for a word-final trigger as in cases of *bona fide* harmony like in *Philippe*-type words. We thus expect initial laxing in words like the following, where both the initial and medial vowels are [+high], but the final vowel is not a valid trigger for harmony:

- (17)
- | | |
|-------------------|-------------|
| *kɪ . ʁi . naɪ | ‘Quirinal’ |
| *ɪ . bi . za | ‘Ibiza’ |
| *ɪ . fi . ʒe . ni | ‘Iphigenia’ |

To my knowledge, as a native speaker of this dialect, this is not possible, though further research on this particular data point is necessary. The dissimilation hypothesis makes a similar prediction concerning what I will henceforth refer to as *midi*-type words, that is disyllabic words where both nuclei are [+high, αback, αround], and where the final syllable is open. For all speakers, final [+high] vowels must be [+ATR], as CF does not allow [+high, -ATR] vowels in word final open syllables: * [mɪ . dʒɪ]. It is attested (Dumas 1976, Baronian 2001), and confirmed in this study, that some speakers allow non-final laxing in these types of words: ✓ [mɪ . dʒɪ]. The pattern can be described as a case of dissimilation. If non-final laxing in *midi*- and *illicite*-type words is the result of dissimilation, then we would expect speakers who allow non-final laxing in *illicite* words to be the same as those who accept non-final laxing in *midi* words.

The following three figures show that in actual fact, no such correlation is plausible. For every non-local speaker (JFO, MES and ML), the first figure below shows acceptance rates for *midi*-type words with a tense non-final vowel compared to those for *midi*-type words with a lax non-final vowel. We see that two out of three speakers do accept non-final laxing in *midi*-type words giving a rate of 50% or more. So far, this is consistent with the dissimilation hypothesis’s prediction:

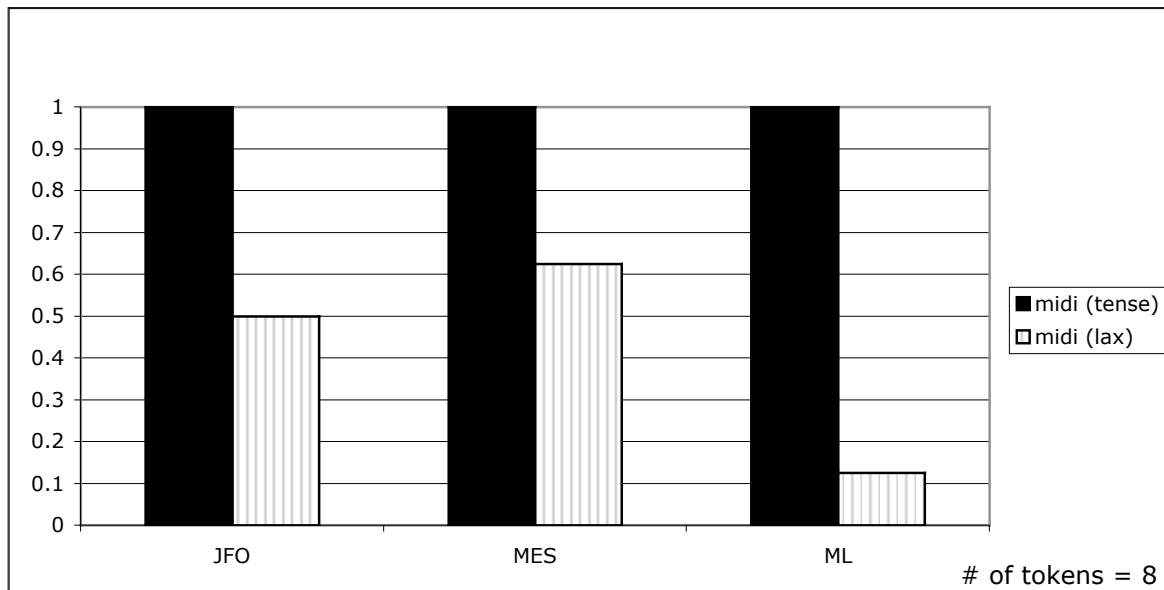


Figure 12: Non-local speakers: comparison of acceptance rates for *midi*-type words with a tense non-final vowel and *midi*-type words with a lax non-final vowel.

The next figure shows however, that the non-local speakers give much lower acceptance rates to tokens similar to *midi*-type words (with a lax non-final vowel), but where the two vowels differ by at least one feature. I will henceforth refer to these words as *Julie*-type words ([ʒy. li] ‘Julie’).

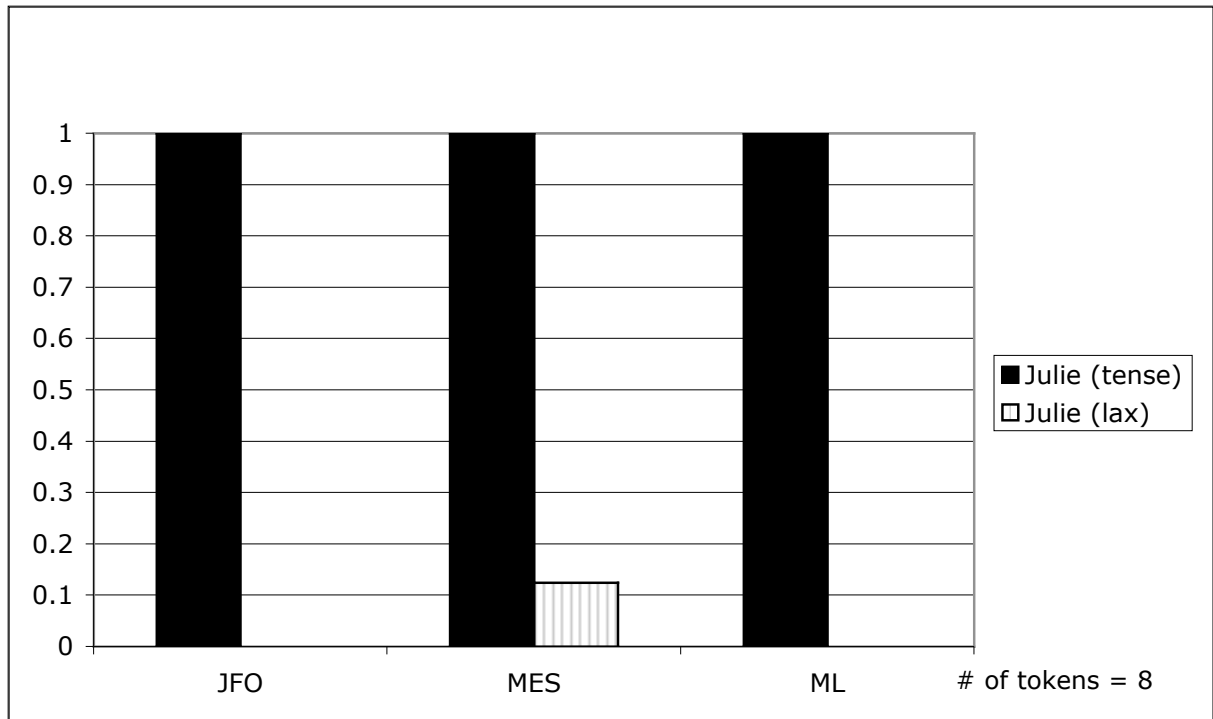


Figure 13: Non-local speakers: comparison of acceptance rates for *medi*-type words with a tense non-final vowel and *medi*-type words with a lax non-final vowel.

No such discrepancy can be observed between *illicite* words. The twelve *illicite* words tested in figure six are evenly divided between those whose first two vowels are identical (henceforth, *Philippines*²⁸-type words), and those whose first two vowels differ by at least one feature (henceforth, *juridique*²⁹-type words). The following figures compare the acceptance rates for *Philippines*- and *juridique*-type words per type of harmony for each speaker:

²⁸ <Philippines> [f i . l i . p i n] ‘Philippines.’

²⁹ <juridique> [ʒy . ʁ i . dʒ i k] ‘judicial.’

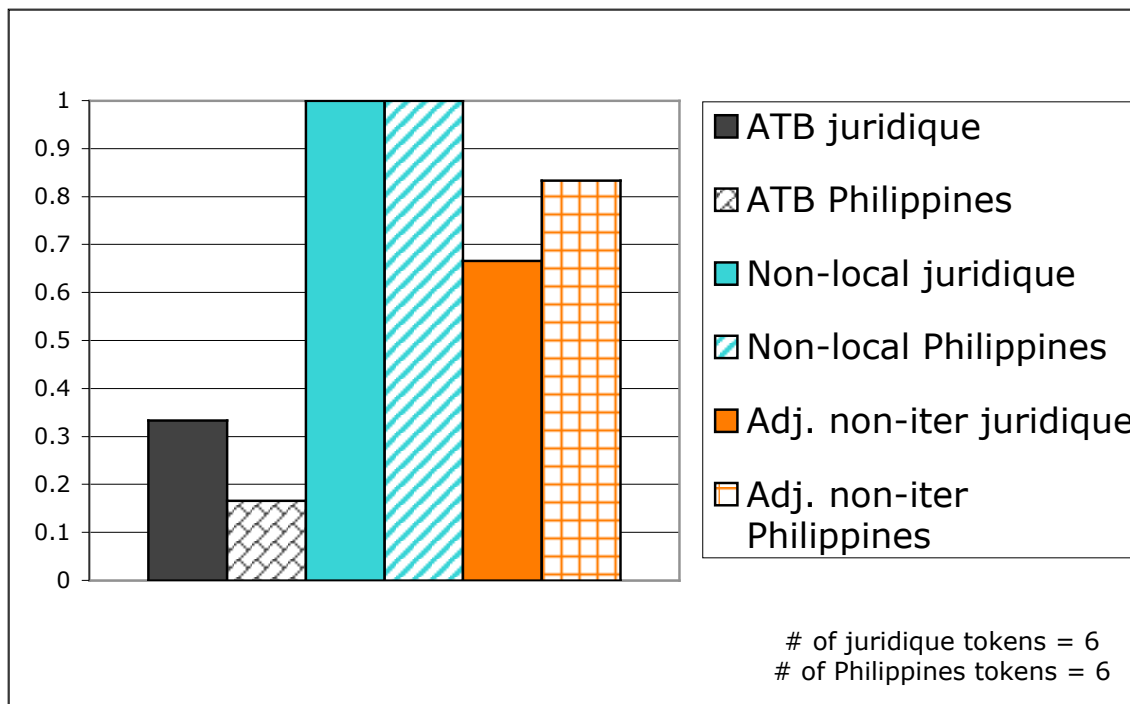


Figure 14: Acceptance rates for *juridique*-type words compared to acceptance rates for *Philippines*-type words in a non-local speaker (JFO).

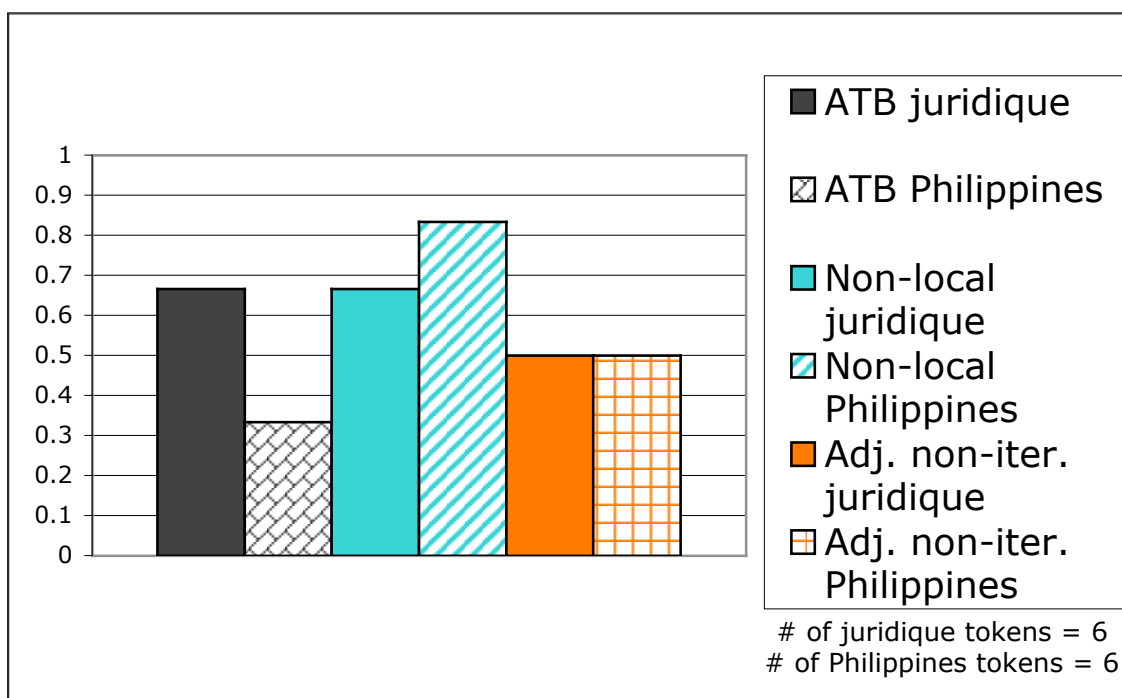


Figure 15: Acceptance rates for *juridique*-type words compared to acceptance rates for *Philippines*-type words in a non-local speaker (MES).

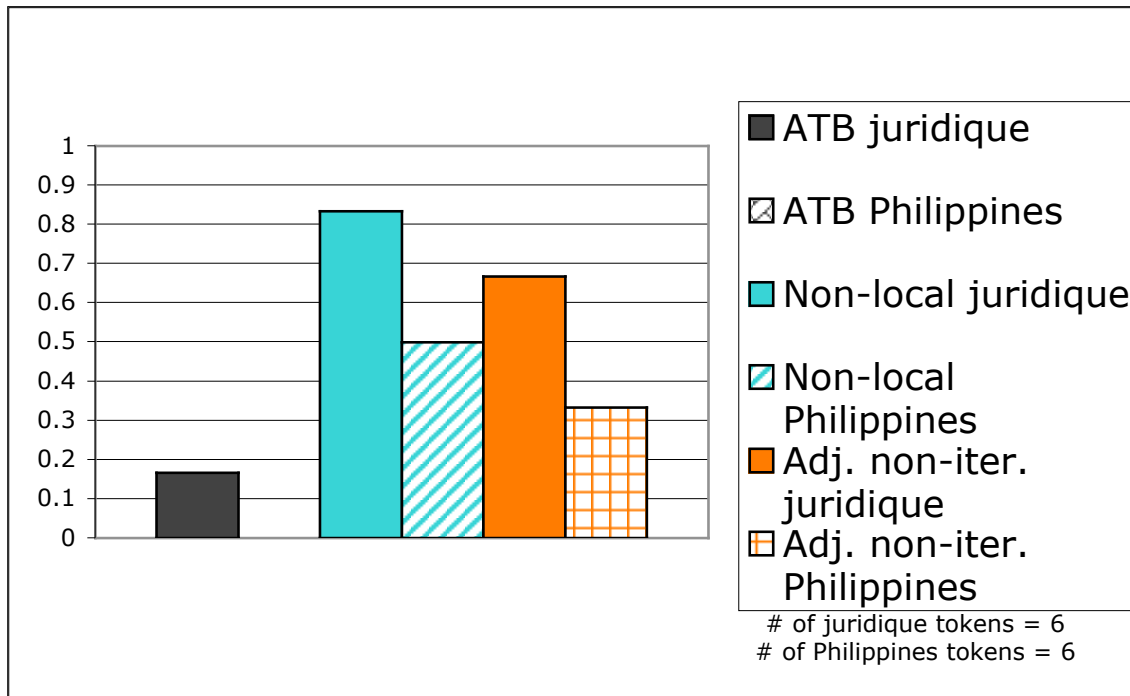


Figure 16: Acceptance rates for *juridique*-type words compared to acceptance rates for *Philippines*-type words in a non-local speaker (ML).

In Figure 14, Figure 15 and Figure 16, we see that there is no clear trend that *Philippines* words are given a higher acceptance rate than *juridique* words, which what we should expect if this were truly a case of dissimiation like the one we find for *midi*-type words. The behaviour does not appear comparable. Speaker JFO gives the same acceptance rate to both types of words for the non-local pattern, and gives a slightly higher acceptance rate to *Philippines*-type words when it comes to the adjacent non-iterative pattern, but his or her behaviour is the reverse for the ATB pattern. Speaker MES gives a slightly higher acceptance rate for *Philippines*-type words in the non-local pattern, but his or her behaviour is the reverse for the ATB pattern. Speaker MES gives the same acceptance rate for both types of words in the adjacent non-iterative pattern. Finally, speaker ML gives a very low acceptance rate for both types of words in the ATB pattern (the acceptance rate for ATB

Philippines-type words is 0%), but gives a slightly higher acceptance rate to *juridique*-type words in the other two patterns. This goes against our expectations if non-final laxing were due to dissimilation in these words as in *midi*-type words.

Even though two out of three non-local speakers do accept non-final laxing in *midi*-type words, it is not the case that initial [+high] vowel laxing in *illicite*-type words is due to dissimilation. It appears that speakers JFO and MES accept non-final laxing in *midi*-type words because they do have a rule of dissimilation, but one which affects only words that fit the description of *midi*, that is, disyllabic words containing two identical [+high] vowels. If the two vowels differ by at least one feature, the dissimilation rule does not apply (cf. *Julie*-type words). If dissimilation were responsible for initial vowel laxing in *illicite*-type words, we would expect there to be the same discrepancy between words whose two first vowels are identical (*Philippines*-type words) and words whose two first vowels differ by at least one feature (*juridique*-type words). The expectation is not met, as the two categories of *illicite* words do not show this discrepancy. For this reason, I will assume that the non-local pattern of harmony, though unusual, is a case of harmony just like the ATB or the adjacent non-iterative pattern.

4.2.2.3 Adjacent non-iterative speakers

Four out of 12 speakers, NM, TG, MEA and MCS, show a preference for the adjacent non-iterative pattern, as shown by the following figure:

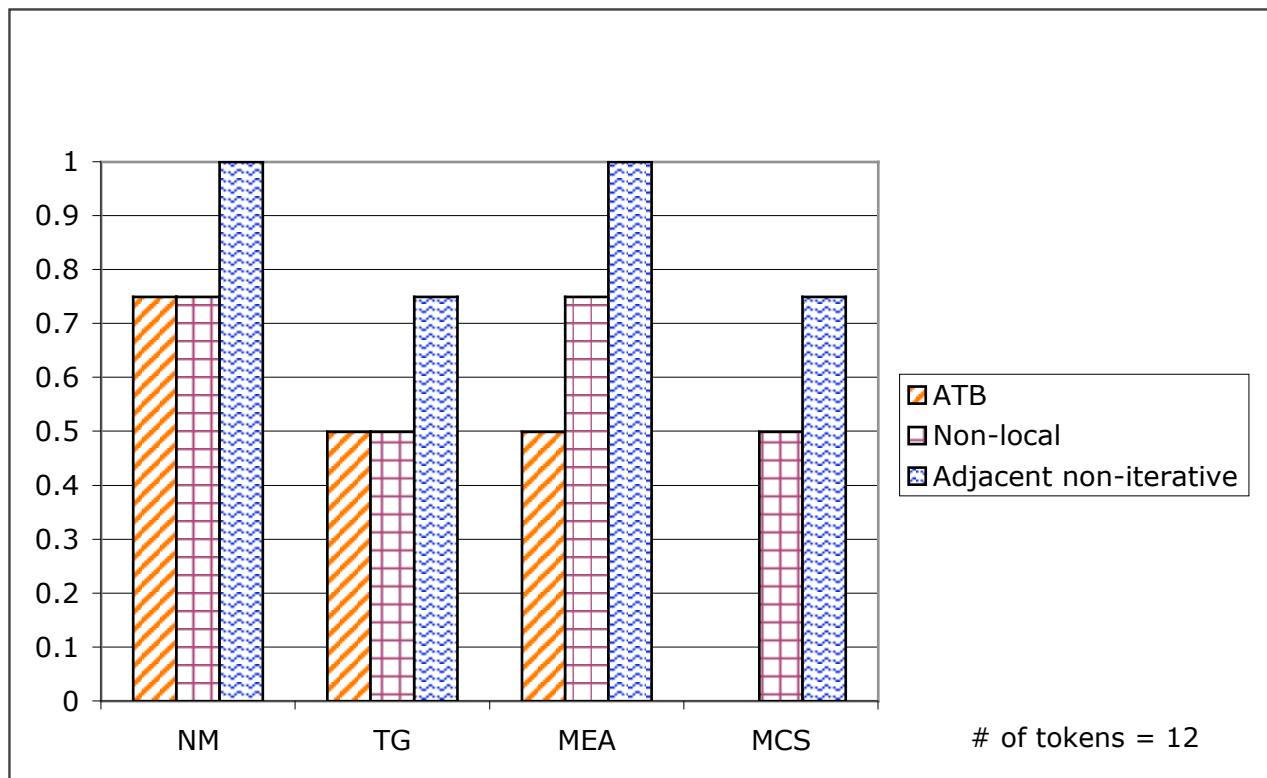


Figure 17: ‘Adjacent non-iterative’ speakers NM, TG, MEA and MCS.

Based on these numbers, I will assume that the adjacent non-iterative speakers represent speakers of a possible grammar of CF.

4.2.2.4 Other speakers: BGB, LL, MB

The three remaining speakers in our pool of subjects show behaviour that resists classification into the three idealised groups established in the previous subsections. Speaker BGB gives low acceptance rates to harmonic forms relative to standard ones. This is illustrated in the figure below:

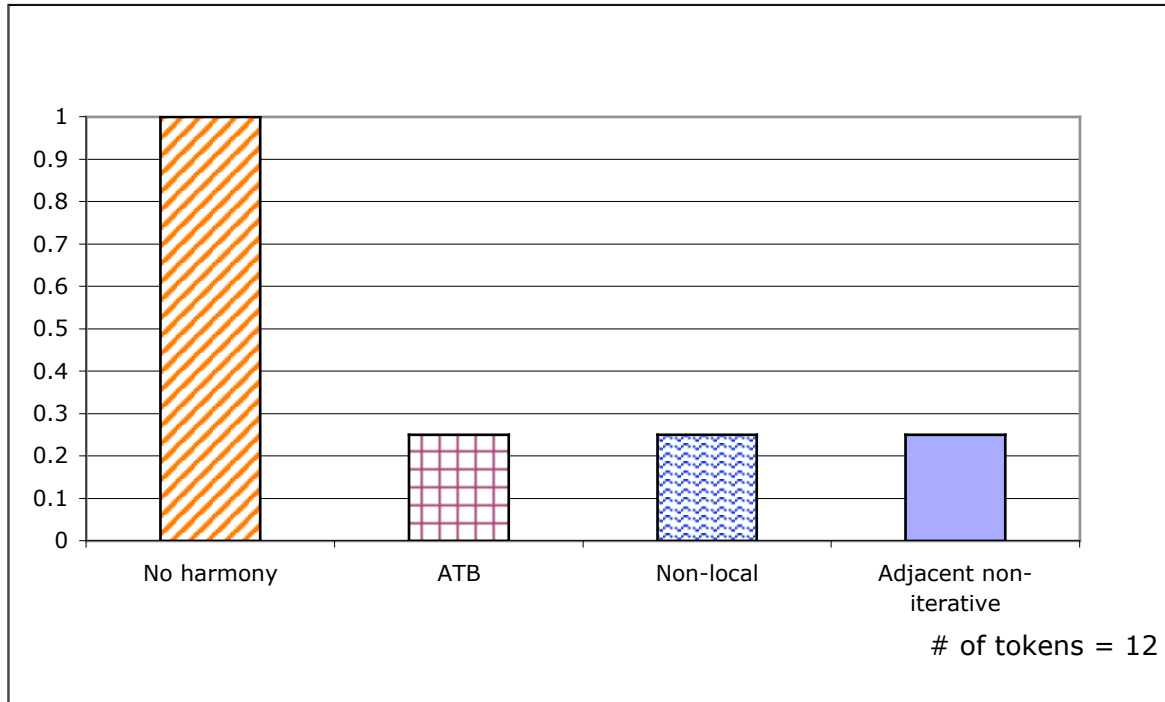


Figure 18: BGB: a quasi-non harmonising speaker.

Since it is suspected that harmony is a feature associated with a more casual register, it is perhaps not surprising to encounter speakers who do not accept harmonic forms as being ‘natural’ in their register, since certain speakers tend to avoid specific registers altogether, or at least, report avoiding them. What is interesting about BGB’s behaviour, is that it is somewhat inconsistent. In figure 1, we see that BGB accepts 50% of harmonised disyllabic forms as ‘natural.’ In figure 18, BGB only accepts 25% of forms for any harmonic pattern. The behaviour is only somewhat inconsistent, since we know from figure 9 that, though BGB does accept 50% of forms, s/he is the speaker who gives the lowest acceptance rate for disyllabics. All speakers except BGB accept harmony in disyllabics with a rate of 75% or more. Also, BGB’s dispreference for harmonic forms is reiterated for all other types of words. Though I will classify BGB as a ‘non-harmonising’ speaker for these reasons, this does not exclude the fact that BGB may harmonise in some tokens, which, for reasons that are yet unclear, may have a greater propensity to harmonise. The four disyllabic words accepted as natural by BGB are <Philippe> (‘Phillip’), <limite> (‘limit’), <minute>

(‘minute’) and <pourrite> (‘rotten, fem.’). It is my personal intuition as a native speaker that these words are rarely pronounced in their standard form, in all registers. This is especially true for <pourrite>. The word for ‘rotten’ has two possible feminine forms, each associated with a different register. The one associated with a higher register, and deemed ‘correct’ is identical to the European French form <pourrie> ([pu. ʁi]), while <pourrite> ([pu. ʁɪt]) is deemed ‘incorrect’ and associated with a lower register. Non-final laxing may also be more likely as a result of second and third formant lowering caused by the following uvular (see footnote 24).

Speakers LL and MB show equal preference for two categories. In the figure below, we see that LL gives equal acceptance rates to the ATB and non-local patterns:

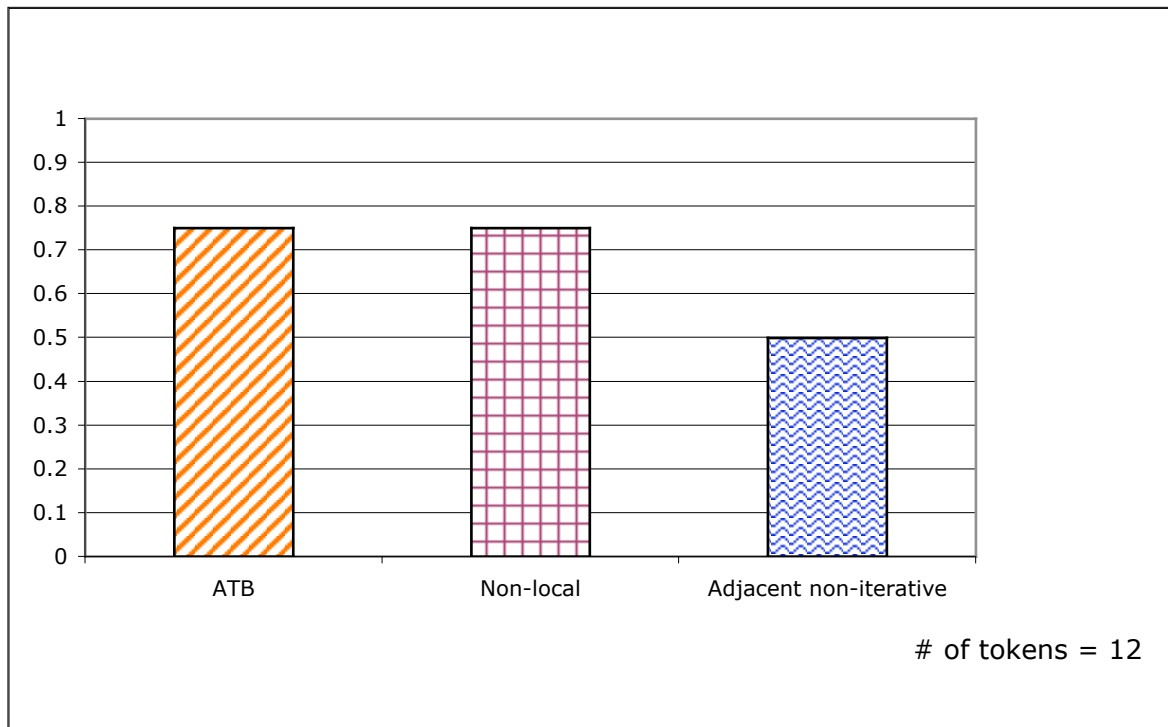


Figure 19: Speaker LL- equal acceptance rates for ATB and non-local patterns.

In contrast, speaker MB gives equal acceptance rates to the non-local and adjacent non-iterative patterns:

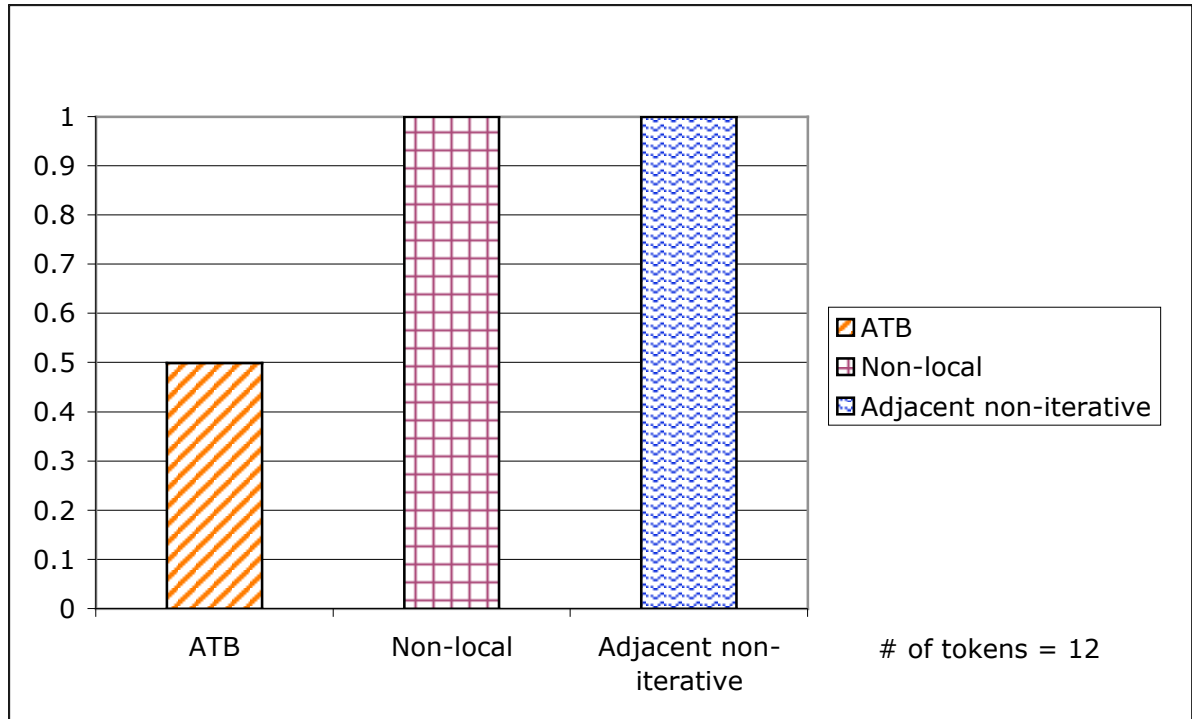


Figure 20: Speaker MB- equal acceptance rates for non-local and adjacent non-iterative patterns.

No speaker was found who accepted the adjacent non-iterative and ATB pattern equally, or all three patterns equally. There is no reason to think however that, in a broader population sample, we should not find such speakers. So far, it has been clear that, though speakers may report a general preference for a given pattern, speakers do not do so to the total exclusion of other patterns. In terms of production, this probably translates as variable behaviour.

Though behaviour may be variable, this does not undermine my claim relative to the constraints on language competence that are suggested by these data. If a given speaker alternatively produces forms that are generated by grammar A or grammar B, it remains true that both grammars A and B are possible human grammars. Where the present analysis ‘idealises’ somewhat, is that I am assuming that grammars A and B can exist in isolation from each other. In this light, it is thus not surprising to find two speakers who have an equal preference for two or more patterns. This may or may not predict that speakers LL and MB produce both of their preferred patterns in equal proportion. That is an empirical question

that remains to be answered. The prediction that is relevant for this study however, is that, based on the assumption that LL and MB's behaviours will be consistent across different word types, we expect them to either show equal preference for their preferred patterns for all word types, or show a preference for either pattern. The latter prediction appears correct, as shown in the next subsections.

4.2.3 Harmony in tetrasyllabics

In the case of trisyllabic words, we saw that the number of attested patterns of harmony is equal to the number of logically possible grammars. This is not the case for tetrasyllabics however- the number of attested grammars is only a subset of those that are logically possible. The grammar is thus constrained in the number of outputs that it permits. I will propose in the second part of this dissertation that the constraints lie in the parameters that determine the CF grammar (iterativity, directionality). Henceforth, the term 'tetrasyllabics' refers to words of four syllables whose four nuclei are all [+high] vowels. Alternatively, I will refer to tetrasyllabics as *similitude*-type words ([si.mi.li.t^sɪd] 'similarity'). *Similitude*-type words are very few in number in the CF lexicon (8 in total), and it is my feeling as a native speaker that none of them are words like *Philippe* ('Phillip') or *minute* ('minute') that are rarely said without harmony. This does not mean however that harmony is impossible. Though they are few in number, or rather because they are few in number, tetrasyllabics provide us with rich ground for observing 'pure' grammatical judgments (see Nevins, Poliquin & Perfors 2006). Tetrasyllabics allow us to determine in which ways the grammar is constrained. Examples of tetrasyllabic words are provided here:

(18) *Tetrasyllabic words*

si.fi.li.t ^s ɪk	'syphilitic'
d ^z i.mi.ny.t ^s ɪf	'diminutive'

i . ni . bi . t ^s I f	‘inhibitive’
i . ni . bi . t ^s I S	‘inhibiting person, fem.’
i . ly . mi . nI S M	‘illuminism’

Tetrasyllabics have three potential targets for the harmony rule, rather than two in trisyllabics, thus increasing the number of logically possible possible outputs to 7. If we add the non-harmonic output, we obtain a total of eight logically possible outputs, only four of which are attested. They are listed in (19); attested outputs are marked with a ‘✓,’ while unattested outputs are marked with a ‘✗.’

(19) *Logically possible outputs for tetrasyllabics*

a. no harmony	si . mi . li . t ^s Yd	✓
b. across-the-board	s <u>I</u> . m <u>I</u> . l <u>I</u> . t ^s Yd	✓
c. non-local	s <u>I</u> . mi . li . t ^s Yd	✓
d. adjacent non-iterative	si . mi . l <u>I</u> . t ^s Yd	✓
e. local 2 iterations	si . m <u>I</u> . l <u>I</u> . t ^s Yd	✗
f. non-local non-initial	si . m <u>I</u> . li . t ^s Yd	✗
g. non-local non-initial iterative	s <u>I</u> . m <u>I</u> . li . t ^s Yd	✗
h. non-local & local non-iterative	s <u>I</u> . mi . l <u>I</u> . t ^s Yd	✗

The only attested patterns among our 12 CF speakers are exactly those found for trisyllabics: the ATB pattern, the non-local pattern and the adjacent non-iterative pattern. Though patterns in (19)e-h are unattested as far as the available data is concerned, I will not claim that they are necessarily impossible, simply, computationally more complex, and as a result, less likely. This point will be stated more completely in the second part of the dissertation.

For now, all I assume is that these patterns are unattested, and thus the goal will be to provide an analysis that only derives the attested patterns.

4.2.3.1 ATB speakers: tetrasyllabic preferences

Tetrasyllabics also allow us to observe if speakers are consistent in their preferences for certain patterns. The following figures show that speakers who prefer the ATB, non-local or adjacent non-iterative patterns maintain those preferences when it comes to tetrasyllabics. In the following figure, we see that JB and HRZ, subjects who were identified as ATB speakers, also prefer the ATB pattern in the case of tetrasyllabics. The stimulus for this experiment, on which all tetrasyllabic figures are based, consisted of eight tetrasyllabic words, each with eight different pronunciations for a total of 64 tokens. With 12 speakers, this yielded a total of 768 answers:

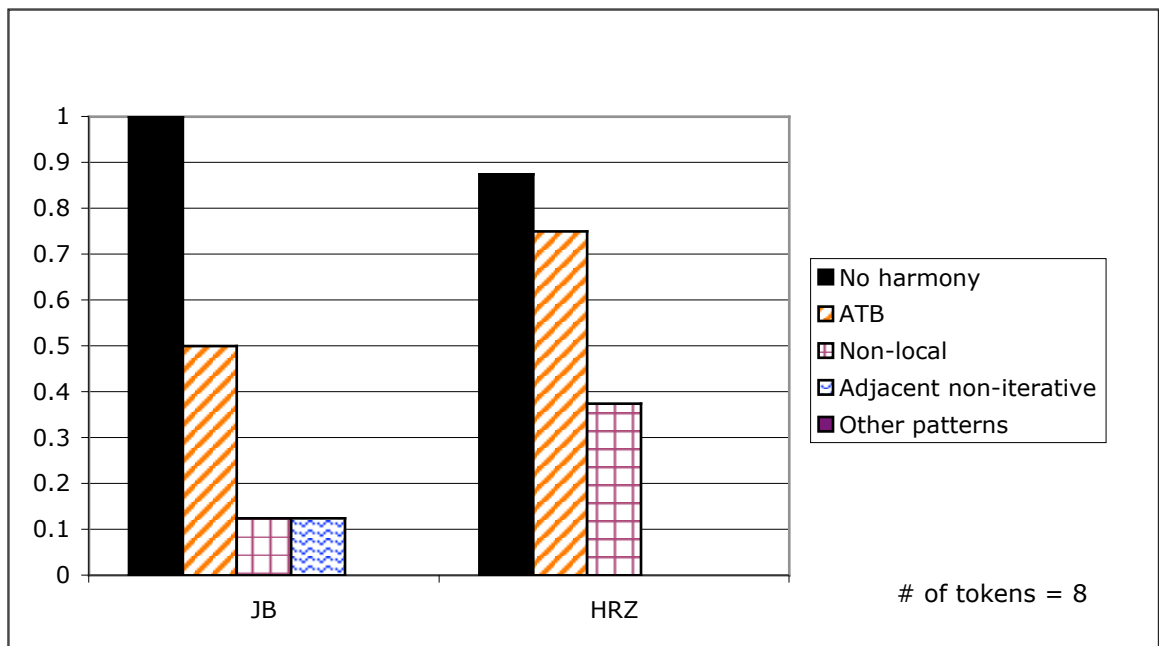


Figure 21: ATB speaker preferences for tetrasyllabic stimuli.

Though JB and HRZ both show a preference for the ATB pattern over other patterns in the case of tetrasyllabics, JB does show a drop in his/her acceptance rate when it comes to tetrasyllabics. While s/he gave a 75% acceptance rate for trisyllabics with an ATB pattern,

s/he gave a 50% acceptance rate for tetrasyllabics with an ATB pattern. The fact remains that this speaker does prefer the ATB pattern over other patterns insofar as s/he likes harmony in tetrasyllabics at all. This might be explained by the fact that tetrasyllabics with four [+high] vowels have relatively low frequency in CF, and added to the fact that harmony is optional in this language, are not often heard pronounced with harmony. We can speculate that for some speakers, this contributes an element of doubt in their judgment, and as a result prods speakers to judge the standard, non-harmonic form as the only ‘natural’ pronunciation. That being said, it is still the case that JB’s behaviour is consistent in his or her treatment of tri- and tetrasyllabic stimuli.

Importantly though, neither of the speakers accept any other pattern aside from the ATB, non-local and adjacent non-iterative patterns. All other patterns were each given acceptance rates of 0%.

4.2.3.2 Non-local speaker preferences for tetrasyllabic stimuli

Non-local speakers’ behaviour in the case of tetrasyllabics matches their behaviour for trisyllabics. All speakers exhibit a general drop in acceptance rates in the case of tetrasyllabics, which, again, may be the effect of tetrasyllabics being uncommon in the register where harmony is more likely to surface. Nevertheless, speakers remain consistent in preferring the non-local pattern, inasmuch as harmony is acceptable at all in tetrasyllabics:

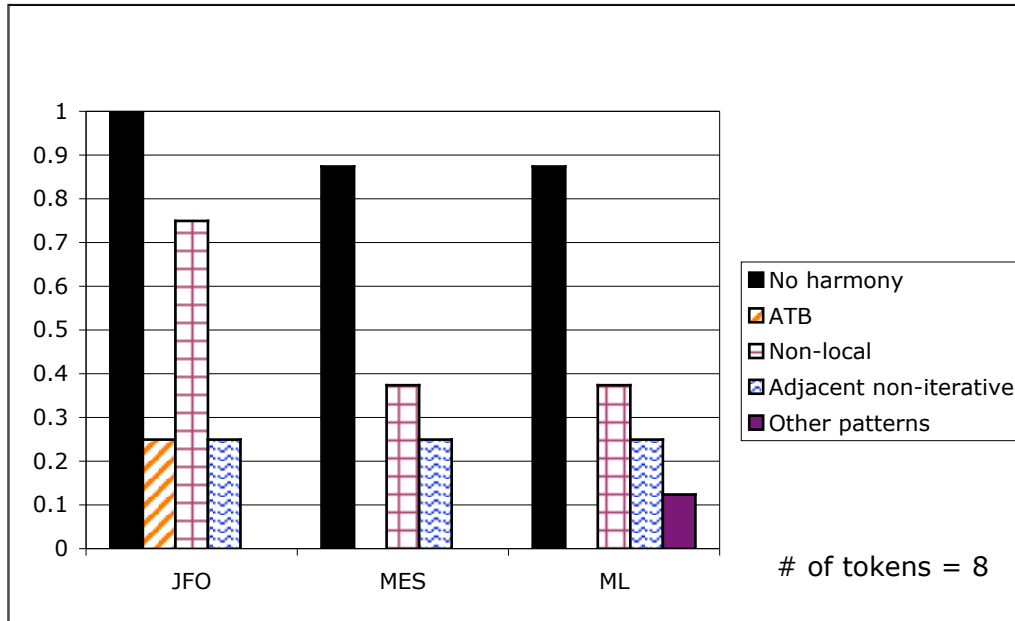


Figure 22: Non-local speaker preferences for tetrasyllabic stimuli.

Speaker ML does give a very low acceptance rate to the non-local non-initial pattern, accepting one out of eight forms for that pattern ($[s\dot{i} . m\underline{i} . l\dot{i} . t^s yd]$). S/he is only one out of two speakers to accept any of the ‘other patterns.’ Though I do argue that these patterns are not ‘impossible’ as far as UG is concerned, I will take the stand that they are not producible given the parameters that I assume for CF. I will thus attribute ML’s acceptance rate for the non-local non-initial pattern to speaker error, given that the rate is so low, and that only one other speaker gives an acceptance rate above 0 for any of these patterns³⁰.

4.2.3.3 Adjacent non-iterative speaker preferences for tetrasyllabics

The same consistency is observed in adjacent non-iterative speakers. Two out of four speakers (NM and MEA) show a drop in their overall acceptance rates in the case of tetrasyllabics as compared to trisyllabics, but all prefer the adjacent iterative pattern inasmuch as they like harmony in these forms. The other two speakers (TG and MCS) give

³⁰ Speaker NM (adjacent non-iterative) accepts one out of eight tokens with the ‘adjacent two iterations’ pattern.

the same acceptance rate for the adjacent iterative pattern in trisyllabics and tetrasyllabics (0.75):

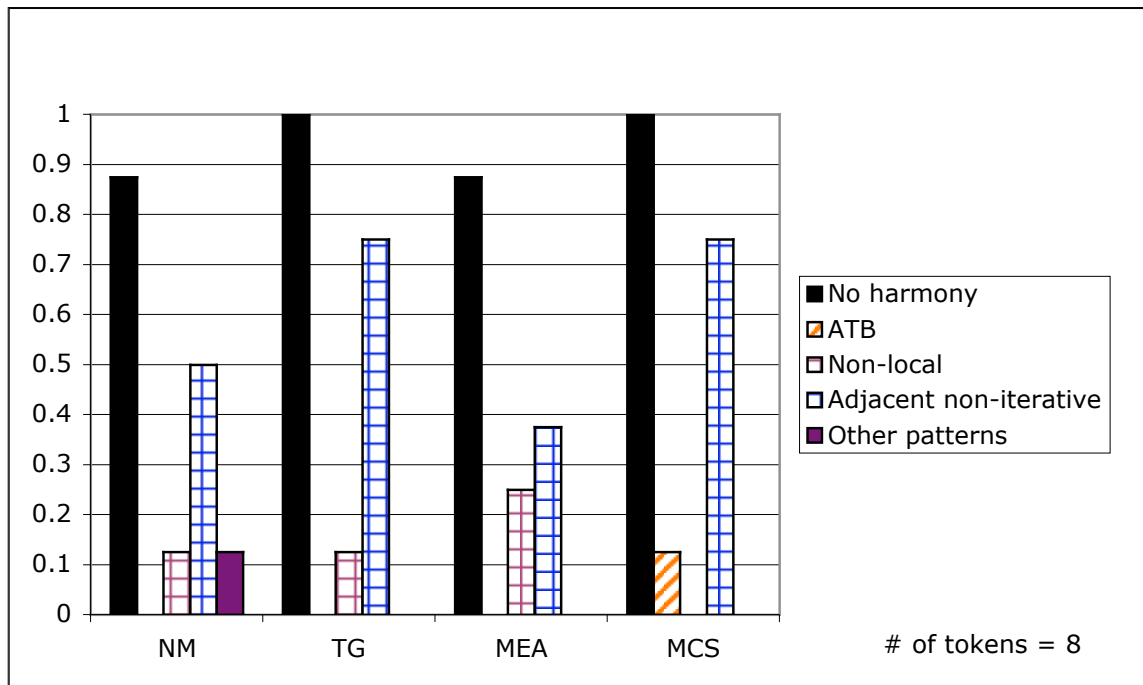


Figure 23: Adjacent non-iterative speaker preferences for tetrasyllabic stimuli.

Speaker NM, like ML among the non-local speakers, also accepts one out of eight tokens of the ‘adjacent two iterations’ pattern. Like for ML, I will assume that this is due to speaker error since it does not follow the general trend.

Speakers’ consistent behaviour confirms the prediction made by the underdetermined analysis of PLD, namely, that only three generalisations are possible based on disyllabics. The hypothesis is confirmed by trisyllabic forms in that all three patterns are attested, but the hypothesis is even more strongly supported by tetrasyllabic forms where, potentially, more than three patterns may have been attested, given the greater number of targets. The hypothesis that only three patterns should exist in the case of tetrasyllabics is strongly supported by the fact that the totality of speakers reject other patterns altogether.

4.2.3.4 Other speakers: BGB, LL, MB

Our other speakers include a non-harmonising speaker, BGB, and two speakers who have an equal preference for two patterns, the ATB and non-local patterns in the case of LL, and the non-local and adjacent non-iterative in the case of MB. So far, speakers have been consistent in maintaining the same preferences for tetrasyllabics that they had for trisyllabics. If BGB, LL and MB are consistent as well, we expect them to maintain their dispreference for harmony (BGB), or to maintain an equal preference for two patterns (LL and MB). The expectation is met in the case of BGB, who also rejects harmonic tetrasyllabic tokens, or at the very least, gives them a low acceptance rate in comparison to non-harmonic standard forms. In the case of LL and MB, we see some intra-speaker variation at work, since both of them gives a higher acceptance rate to one of their preferred patterns, but neither of them gives an equal acceptance rate to both their preferred patterns. In neither case though do they prefer a pattern that they dispreferred for trisyllabics.

BGB's acceptance rates for tetrasyllabics are illustrated in the figure below, which represents this speaker's dispreference for harmony:

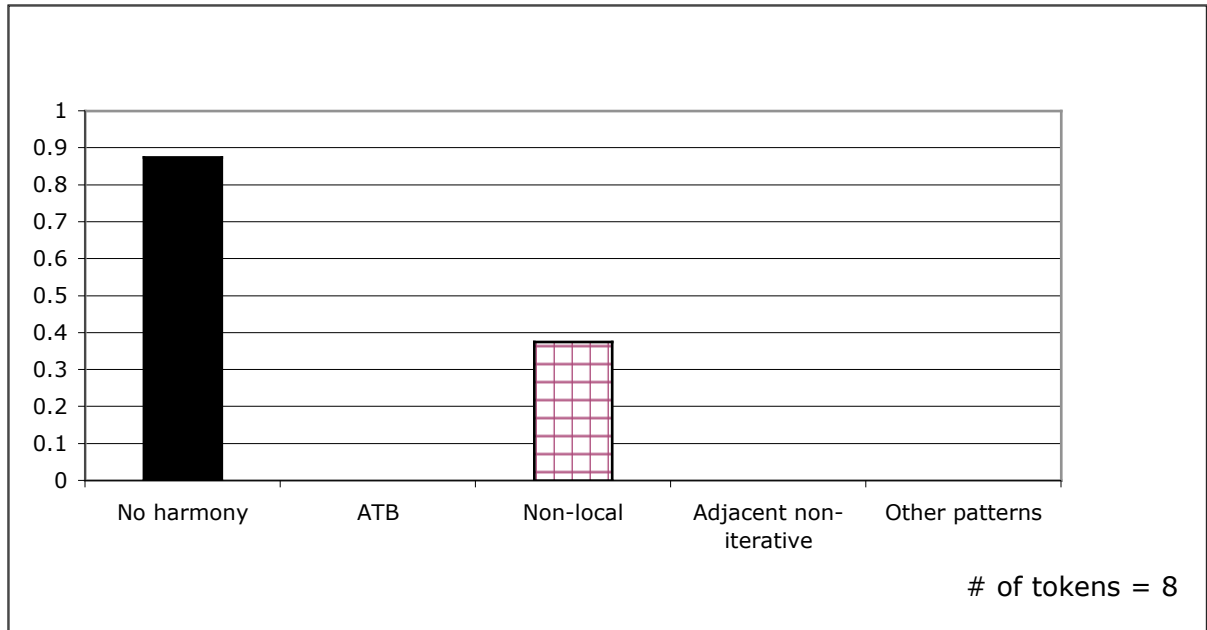


Figure 24: BGB: dispreference for harmony in tetrasyllabics

Interestingly, though BGB did not show any preference for the non-local pattern in trisyllabics, the speaker does accept 3 out of 8 tetrasyllabics with the non-local pattern as ‘natural.’ Though this may reflect some preference for the non-local pattern at some level, something s/he did not show for trisyllabics as a result of intra-speaker variation, I will not consider this result significant for two reasons: a) the acceptance rate for non-local tetrasyllabics in figure 20 is still relatively low, and b) I am assuming all of these judgment data to be representative of the psychological reality of these grammars because results are consistent across forms. Since BGB is only really consistent in having a general dispreference for harmony, especially in non-disyllabic forms, I still consider BGB a non-harmonic speaker.

In figure 19, LL showed an equal preference for the ATB and non-local patterns. When tested on tetrasyllabics, this speaker showed a preference for the non-local pattern. LL remains somewhat consistent in still showing a dispreference for the adjacent non-iterative

pattern (an even stronger one for tetrasyllabics in fact), and still accepting some tetrasyllabic tokens of the ATB pattern:

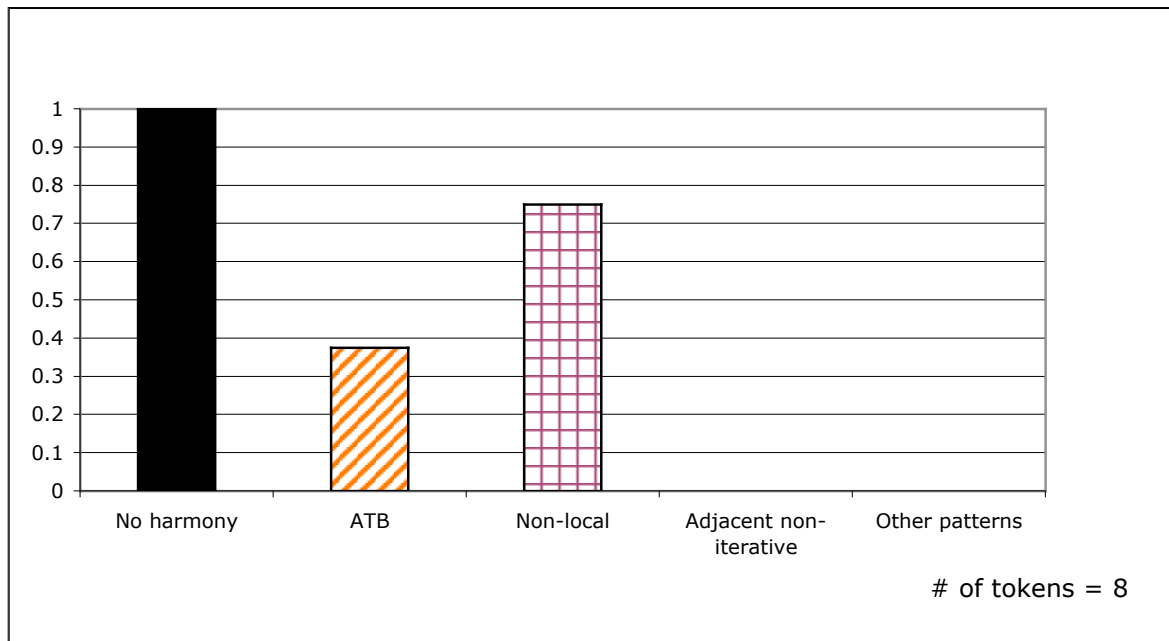


Figure 25: LL: preference for the non-local pattern in tetrasyllabics.

Speaker MB shows similar behaviour in also preferring the non-local pattern over the adjacent non-iterative pattern, which s/he liked equally for the trisyllabics. Since both ambivalent speakers behave like this, this may or may not show a general propensity to prefer the non-local pattern in tetrasyllabics over other patterns. I will leave this question open for now, because this trend is certainly not confirmed by the behaviour of the other speakers. This is a minor point to be investigated as the pool of speakers for this research project increases.

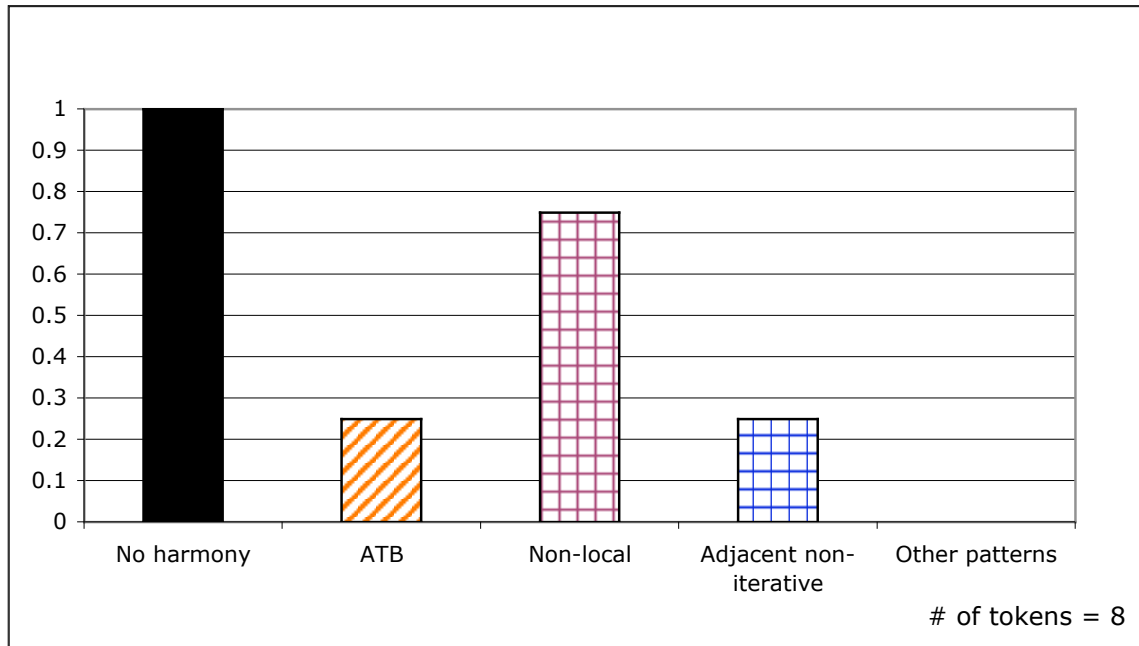


Figure 26: MB: preference for the non-local pattern in tetrasyllabics.

4.2.4 Neutral vowels: opacity and transparency as a function of locality

Data reported so far clearly shows that grammars generating CF harmony can differ with respect to locality parameters. Adjacent non-iterative speakers only allow the target most adjacent to the trigger to undergo harmony. Non-local speakers only allow the leftmost³¹ vowel in the word domain to undergo harmony. As discussed above, non-local speakers allow a pattern predicted to be impossible under the ‘No Line Crossing’ constraint (Goldsmith 1981, 1990). If this is the case, we should expect non-final laxing to be allowed by these speakers in three-syllable words where the target and trigger are separated by a medial neutral vowel that projects a [+ATR] feature. I will henceforth refer to such words as *inédite*-type words. Some examples of *inédite* words are provided here (words are represented in their non-harmonic forms):

³¹ I describe the initial vowel of *illicite* and *similitude* words as ‘leftmost’ instead of ‘initial.’ A subset of non-local speakers allows the leftmost [+high] vowel to harmonise in *définitif*-type words (e.g. [de. fɪ. ni. t^sɪf]), so that the vowel cannot be described as ‘initial’ in the sense of ‘word-initial.’

(20)

gli.se.ʁɪd	‘glycerid’
i.be.ʁɪk	‘Iberian’
ʃi.me.ʁɪk	‘chimerical’
ny.me.ʁɪk	‘digital’
si.ne.t ^s ɪk	‘kinetics’
li.be.lɥl	‘dragon-fly’
y.te.ʁys	‘uterus’

Adjacent non-iterative speakers however are not expected to give high acceptance rates to *inédite* words with non-final laxing. Since the trigger and target are separated by another vowel in *inédite* words (whether [+high] or [-high]), the trigger and target are not in a relationship of strict adjacency. This is assuming of course, pre-theoretically, that a strict adjacency requirement is what determines adjacent non-iterative speakers’ preference for [i.lɪ.sɪt] over [ɪ.li.sɪt].

Predictions for ATB speakers are difficult pre-theoretically. If we assume a vowel harmony rule that laxes all non-final vowels simultaneously, then we might expect ATB speakers to give a high acceptance rate to *inédite* words with non-final laxing. This is provided of course that these speakers allow two segments projecting a [-ATR] feature when an intervening segment projects a [+ATR] segment. If this is not the case, then we expect ATB speakers to reject *inédite* tokens with non-final laxing.

In the following sections, I will discuss each dialect in the order they were considered in the present section (Non-local, adjacent non-iterative and ATB) rather than the order used in previous subsections (ATB, Non-local, adjacent non-iterative).

4.2.4.1 Non-local speakers' acceptance rates for non-final laxing in *inédite* words

Non-local speakers' acceptance rates for non-final laxing in *inédite* words is compared to their respective acceptance rates for the non-local pattern in *illicite* words. I have chosen this comparison for the simple reason that our idealisation of these speakers (JFO, MES and ML) as non-local speakers is based on their acceptance rates for *illicite* words. If their average acceptance rates for *inédite* words does not differ significantly from their acceptance rates for *illicite* words with the non-local pattern, I will assume that their behaviour is consistent with the prediction that they should accept non-final laxing in *inédite* words. Their acceptance rates are illustrated here:

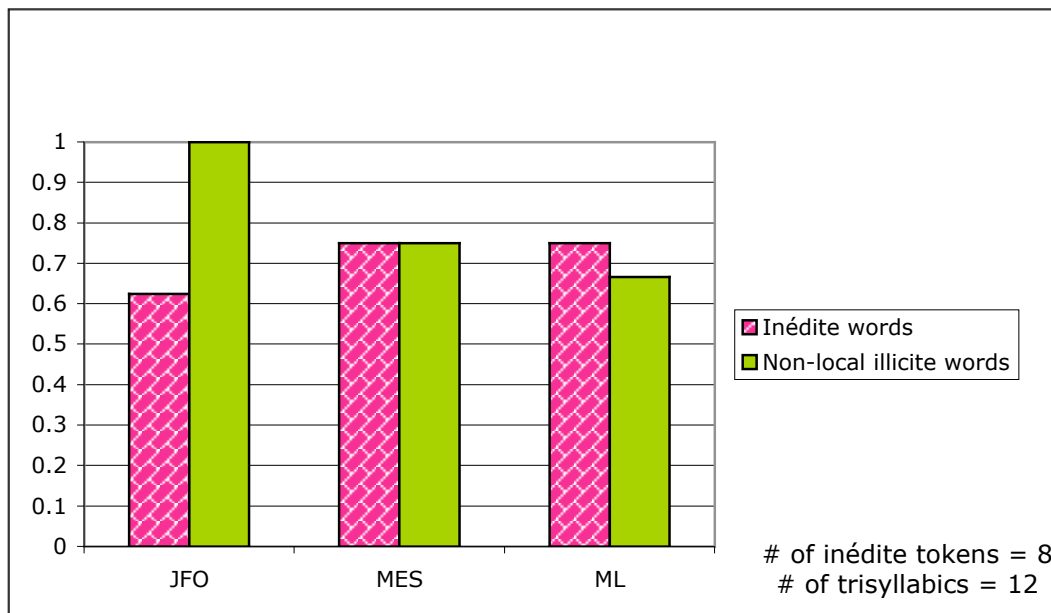


Figure 27: Non-local speakers' acceptance rates for non-final laxing in *inédite* words compared to acceptance rates for *illicite* words with the non-local pattern.

All the non-local speakers accept non-final laxing in *inédite* words above the 50% mark. Since there is no objective measure of acceptance to classify speakers according to their statistical judgments, a comparison is in order. Speakers show mixed results. JFO shows a decrease in acceptance rates for *inédite* words compared to his or her acceptance rates for the

illicite words with the non-local pattern. MES on the other hand gives an equal rate for both types of words, and ML shows a slightly higher acceptance rate for non-final laxing in *inédite* words.

4.2.4.2 Adjacent non-iterative speakers' acceptance rates for non-final laxing in *inédite* words

If the hypothesis is correct that adjacent non-iterative speakers have a dispreference for non-local patterns of harmony, we expect them to have very low acceptance rates for non-final laxing in *inédite* words, as opposed to very high acceptance rates for the adjacent non-iterative pattern in *illicite* patterns. The hypothesis is strongly supported by the results shown in the following figure:

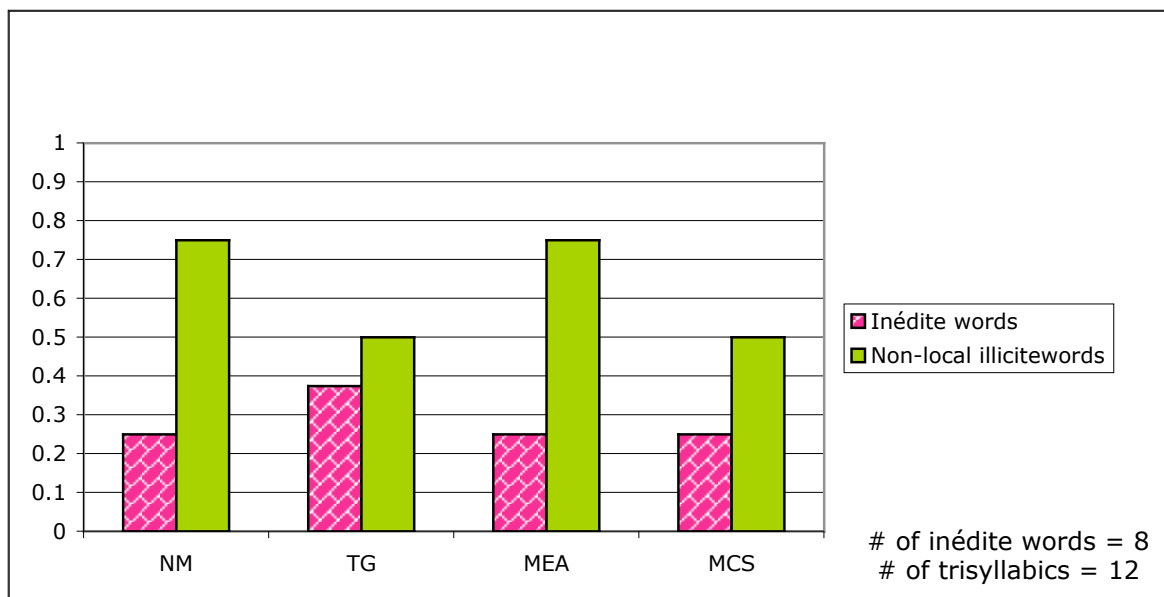


Figure 28: Adjacent non-iterative speakers' acceptance rates for non-final laxing in *inédite* words compared to acceptance rates for *illicite* words with the adjacent non-iterative pattern.

Adjacent non-iterative speakers' acceptance rates for non-final laxing in *inédite*-type words are comparatively low; all of them are below the 50% mark (cf. non-local speakers). This shows a dramatic decrease from their acceptance rates for the adjacent iterative pattern for *illicite* type words.

4.2.4.3 ATB speakers' acceptance rates for non-final laxing in *inédite* words

As *inédite* words are concerned, it is not clear what ATB speakers should accept. On the one hand it is possible that the ATB pattern is outputted by a grammar with an iterative, but strictly local application of a harmony process, in which case the non-final laxing in *inédite* words should be dispreferred. On the other hand, it is possible that the harmony process applies simultaneously, as is assumed in classical derivational phonology (Chomsky & Halle 1968), in which case we predict that non-final laxing in *inédite* words would be accepted.

Both predictions are correct. Though we have only two ATB speakers (JB and HRZ), the speakers seem split on the question of *inédite* words:

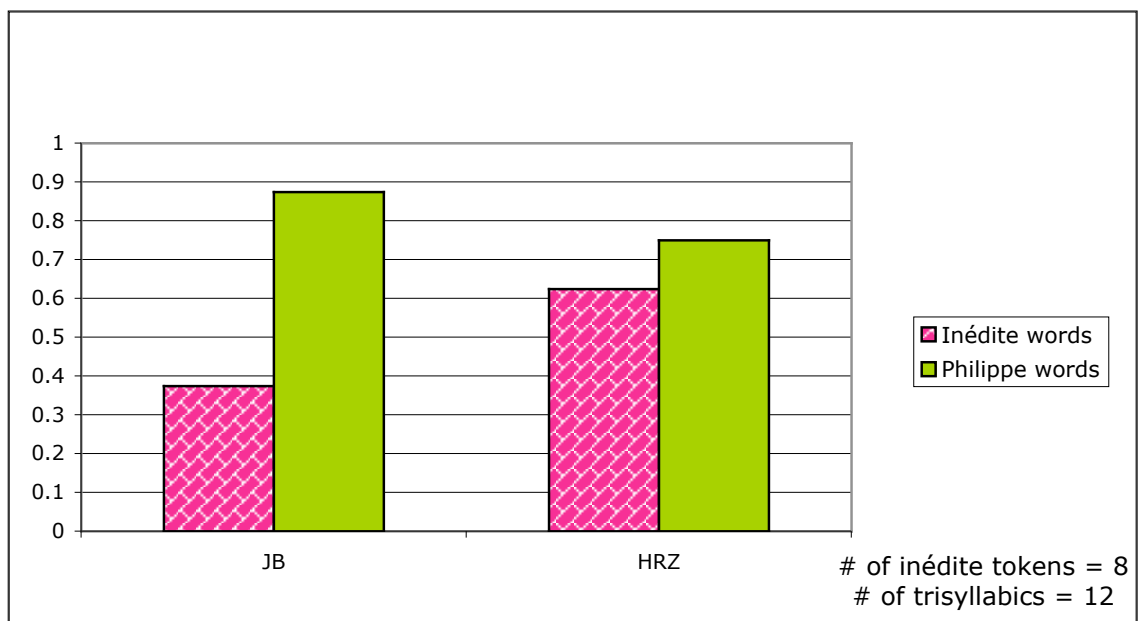


Figure 29: ATB speakers' acceptance rates for non-final laxing in *inédite* words compared to acceptance rates for *illicite* words with the ATB pattern.

Since we have only two speakers in this category, it is impossible to perform a pairwise t-test to see if each of their acceptance rates differ significantly between the two types of words. The preceding figure does show however, that ATB speakers will go either way. Since the results are somewhat indeterminate, I will assume this is the case for this grammar until further results can be collected.

4.2.4.4 Other speakers

We expect the non-harmonising speaker (BGB) to give a low acceptance rate to non-final laxing in *inédite*-type words, which is indeed what we find:

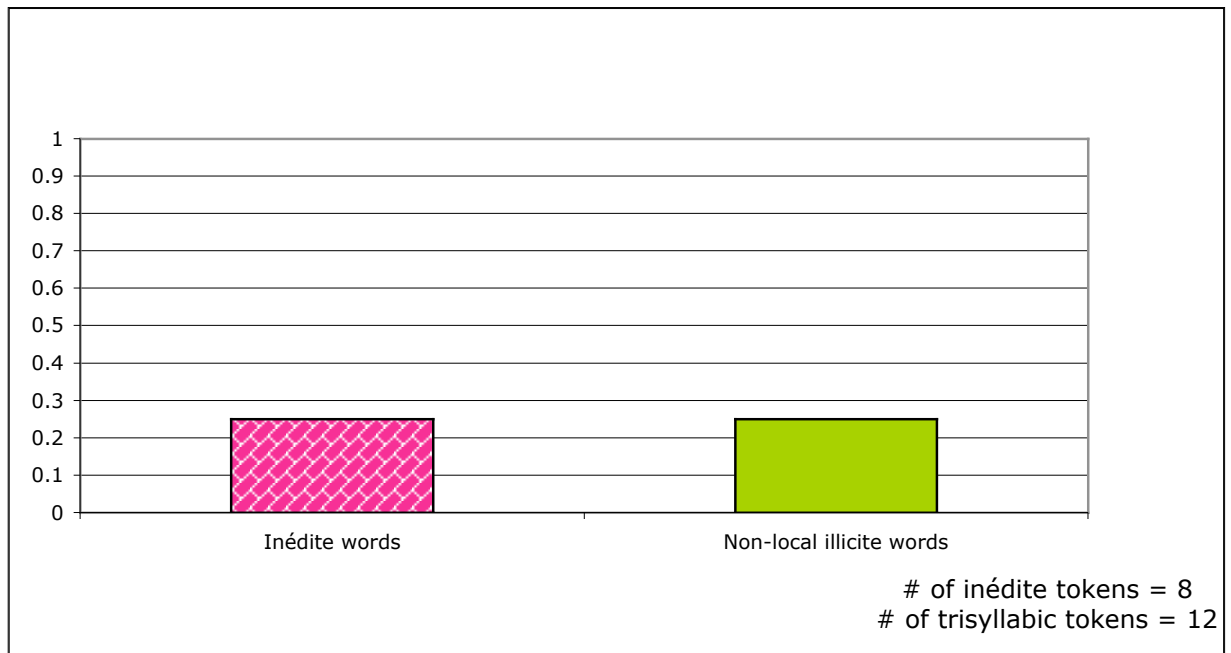


Figure 30: Non-harmonising speaker's acceptance rate for non-final laxing in *inédite* words, compared to acceptance rates for all harmony patterns in *illicite* words.

As for the ambivalent speakers (LL and MB), the prediction is that LL, who likes ATB and non-local patterns equally for *illicite* words, should like non-final laxing in *inédite* words,

since it seems the speaker accepts non-local patterns of harmony. There is the possibility that LL gives a high acceptance rate to the ATB pattern, but still parametrises for strict locality, so that s/he would give a low acceptance rate to *inédite* words with non-final laxing. It is the former prediction however that appears correct:

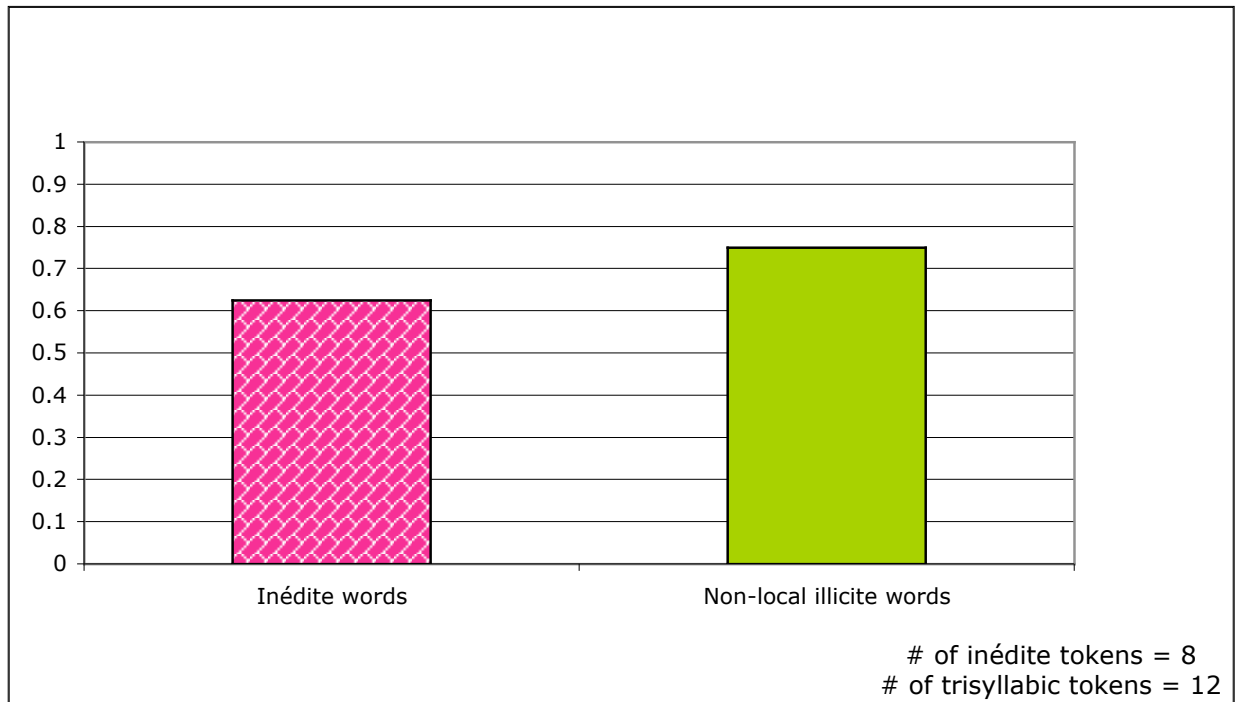


Figure 31: LL's acceptance rate for non-final laxing in *inédite* words, compared to acceptance rates for the speakers preferred harmony patterns in *illicite* words.

Speaker MB, who gave equal preference to the non-local and adjacent non-iterative patterns, is expected to go either way as *inédite* words are concerned. We find however that the speaker accepts *inédite* words with a 100% rating:

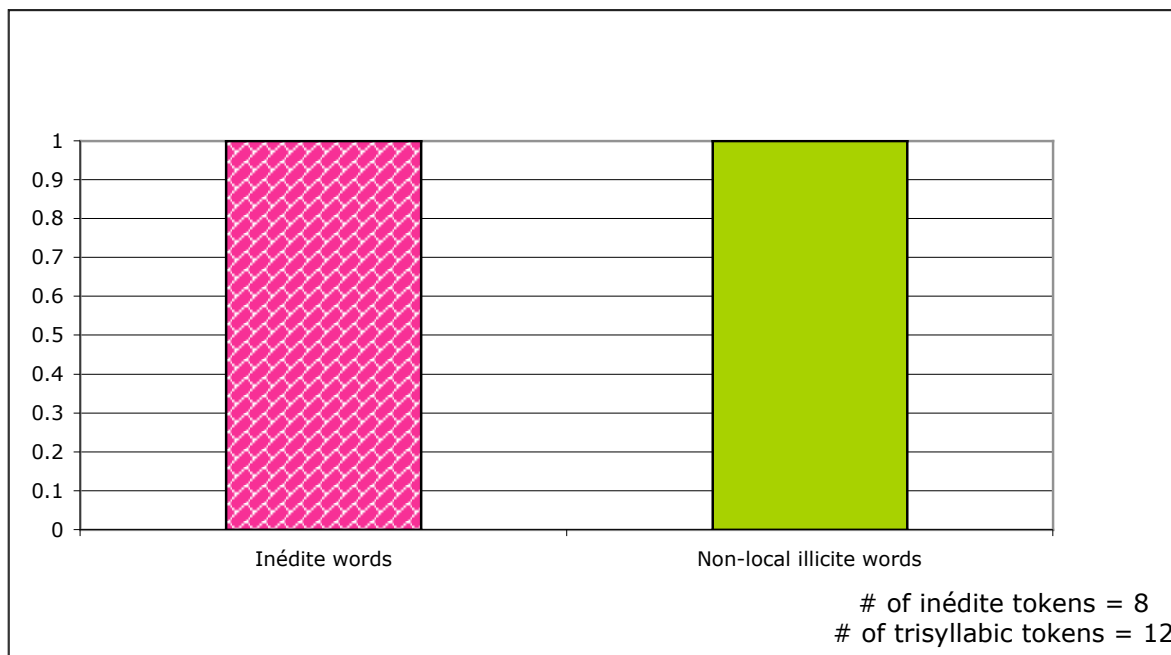


Figure 32: MB's acceptance rate for non-final laxing in *inédite* words, compared to acceptance rates for the speakers preferred harmony patterns in *illicite* words.

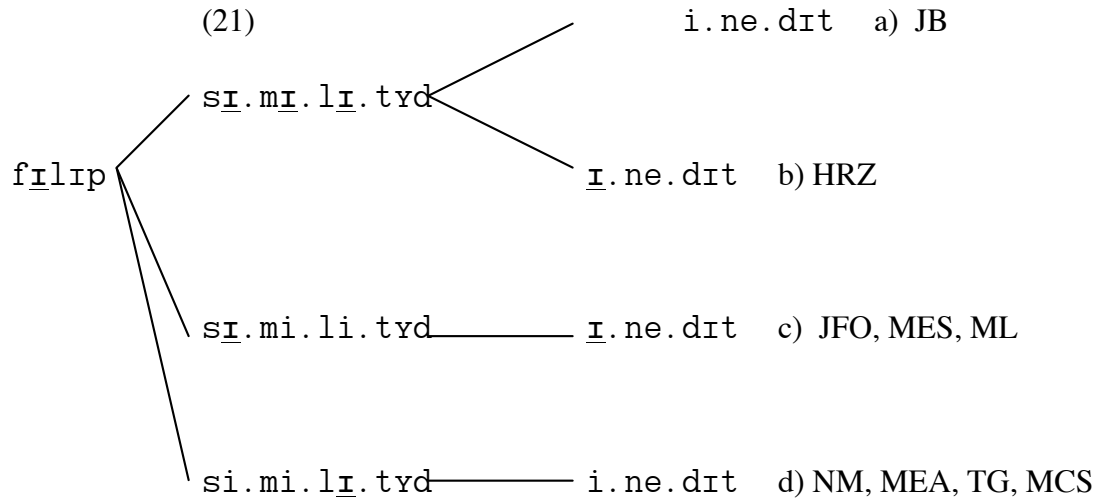
Other speakers' behaviours are thus not inconsistent with what are possible predictions.

4.3 Summary: attested and unattested grammars of CF with respect to locality

Acceptance rates for different word types show attest the existence of four possible grammars of CF as concerns vowel harmony³². The four grammars can be described in terms of their preferences for *similitude*- and *inédite*-type words³³; in all four grammars, the harmonic pronunciation is always accepted for disyllabics:

³² There is of course a fifth grammar, one where harmonic forms are never accepted.

³³ I remind the reader that judgments for *illicite*-type words were consistent with those rendered for *similitude*-type words, so that they are equivalent in terms of describing the different grammars.



I have proposed in the present part of the dissertation that nanovariation with respect to locality and iterativity is due to an underdetermined analysis of PLD forms, i.e. disyllabics. In the second part of this dissertation, I will account for these four grammars by proposing that all apply the same harmony rule, but that the rule can be parametrised for being [\pm iterative], for directionality, i.e. whether it starts applying from the left or right edge of the word.

5 Conclusion

The main contribution of this chapter will have been to show that CF vowel harmony is indeed variable, confirming the informal observations of Dumas (1987), but that the variation is systematic: speakers' preferences for a given pattern is systematic across types of words. Since preferences for a pattern are rarely to the exclusion of other patterns, we can assume that parameter settings are probabilistic leading to intra-speaker variation. This chapter has also proposed that CF vowel harmony is a case of 'nanovariation.' Speakers differ as to which value of a parameter they are probabilistically likely to set, which is the cause of inter-speaker variation.

Despite this variation, the general goal of this thesis is to model the grammars that will output the different variants. In other words, it is not my goal to study how variation interacts with phonological component, but rather how the phonological component can be modeled to produce the different variants attested here, and not produce variants that are unattested. The second part of this dissertation will be concerned with the technical details of this model, including the theoretical consequences of the assumptions that must be held (e.g. the existence of non-local harmony). The second part of the dissertation will also briefly outline a working research program, whose aim is to study the causes of variation, and its relationship with the phonological component (see Nevins, Poliquin & Perfors (2006), and Poliquin & Nevins (2006)).

Appendix: Stimuli

1) Stimuli for Table 1, and Figure 1

[de. bɪt]	‘debit, v.’	[a. bi]	‘suit’
[de. byt]	‘begin’	[a. by]	‘abuse’
[de. but]	‘dismiss’	[a. bu]	‘finished’

2) Stimuli for Table 2, Table 3, Table 5, Figure 2, Figure 3, Figure 4, and Figure 6.

[si. ʁi. lɪk]	‘cyrillic’
[si. ny. zɪt]	‘sinusitis’
[pɛi. mi. t ^s ɪf]	‘primitive’

Stimuli were included in the following text, which speakers were asked to read aloud.

The words above are in boldface and italics. Target words were not differentiated like this in the text presented to speakers:

Production task text

Philippe: Allo?

Mireille: Allo! Comment ça s’est fait qu’t’étais pas là hier soir!? On t’a attendu toute la soirée! On pensait qu’tu t’étais fait frapper par un bus, quéque chose! En tout cas t’as manqué toute une soirée! C’tais l’fun en crime! Y avait du bon vin! Le dernier *millésime*!

Pourquoi qu’t’es pas v’nu finalement? T’es pas malade *toujours*?

P: Moi j’ai passé une soirée *pourrite*! Chu malade comme un chien! J’dois avoir une *cytise* avec d’la *cellulite* ou d’la *rubellite*, en tout cas quéque chose dans mon *utérus*. . . J’ai tellement d’*mucus* que quand j’mè lève pour me moucher j’*titube*, j’peux quasiment pas m’rendre.

- M: *Philippe Buret*, t'en as pas d'utérus! J'veux pas t'*juger* là, mais t'es don' ben *stupide*! C'est pas des maladies ça! T'as yinque une *sinusite*. C'est pour ça qu't'es pas v'nu pour *finir*? On était su' l'*qui-vive* toute la soirée!
- P: Ouain. J'étais *poussif* en titi. Pour moi i' m'faudrait quéque chose, d'l'acide *citrique* peut-être, ou *nitrique*, ché pus. Laquelle est *vomitive*? Pis laquelle qui est un *diurétique*?
- Je sais pas pourquoi chu malade de même! Ça doit être parce que j'me *fragilise* avec l'âge. J'dois faire de la fièvre, j'vois des *libellules* qui *irisent* ma vue.
- M: Aye! J'veux pas qu't'*utilises* ces affaires-là! Tu déprimes de *solitude*! C'est yinque ça! Prends juste de la lotion *antitussive*, tu vas êt' correct!
- T'es juste malade parce que la *nourriture* que tu manges est pas *nutritive* ben ben. Qu'est-ce t'as mangé hier par exemple?
- P: Euh. . Une *choucroute* pis une *poutine*. C'est pour avoir le maximum de *glycérides*.
- M: Ben là y a des *limites*! Trop de *lipides* c'est pas bon! Tu vas jamais *réussir* à être en forme de même!
- P: *Mireille*! Laisse-moi une chance! J'ai quand même mis du *vinaigre* sur c'que j'ai mangé, ça coupe le gras non? J'en ai mis tellement que j'ai des *brûlures* s'a langue astheure!
- M: Ben non! Tu manges comme un *primitif*. Va falloir que tu t'*accoutumes* à pas manger yinque des *pourritures* de même. Sinon, pis j'en ai la *certitude*, tu vas continuer à être malade.
- P: Wo *minute*-là! Le *gourou* d'la santé, tu m'*intimides* pas! J'en ai assez d'ma mère pis ma fille *illégitime* qui m'disent la même affaire, i'm' *suffisent* merci.
- M: J'en sais pas plus que toi, mais i'm' semble que chu *intuitive* pour ces affaires-là. C'est pas qu'on veut êt' *punitives*. Dans l'fond, c'est toi ton prop' *bourreau*. . .
- Aye, j'ai une question pour toi l'*cinéphile*, ça pas rapport: connais-tu l'film qui est sorti basé sur *Ulysse*, en version plus politique? Est-ce qu'i' est sorti en DVD?
- P: Ben, avant qu'ils *numérisent* ça, ça va prendre du temps. Pis avant qu'ils *diffusent* ça à la télé, ça va être des coûts *prohibitifs*! Si tu veux par exemple,

mon chum y a une version piratée. Les sous-titres sont en alphabet *cyrillique* ou en *chinois*, mais bon. . .

- M: I faudrait que j'me *russise* ou que j'me *sinise* avant. Merci, non. C'est parce qu'i faut que j'lise le livre pour mon cours d'*éditrice*, pis ça m'tente pas. C'est ben trop long!
- P: Oui, mais ça vaut la peine! C'gars-là y avait une imagination *chimérique*!
- M: Ouain. Ben on verra. Va falloir qu'j'dise au prof en *rougissant* que j'connais pas l'histoire.
- P: C'est plate.
- M: En tout cas, j't'appelle parce qu'on s'en va au musée tout à l'heure. Viens t'en 'ec nous aut'!
- P: Tu dis ça don' ben sur un ton *exécutif*! Qui ça 'on'?
- M: *Gisèle* ma voisine pis son chum.
- P: Ah oui! Le gars qui a un nom québécois: *Bruno Bouleau*! Qu'est-ce qui fait dans vie encore?
- M: Y est avocat, il fait du litige. En tout cas, j'y vas avec eux-aut' pis leurs jumelles: *Lucie* pis *Louise*.
- P: Ben, ch'peux pas sortir moi! Les abeilles vont m'faire des *piqûres* terribles!
- M: Les abeilles! On peut pas gagner avec toi! Pense don' d'façon *positive*! Mets-toi d'la lotion *insectifuge*. . .
- P: *Apifuge*! C'est mieux.
- M: Relaxe là! Faudrait pas qu'tu t'*suréquipes*.
- P: À quel musée vous allez?
- M: À celui sur le *périphérique*, celui près du monument en *pyrite* de *Vitruve* aux gazés à l'*ypérite*.
- P: OK, ché lequel. Ça d'manderait que j'me *flexibilise* ben trop pour aller là. Qu'est-ce que vous allez voir?

- M: Plein d'affaires! Les p'tites veulent qu'on *participe* à un atelier d'*bougies*, puis qu'on aille voir l'exposition sur les *murènes*. Bruno lui, il veut voir l'exposition sur *Ninive* au *néolithique*.
- P: C'est-tu des *couchitiques* ou des *hittites* qu'i y avait là?
- M: Ni l'un ni l'autre.
- P: Scuse. C'est la maladie, j'en perds mon latin.
- M: Ton latin! *Latinise-toi* don'! Moi j'veux voir l'exposition sur les *missives iréniques* de la diplomatie espagnole pis portugaise, pis de tous ces pays là.
- P: Le monde *ibérique*?
- M: C'est ça.
- P: Faut-tu payer pour aller à c'musée là?
- M: Non, mais c'est un système *contributif*, tu payes c'que tu peux.
- P: Une chance, parce que j'*budgetise* de c'temps-ci.
- M: Alors tu viens?
- P: Ça a l'air le fun. J'pense qu'irai faire un tour.
- M: OK. Mets un *gilet*, faudrait pas qu'ta grippe rempire!

3) Stimuli for Figure 8

[fɪ.lɪp]/[fi.lɪp]	'Phillip'
[mɪ.nɪt]/[mi.nɪt]	'minute'
[lɪ.mɪt]/[li.mɪt]	'limit'
[pʊ.ɾɪt]/[pu.ɾɪt]	'rotten (fem.)'
[st ^s y.pɪd]/[st ^s y.pɪd]	'stupid'
[mʏ.kʏs]/[my.kʏs]	'mucus'

[ʃu.kʁʊt]/[ʃu.kʁʊt] ‘sauerkraut’

[pu.t^sɪn]/[pu.t^sɪn] ‘poutine’

4) Stimuli for Figure 9

Philippe-type words

See 3) above

Mitaine-type words

*[ʃɪ.nwa]/[ʃi.nwa] ‘Chinese’

*[ʒy.mɛl]/[ʒy.mɛl] ‘binoculars’

*[mi.ʁɛj]/[mi.ʁɛj] ‘Mireille’

*[ʒɪ.lɛ]/[ʒi.lɛ] ‘sweater’

*[vi.nɛgʁ]/[vi.nɛg] ‘vinegar’

*[bʁy.no]/[bʁy.no] ‘Bruno’

*[ly.si]/[ly.si] ‘Lucy’

*[ʒy.ʒe]/[ʒy.ʒe] ‘to judge’

5) Stimuli for Figure 10, Figure 11, **Figure 14**, Figure 15, Figure 16 Figure 17, Figure 18, Figure 19, Figure 20, Figure 24, Figure 25, and Figure 26

Philippines-type words

[si.fi.lɪs] ‘syphilis’

[mi.ʁi.fɪk] ‘fabulous’

[si.bi.lɪn] ‘enigmatic, fem.’

[fi.li.pɪn] ‘Phillipines’

[ly.py.lɪn]	‘lupulin’
[ɛi.dʒi.kʏl]	‘ridicule’

Juridique-type words

[ʒy.ɛi.dʒɪk]	‘judicial’
[si.ny.zɪt]	‘sinusitis’
[ply.mi.t ^s ɪf]	‘minute-book’
[py.ni.t ^s ɪf]	‘punitive, masc.’
[fi.gy.lɪn]	‘figuline’
[li.mu.zɪn]	‘limousine’

6) Stimuli for Figure 12

Midi-type words

[mɪ.dʒi]/[mi.dʒi]	‘noon’
[fɪ.ni]/[fi.ni]	‘finished’
[ʃɪ.mi]/[ʃi.mi]	‘chemistry’
[zʊ.lu]/[zu.lu]	‘Zulu’
[ɪ.si]/[i.si]	‘here’
[ʃɪ.pi]/[ʃi.pi]	‘shrew, fig.’
[gʊ.ɤu]/[gu.ɤu]	‘guru’
[ʊ.tu]/[u.tu]	‘Hutu’

7) Stimuli for Figure 13

Julie-type words

[ʒy.li]/[ʒy.li]	‘Julie’
[sɪ.gy]/[si.gy]	‘hemlock’
[pu.li]/[pu.li]	‘pulley’
[mɪ.lu]/[mi.lu]	‘Milou’
[vu.ly]/[vu.ly]	‘wanted’
[sy.li]/[sy.li]	‘Sully’
[ɪ.bu]/[i.bu]	‘owl’
[ku.ɤy]/[ku.ɤy]	‘run, part.’

8) Stimuli for Figure 21, Figure 22, and Figure 23

Similitude-type words

[si.fi.li.t ^s ɪk]	‘syphilis patient’
[d ^z i.mi.ny.t ^s ɪf]	‘diminutive, masc.’
[i.ni.bi.t ^s ɪf]	‘inhibitive, masc.’
[si.mi.li.t ^s ɪd]	‘similarity’
[i.ly.mi.nɪst]	‘illuminist’
[fi.gy.ɤi.nɪst]	‘figurine maker’
[i.ni.bi.tɤɪs]	‘inhibitor, fem.’
[d ^z i.si.pli.nɪst]	‘disciplinarian’

9) Stimuli for Figure 27, Figure 28, Figure 29, Figure 30, Figure 31, and Figure 32

Inédite-type words

[i.ne.dʒɪt]	‘unpublished, fem.’
[i.be.ɪk]	‘Iberian’
[li.be.lɪ]	‘dragon-fly’
[si.ne.fil]	‘cinophile’
[sy.ɛ.kɪp]	‘over equip’
[gli.se.ɪd]	‘glyceride’
[mi.le.zɪm]	‘vintage’
[y.te.ɪs]	‘uterus’

Chapter 3: Opaque Vowel Harmony

1 Chapter overview

The goal of the present chapter is to introduce some data relating to the interaction of CF vowel harmony with other processes of CF phonology. Specifically, I will be presenting data relating to the interaction of vowel harmony with two processes: pre-fricative tensing and open-syllable tensing, both of which result in separate cases of opacity. These two processes, in a derivational framework, counterbleed harmony, and thus deprive it, on the surface, of its conditioning environment. These two examples of opacity, which I will account for in a rule-based framework, are the basis for one of the main claims of this dissertation, namely, that non-derivational frameworks are inadequate to account for such facts. These non-derivational frameworks include Optimality Theory (OT; Prince & Smolensky 1993/2004), and all of its relevant modifications meant to account for non-paradigmatic opacity. These issues will be discussed in the second part of this dissertation. For now, the present chapter aims only to present these patterns, and importantly, to argue for their synchronic productivity. It has been argued in works by Mielke *et al.* (2003) and Sanders (2003), that opacity does not constitute a challenge to parallelist versions of OT. These authors predict that all purported cases of opacity can either be accounted for transparently, or shown to be unproductive. This chapter argues against this position by showing that CF's two patterns of opaque vowel harmony cannot be accounted for transparently, and are fully productive.

The chapter begins by showing the interaction of vowel harmony with 'pre-fricative tensing.' [+high] vowels that precede a tautosyllabic voiced fricative must be [+ATR], e.g. [sa.li:v] 'saliva' *[salɪv]. If pre-fricative tensing were applied before harmony, harmony would not apply in words ending in a voiced fricative, since triggers must be [-ATR]. Harmony applies anyway, suggesting that pre-fricative tensing follows the application of harmony, which itself follows closed syllable laxing: e.g. [mɪ.sɪ:v]

(<missive>, ‘letter’). (I will argue in the next part of this dissertation that this pattern must be accounted for derivationally, by assuming an intermediate representation in which the final [+high] vowel has undergone final closed syllable laxing, and the non-final vowel has undergone harmony: [mɪ . sɪv]). Following the presentation of these facts, the present chapter will go on to propose two potential transparent accounts for these facts. I show, using judgment data collected from CF speakers, that both these accounts make erroneous predictions. Also using judgment data, I show that the pattern extends to both nonce words and low frequency words, thus arguing for its synchronic productivity³⁴.

The chapter then presents the case of *musical*-type words (‘musical’). These refer to morphologically complex words whose stems can exhibit harmony: [mɥ . zɪk] (‘music’).

If a resyllabifying suffix is concatenated to such a stem, the non-stem-final vowel can retain its lax quality inherited from harmony, but the stem-final vowel must be [+ATR]:

[mɥ . zi . kaɭ], *[mɥ . zɪ . kaɭ]. The conditioning environment for harmony is obscured by what I propose is an open-syllable tensing rule, which counterbleeds harmony. Following the same line of argument as for *missive*-type words, I show that potential transparent accounts for this phenomenon are misdirected, and that the pattern is fully productive.

Importantly, I also show that *musical*-type words involve the notion of the ‘cycle’ assumed in Lexical Phonology (Kiparsky 1982a, 1985). Given that this pattern is fully productive in the language, *musical*-type words constitute another important argument in favour of a derivational model of phonology.

³⁴ I have argued for the productivity of this type of opacity in Poliquin (2006).

2 Opaque allophony: the interaction of vowel harmony and ‘pre-fricative tensing.’

2.1 Pre-fricative tensing

[+high] vowel laxing, as shown in the previous chapter, is obligatory in final closed syllables. This is only true however if the coda consonant is not a voiced fricative (/v, z, ʒ, ʁ/). If a [+high] vowel is in a final or non-final syllable that is closed by voiced fricative, the [+high] vowel must be [+ATR]. It is a general fact of CF that final vowels lengthen before coda voiced fricatives, however, only [+high] vowels additionally undergo tensing. This process will be henceforth referred to as *pre-fricative tensing*. It is illustrated in (1). It should be noted however that [+high, +ATR] vowels are long only before final voiced fricatives; for instance a [+high, +ATR] vowel in an open syllable is not long (compare tables 1a and 1b in the previous chapter).

(1) *Pre-fricative tensing in final syllables*

sa.li:v	‘saliva’	*sa.lɪv
ve.zy:v	pr. name	*ve.zɪv
a.pʁu:v	‘approve’	*a.pʁʊv
e.gli:z	‘church’	*e.gɫɪz
e.kly:z	‘locks’	*e.kɫɪz
pœ.lu:z	‘lawn’	*pœ.lʊz
vɛʁ.t ^s i:ʒ	‘vertigo’	*vɛʁ.t ^s ɪʒ
de.ly:ʒ	‘flood’	*de.lɪʒ
ʁu:ʒ	‘red’	*ʁʊʒ

de.li:ʙ	‘delirium’	*de.lɪʙ
se.ʙy:ʙ	‘door lock’	*se.ʙʏʙ
bõ.ʒu:ʙ	‘hello’	*bõ.ʒʊʙ

Past authors such as Dumas (1981) have assumed that pre-fricative tensing is a by-product of vowel lengthening. Though this is perhaps the case historically, I maintain that the pre-fricative tensing rule and the lengthening rule are best kept separate since they have slightly different structural descriptions. If a [+high] vowel is in a syllable closed by a voiced fricative, it must be [+ATR] whether the syllable is final or not (see (2)). Lengthening, however, only occurs when the syllable is final and closed by a voiced fricative. Also, as the data show in (3), lengthening applies to all vowels in word-final syllables closed by a voiced fricative, while pre-fricative tensing only applies to [+high] vowels.

(2)

uz.bɛk	‘Uzbek’	*uz.bɛk	*u:z.bɛk
syz.rɛ̃	‘feudal lord’	*syz.rɛ̃	*sy:z.rɛ̃
iʙ.syt	‘hirsute’	*iʙ.syt	*i:ʙ.syt
fyz.laʒ	‘fuselage’	*fyz.laʒ	*fy:z.laʒ
iz.ra.ɛl	pr.name	*iz.ra.ɛl	*i:z.ra.ɛl

(3)

e.le:v	‘pupil’	*e.lɛv	*e.le:v
e.pʙæ:v	‘test’	*e.pʙæv	*e.pʙø:v
e.lo:ʒ	‘praise’	*e.loʒ	*e.lo:ʒ
i.no:v	‘innovate’	*i.nov	*i.no:v

As I have presented the phenomenon here, pre-fricative tensing has the opposite effect of closed syllable laxing in that it forces [+high] vowels to be tense. If that is the case, we would expect this process to deprive vowel harmony of its conditioning environment. I will show in this chapter that harmony applies before pre-fricative tensing however, so that the conditioning environment for harmony is obscured, yielding a case of opacity.

I will also show that opacity is only motivated for a subset of CF speakers. For other speakers, pre-fricative tensing and lengthening are followed by a diphthongisation rule, whereby long vowels are diphthongised. Long vowel to diphthong pairings are shown here:

(4)

i :	→	ɪ ⁱ
y :	→	ʏ ^y
u :	→	ʊ ^u

As illustrated in (2), diphthongs have a lax nucleus and a tense off-glide. The diphthongisation rule thus provides a lax nucleus with which previous [+high] vowels can harmonise. This is assuming that the target vowels would harmonise with the lax nucleus perhaps because of greater linear proximity. Greater linear proximity holds for all potential targets, since they are always to the left of the trigger. For these diphthongising speakers, both the laxing and diphthongisation rule feed the harmony rule, in which case the interaction of harmony with pre-fricative tensing would be transparent for these speakers.

2.2 Vowel harmony data and generalizations

In this section, I will give a very brief description of harmony as it occurs in disyllabic words, summarising the facts presented in the previous chapter. Harmony can also occur in tri- and tetrasyllabic words whose nuclei are all [+high], or that have at least one [+high] non-final vowel (e.g. *inédite*-type words). These sorts of examples show that CF speakers

differ in terms of locality and rule application parameters. A full account of these facts will be presented in the next chapter.

In CF, vowel harmony occurs when a [+high] vowel in a non-final open syllable projects a [-ATR] autosegment. Non-final [+high] vowels may only project a [-ATR] autosegment if the final vowel within the same word projects a [-ATR] autosegment as a result of closed syllable laxing. This is illustrated in (5):

(5) a. *Representation of CF vowel harmony*

[-ATR] [-ATR]

| |

fɪ . lɪp

b. *Characteristics of CF vowel harmony*

Harmonic feature: [-ATR]
 Trigger: Word final [+high] vowels in closed syllables
 Target: Non-final [+high] vowels in open syllables.
 Domain: Word

More examples of harmony in disyllabic words are provided in (6); it should be reiterated that vowel harmony is an optional process, so that non-final [+high] vowels need not be [-ATR] if the environment for vowel harmony is met:

(6) *Harmony in disyllabics*

Harmonic forms		Standard forms
fɪ . lɪp	pr. name	f i . lɪp

mɪ.nɪt	‘minute’	mi.nɪt
dʒɪ.sʊt	‘dissolved, fem.’	dʒi.sʊt
st ^s ɪ.pɪd	‘stupid’	st ^s y.pɪd
mɪ.kʏs	‘mucus’	my.kʏs
t ^s ɪ.mʊʃ	‘fly paper’	t ^s y.mʊʃ
pu.βɪt	‘rotten, fem.’	pu.βɪt
ku.t ^s ɪm	‘custom’	ku.t ^s ɪm
ʃu.kβʊt	‘sauerkraut’	ʃu.kβʊt

A non-final [+high] vowel in an open syllable may not project a [-ATR] feature if the final vowel is not [+high, -ATR]. I will henceforth refer to words with a [+high] non-final vowel and neutral final vowel as *mitaine*-type words:

(7) *Mitaine-type words*

mi.tɛn	‘mitt’	*mɪ.tɛn
pɪ.βat	‘pirate’	*pɪ.βat
si.gɔŋ	‘stork’	*si.gɔŋ
ky.βe	‘priest’	*ky.βe
ly.kɑɲ	‘attic window’	*ly.kɑɲ
y.ze	‘used’	*y.ze

du.lœʁ	‘pain’	*du.lœʁ
su.vã	‘often’	*su.vã
pu.ʁi	‘rotten’	*pu.ʁi

Examples in (7) show that in open syllables, [+high] vowels must be [+ATR] unless they can project a [-ATR] feature by harmony. Examples in (7) also stand in contrast to the following examples, in which the final [+high] vowel is not [-ATR], but [+ATR] because of prefricative tensing. In these examples, the non-final [+high] vowel can be [-ATR] as if harmony applied, unlike the examples in (7) where non-final laxing is disallowed:

(8) *Non-diphthongising speakers*

Harmonic forms		Standard forms
kɪ.vi:v	‘alert’	ki.vi:v
vɪ.tʁy:v	pr. name	vi.tʁy:v
ɪ.ʁi:z	‘to make iridescent’	i.ʁi:z
d ^z ɪ.fy:z	‘diffuse’	d ^z i.fy:z
li.t ^s i:ʒ	‘litigation’	li.t ^s i:ʒ
fɪ.ni:ʁ	‘to finish’	fi.ni:ʁ
pɪ.ky:ʁ	‘vaccine’	pi.ky:ʁ
bʁy.ly:ʁ	‘burn’	bʁy.ly:ʁ
ʁy.si:z	‘russify’	ʁy.si:z
sy.bi:ʁ	‘to undergo’	sy.bi:ʁ
y.mu:ʁ	‘humour’	y.mu:ʁ

pu.sɪ:v	‘lazy, fem.’	pu.sɪ:v
su.mi:z	‘submitted, fem.’	su.mi:z
bu.si:ɛ	‘to redden’	bu.si:ɛ
tu.zu:ɛ	‘always’	tu.zu:ɛ
mu.ɸy:ɛ	‘die, pret.’	mu.ɸy:ɛ

I propose that non-final laxing is allowed for the words in (8) because vowel harmony applies at an intermediate level of representation. The vowel harmony rule and the prefricative tensing rule are in counter-bleeding order. The transcriptions in (8) reflect my pronunciation, as well as that of a subset of speakers used in this study. Many speakers of CF diphthongise the final [+high] vowel however, so that the words in (8) are actually produced as in (9):

(9) *Diphthongising speakers*

kɪ.vɪ ⁱ v	‘alert’
vɪ.tɸy ^y v	pr. name
ɪ.ɸɪ ⁱ z	‘to make iridescent’
d ^z ɪ.fy ^y z	‘diffuse’
lɪ.t ^s ɪ ⁱ ʒ	‘litigation’
fɪ.nɪ ⁱ ɸ	‘to finish’
pɪ.ky ^y ɸ	‘vaccine’
bɸy.lɪ ^y ɸ	‘burn’

ɤY . SI ⁱ Z	‘russify’
SY . bI ⁱ ɤ	‘to undergo’
Y . mU ^u ɤ	‘humour’
pu . SI ⁱ v	‘lazy, fem.’
SU . mI ⁱ Z	‘submitted, fem.’
ɤU . SI ⁱ ɤ	‘to redden’
tU . ʒU ^u ɤ	‘always’
mU . ɤY ^y ɤ	‘die, pret.’

I propose that there exist two differences between non-diphthongising speakers and diphthongising speakers. Aside from having a diphthongising rule, whereby long vowels diphthongise, diphthongising speakers also order their pre-fricative tensing rule before harmony so that they are in feeding order. The orderings for each set of speakers are illustrated in (10) below:

(10) a. *Non-diphthongising speakers (see (8))*

UR	/misiv/	
Laxing Rule	mi . SIV	} Feeding order
Harmony Rule	mI . SIV	
Pre-fricative Tensing Rule	mI . siV	} Counter-bleeding order
Lengthening Rule	mI . si:v	
SR	[mi . si:v]	

b. *Diphthongising speakers (see (9))*

UR	/mɪsɪv/
Laxing rule	mɪ . sɪv
Pre-fricative Tensing Rule	mɪ . sɪv
Lengthening Rule	mɪ . sɪ : v
Diphthongising Rule	mɪ . sɪ ⁱ v
Harmony Rule	mɪ . sɪ ⁱ v
SR	[mɪ . sɪ ⁱ v]

Phonetic data in the next section will show that non-diphthongising speakers clearly have a monophthongal [+ATR] final vowel. That being the case, it is impossible to motivate vowel assimilation (i.e. harmony) on the surface, which is the reason for positing a counter-bleeding ordering of harmony and pre-fricative tensing. For diphthongising speakers, harmony is always surface true. If a [+high] vowel precedes a coda consonant other than a voiced fricative, the [+high] vowel is [-ATR], and triggers harmony. If the final [+high] vowel precedes a coda voiced fricative, it becomes long by the lengthening rule. Since it is long, it can be diphthongised. If it is diphthongised, it has a [-ATR] nucleus. Non-final vowels can thus assimilate the [-ATR] quality of the final diphthong.

The important difference between the two dialects is the different orderings of pre-fricative tensing with respect to harmony. In the case of non-diphthongising speakers, I am assuming they have a diphthongising rule that does not target [+high] vowels. In my dialect, I will diphthongise [-high] vowels when they precede voiced fricatives, but not [+high] vowels. As for diphthongising speakers, the diphthongising rule is generalised to all vowels (see Dumas 1981). I assume that diphthongising speakers also have a laxing rule, since in all

dialects of CF [+high] vowels obligatorily lax in final closed syllables³⁵.

2.3 Phonetic data: diphthongising and non-diphthongising speakers

This section will show acoustic data on non-final and final [+high] vowels in *missive*-type words as spoken by diphthongising and non-diphthongising speakers. Six speakers participated in this study, half of which were diphthongising (GC, HRZ, ML) and the other half non-diphthongising (LPH, KB, PC). Speakers were asked to read a set of four *missive*-type words incorporated into a carrier sentence. The target word carried the intonational focus of the sentence, but was neither initial or final. The carrier sentence was the same for each word:

- (11) *Carrier sentence*
- J' ai dit X tout de suite
- I have said X right now.

Speakers' utterances were recorded using Praat, which was also used to measure formant frequencies. Owing to the optionality of harmony in this language, not all target words featured non-final laxing in speakers' pronunciations. Only those words in which the initial vowel was lax were taken into account. As a result, speakers are represented using partially overlapping subsets of the four target words.

The two following subsections will show scatter plots for each speaker in which the F1

³⁵ As mentioned in the introduction to the dissertation, I am excluding the 'Maritime' dialects of CF, which include Acadian French, and some dialects of Gaspésie in which there is no closed syllable laxing, and thus no harmony.

values for initial and final vowels are plotted against F2-F1 values. Formant values for each vowel were measured at three points. The first point of measurement was located on the second peak of the wave length after the formant transition, while the last point of measurement was located on the second to last peak before the final formant transition. The second point of measurement was located midway between the first and last. The points on the scatter plots represent those formant values measured at each point and averaged out.

Since non-diphthongising speakers produce a monophthongal long tense vowel in a final position (as a result of pre-fricative tensing), we expect their final vowels to be less central than initial vowels, which are lax as a result of harmony. Final vowels for non-diphthongising speakers should thus have lower F_1 values than initial vowels, and higher F_2 values³⁶. Vowels for non-diphthongising speakers should thus pattern in separate clusters. In the case of diphthongising speakers however, we expect initial and final vowels to pattern into a single cluster. Since diphthongising speakers' final vowels feature a lax nucleus, averaged-out formant values will make them seem central, just like initial vowels. Final vowels' tense off-glide may lower average F_1 values and raise F_2 values, but we expect lax initial vowels and final vowels to pattern approximately the same way.

2.3.1 Non-diphthongising speakers

The following three scatter plots show formant values for initial and final vowels in *missive*-type words, as spoken by non-diphthongising speakers, which include one female (KB) and two males (LPH and PC). Scatter plots represent each speaker's speech individually, since speakers' different pitch levels influence formant values, which obscures the otherwise neat distribution of tense and lax vowels within the vowel space. Initial vowels are represented by

³⁶ The differences between tense and lax vowels were measured in terms of F_1 and F_2 , based on the characterisation of this difference made in terms of these formants in Stevens (1998) (among others, see previous chapter).

triangles, and final vowels with rectangles:

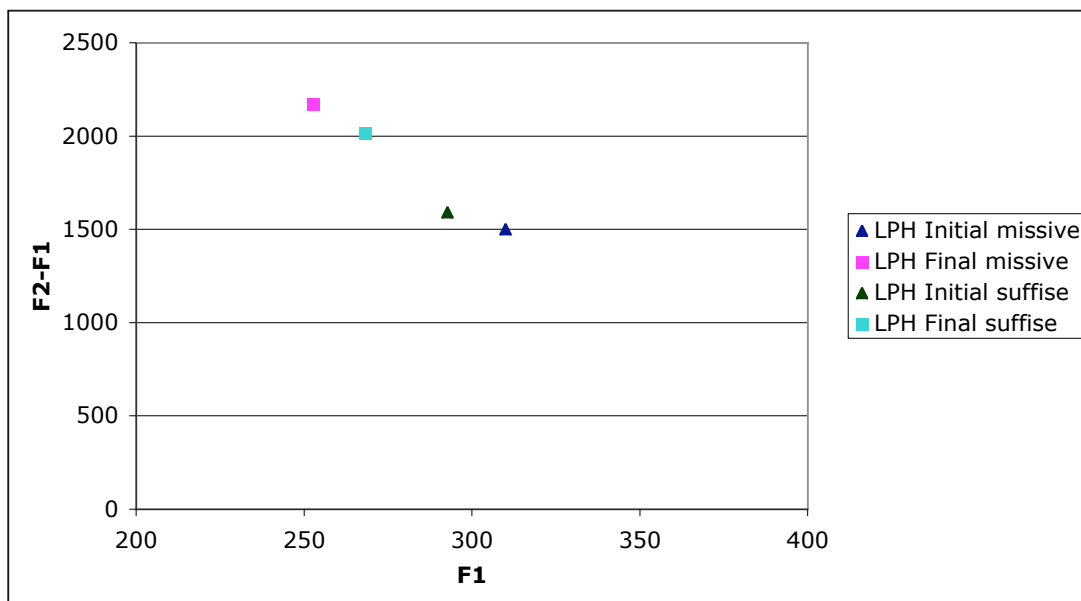


Figure 33: Initial and final vowels in *missive*-type words featuring non-final laxing for a non-diphthongising speaker (LPH).

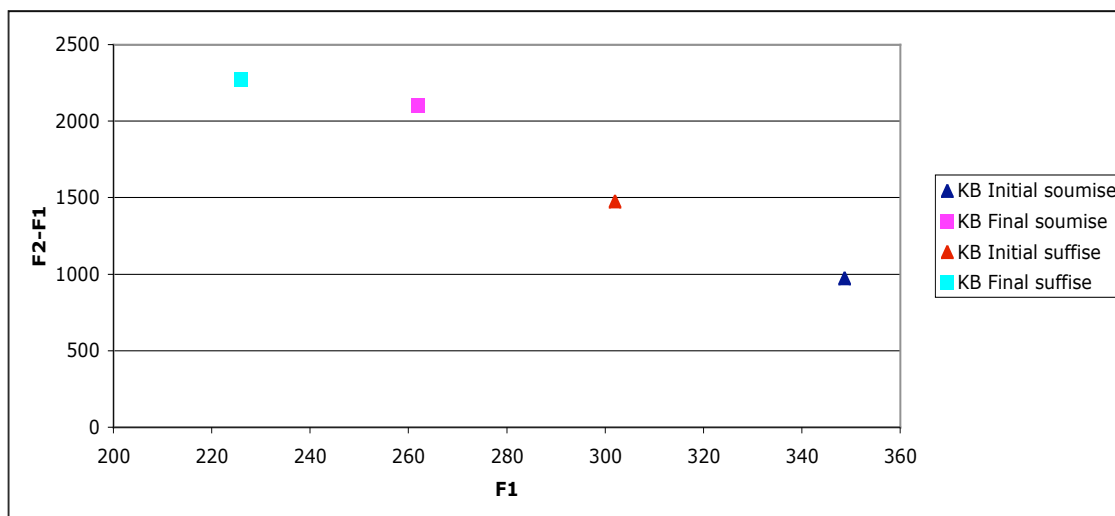


Figure 34: Initial and final vowels in *missive*-type words featuring non-final laxing for a non-diphthongising speaker (KB).

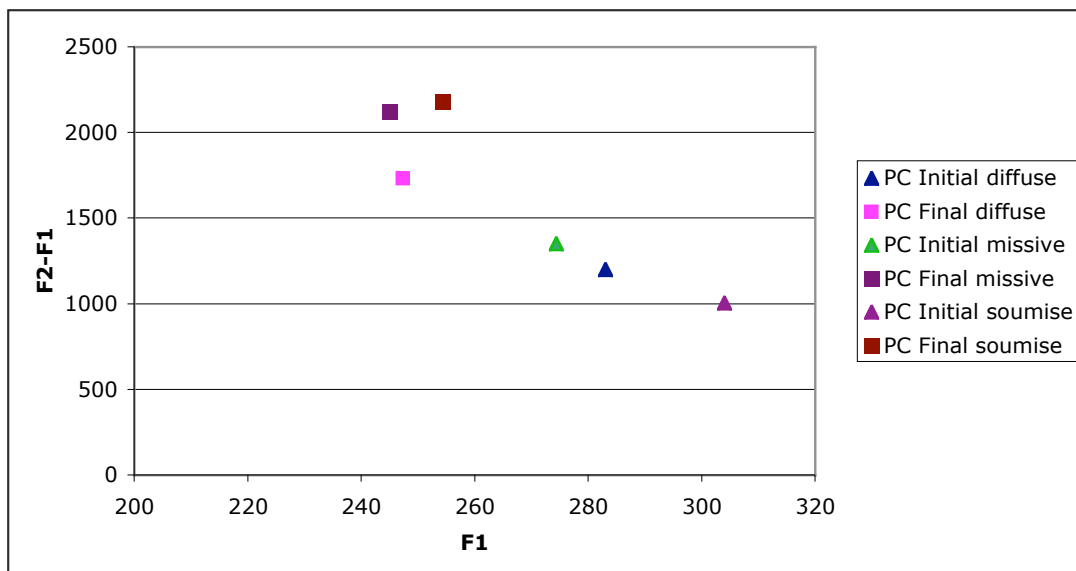


Figure 35: Initial and final vowels in *missive*-type words featuring non-final laxing for a non-diphthongising speaker (PC).

For the three speakers, we see that all initial vowels have lower F_1 and lower F_2-F_1 values, indicating that final vowels are higher and fronter, and thus have a ‘tenser’ quality.

The question now is, are final vowels tense throughout their duration? The following three plots show F_1 values of non-diphthongisers of final vowels over their entire duration, from their initial formant transition to their final formant transition. If these are truly monophthongs, then we expect F_1 to remain approximately constant throughout the duration of the vowel. A diphthong would be characterised by a gradual or even sharp drop in F_1 , indicating a tenser off-glide towards the end of the vowel. The following curves are indicative that non-diphthongisers’ final vowels are indeed monophthongs, since F_1 is stable.

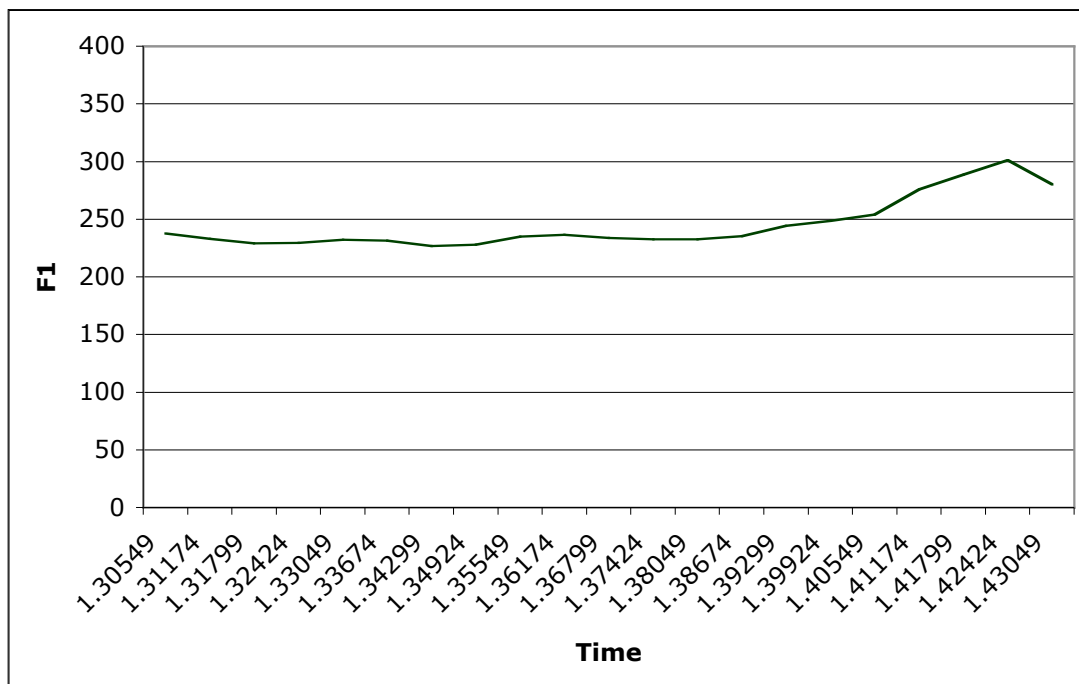


Figure 36: F_1 values over time for final vowel in word ‘missive’ as spoken by a non-diphthongising speaker (LPH).

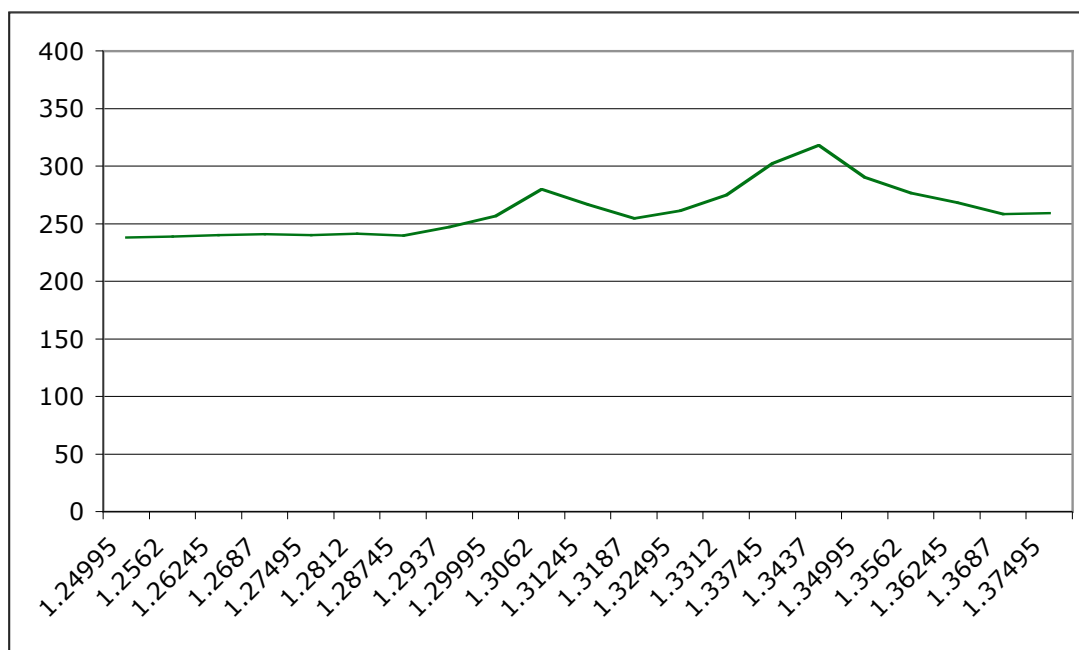


Figure 37: F_1 values over time for final vowel in word ‘suffise’ as spoken by a non-diphthongising speaker (LPH).

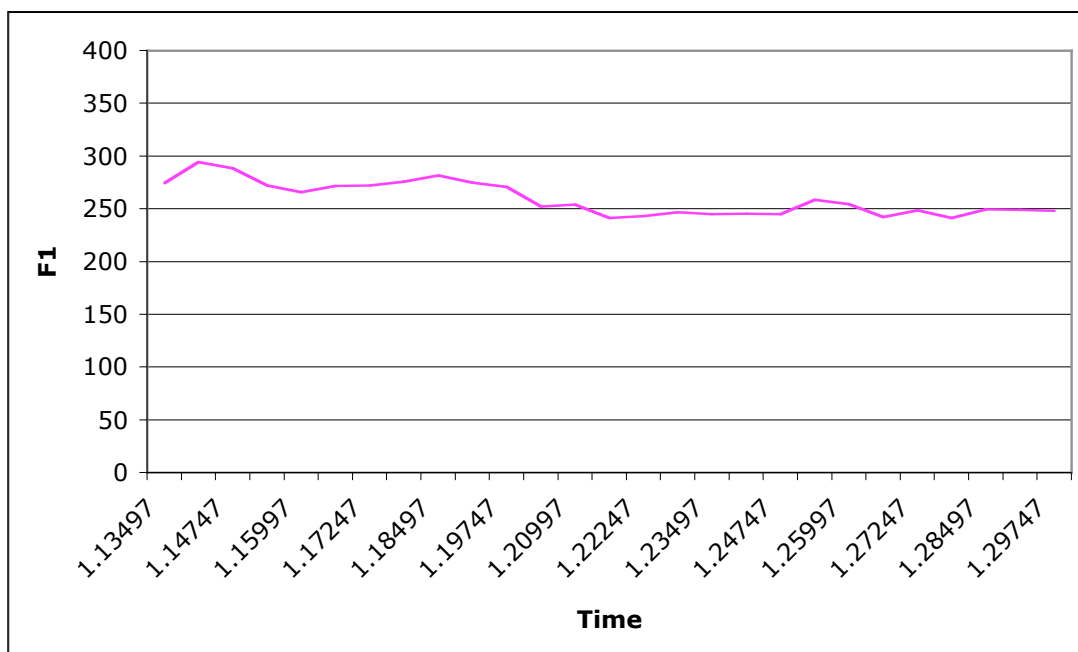


Figure 38: F_1 values over time for final vowel in word ‘soumise’ as spoken by a non-diphthongising speaker (KB).

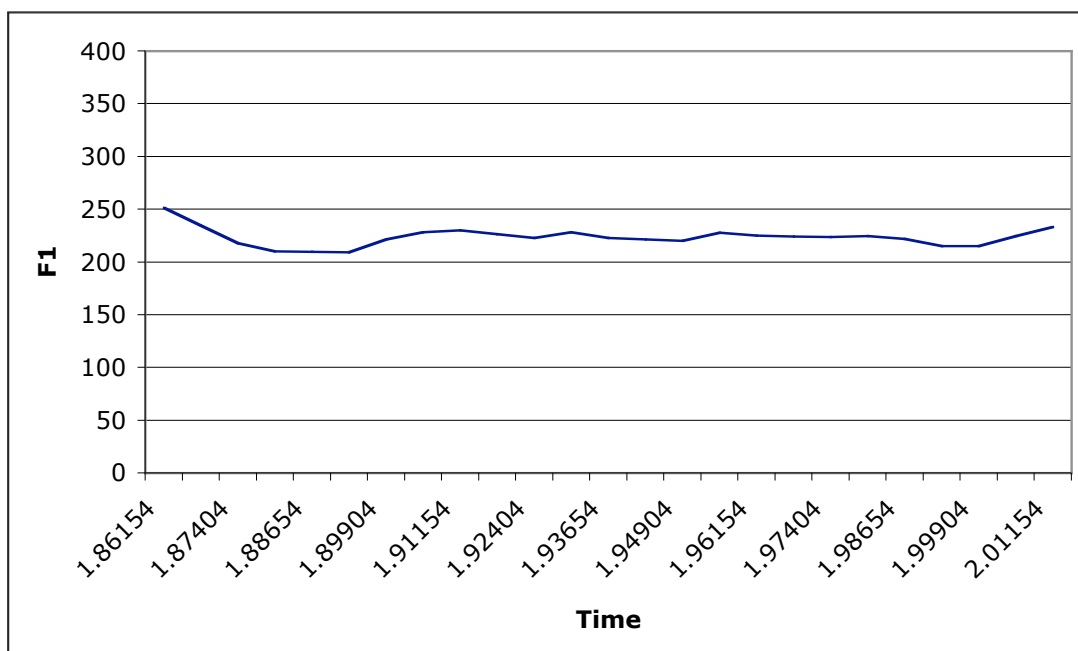


Figure 39: F_1 values over time for final vowel in word ‘suffise’ as spoken by a non-diphthongising speaker (KB).

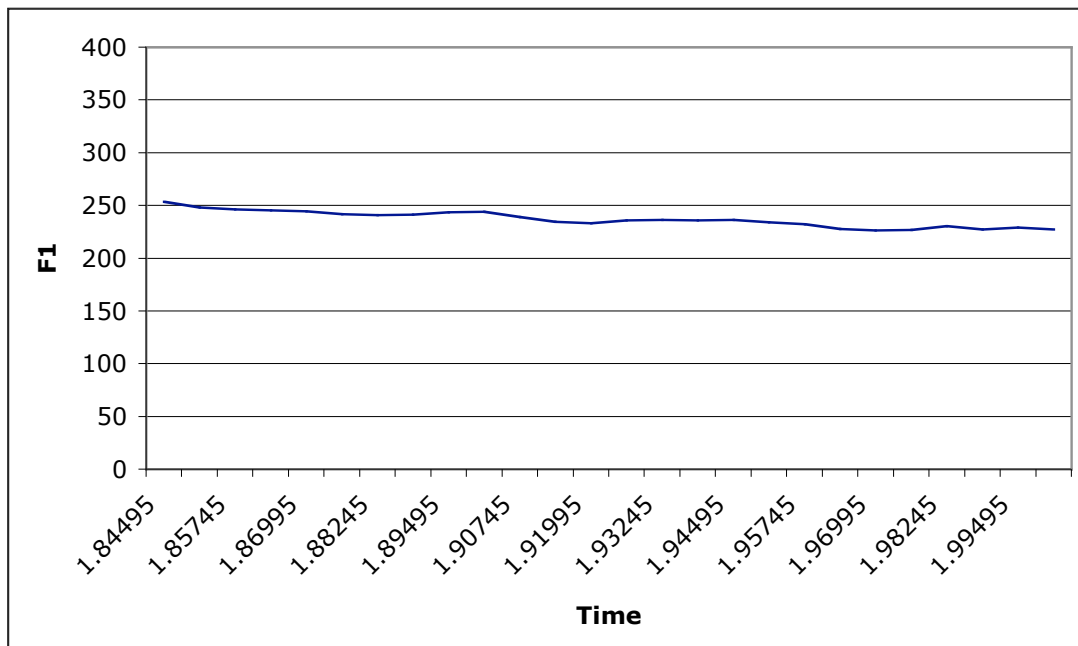


Figure 40: F_1 values over time for final vowel in word ‘diffuse’ as spoken by a non-diphthongising speaker (PC).

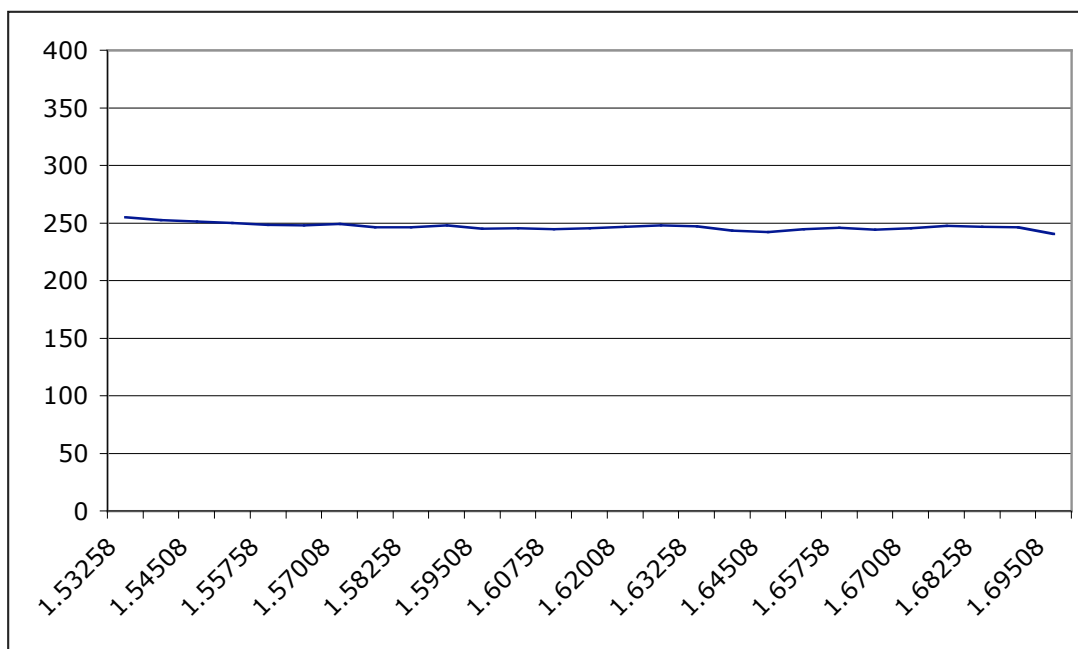


Figure 41: F_1 values over time for final vowel in word ‘missive’ as spoken by a non-diphthongising speaker (PC).

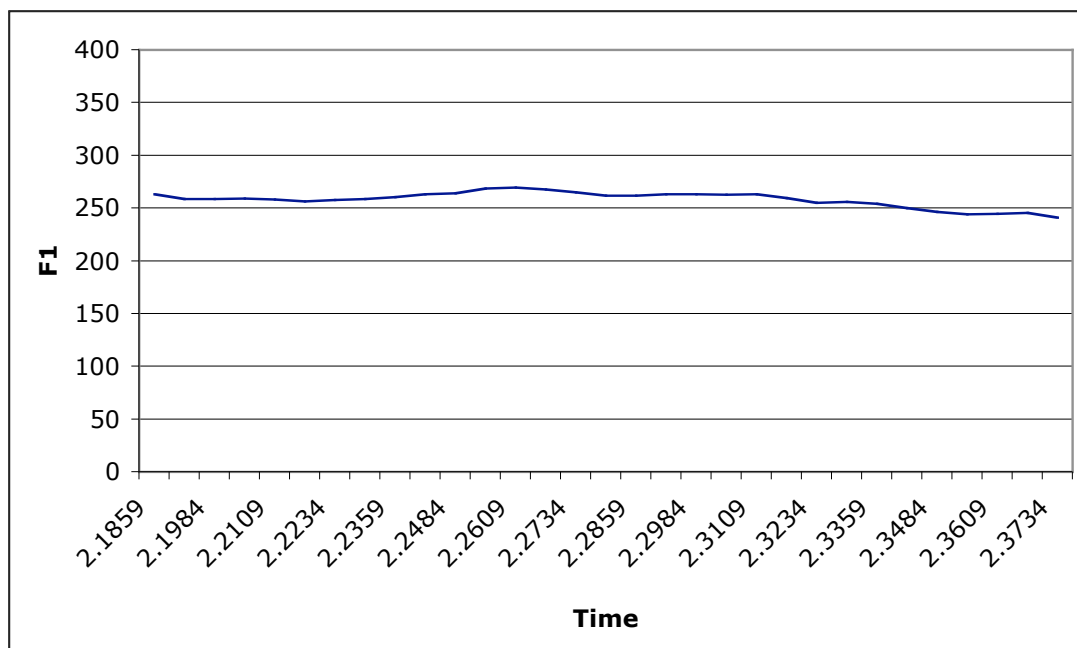


Figure 42: F₁ values over time for final vowel in word ‘soumise’ as spoken by a non-diphthongising speaker (PC).

2.3.2 Diphthongising speakers

As mentioned above, diphthongising speakers’ initial and final vowels should have similar formant frequencies, since final vowels have a lax nucleus. This is indeed what we find for all three diphthongising speakers. Initial and final vowels, represented by triangles and rectangles respectively, do not pattern in separate clusters:

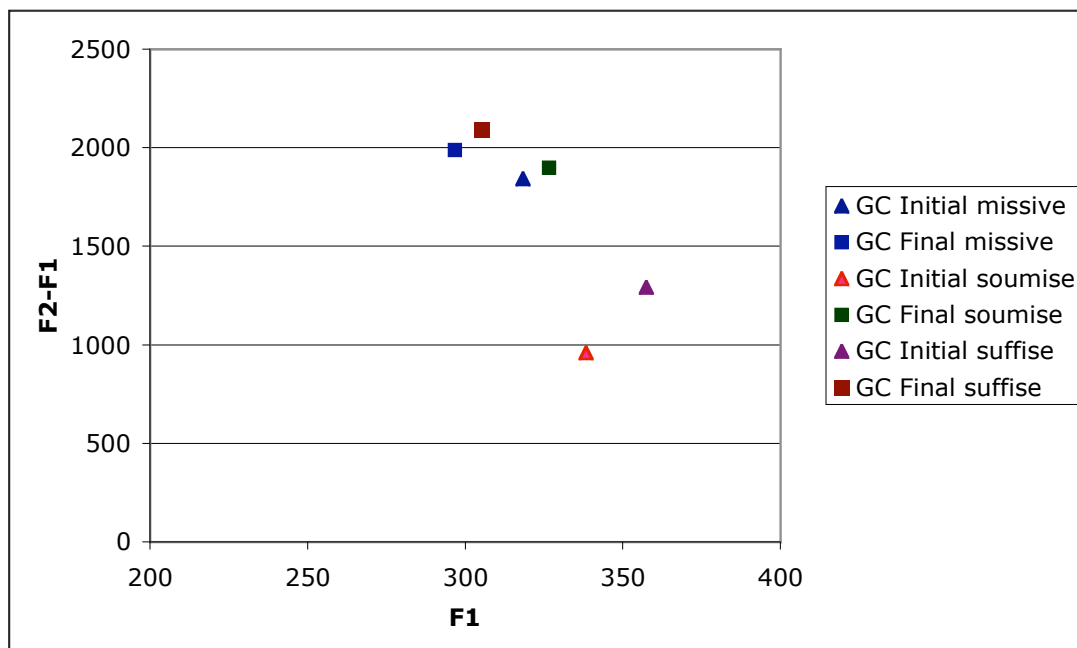


Figure 43 : Initial and final vowels in *missive*-type words featuring non-final laxing for a diphthongising speaker (GC).

All of speaker GC's final vowels tend to have higher values for F_2-F_1 , which may be the effect of the tense off-glide. That being said, all of GC's vowels have a value of 300 Hz and above. This should be compared with non-diphthongising speakers final vowels which are all below 300 Hz, indicating that, though GC's final vowels have a high F_2-F_1 value, GC's final vowels are lower on average, and hence probably have a laxer quality.

Speaker HRZ only produced one token with non-final laxing, but the data is interesting nonetheless, since both initial and final vowels for this speaker have approximately the same value for F_1 . Like for GC, his or her final vowel has a higher F_2 , which again might be attributed to the effects of the off-glide:

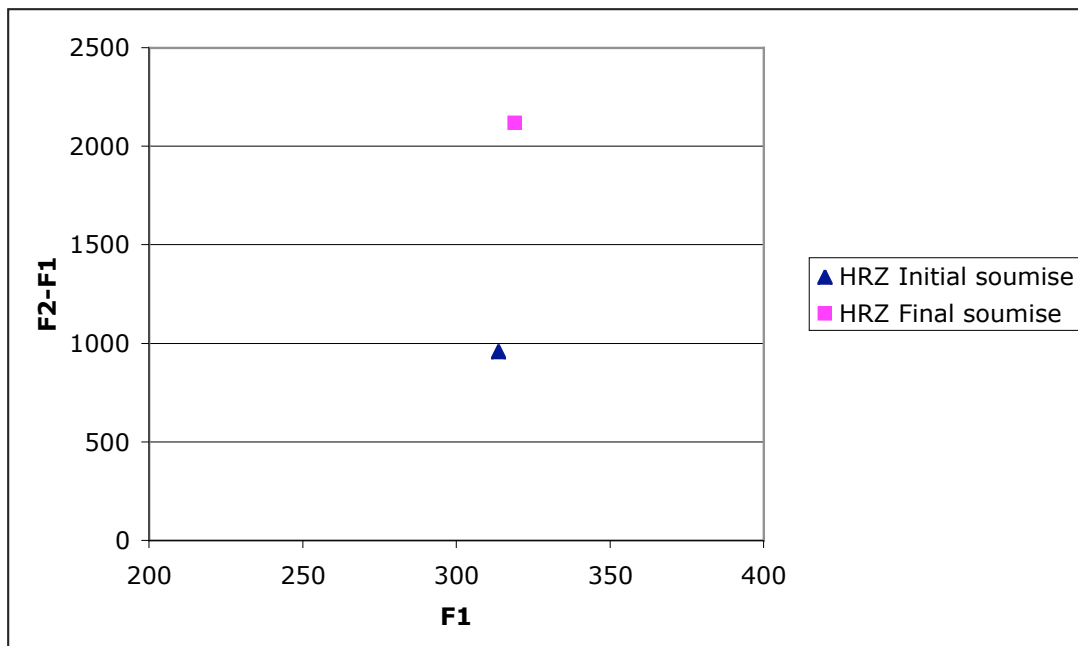


Figure 44: Initial and final vowels in *missive*-type words featuring non-final laxing for a diphthongising speaker (HRZ).

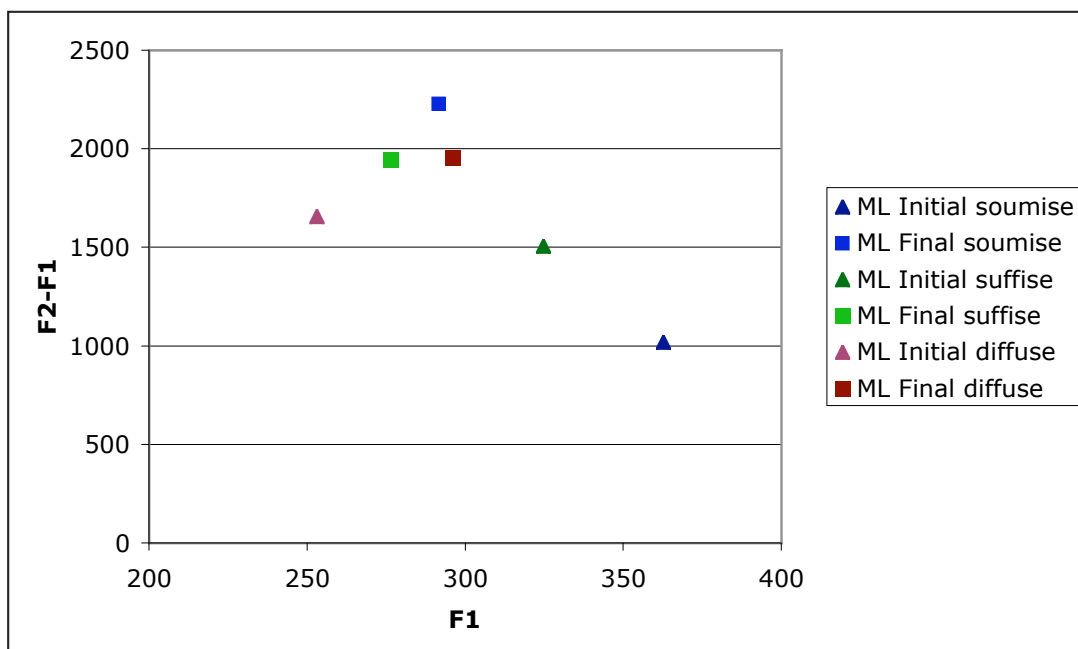


Figure 45: Initial and final vowels in *missive*-type words featuring non-final laxing for a diphthongising speaker (ML).

Speaker ML shows a clustering pattern similar to that of GC, though ML's final vowels appear tense given their high values for F_2 and their F_1 values above 300 Hz. The following figures show however, that ML's final vowels are diphthong-like, exhibiting a downwards trend in F_1 values throughout the vowel:

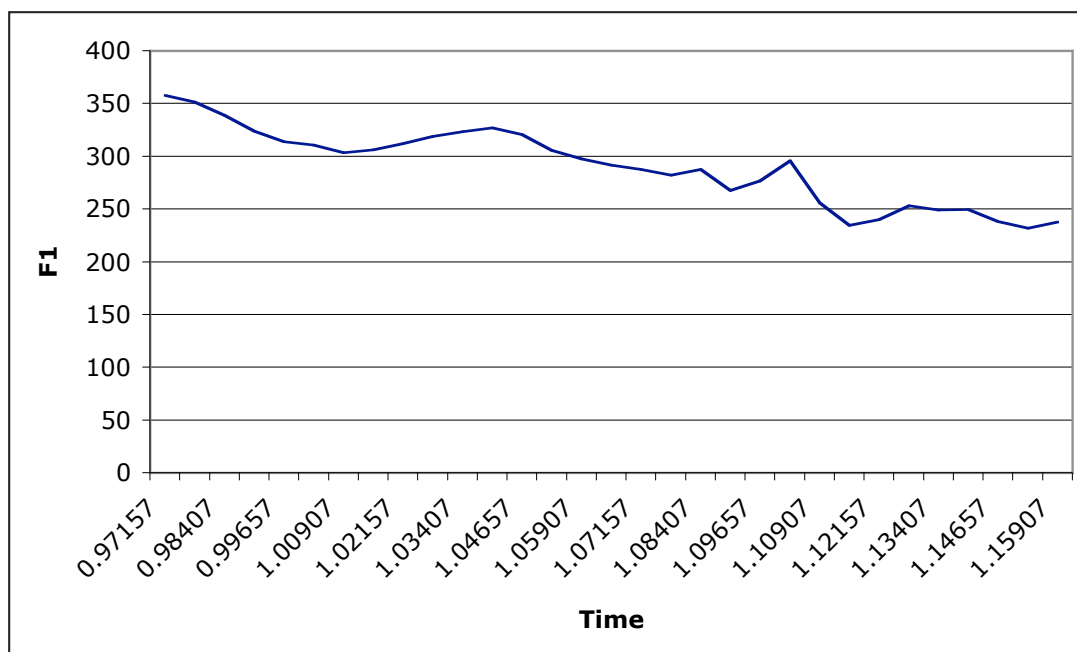


Figure 46: F_1 values over time for final vowel in word 'soumise' as spoken by a diphthongising speaker (ML).

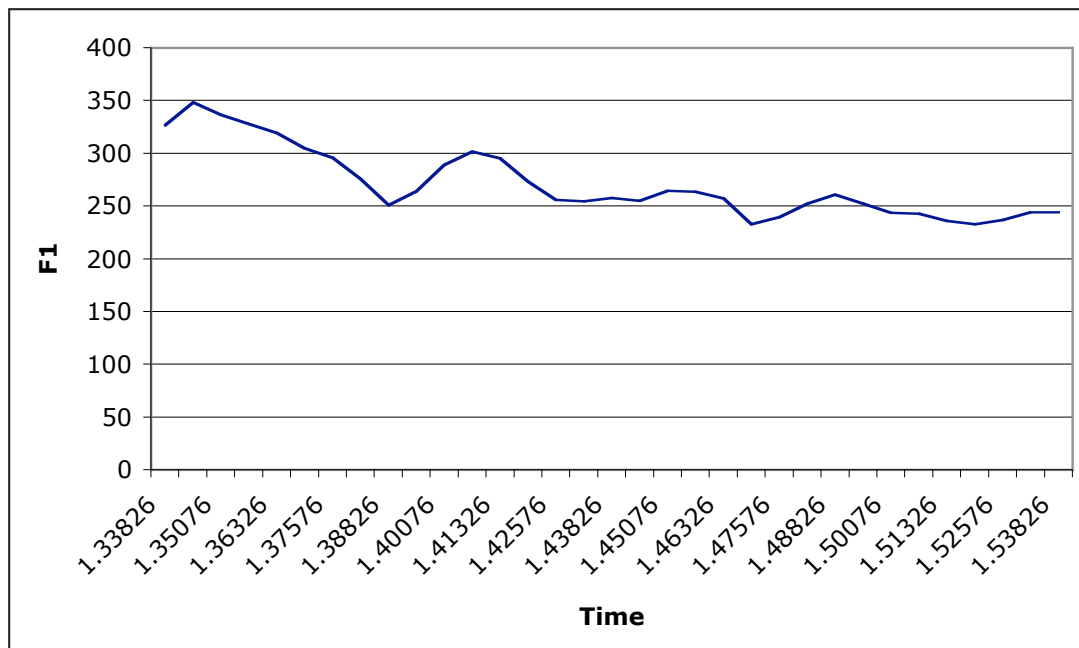


Figure 47: F₁ values over time for final vowel in word ‘suffise’ as spoken by a diphthongising speaker (ML).

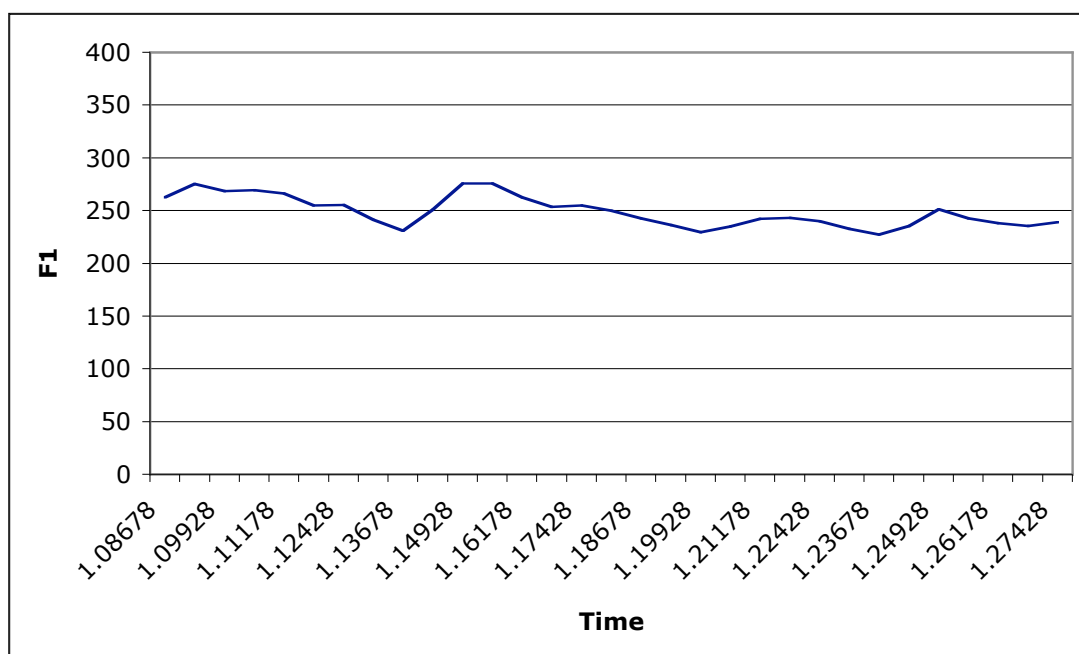


Figure 48: F₁ values over time for final vowel in word ‘diffuse’ as spoken by a diphthongising speaker (ML).

All diphthongising speakers' final vowels exhibit similar downward trends in their F_1 values over time:

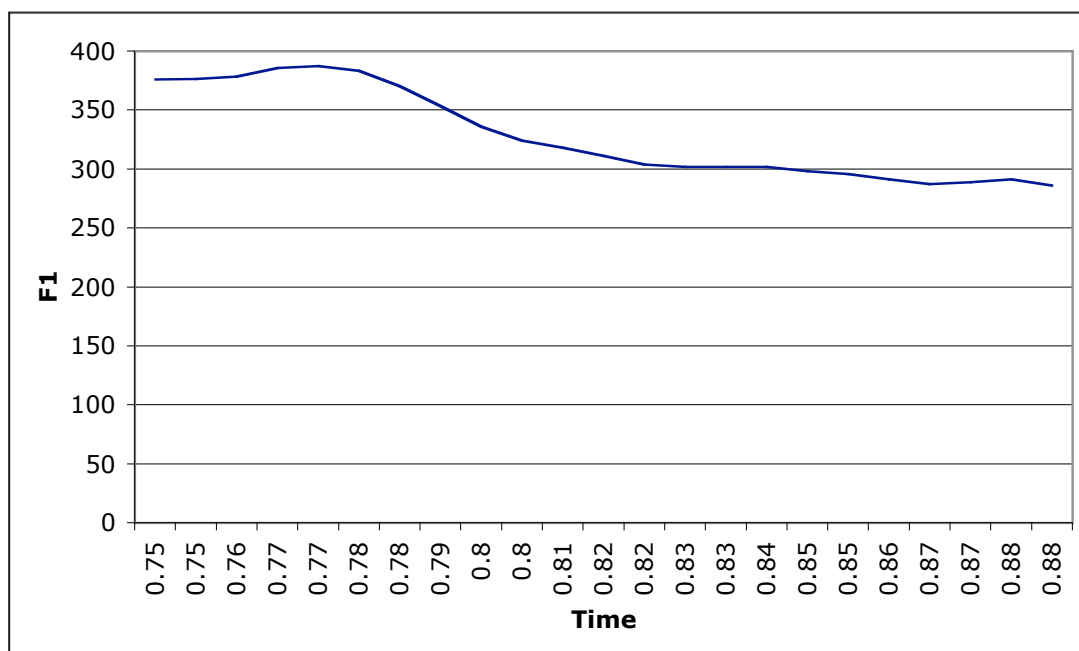


Figure 49: F_1 values over time for final vowel in word 'soumise' as spoken by a diphthongising speaker (GC).

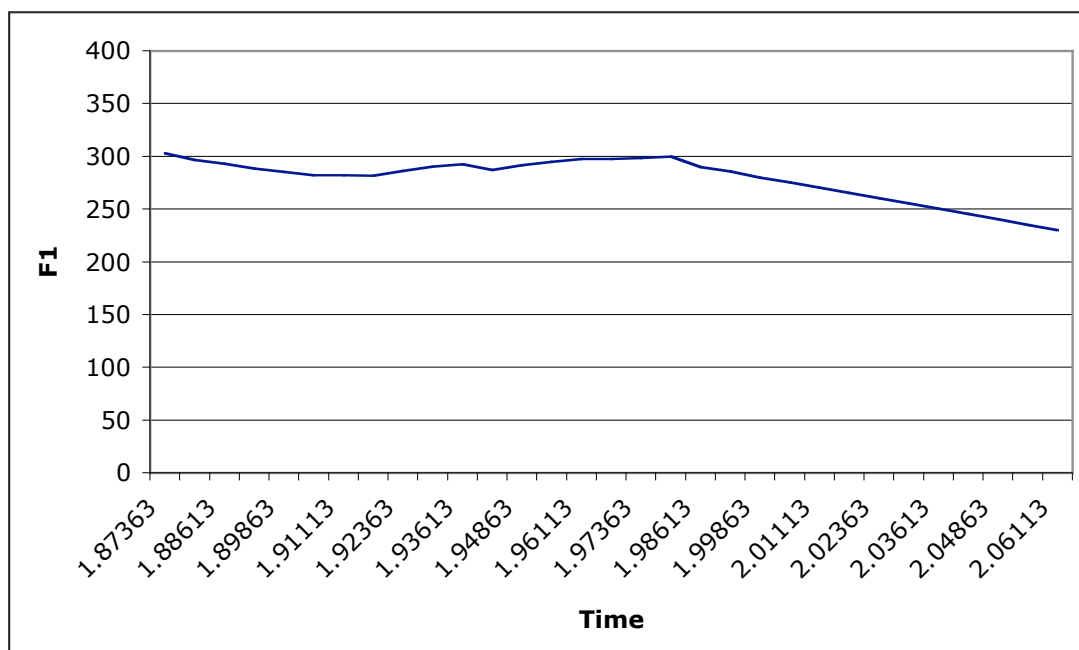


Figure 50: F_1 values over time for final vowel in word ‘missive’ as spoken by a diphthongising speaker (GC).

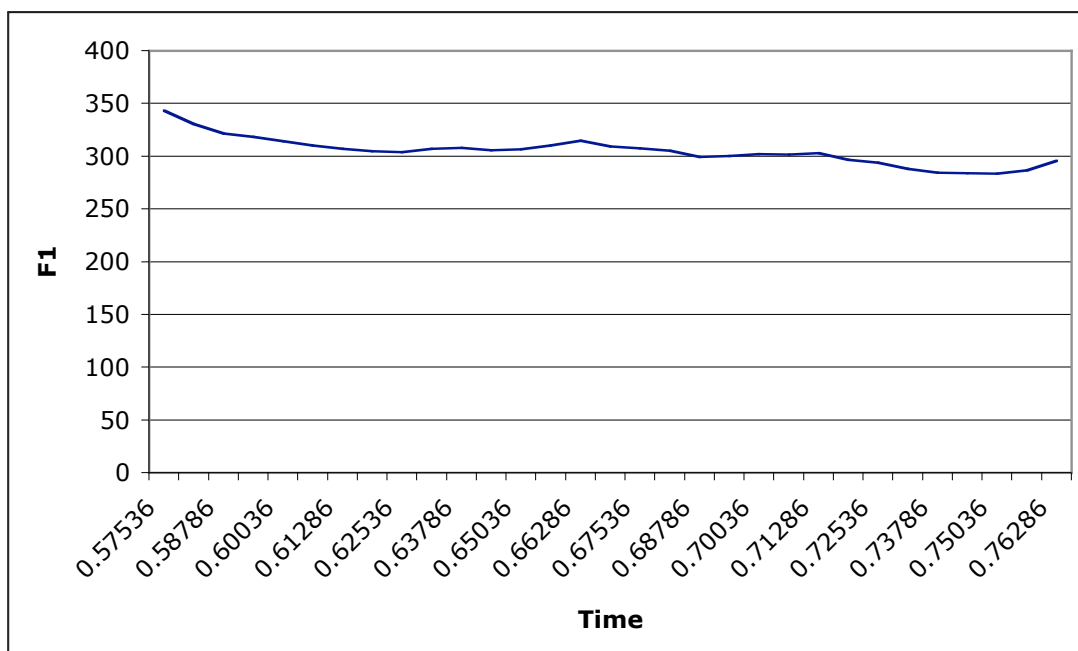


Figure 51: F_1 values over time for final vowel in word ‘suffise’ as spoken by a diphthongising speaker (GC).

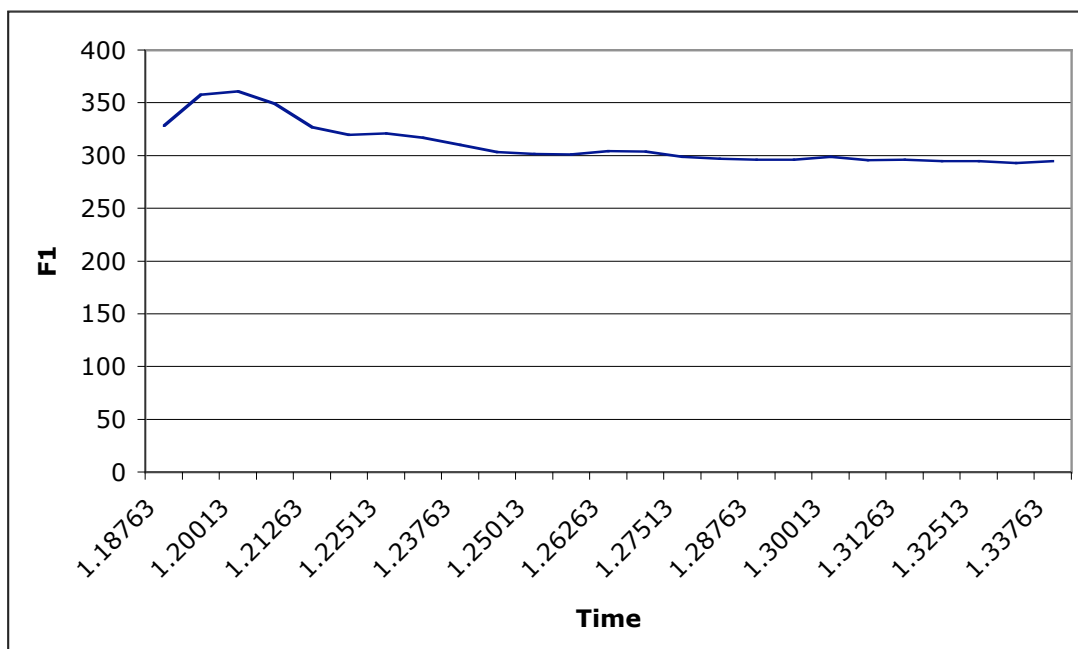


Figure 52: F₁ values over time for final vowel in word ‘soumise’ as spoken by a diphthongising speaker (HRZ).

In the second part of this dissertation, in which I provide an account for CF vowel harmony, I will focus on the speech of non-diphthongising speakers, since they present a pattern that can only be analysed as a case of derivational opacity. The following subsections will argue that this pattern is productive and cannot be accounted for transparently. The argument will be based on judgment data collected from CF speakers. The argument that non-final laxing in *missive*-type words is synchronically productive and non-transparent is crucial if we are to use this data in a reassessment of ‘transparency-biased’ analytical frameworks like Optimality Theory (OT; Prince & Smolensky 1993/2004). This will be one of the main topics of the second half of this dissertation, which will contribute to the growing literature on the treatment of opacity in OT³⁷.

It has been recently proposed in Mielke *et al.* (2003) and Sanders (2003) that opacity is not a problem for purely parallelist versions of OT³⁸, if we can account for seemingly opaque patterns transparently, or if these patterns are not productive. If these patterns are not productive, then what appear to be the effects of non-surface true processes can be assumed to be lexicalised. In short, the argument is that, if a pattern is not productive, then its effects are not predictable, and thus should be included in the underlying representation. I hold these authors’ arguments to be sound; if I am to use these data as an argument against parallelism, then potential transparent accounts should be proven wrong, and the productivity of the pattern should be demonstrated.

2.4 Reassessing transparent accounts of CF vowel harmony facts

In this section, I will present two potential transparent accounts for the facts presented so far

³⁷ See, among many others: McCarthy (1999, 2003)

³⁸ Including, most notably, the original version of the framework proposed in Prince & Smolensky 1993/2004).

on the interaction of harmony and pre-fricative tensing. The first, proposed in Déchaîne (1991), argues that non-final laxing is conditioned by stress: [+high] vowels in syllables bearing primary or secondary stress can be lax. The second transparent account involves Dumas's (1981) proposal that CF has an assimilation rule that accounts for transparent harmony cases like [fɪ . lɪp], but also a dissimilation rule that accounts for opaque harmony cases like [mɪ . sɪ :v]. Both accounts are refuted using data from a judgment task performed by 12 speakers of CF. The methodology used to collect these results is the same as that used to collect results reported in the previous chapter. I will outline the methodology once more here:

12 speakers of CF, 8 females and 4 males, all volunteers from the Montreal area, were asked to perform a judgment task. The task consisted of listening to utterances that were pre-recorded on a cassette tape by the author, and indicating a binary choice between natural- and unnatural-sounding utterances on a pre-prepared form. Utterances consisted of single words of different categories (example categories: *Philippe*-words vs. *mitaine*-words). Each type of word had two pronunciations, one with non-final laxing (fɪ . lɪp ; mɪ . tɛn) and one without (fɪ . lɪp ; mɪ . tɛn). Words of different categories were randomized, and mixed in with words of other categories used for other tests. Utterances on the recording were elicited one at a time, with a one second interval between them. Each utterance was repeated twice in a row to ensure optimal perception by the speaker. Utterances were numbered on the recording, and corresponded to a number on the pre-prepared form beside which speakers saw the words 'yes' or 'no.' During the one second interval separating each utterance on the recording, speakers were to circle if 'yes' the utterance just heard sounded natural, or 'no' if it sounded unnatural. 'Natural' was defined to speakers beforehand as 'a pronunciation they would use in their own speech in the context of a casual conversation between two speakers of Canadian French.' The reason for this is that vowel harmony is suppressible, and in my personal experience, more likely to be so in the context of a formal conversation, or in the

context of a conversation between a CF speaker and a speaker of non-Canadian French. The proportion of ‘yes’ answers in a given category is termed the ‘acceptance rate’ of that category, and is assumed to be an indicator of the category's naturalness. Acceptance rates are represented by a number ranging between 0 and 1.

I personally recorded the stimuli for the experiment for a number of reasons: a) utterances could only be synthesized with great difficulty, and possibly at the cost of making all of them sound unnatural, b) many of the utterances happen to be very unnatural and thus difficult to pronounce so that an untrained speaker might stumble in recording them, thus biasing the experiment; I could train myself to pronounce unnatural utterances in the most neutral fashion, c) though this is not the case for disyllabics, vowels in unstressed syllables are often reduced; again, I trained myself to make each vowel resound clearly³⁹. All recordings were submitted to a non-participating French speaker to assess whether any form or group of forms was favorably or unfavorably biased. No such bias was found. For each figure in the next section, I will indicate how many target utterances from each category were used, and how many responses were obtained from speakers.

2.4.1 Déchaîne (1991): opaque vowel harmony and the Weight-to-Stress principle

Déchaîne (1991) proposes a transparent account of opaque vowel harmony in which the distribution of [+high] allophones is determined by stress. Déchaîne's general account of CF laxing provides a solution to CF opacity that appeals to surface properties only. In CF, as in standard European French (SEF), final syllables bear primary stress, while initial syllables bear secondary stress (see Astésano 2001, Boudrault 2002, D. Walker 1984). Déchaîne argues that [+high] vowels can surface as [-ATR] in all stressed syllables (final and non-

³⁹ See section 3.1 of previous chapter for vowel duration in the stimulus.

final), thus explaining the presence of [+high, -ATR] vowels in both *Philippe*- and *missive*-type words, though only the former shows the proper surface environment for harmony to occur.

Déchaîne's account is based on two facts:

- a) non-final laxing of [+high] vowels in open syllables tends to only occur in initial syllables, which in CF bear secondary stress, and
- b) non-final laxing of [+high] vowels in open syllables is also allowed in words like <midi>, <fini>, <zoulou>, where the final [+high] vowel is not [-ATR], nor is the final syllable closed (see below for examples):

- (12) *Non-final laxing in 'midi'-type words*
- mɪ . dʒi or mi . dʒi <midi> 'noon'
- fɪ . ni or fi . ni <fini> 'finished'
- ʃɪ . mi or ʃi . mi <chimie> 'chemistry'
- zʊ . lu or zu . lu <zoulou> 'Zulu'
- ɪ . si or i . si <ici> 'here'
- ʃɪ . pi or ʃi . pi <chipie> 'bitch'
- gʊ . ɸu or gu . ɸu <gourou> 'guru'
- u . tu or u . tu <houtou> 'Hutu'

There are a number of strong counter-arguments to Déchaîne's proposal however:

Déchaîne predicts that, if non-final laxing is tied to secondary stress, all first syllables should

be [-ATR], regardless of whether the final syllable is closed or has a [+high] nucleus. A word like [mi . tɛn] should have a [-ATR] non-final vowel as much as [fɪ . lɪp]. This contradicts the data provided in (7), which showed that non-final laxing cannot occur unless the rightmost [+high] vowel is [-ATR] as a result of laxing (in the transparent case of harmony). This is supported by evidence collected from CF speakers.

For this part of the experiment, each category comprised 16 tokens; the 12 speakers yielded a total of 768 answers. With two pronunciations per token, speakers were presented with a total of 64 stimuli. Results are provided in figure 1 below; a list of tokens is provided in the appendix:

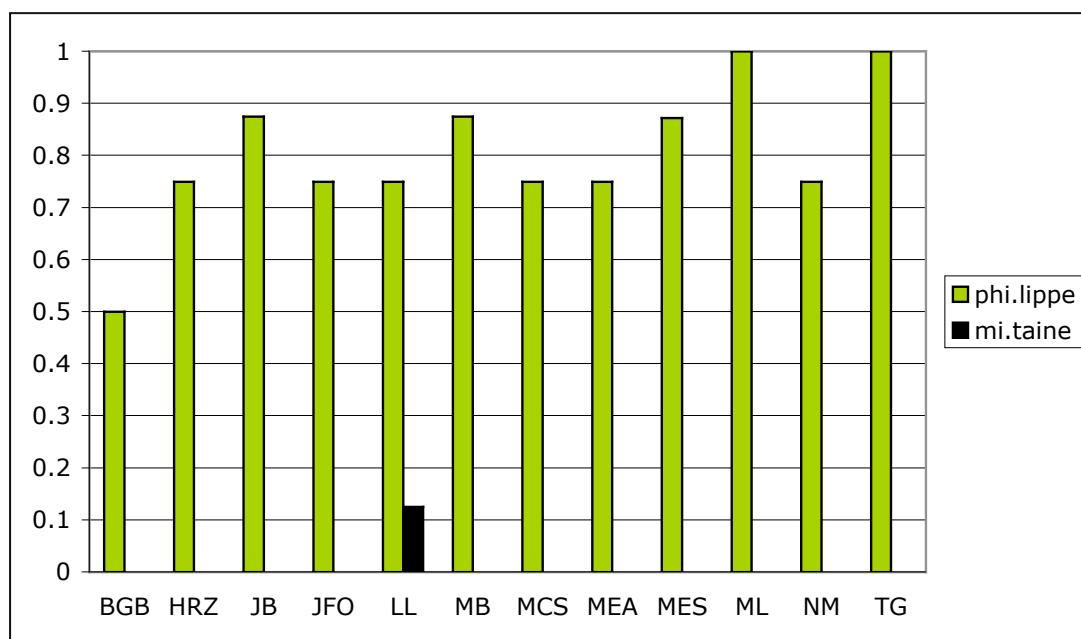


Figure 53 : Rate of acceptance (% of 'yes' answers) by speaker for *Philippe*- and *mitaine*-type words featuring non-final laxing.

Figure 21 reveals the acceptance rate for *Philippe*-type words with non-final laxing is far superior than for *mitaine*-type words with non-final laxing. Only one speaker accepted some *mitaine*-type words with non-final laxing (LL), and even in this case, less than 15% of them. This disconfirms Déchaîne's hypothesis, which predicts that average rates of acceptance should be about equal, since non-final syllables in both categories of words bear secondary

stress.

The results in figure 21 also discount the possibility that non-final laxing in *missive*-type words is due to analogy with *Philippe*-words, which would provide a transparent account of the seemingly opaque *missive* words. If non-final laxing was truly licensed by analogy, we would expect non-final laxing to be possible in *mitaine*-type words as well, at least to a greater degree than what we find in figure 21. This is not the case however. The results in figure 21 also contradict the hypothesis that non-final laxing in CF is due to influence from English. Though it is true that *Philippe*-type words do often have English cognates in which the initial vowel is lax (English: [fɪ . lɪp]), if non-final laxing were due to English influence, we would expect non-final laxing to be possible in all cognates. For example, we should expect *[mɪ . tɛn] to be possible on the basis that there exists a cognate [mɪ . ʔn] (<mitten>) in English, but this is not the case.

2.4.2 Assimilation and dissimilation

As mentioned in the previous subsection, Déchaîne's proposal is partly based on the fact that non-final laxing is also possible for some speakers in words like [mɪ . d^zi], where both the rightmost and leftmost [+high] vowels are [+ATR] and in open syllables. The question is: if non-final laxing is possible in *midi*-type words as well as in *Philippe*-type words, is it possible that non-final laxing in *missive*-type words the result of a process different from (opaque) harmony that does not involve opaque interactions? Dumas (1976, 1981) has proposed that non-final laxing in these cases is the result of a dissimilation rule, while *Philippe*-type cases are the output of an assimilation rule (i.e. harmony).

Though Dumas does not propose this, one could argue that opaque vowel harmony cases (e.g. [mɪ . sɪ : v]) could also be explained by appealing to dissimilation. One could

hypothesize that *missive*-type cases would be, like *midi*-type cases, the result of a dissimilation process. *Philippe*-type cases on the other hand would be the result of an assimilation process, essentially equivalent to harmony.

There is reason to believe, however, that the processes whose outputs have non-final laxing in *midi*-type words, and non-final laxing in *missive*-type words have different structural descriptions. It appears that non-final laxing in *midi*-type words is only licensed when both vowels in the word are identical, which motivates Dumas's hypothesis that CF does have a dissimilation process. There is no such restriction on *missive*-type words however; both words with identical vowels (e.g. *missive*-type) and with non-identical vowels can exhibit non-final laxing (e.g. henceforth *piqûre*-type words, see (14)). Words in (13) show however that non-final laxing is disallowed if the final syllable is not closed and vowels are not identical (*Julie*-type words, henceforth):

(13)	<i>Julie-type words</i>		
	ʒy.li	*ʒy.li	pr. name
	si.gy	*sɪ.gy	'hemlock'
	pu.li	*pu.li	'pulley'
	mi.lu	*mɪ.lu	pr. name
	vu.ly	*vu.ly	'wanted'
	sy.li	*sy.li	pr. name
	i.bu	*ɪ.bu	'owl'
	ku.ɸy	*ku.ɸy	'run, part.'

(14) *Piqûre-type words*

pi.ky:ɤ	‘sting, n.’	✓pɪ.ky:ɤ
sy.βi:ɤ	‘to sour’	✓sɥ.βi:ɤ
fβi.bu:ɤ	pr. name	✓fβɪ.bu:ɤ
su.βi:ɤ	‘smile’	✓sɥ.βi:ɤ
y.mu:ɤ	‘humour’	✓ɥ.mu:ɤ
su.d ^z y:ɤ	‘solder’	✓sɥ.d ^z y:ɤ

The asymmetry between *midi/Julie*-type words and *missive/piquête*-type words is illustrated by the acceptance rates reported in figure 22. Results were collected using the same method as for figure 21. In this case, each category had 8 tokens for a total of 32 forms (the list of stimuli is provided in the appendix). A total of 384 answers were collected:

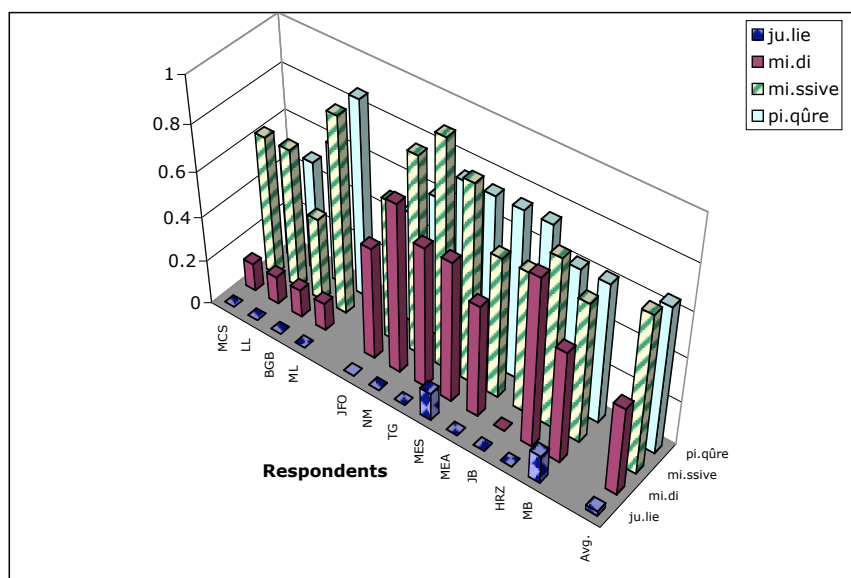


Figure 54 : Rates of acceptance for *midi*-, *Julie*-, *missive*- and *piquête*-type words with non-final laxing.

Firstly, Figure 23 reveals that for all speakers, the rate of acceptance for non-final laxing in

midi-type words is much higher than for *Julie*-type words where the vowels are not identical. The difference in their average rates of acceptance was judged significant by means of a 2-tailed pairwise t-test with $p < 0.05$. Opaque vowel harmony words do not show this difference between words with or without identical vowels. The difference in the average rates of acceptance was judged non-significant by means of a 2-tailed pairwise t-test with $p > 0.1$. Secondly, the figure also shows that some speakers also dislike laxing in *midi*-type words (see MCS, BGB, LL and ML), which suggests not all speakers have the dissimilation rule. These respondents behave consistently with other speakers with respect to non-*midi*-type words.

Because of these results, I propose that non-final laxing in *midi*-type words is due to a dissimilation process that is independent from vowel harmony. The dissimilation rule is formalised here:

(15) *Dissimilation rule*

[+high, α round, β back] \rightarrow [-ATR] / $_]_{\sigma} . C_0 [+high, \alpha$ round, β back] #

2.5 The productivity of opaque vowel harmony

Stress-conditioned laxing and dissimilation, the two transparent accounts of opaque vowel harmony outlined in section 2.4, can be rejected on very strong bases, which strongly suggests that opaque CF vowel harmony must be considered a case of derivational opacity. Nevertheless, there remains the question of productivity. As argued in Mielke et al. (2003) and Sanders (2003), opacity may very well be said to exist given surface evidence, but does not exclude the possibility that what appears to be the result of an opaque derivation is in fact a lexicalized phenomenon that is no longer productive synchronically. If that possibility is not discounted, we cannot reasonably argue that opaque CF vowel harmony is truly a case of

derivational opacity, since it may be lexicalised. If opaque CF vowel harmony is synchronically productive however, there is reason to believe that the process is learnable, and hence, that opacity is a psychologically real phenomenon.

The productivity of opaque vowel harmony was tested on the same 12 speakers of CF using the same judgment task method as outlined in section 2.4. Two separate tests were performed to test the productivity of opaque vowel harmony. The first test was performed to see if opaque vowel harmony extended to nonce forms, while the second tested the extension of opaque vowel harmony to very low frequency words.

2.5.1 Evidence for the productivity of CF opaque vowel harmony (nonce words)

To test the extension to nonce words, speakers were given 8 nonce words of the *missive*-type, N-*missive*-type words, where ‘N’ stands for ‘nonce,’ and 8 real *missive*-type words, R-*missive*-type words, where ‘R’ stands for ‘real.’ With two pronunciations per token, speakers were presented with 32 tokens for a grand total of 384 answers (see appendix for list of stimuli). Results are given in figure 3 below:

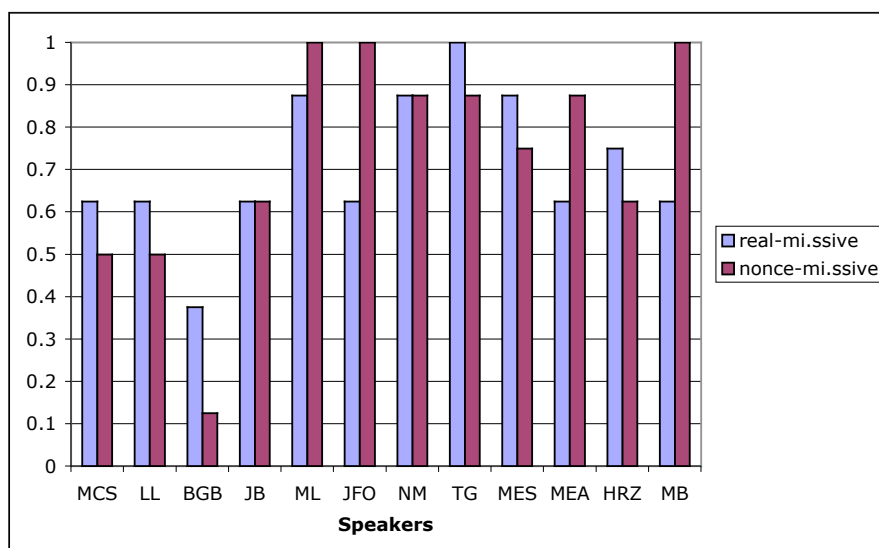


Figure 55: Rates of acceptance for real vs. nonce disyllabic opaque vowel harmony words per speaker.

Figure 24 reveals that the acceptance rate for nonce words versus real words varies significantly from speaker to speaker, but that the acceptance of nonce words is above the 50% mark for the majority of speakers. However, those speakers who gave a lower acceptance rate for N-missive-type words are also those speakers who gave a lower rate of acceptance for R-missive-type words as well. This may reflect a bias of speakers against more casual speech, though this was not controlled for specifically.

At the time this test was run, speakers were not screened for whether they were diphthongising speakers or non-diphthongising speakers. As can be seen in figure 23, the results include the judgments of two diphthongising speakers (HRZ and ML). The productivity of non-final laxing in *missive*-type words is not surprising in the case of diphthongising speakers, since harmony is not opaque for them. One might assume however, that the pool of CF speakers used in this study includes speakers of both dialects. If that is the case, there does not seem to be any difference between the two groups with regards to the acceptability of non-final laxing in *missive*-type words. If the opaque pattern in diphthongising speakers were unproductive, we would expect their acceptance rates for non-final laxing in nonce words to be much lower. This is not the case. Furthermore, I myself am not a diphthongising speaker. The stimuli's final vowels were thus monophthongal. For almost all speakers then, non-final laxing is deemed natural in *missive*-type words, whether the final vowel is diphthongised or not. In other words, for diphthongising speakers the lax nature of the final diphthong may not be a necessary condition for laxing of the non-final vowel. This opens the possibility that, even for diphthongising speakers, the final vowel is tense at an intermediate level of representation (i.e. before the diphthongising rule is applied). Hence, non-diphthongisers and diphthongisers may not be differentiated by rule ordering

after all (as proposed in (10)), and that harmony is also opaque in their case. These issues require further testing however. Until then, I will maintain my hypothesis that speakers differ with respect to ordering for lack of contrary evidence.

On average however (see figure directly below), the difference in rates of acceptance between the two categories is insignificant with $p > 0.1$. This suggests that the productivity of CF opaque vowel harmony is very robust:

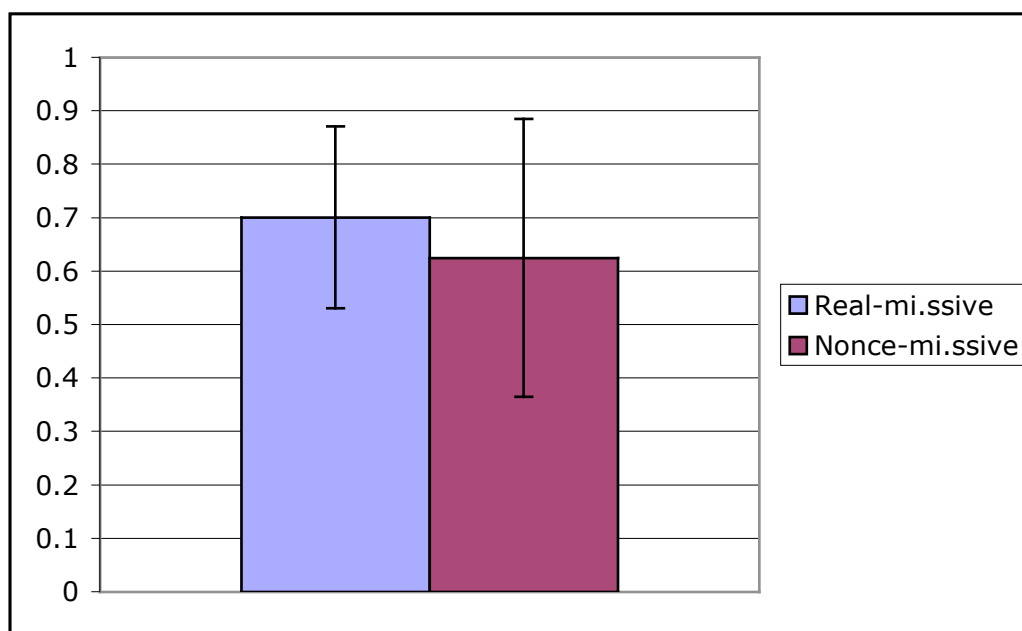


Figure 56: Rates of acceptance for real vs. nonce disyllabic *missive*-type words.

2.5.2 Evidence for the productivity of CF opaque vowel harmony (low frequency words)

The productivity of opaque vowel harmony is confirmed when one compares high frequency words with low frequency words. The argument is this: according to Bybee (2001), phonological processes tend to be more productive in high frequency tokens than low frequency ones (e.g. contraction in English); if we can show that opaque harmony is

productive in both high and low frequency words, we have a strong basis to argue that opaque vowel harmony is very productive in CF, and thus must be accounted for by our model grammar.

Frequency rates of words submitted to speakers were determined by the Frantext database made available by the CNRS (Boris New & Christian Pallier). The database searches 3665 French texts and gives frequency rates in millions of hits. It was determined that high frequency words were those obtaining more than 10 million hits, while low frequency words were those words obtaining less than 0.5 million hits. Rates are given in table 1 below:

Hi freq		Lo freq	
Word	Freq	Word	Freq
nourrir	17.81	Ninive	0.1
toujours	797.39	stylise	0.1
soumise	14.02	qui-vive	0.02
Louise	15.58	irise	0.22
dirige	14.27	cytise	0.03
futur	23.61	vitruve	0.25
subir	20.8	russise	0.01
finir	41.06	sinise	0.01

Table 6: Frequency rates in millions of hits

8 high frequency words and 8 low frequency words were submitted to speakers for evaluation. Again, each had two pronunciations, one with non-final laxing and one without, for a total of 32 tokens. Speakers gave a total of 344 answers. The following figure shows the rate of acceptance of each word plotted against their respective frequency rate. If a correlation existed between rate of acceptance and frequency, a positive, monotonic

correlation between the rate of acceptance and the rate of frequency would be expected. The expectation is not met:

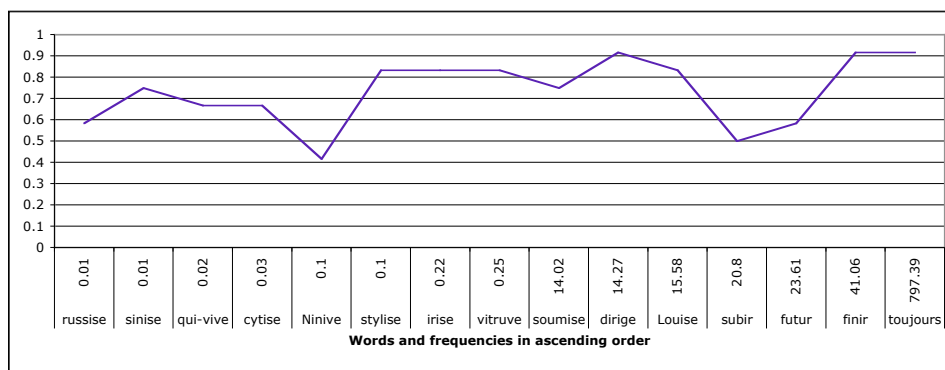


Figure 57 : Rate of acceptance of low and high frequency words with non-final laxing in relation to frequency rate.

Rather, figure 25 shows that there is no discernable correlation between rate of acceptance and frequency rate. Out of the 16 words tested, 12 were given an average acceptance rate of 60% or more, 7 out of those 12 words being low frequency words.

Figure 25 shows the pooled acceptance rates for each word of all speakers. The acceptance rates per speaker are given in figure 26 below:

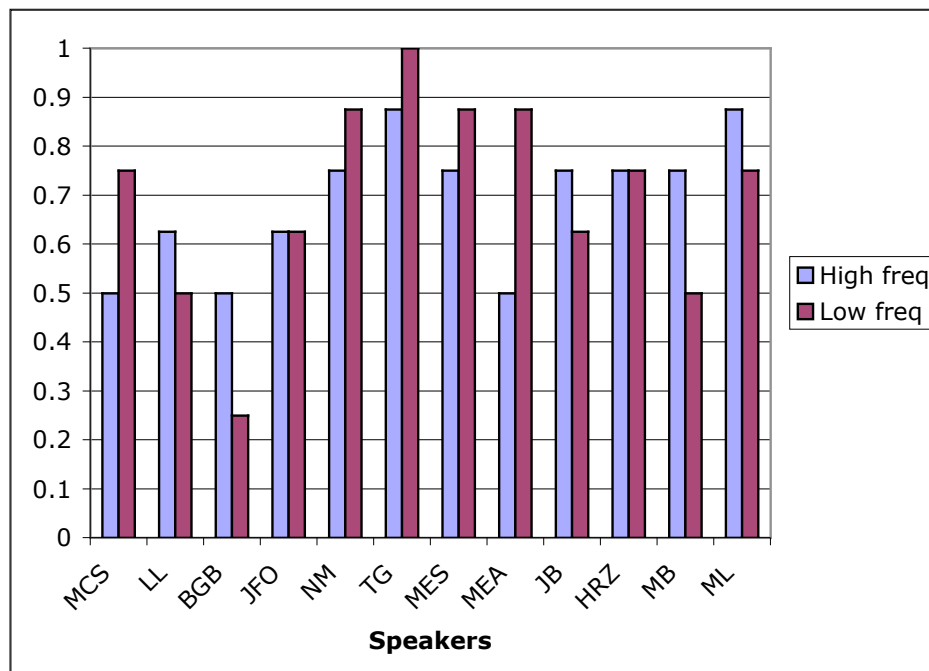


Figure 58 : Average rates of acceptance for high and low frequency words with non-final laxing per speaker.

The absence of correlation between rate of frequency and rate of acceptance is again apparent in figure 26, where one can see that 7 out of 12 speakers have given equal or higher rates of acceptance for low frequency words, showing that opaque vowel harmony is not a process limited to a certain portion of the lexicon, but can also be extended to words which may or may not have ever been encountered by the speakers interviewed here.

We can conclude with certainty that non-final laxing is productive in *missive*-type words for all speakers, whether they are diphthongising or not. These preliminary results thus indicate that there does not appear to be a correlation between diphthongising and productivity of non-final laxing in *missive*-type words, as suggested in Dumas (1981) and McLaughlin (1986). At the very least, there is no evidence that this is the case.

2.6 Opaque harmony in trisyllabic words of the *utilise*-type

The next subsection shows that opaque harmony extends to trisyllabic words whose final coda is a voiced fricative, henceforth *utilise*-type words ([y . t^si . li : z] ‘use, v.’).

Examples of *utilise*-type words are provided here:

(16)	<i>Utilise</i> -type words	
	ny . tʁi . t ^s i : v	‘nutritional, fem.’
	nu . ʁi . t ^s y : ʁ	‘food’
	fy . ʒi . t ^s i : v	‘fugitive, fem.’
	y . ni . t ^s i : v	‘unitive, fem.’
	vi . ʁi . li : z	‘virilise’
	ly . si . fy : ʒ	‘lucifugous’
	i . pi . fy : ʒ	‘fireproof’
	mi . ni . mi : z	‘minimise’

As shown in chapter 1, speakers are consistent in their preference for different patterns of harmony. Like for trisyllabics of the *illicite* type, there are three possible patterns of harmony for *utilise*-type words, in addition to the standard ‘no harmony’ pattern, in which none of the non-final [+high] vowels are laxened. The four possibilities are provided here:

(17)		
	No harmony	y . t ^s i . li : z
	Across-the-board	<u>y</u> . t ^s <u>i</u> . li : z
	Non-local	<u>y</u> . t ^s <u>i</u> . li : z

Adjacent non-iterative y. t̥^sɪ. li : z

Speakers can be classified according to their preferences for one pattern or the others.

Speakers gave the same preferences for tetrasyllabics of the *similitude* type, thereby showing consistency in their preferences. Speakers are similarly consistent with *utilise*-type words.

Across-the-board (ATB) speakers also show a preference for the ATB pattern in *utilise* words as shown in the following figure:

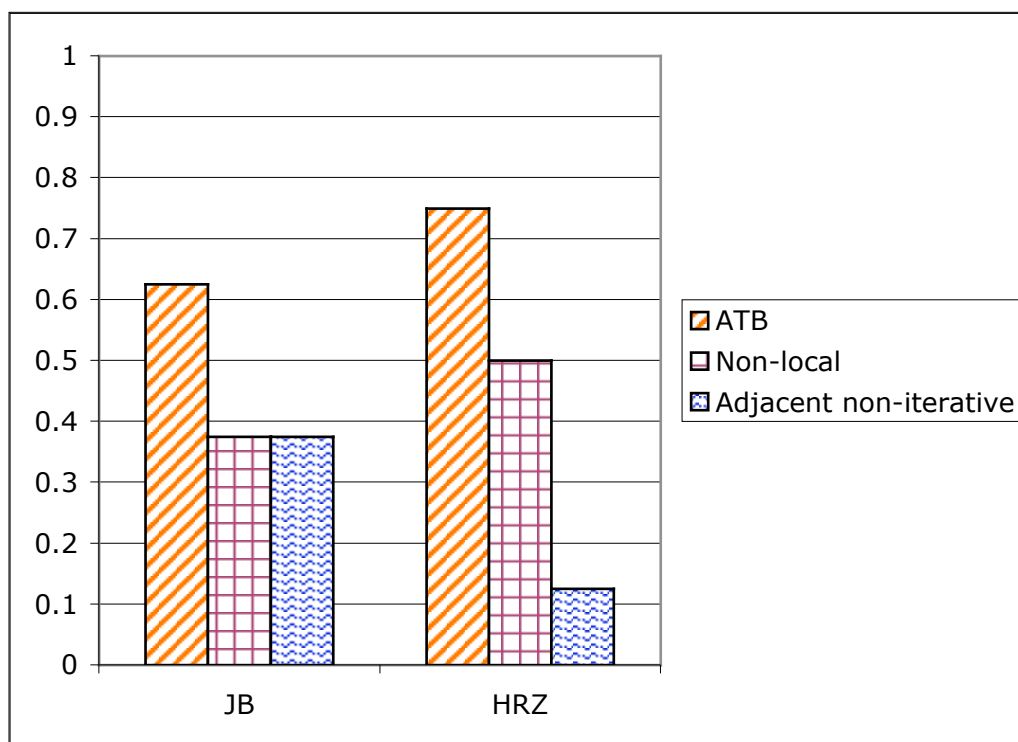


Figure 59: Acceptance rates for different patterns of harmony in *utilise*-type words: ATB speakers.

As we can see from figure 29, ATB speakers also prefer the ATB pattern in the case of *utilise*-type words. The same consistency is observed in non-local and adjacent non-iterative speakers:

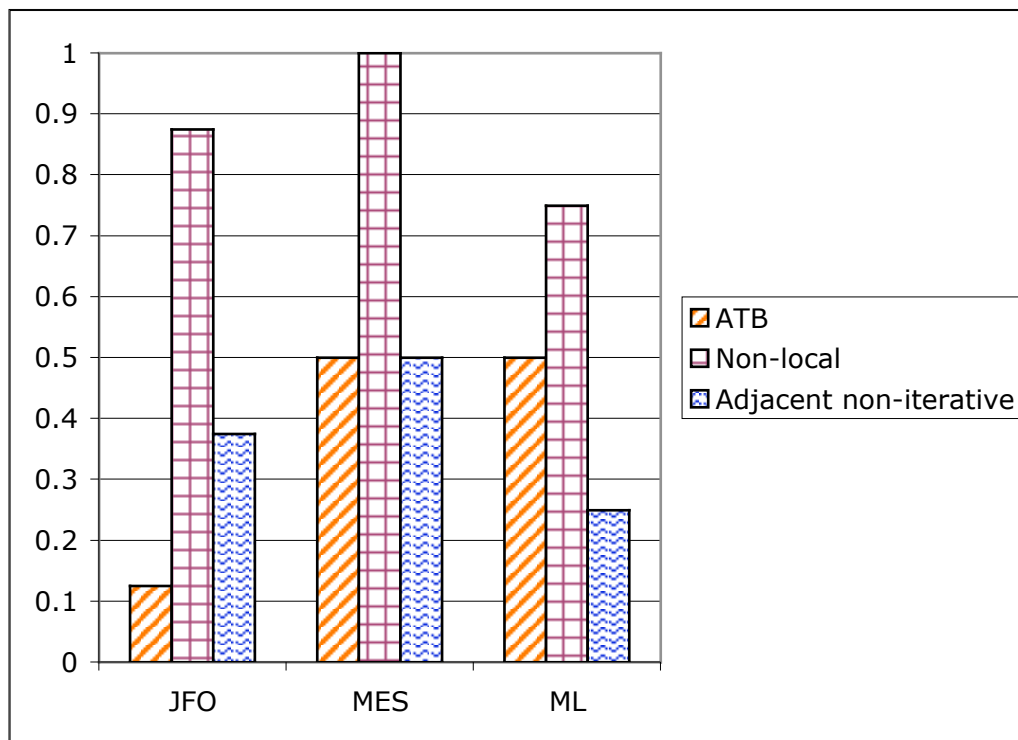


Figure 60: Acceptance rates for different patterns of harmony in *utilise*-type words: Non-local speakers.

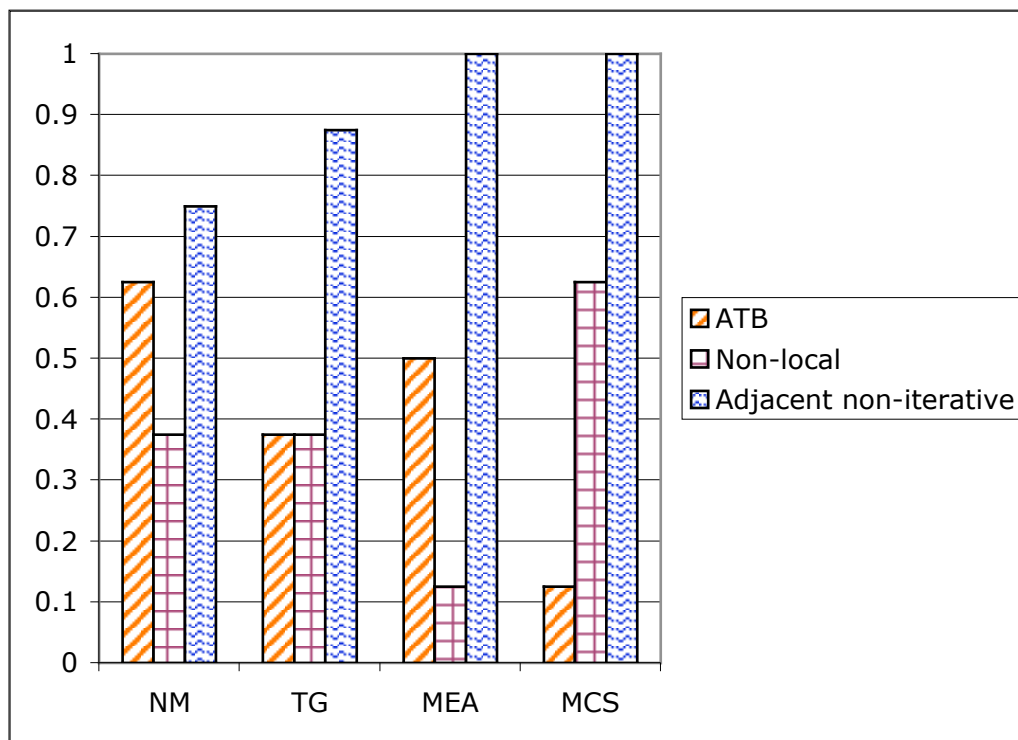


Figure 61: Acceptance rates for different patterns of harmony in *utilise*-type words: Adjacent non-iterative speakers.

Tetrasyllabics ending in a voiced fricative were not tested, unfortunately. I judged such words, like [i.ni.bi.t^si:v] ('inhibitive,' fem.), to be too few in number to provide significant results.

These facts on opaque vowel harmony will be central to the discussion in the theoretical component of this dissertation, which will test accounts of this phenomenon in several varieties of OT, including Stratal OT (Kiparsky 2000, Bermudez-Otero 1999, forthcoming), Sympathy (McCarthy 1999, 2003) and Targeted Constraints (Bakovic & Wilson 2001, Wilson 2001). The example will be crucial in showing the inadequacy of the latter two frameworks in accounting for opacity phenomena.

As mentioned in this chapter, I propose a very traditional, rule-based account for these facts, in which the harmony rule is counter-bleed by a pre-fricative tensing rule. These rules are fully formalised in the next chapter.

3 The cyclical application of laxing and harmony

3.5 CF vowel harmony in Lexical Phonology: a brief outline of an analysis

CF vowel harmony is different from more familiar harmony systems, such as those found in Turkic or African languages⁴⁰, in that vowel harmony is regressive, and does not involve feature filling of an 'unspecified' suffix vowel. CF harmony is stem-internal, as illustrated

⁴⁰ Among countless works on vowel harmony, see Archangeli & Pulleyblank (1994), Polgárdi (1998) or Nevins (2004) for general reviews and discussions.

by our canonical example [fɪ . lɪp] (‘Phillip’). The purpose of this section will be simply to present data that is challenging to a rule-based framework like Lexical Phonology (henceforth, LP; Kiparsky 1982a, 1985), which assumes that levels of morphology are associated with the cyclic application of phonological rules.

CF vowel harmony data is somewhat challenging to earlier versions of this framework (references cited above), because there is evidence that a vowel harmony rule should apply cyclically as well as post-cyclically. This evidence comes from words in which we see the effects of harmony having applied at the stem level, and being partially conserved through further levels of morphological building (this evidence will come from *musical*-type words described below: [my . zi . kal] ‘musical’). Conversely, there is also evidence from morphologically complex tri- and tetrasyllabic words of the *illicite* and *similitude* types, that vowel harmony should be a post-cyclic rule⁴¹, applying only when morphological building is completed. The second part of this dissertation will resolve this conflict within the framework of LP, by proposing that harmony is in fact a word-level phenomenon, but that the word level is divided into two further sublevels defined by different classes of affixes. This is a proposal along the lines of Borowsky (1986, 1992). In other words, I will propose that, in the case of suffixes that include a harmony trigger (that is, a lax [+high] vowel), harmony does not apply until the affix is concatenated. In the case of other suffixes, harmony can apply to the morphologically simplex stem. Again, I save the details of the analysis for the next chapter. The purpose of the present section is mainly to show that a case of opacity involving the cyclic application of harmony is productive, and, secondarily, to introduce the reader to data that will be central to the discussion of rule ordering in CF⁴².

The following data show that laxing and harmony in CF clearly apply at an early level of

⁴¹ This follows Booij & Rubach (1987), who propose a component of post-cyclic rules, which apply after the completion of word building, but prior to insertion in the syntax.

⁴² The data will be reintroduced where relevant in the next chapter.

morphological building, and that their effects are maintained at further levels. A stem like /tɪmɪd/ ('timid') features the conditioning environment for laxing and harmony, and can surface as [t^sɪ.mɪd]. If a non-resyllabifying suffix is concatenated, like the adverbial suffix /mã/ (<-ment>, roughly equivalent to '-ly' in English), we can get the following output: [t^sɪ.mɪd.mã], where the laxing effects of harmony can still be observed on the non-final vowel. More examples of this type are provided below, including one trisyllabic ((18)g-i), in which all patterns of harmony can surface:

- (18) *Cyclical effects of harmony*
- | | | | | |
|----|-------------------------|---|----------------------------|--------------------------|
| a. | SY.bɪt | → | SY.bɪt.mã | 'sudden'; 'suddenly' |
| b. | fɸɪ.ʒɪd | → | fɸɪ.ʒɪd.mã | 'frigid'; 'frigidly' |
| c. | ɸɪ.ʒɪd | → | ɸɪ.ʒɪd.mã | 'rigid'; 'rigidly' |
| d. | st ^s Y.pɪd | → | st ^s Y.pɪd.mã | 'stupid'; 'stupidly' |
| e. | lY.sɪd | → | lY.sɪd.mã | 'lucid'; 'lucidly' |
| f. | d ^z ɪ.vɪn | → | d ^z ɪ.vɪn.mã | 'divine'; 'divinely' |
| g. | ʒY.ɸɪ.d ^z ɪk | → | ʒY.ɸɪ.d ^z ɪk.mã | 'judicial'; 'judicially' |
| h. | ʒY.ɸi.d ^z ɪk | → | ʒY.ɸi.d ^z ɪk.mã | |
| i. | ʒy.ɸɪ.d ^z ɪk | → | ʒy.ɸɪ.d ^z ɪk.mã | |

The cyclical effects of harmony can also be observed when a *resyllabifying* suffix is concatenated. The non-stem-final vowel, the target of harmony, can retain its lax quality in the morphologically complex word, but the stem-final vowel, which is resyllabified, must be tense. This is illustrated in the following words, which I will henceforth refer to as *musical-*

type words:

- (19) *Musical-type words*
- a. sɪ.klɪk → sɪ.kli.si.te *sɪ.klɪ.si.te ‘cyclic’; ‘cyclicality’
- b. mɪ.zɪk → mɪ.zi.kal *mɪ.zɪ.kal ‘music’; ‘musical’
- c. sɪ.vɪl → sɪ.vi.li.te *sɪ.vɪ.li.te ‘civil’; ‘civility’
- d. ɪ.βɪn → ɪ.βi.nwɔɓ *ɪ.βɪ.nwɔɓ ‘urine’; ‘urinal’
- e. ku.t^sɪm → ku.t^sy.mje *ku.t^sy.mje ‘custom’; ‘customary’
- f. mɪ.nɪt → mɪ.ny.tɪɪ *mɪ.nɪ.tɪɪ ‘minute’; ‘timer’
- g. st^sɪ.pɪd → st^sɪ.pi.d^zi.te *st^sɪ.pi.d^zi.te ‘stupid’; ‘stupidity’

We must assume that, at an early level of word building, the final vowel in [t^si.miɪd] is lax, so that it can trigger harmony. A non-final [+high] vowel in an open syllable cannot be [-ATR] otherwise: e.g. vi.la:ɜ → vi.la.ɜwa (‘village’; ‘villager’), not *vi.la:ɜ → *vi.la.ɜwa. But it must also be explained why, in the morphologically complex word, the ‘stem-final’ vowel in [mɪ.zi.kal] must be tense. As I will show in subsection 3.6, tensing of this vowel is obligatory. I will account for this in the following chapter by proposing a cyclic level 2 rule that forces all [+high] vowels in open syllables to be [+ATR]. I will henceforth refer to this rule as ‘open-syllable tensing,’ not to be confused with ‘pre-fricative tensing,’ which only applies to [+high] vowels preceding tautosyllabic voiced fricatives. The rule is constrained however by the Strict Cycle Condition (see Chomsky 1973, Mascaro 1976, Halle 1978, Kiparsky 1982): only those [+high] vowels that have undergone resyllabification on the level 2 cycle (during which non-harmony-triggering suffixes like [aɪ] are concatenated) are subject to the tensing rule.

Data in (18) and (19) seem to show that vowel harmony must apply at an early level of word building, since its effects are carried over in the morphologically complex word. If we only consider the data in (18), it is not clear why this assumption is necessary. One could hypothesise that harmony does not require the trigger to be word-final, in which case harmony could apply after concatenation of the adverbial suffix <-ment>. The data in (19) contradict this potential hypothesis, because these words are morphologically complex, but do not feature the conditioning environment for harmony, whether we assume the trigger should be final or not. As I will discuss below, *musical*-type words are another case of opaque harmony. Again, harmony overapplies. Within the general view of morphology assumed by the LP framework, one can assume that a word like *musical* is formed on the stem *musique* ([my . zɪk]), which does exhibit the conditioning environment for harmony. It thus follows from these assumptions that harmony should apply at an early level of word building. I am using the expression ‘early level of word building’ out of deliberate vagueness. It is unclear from the data in (18) and (19) whether harmony applies at the stem or word level. Both are plausible. By using morphologically complex tetrasyllabic words like [i . ly . mi . nɪsm] (<illumine> + <isme> ‘illuminism’), we can show that harmony cannot apply at the stem level. The following derivation of *illuminisme* shows that assuming harmony applies at the stem level makes the wrong prediction if we assume harmony applies in the adjacent non-iterative pattern:

(20) *Derivation of morphologically complex word assuming (wrongly) that harmony applies on the stem cycle.*

Stem cycle

Input	/ilymin/
Syllabification	i . ly . min
Laxing	i . ly . m <u>ɪ</u> n

VH i . ly . mIn

Word cycle

Input /i . ly . mIn/ + /ism/

Syllabification i . ly . mI . nIsm

Laxing i . ly . mI . nIsm

VH vacuously satisfied

Output *[i . ly . mI . nIsm]

If we assume vowel harmony applies on the stem cycle, the medial vowel is laxed. Then, by adding a suffix containing a trigger for harmony, we initiate a new cycle, in which harmony is vacuously satisfied. The resulting tetrasyllabic output is *[i . ly . mI . nIsm], which is unattested. I remind the reader that only three out of seven possible patterns of harmony are attested for tetrasyllabics: ATB [I . ly . mI . nIsm], non-local [I . ly . mi . nIsm], and adjacent non-iterative [i . ly . mI . nIsm]. To ensure that the grammar only outputs these three patterns of harmony, we must assume that harmony only applies when the final suffix that triggers harmony is concatenated. In other words, harmony is sensitive to the word boundary. As I will show in more detail in the next chapter, this does not mean we can assume that harmony applies post-cyclically, since it must be followed by a tensing rule to account for the *musical* facts. If harmony were post-cyclic, the tensing rule should be as well, by the principle of rule ordering. The tensing rule, however, is subject to the strict cyclicity condition, which only operates on cyclic rules. If the tensing rule is cyclic, then so must be harmony. The *illuminisme* and *musical* facts can both be accounted for if we assume that the word level is split into two sublevels, as mentioned above. The first sublevel is associated with concatenation of ‘harmony suffixes’ like <-isme> or <-iste>, while the

second sublevel is associated with the concatenation of other suffixes. This is a rudimentary division of CF affixes, further research may show that a subset of ‘other suffixes’ are actually best analysed as word sublevel 1 suffixes. We thus obtain the following derivation:

(21) *Derivation of <illuminisme> and <musical> facts*

Stem cycle

Inputs	[[ilymin]ism]	[[myzik]al]
Syllabification	[[i.ly.min]ism]	[[my.zik]al]

Word cycle 1

Inputs	[[i.ly.min]ism]	[[my.zik]al]
Syllabification	[i.ly.mi.nism]	[[my.zik]al]
Laxing	[i.ly.mi.n \underline{I} sm]	[[my.z \underline{I} k]al]
Harmony	[i.ly.m \underline{I} .nISM]	[[m \underline{Y} .zIk]al]

Word cycle 2

Inputs	[i.ly.mI.nISM]	[[mY.zIk]al]
Syllabification	[i.ly.mI.nISM]	[mY.zI.kal]
Laxing	satisfied	-----
Harmony	satisfied	-----
Tensing	-----	[mY.zi.kal]
Outputs	[i.ly.mI.nISM]	[mY.zi.kal]

The *musical* facts can only be accounted for if we assume that harmony and open-syllable tensing are in counter-bleeding order. As mentioned above, this is another case of opacity,

which, as I will show in the second part of the dissertation, proves challenging for classical OT, but also for many of its later revisions, including stratal OT (Kiparsky 2000; Bermudez-Otero 1999, forthcoming) and targeted constraints (Bakovic & Wilson 2001; Wilson 2001). But, as I have made clear in section 2.5, to assume that this is truly a case of opacity, we must rule out two things, that, a) the pattern can be accounted for transparently, and b) that the pattern is unproductive. This is the topic of the following section.

3.6 The productivity of the *musical* pattern

Firstly, I must address the question of whether the pattern in (19) can be accounted for transparently. One could propose the same potential accounts for the *musical* facts as for the *missive* facts. One could propose that the initial vowel is lax, while the medial one is tense because initial vowel laxing is licensed by secondary stress, which in French is borne on the initial syllable. This would be the account proposed in Déchaîne (1991). As explained in section 2.4.1, this analysis over-generates, in that it predicts that all initial [+high] vowels should be able to lax. This is not the case, as clearly shown in figure 21; non-final laxing in a word like *mitaine* is practically not accepted by any speaker: *[mɪ . tɛn]. One could also propose that non-final laxing in *musical*-type words is due to a dissimilation rule. By dissimilation, the initial vowel would become lax because the following medial vowel is tense. Figure 22 shows that, though all speakers accept non-final laxing in *missive*-type words, only a subset of speakers accept non-final laxing in *midi*-type words. One would expect all speakers to accept both if non-final laxing in *missive*-type words were the result of dissimilation. The same argument can be presented in the *musical* case. I will show below that, out of all speakers who provided judgments on *musical* words, all accepted non-final laxing, without exception. Again, the same cannot be said for *midi*-type words.

But is non-final laxing in *musical* words productive? To test the productivity of this pattern,

I set up two experiments, whose methodology differs slightly from the one used to collect all results reported thus far. The 12 speakers who participated in these experiments only partially overlap with those who participated in all previous experiments. The first experiment was performed using 8 real words of the *musical* type. Words are provided here:

(22) *Musical productivity experiment stimuli*

my.zɪk	my.zi.kal	‘music’; ‘musical’
i.ʁɪt	i.ʁi.ta.sjõ	‘irritate’; ‘irritation’
ʁu.kul	ʁu.ku.le	‘warble’; ‘to warble’
ky.mɪl	ky.my.le	‘cumulate’; ‘to cumulate’
si.mɪl	si.my.la.sjõ	‘simulate’ ; ‘to simulate’
mi.liɪt	mi.li.tã	‘militate’ ; ‘militant’
vi.zɪt	vi.zi.te	‘visit’; ‘to visit’
ku.ʁus	ku.ʁu.se	‘anger’ ; ‘to anger’

Participants were asked to read only the root, e.g. <irrite> ([i.ʁɪt]; ‘irritate’). All speakers read the words with final closed syllable laxing, and most did not produce harmony. Speakers were then asked if they accepted a pronunciation where both non-final and final vowels were lax: [ɪ.ʁɪt]. All said they accepted the harmonic pronunciation⁴³. I provided the pronunciations in person, only in auditory form; speakers were only given the root in writing. I then asked the speakers if they could tell the difference between the standard pronunciation [i.ʁi.ta.sjõ] and the pronunciation [ɪ.ʁi.ta.sjõ], in

⁴³ The experiment was actually performed on 15 speakers in total. I rejected the results of those speakers who did not accept the harmonic pronunciation.

which only the first [+high] vowel is lax. This was to ensure that speakers actually heard this subtle difference. If they answered in the affirmative, I asked speakers to tell me which of the three following pronunciations sounded most natural to them: [ɿ . ʌi . ta . sʝõ] (harmonic stem-initial vowel), [ɿ . ʌɿ . ta . sʝõ] (all stem vowels harmonic) or [i . ʌɿ . ta . sʝõ] (harmonic stem-final vowel). I varied the order of presentation randomly by word and by speaker. As can be seen from the following figure, speakers unanimously chose the first pronunciation, [ɿ . ʌi . ta . sʝõ], as the most natural. Results for this test are different from the sort of results we have seen so far, in that they exhibit no variation at all. All speakers rejected any pronunciation featuring a stem-final lax [+high] vowel⁴⁴:

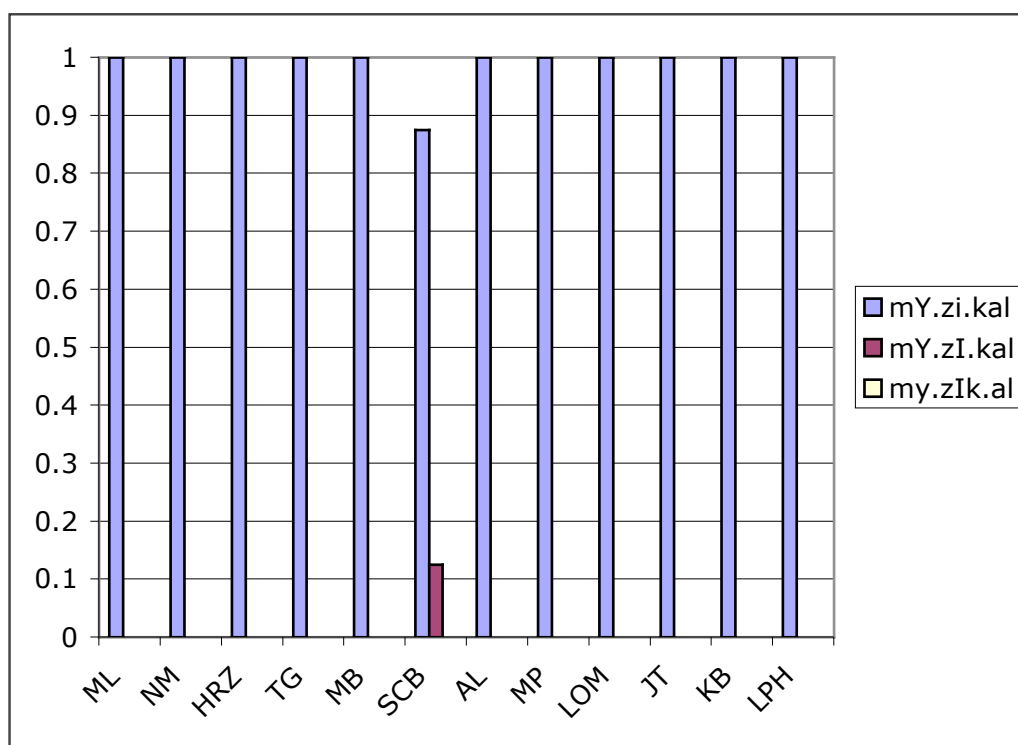


Figure 62 : Acceptance rates for non-final laxing patterns in *musical*-type words.

⁴⁴ There is the exception of speaker SCB, who accepted the pronunciation [kʏ . mʏ . lɛ] as more natural than the others. This may be due to speaker error, but exceptionally, I repeated the stimulus in this case to make sure s/he had not misheard. The speaker maintained his or her original answer.

What should also be noted is that some of the speakers used in this experiment also participated in experiments in which they were tested for preferences among patterns for tri- and tetrasyllabics (see ML, HRZ, NM, TG, MB)⁴⁵. Though these speakers are of different ‘dialects’ with respect to tri- and tetrasyllabic stimuli (*illicite*-type words and *similitude*-type words), they behave identically with respect to lax stem-final vowels in open syllables. Naturally, we expect their behaviour to be different if the *musical*-type words have more than one stem-non-final vowel: e.g. [i . l y . m i . n a . s j ɔ̃] ‘illumination.’ I did not test for these words formally because they are rather few in number. As a non-local speaker, I prefer [ɿ . l y . m i n] over other pronunciations. If I form a morphologically complex word like <illumination>, the pronunciation [ɿ . l y . m i . n a . s j ɔ̃] is much better than *[ɿ . l y . m ɿ . n a . s j ɔ̃], where the stem-final vowel is lax; in fact, the latter pronunciation is awful. I also prefer [ɿ . l y . m i . n a . s j ɔ̃], to the ATB version, [ɿ . l ʏ . m i . n a . s j ɔ̃], and the adjacent non-iterative version [i . l ʏ . m i . n a . s j ɔ̃], but the latter two patterns are simply dispreferred, not impossible like *[ɿ . l y . m ɿ . n a . s j ɔ̃], where the stem final vowel is lax. The same sorts of judgments were informally given by speaker NM, an adjacent iterative speaker, who preferred [i . l ʏ . m i . n a . s j ɔ̃] over other patterns of

⁴⁵ Donca Steriade and Andrew Nevins have pointed out an interesting discrepancy in the behaviours of speakers who participated in both the more general study of CF vowel harmony (reported in ch. 2) and the study reported here, which deals with the productivity of the *musical* pattern. One will notice that speakers ML, NM, HRZ, TG and MB accept 100% of tokens with harmony in the *musical* study (true for real and nonce forms), but rarely accept harmony in *Philippe* words at the same rate. This may have one or several causes: 1) speakers might simply be less consistent than they appear to be; they might be consistent for one sitting of the experiment, but not maintain that consistency in a second sitting several months later; this highlights the importance of checking speakers’ judgments more than once using the same stimuli so that consistency is well motivated (or disconfirmed, as the case may be). 2) this may be due to nature of the methodology, which was difference for the second installment of the experiment (checking the *musical* case). For the second installment, speakers were not listening to a tape. Rather I asked directly if a given form was natural with harmony. I only proceeded to the next question once speakers had responded (either in the positive or negative). Speakers thus had more time to think about the stimulus. This might indicate that harmony in disyllabics (only disyllabic roots were tested) is in fact much more ‘natural’ than what the results for *Philippe*-type words indicate in chapter 2. Either way, all experiments will be repeated in future investigation of this issue.

harmony, but thought [i . lɪ . mɪ . na . s j ɔ̃], where the stem-final vowel is lax, was terrible. The same goes for HRZ, an ATB speaker.

Now the productivity of the *musical* pattern is very clear from the results of the second experiment, which involved nonce words. In this experiment, the same speakers were asked to read a monosyllabic root with a word final [+high] vowel in an open syllable. Onsets were composed of a single voiced consonant (voiceless consonants were avoided, since [+high] vowels tend to be harder to perceive when between two voiceless consonants, even when stressed). The monosyllabic nonce roots are provided below:

(23) *Monosyllabic nonce roots*

ʒi

mi

gi

ʁi

by

ly

vy

my

mu

zu

du

lu

Speakers were provided these root one at a time and asked to read them to make sure they did pronounce a tense vowel, which they all did, since CF does not allow lax [+high] vowels in word-final open syllables. This was done to ensure that speakers were not biased to pronounce certain nonce syllables with a lax vowel. This could conceivably have occurred if there existed a certain word starting with one of these syllables which was often pronounced with harmony.

Speakers were then asked to concatenate the real (but modified⁴⁶) suffix [t^sɥd] (<tude> ‘state of being x’) to the nonce syllable, and to pronounce the resulting word. Speakers generally produced the ‘standard’ variant, e.g. [lɥ.t^sɥd]. Speakers were then given the following scenario: pretending the <Lu>’s were a nation, they could refer to the state of being a <Lu> by talking about their <lutude>, if the <Lu>’s spoke CF, could they pronounce <lutude> [lɥ.t^sɥd] (with harmony)? The same question was asked for all nonce syllables. If speakers answered ‘yes’ they were asked the next question, which was: ‘Now, if we were to make an adjective from this word, <lutude>, it would be [lɥ.tɥ.d^zi.nal] (by suffixation of the nominal suffix <-inal>), do you agree. If speakers, answered yes, I asked a fourth question: out of the three following pronunciations, which is the most natural for this adjective: [lɥ.t^sɥ.d^zi.nal] (expected), [lɥ.t^sɥ.d^zi.nal] (all stem vowels harmonic) or [lɥ.t^sɥ.d^zi.nal] (stem final vowel harmonic)?

Again, if speakers answered the first question in the negative, their results were excluded. Out of the 15 speakers, 10 answered yes to the first question. The 5 remaining speakers answered ‘no’ to the first question, and their results are not included here. The 10 speakers who did complete the task, had uniform results, shown in the following figure:

⁴⁶ The point was to find a suffix that would induce harmony, and the suffix <-itude> was found to be most convenient, because it is reasonably productive, and could be worked into a scenario to help speakers ‘pretend’ the nonce words were real words.

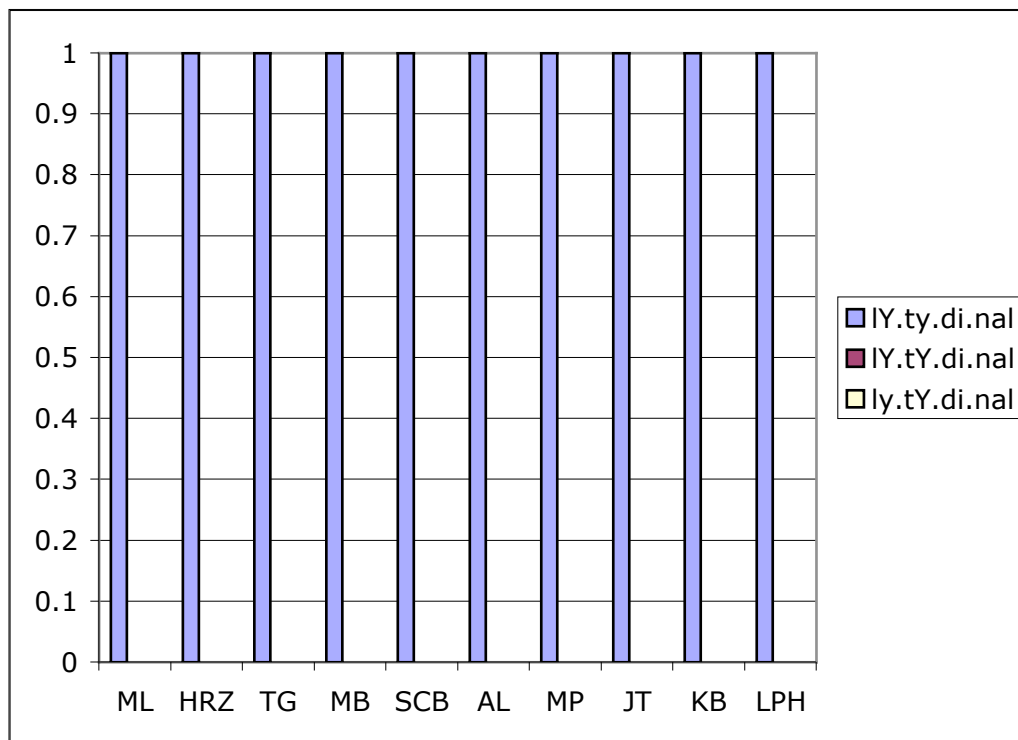


Figure 63: Acceptance rates for non-final laxing patterns in nonce *musical*-type words.

All of the speakers who completed the task agreed that the pronunciations with a lax, resyllabified stem-final vowel were unnatural. Again, judging by speakers' reactions, it was clear that there was no room for doubt. This is different from the task in which judgments were asked for harmony patterns in tri- and tetrasyllabic words, where speakers' judgments were less uniform. The results of this test clearly show that the *musical* pattern can extend to nonce forms and is thus fully productive in the language.

These results do beg another question though: In the second chapter of this work, I have shown that speakers vary in their preferences for different patterns of harmony when it comes to tri- and tetrasyllabic words. I have proposed that such variation is due to an underdetermined analysis of the primary linguistic data, which is uninformative to the learner on whether harmony is an iterative or local process. Productivity results for the *musical* pattern suggests that there is no variation when it comes to which vowel can be lax in

musical-type words, and which cannot. By my proposal, it should follow that learners have enough information in the PLD to be able to make a stable generalisation on this point. As I've pointed out in the first chapter, we do not have a clear answer as to how much PLD on a point of grammar constitutes enough evidence for the learner to acquire this point of grammar. Be that as it may, we know that speakers all agree on the possibility of harmony in disyllabics, and that disyllabics exhibiting the appropriate environment for harmony number around 400 tokens. The number of *musical*-type words found in the Lexique database number number around 230. That is, there are approximately 230 words with a multisyllabic stem in which harmony is possible and a resyllabifying suffix. The learner also has a lot of evidence that a [+high] vowel that is resyllabified must be tense, though it must be lax prior to concatenation of the suffix (e.g. [fɪn] 'nice' → [fɪ.nɛs] 'finesse' *[fɪ.nɛs]). That being said, the stability of this pattern is not inconsistent with the proposal that variation is connected to undeterminate analysis of the PLD.

4 Conclusion

The fact that opaque vowel harmony is productive in both *missive* and *musical* type patterns allows us to make two important arguments: a), that a model of the phonological component must assume the existence of intermediate representations, and b), that a model of the phonological component must also include the notion of a 'cycle.' These arguments will be fleshed out in the following chapter, which proposes a derivational account of all facts surrounding vowel harmony and its interactions with other phonological processes and morphological building. This model will be further supported by data drawn from other languages. Chapter 4 will then push the argument further by showing that non-derivational alternatives to the model I assume fail to make the correct predictions concerning these type of data.

Appendix: Stimuli

1) Stimuli used for data presented in Figure 33 to Figure 52.

[d ^z i.fy:z]/[d ^z ɪ.fy:z]	‘diffuse’
[su.mi:z]/[sʊ.mi:z]	‘submitted, fem.’
[sy.fi:z]/[sʏ.fi:z]	‘enough, v.’
[mi.si:v]/[mɪ.si:v]	‘letter’

2) Stimuli used for data presented in **Figure 53**.

Philippe-type words

[fɪ.lɪp]/[fi.lɪp]	‘Phillip’
[mɪ.nɪt]/[mi.nɪt]	‘minute’
[li.mɪt]/[li.mɪt]	‘limit’
[pu.ʁɪt]/[pu.ʁɪt]	‘pourrite’
[st ^s y.pɪd]/[st ^s y.pɪd]	‘stupid’
[my.kys]/[my.kys]	‘mucus’
[ʃu.kʁut]/[ʃu.kʁut]	‘sauerkraut’
[pu.t ^s ɪn]/[pu.t ^s ɪn]	‘poutine’

Mitaine-type words

*[ʃɪ.nwa]/[ʃi.nwa]	‘Chinese’
*[ʒy.mɛl]/[zy.mɛl]	‘binoculars’
*[mɪ.ʁɛj]/[mi.ʁɛj]	‘Mireille’

*[ʒɪ.lɛ]/[ʒi.lɛ]	‘sweater’
*[vɪ.nɛgɤ]/[vi.nɛg]	‘vinegar’
*[bɤy.no]/[bɤy.no]	‘Bruno’
*[ly.si]/[ly.si]	‘Lucy’
*[ʒy.ʒɛ]/[ʒy.ʒɛ]	‘to judge’

3) Stimuli used for data presented in Figure 54.

Missive-type words

[mɪ.si:v]/[mi.si:v]	‘letter’
[d ^z ɪ.vi:z]/[d ^z i.vi:z]	‘divide, v.’
[tu.ʒu:ɤ]/[tu.ʒu:ɤ]	‘always’
[li.t ^s i:ʒ]/[li.t ^s i:ʒ]	‘litigation’
[bɤy.ly:ɤ]/[bɤy.ly:ɤ]	‘burn, n.’
[fɪ.ni:ɤ]/[fi.ni:ɤ]	‘to finish’
[ki.vi:v]/[ki.vi:v]	‘alert, n.’
[ɪ.ɤi:z]/[i.ɤi:z]	‘to make iridescent’

Piqûre-type words

[pɪ.ky:ɤ]/[pi.ky:ɤ]	‘sting’
[sy.fi:z]/[sy.fi:z]	‘suffice’
[d ^z ɪ.fy:z]/[d ^z i.fy:z]	‘broadcast’
[pu.si:v]/[pu.si:v]	‘lazy, fem.’

[sy. fi:z]/[sy. fi:z]	‘suffice’
[su. d ^z y:ɸ]/[su. d ^z y:ɸ]	‘solder’
[fɸɪ. t ^s y:ɸ]/[fɸi. t ^s y:ɸ]	‘fried foods’
[sy. ɸi:ɸ]/[sy. ɸi:ɸ]	‘to sour’

Midi-type words

[mɪ. d ^z i]/[mi. d ^z i]	‘noon’
[fɪ. ni]/[fi. ni]	‘finished’
[ʃɪ. mi]/[ʃi. mi]	‘chemistry’
[zu. lu]/[zu. lu]	‘Zulu’
[ɪ. si]/[i. si]	‘here’
[ʃɪ. pi]/[ʃi. pi]	‘shrew, fig.’
[gu. ɸu]/[gu. ɸu]	‘guru’
[u. tu]/[u. tu]	‘Hutu’

Julie-type words

[ʒy. li]/[zy. li]	‘Julie’
[sɪ. gy]/[si. gy]	‘hemlock’
[pu. li]/[pu. li]	‘pulley’
[mɪ. lu]/[mi. lu]	‘Milou’
[vu. ly]/[vu. ly]	‘wanted’
[sy. li]/[sy. li]	‘Sully’
[ɪ. bu]/[i. bu]	‘owl’

[kʊ.ɾy]/[kʊ.ɾy] ‘run, part.’

4) Stimuli used for data presented in Figure 55 and Figure 56

Real *missive*-type words

See *missive*-type words in 3 above.

Nonce *missive*-type words

[bly.ni:v]/[bly.ni:v]

[su.ɾu:z]/[su.ɾu:z]

[ly.ki:z]/[ly.ki:z]

[ky.ny:z]/[ky.ny:z]

[y.gi:ɾ]/[y.gi:ɾ]

[su.ly:ɾ]/[su.ly:ɾ]

[mu.bi:ɾ]/[mu.bi:ɾ]

[bɪ.li:ʒ]/[bi.li:ʒ]

5) Stimuli used for data presented in Figure 57, Figure 27 and Figure 28.

High frequency *missive*-type words

[nu.ɾɪ:ɾ]/[nu.ɾɪ:ɾ] ‘to nourish’

[tu.ju:ɾ]/[tu.ju:ɾ] ‘always’

[su.mi:z]/[su.mi:z] ‘submitted, fem.’

[lu.i:z]/[lu.i:z] ‘Louise’

[dʒɪ.βiʒ]/[dʒi.βiʒ]	‘direct’
[fy.t ^s yβ]/[fy.t ^s yβ]	‘future’
[sy.bi:β]/[sy.bi:β]	‘to undergo’
[fi.ni:β]/[fi.ni:β]	‘to finish’

Low frequency *missive*-type words

[ni.ni:v]/[ni.ni:v]	‘Nineveh’
[st ^s ɪ.li:z]/[st ^s i.li:z]	‘stylise’
[ki.vi:v]/[ki.vi:v]	‘alert, n.’
[ɪ.βi:z]/[i.βi:z]	‘to make iridescent’
[si.t ^s i:z]/[si.t ^s i:z]	‘laburnum’
[vi.tβy:v]/[vi.tβy:v]	‘Vitruve’
[βy.si:z]/[βy.si:z]	‘to russify’
[si.ni:z]/[si.ni:z]	‘to sinicise’

6) Stimuli used for data presented in Figure 59, Figure 60 and Figure 61.

Different patterns provided in 140.

[ny.tβi.t ^s i:v]	‘nutritional, fem.’
[nu.βi.t ^s y:β]	‘food’
[fy.ʒi.t ^s i:v]	‘fugitive, fem.’
[y.ni.t ^s i:v]	‘unitive, fem.’
[vi.βi.li:z]	‘to make virile’
[ly.si.fy:ʒ]	‘lucifugous’

[i.ni.fy:ʒ]	‘fireproof’
[mi.ni.mi:z]	‘minimise’

7) Stimuli used for data presented in Figure 62.

[my.zɪk]	[my.zi.kal]	‘music’; ‘musical’
[i.ʁɪt]	[i.ʁi.ta.sjõ]	‘irritate’; ‘irritation’
[ʁu.kʊl]	[ʁu.ku.le]	‘warble’; ‘to warble’
[ky.mɪl]	[ky.my.le]	‘cumulate’; ‘to cumulate’
[si.mɪl]	[si.my.la.sjõ]	‘simulate’; ‘to simulate’
[mi.liɪt]	[mi.li.tã]	‘militate’; ‘militant’
[vi.zɪt]	[vi.zi.te]	‘visit’; ‘to visit’
[ku.ʁʊs]	[ku.ʁu.se]	‘anger’; ‘to anger’

8) Stimuli used for data presented in Figure 63.

Root	Suffix 1	Suffix 2
ʒi	[t ^s ɥd]	[i.nal]
mi		
gi		
ʁi		
by		
ly		
vy		

my

mu

zu

du

Chapter 4: Canadian French vowel harmony: An analysis

1 Chapter overview

This chapter proposes that the distribution of [+high] vowel allophones can be derived using five ordered rules: closed syllable laxing, pre-fricative tensing, open-syllable tensing, lengthening, and of course, harmony. My account is couched within a rule based framework, which can account for the following three facts about CF vowel harmony: a) harmony can be non-local, b) vowel harmony can be rendered opaque by pre-fricative tensing, a phenomenon that must be accounted for using intermediate representations, and c) vowel harmony can be rendered opaque by open-syllable tensing, a phenomenon that must be accounted for by assuming that rules can apply cyclically. A reexamination of OT-based frameworks is the topic of the next chapter.

The chapter begins by reviewing each of the proposed rules, and justifying their existence in a cross-linguistic perspective. I propose that all harmony patterns found in CF can be accounted for using a single harmony rule. Two parameters determine how the rule applies: iterativity and directionality. This account predicts that only the three attested patterns for harmony should surface for tri- and tetrasyllabic inputs, but that all parameter setting combinations produce the same output for disyllabic inputs. The account is based on the analysis of transparent vowels found in Archangeli & Pulleyblank (1994). I review their account of neutral vowels in Wolof and Yoruba, and show how this account can predict the existence of all three patterns of harmony we find in CF, and how these patterns should behave with respect to neutral medial vowels.

The chapter also discusses the relationship between iterativity and optionality (see Vaux 2002), and how iterativity and optionality in CF are independent of each other. The discussion goes on to propose that, were vowel harmony optional at each iteration, unattested

tetrasyllabics could be produced, so that their ‘impossibility’ should not be hardwired into UG. Rather, I propose that unattested tetrasyllabics are less likely to surface in the world’s languages because their production necessitates grammars that are computationally more complex. This proposal follows some recent work by Nevins, Poliquin & Perfors (2006) and Poliquin & Nevins (2006).

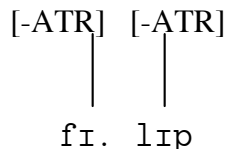
Finally, the chapter proposes an account of the two types of opacity found in CF, both of which were shown to be productive in the previous chapter. I propose a very straightforward account for both types of opacity, which involves rule ordering and cyclic rule application. Comparisons with Central and Eastern Javanese are also provided.

2 Vowel harmony: a rule-based account

2.1 Section Overview

The present section will provide a rule-based account of vowel harmony as it occurs in CF. The account will be couched in the framework of Lexical Phonology (Kiparsky 1982a, 1985), which assumes that the surface representation of phonological strings are derived from a single underlying representation through the application of an ordered set of rules. I will argue in the next chapter that only a derivational framework can account for the full range of facts that concern harmony.

In CF, vowel harmony occurs when a [+high] vowel in a non-final open syllable projects a [-ATR] autosegment. Non-final [+high] vowels may only project a [-ATR] autosegment if the final vowel within the same word projects a [-ATR] autosegment as a result of closed syllable laxing. This is illustrated in (1):

(1) a. *Autosegmental representation of CF vowel harmony*b. *Characteristics of CF vowel harmony*

Harmonic feature:	[-ATR]
Trigger:	Word final [+high] vowels in closed syllables
Target:	Non-final [+high] vowels in open syllables.
Domain:	Word

CF has three [+high] vowel phonemes, each with a [+ATR] and [-ATR] allophone. CF's inventory of [+high] vowel sounds is provided here:

(2) *CF high vowel sounds*

Vowels		[high]	[back]	[round]	[ATR]
/i/	[i]	+	-	-	+
	[ɪ]	+	-	-	-
/y/	[y]	+	-	+	+
	[ɻ]	+	-	+	-
/u/	[u]	+	+	+	+
	[ʊ]	+	+	+	-

All [+high] vowel phonemes of CF are subject to this process; target vowels need only share the feature [+high] with the trigger vowel to undergo harmony. This optional rule of CF is fed by an obligatory laxing rule, which forces [+high] vowels in word-final closed syllables to be [-ATR]. This laxing rule will be formalised in section 2.2. In autosegmental terms, the

laxing rule forces the projection of a [-ATR] autosegment, which, by harmony, can then ‘spread’ to non-final [+high] vowels in open syllables as in (1)a. [+high] vowels in open syllables may not be [-ATR] if the appropriate trigger for harmony is absent: *[mɪ . tɛn].

The characteristics of harmony in (1)b do not list the parameters for locality and iterativity of the process. These parameters are not relevant to the disyllabic example in (1)a, but do become significant when tri- and tetrasyllabic examples are considered (e.g. [i . li . sɪt] ‘illicit’ ; [si . mi . li . t^sɪd] ‘similarity’). In section 2.3, where harmony is formalised, I will show that speakers vary as to their specific parametrisations on these points. I will formalise harmony as a rule forcing [+high] vowels to project a [-ATR] feature of their own, if the final vowel in the same word also projects a [-ATR] feature. Speakers differ in their specific application of the rule. Some speakers first apply the rule on the [+high] vowel most adjacent to the trigger (e.g. [i . lɪ . sɪt]) and continue applying the rule to every subsequent non-final [+high] vowel (if they parametrise the rule as [+iterative]: e.g. [ɪ . lɪ . sɪt]). Other speakers first apply the rule on the [+high] vowels farthest from the trigger (e.g. [ɪ . li . sɪt]) and then apply the rule to subsequent [+high] vowels (if the rule is [+iterative]: e.g. [ɪ . lɪ . sɪt]). If speakers parametrise the rule as [-iterative], only the non-final [+high] vowel at the right or left edge of the domain will harmonise (e.g. [i . lɪ . sɪt] or [ɪ . li . sɪt]). This account predicts a limited variety of grammars, all of which have been attested among CF speakers (see chapter 2).

The following subsections will provide the justifications and formalisations of the vowel harmony rule, and four additional rules of CF that interact with harmony: closed syllable laxing, lengthening, pre-fricative tensing, and open-syllable tensing, the latter two of which give rise to opacity effects. Naturally, harmony and its two parameters of application, iterativity and directionality, will be the objects of greater focus.

Before I provide an analysis of these phenomena, it should be noted that similar patterns of harmony are found in Javanese and Palestinian Arabic. I provide an overview of the Javanese case in section 3.2 of this chapter, since it also exhibits interactions with open-syllable tensing. I will give a few examples of [-ATR] harmony in Palestinian Arabic here, or ‘post-velar harmony’ as it is called in Shahin (2002), from which I draw these examples. The Palestinian Arabic case, though clearly germane to the CF case, will not be object of a thorough analysis, since, to my knowledge, it does present any of the more challenging aspects of CF: variation, opacity, etc. I refer the reader to Shahin (2002) for a more thorough treatment.

In Palestinian Arabic, final vowels in closed syllables must be [-ATR]⁴⁷. Preceding vowels in open syllables, [+high] and [-high], must⁴⁸ also be [-ATR] by harmony (Shahin 2002: 102). Vowels in underlying forms in Times font indicate that value for [ATR] is unspecified underlyingly:

(3) *Palestinian Arabic harmony*

- a. /fɪlm/ → [fɪ.lɪm] *[fi.lɪm] ‘movie’
 b. /kUtɔb/ → [kU.tuɔb] *[ku.tuɔb] ‘books’
 c. /tɪbn/ → [tɪ.bɪn] *[ti.bɪn] ‘straw’
 d. /sɛlk/ → [sɛ.lɪk] *[sɛ.lik] ‘boiled’
 e. /kɪʃr/ → [kɪ.ʃɪr] *[ki.ʃɪr] ‘peel’

⁴⁷ Or [RTR], as Shahin characterises them. I consider [RTR] and [-ATR] to be equivalent.

⁴⁸ Interestingly, this vowel harmony is obligatory

2.2 Laxing and tensing

2.2.1 Closed syllable laxing

In CF, [+high] vowels must be [-ATR] in final closed syllables, unless the syllable is closed by a voiced fricative⁴⁹. The rule is obligatory in final syllables, but optional in non-final closed syllables⁵⁰. The process, which affects all CF [+high] vowels, is illustrated by the following examples (‘✓’ marks an equally acceptable variant):

(3) a. *Obligatory laxing in final closed syllables*

pœ.t ^s it	‘little, fem.’	*pœ.t ^s it
a.lɥm	‘turn on, v.’	*a.lɥm
e.tuf	‘choke’	*e.tuf

a. *Optional laxing in non-final closed syllables*

mi.s.tɛ ^j ʁ	‘mystery’	✓mi.s.tɛ ^j ʁ
tʁyʃ.mā	‘trough-way’	✓tʁyʃ.mā
sul.ʁi	‘drinking spree’	✓sul.ʁi

In an open syllable, final [+high] vowels must be [+ATR], as in the following examples:

(4) *Obligatory tensing in final open syllables*

a.mi	‘friend’	*a.mɪ
pɛ.ji	‘country’	*pɛ.jɪ
ɛʁ.ni	‘hernia’	*ɛʁ.nɪ

⁴⁹ If a [+high] vowel is the nucleus of a final syllable closed by a voiced fricative, the [+high] vowel must be [+ATR] and long.

⁵⁰ Closed syllable laxing of [+high] vowels is one of the key differences that exist between CF and Standard European French, in which [+high] vowels are [+ATR] everywhere, including in closed final syllables.

sa.ly	'hi'	*sa.lɤ
tɛ ^j .t ^s y	'stubborn'	*tɛ ^j .t ^s ɤ
t ^s i.sy	'cloth'	*t ^s i.sɤ

e.gu	'sewer'	*e.gu
bi.zu	'kiss'	*bi.zu
ka.ju	'pebble'	*ka.ju

Thus, [+high] vowels in open syllables must be [+ATR] *unless* they can undergo harmony.

That is, if and only if the final [+high] vowel has undergone laxing. Compare the following forms:

(5) a. *Obligatory tensing of non-final [+high] vowels in words without conditioning environment for harmony.*

mi.tɛn	'mitten'	*mɪ.tɛn
si.gɑɁ	'cigar'	*sɪ.gɑɁ
gi.dõ	'handlebars'	*gɪ.dõ
ʒy.mɛl	'binoculars'	*ʒɤ.mɛl
ky.lɔt	'culotte'	*kɤ.lɔt
fɛy.gal	'frugal'	*fɛɤ.gal
bu.tõ	'button'	*bu.tõ
gu.lo	'bottleneck'	*gu.lo
ku.te	'to cost'	*ku.te

b. *Optional laxing of non-final [+high] vowels in words with conditioning environment for harmony.*

fɪ.lɪp	pr. name	✓fɪ.lɪp
mɪ.nɪt	'minute'	✓mɪ.nɪt
d ^z ɪ.sut	'dissolved, fem.'	✓d ^z ɪ.sut
st ^s y.pɪd	'stupid'	✓st ^s y.pɪd
my.kɪs	'mucus'	✓my.kɪs

t ^s ʏ . mʊʃ	‘fly paper’	✓t ^s y . mʊʃ
pu . ʁɪt	‘rotten, fem.’	✓pu . ʁɪt
ku . t ^s ʏm	‘custom’	✓ku . t ^s ʏm
ʃu . kʁʊt	‘sauerkraut’	✓ʃu . kʁʊt

From the data above, we can make two generalisations:

- 1) In closed syllables, [+high] vowels are [-ATR]. The process responsible for this distribution obligatorily occurs in final syllables, and optionally in non-final syllables.
- 2) In open syllables, [+high] vowels are [+ATR]. The process responsible for this distribution is obligatory, unless vowel harmony can apply, in which case tensing is optional.

I propose that the first generalisation can be accounted for by a rule such as the following:

(6) *Laxing rule*

[+high] → [-ATR]/_C]_o [+high] in closed syllables are [-ATR].

The application of a similar rule is observed in Andalusian Spanish (Hualde 2005), Southern Italian dialects (Calabrese 1998, Kaze 1989), Ngaju Dayak (Brunelle & Riehl 2002) among others. In these languages, the rule generally targets all [-low] vowels, provided that they have [±ATR] allophones. In CF, the rule applies without exception to [+high] vowels, which is why it is formalised in (6) as targetting only [+high] vowels. Though the rule seems to have applied to [-high, -low] vowels historically, diachronic developments have made the application of the rule more complex. These issues are not relevant to harmony, and therefore will not be covered here (see Dumas 1981 for laxing of [-high] vowels).

2.2.2 Tensing in open syllables

The previous section shows that there are two conditions under which [+high] vowels may be [-ATR]:

A [+high] vowel may be [-ATR]:

- 1) if it is in a closed syllable. If the closed syllable is final, a [+high] vowel in this syllable *must* be [-ATR]; if the syllable is non-final, laxing is optional.
- 2) if it is in a non-final open syllable and the final [+high] vowel in the word domain is [-ATR] by virtue of the laxing rule (Harmony).

In all other environments, [+high] vowels in CF must be [+ATR]. I propose that this is due to an open-syllable tensing rule. I assume the existence of this rule follows from the cross-linguistically marked status of [+high, -ATR] vowels. Archangeli & Pulleyblank (1994: 175) propose the constraint *[+high, -ATR] on the basis of the articulatory unnaturalness of the two features' co-occurrence.

2.2.3 Pre-fricative tensing and lengthening

Here I propose another natural rule for CF to account for the phenomenon of 'pre-fricative tensing.' In CF, [+high] vowels must be [+ATR] before tautosyllabic voiced fricatives:

/v, z, ʒ, ʁ/. The rule is formalised here:

(7) *Pre-fricative tensing rule*

[+high] → [+ATR] / _[+vce, +cont]]_σ

Data in (8) show that tautosyllabicity is a necessary condition for pre-fricative tensing. In these examples, a non-final [+high] vowel is followed by a non-tautosyllabic voiced continuant, yet the vowel can be [-ATR] by harmony:

(8) *Tautosyllabicity of pre-fricative tensing*

mʏ . zɪk	‘musique’	zʏ . ʁɪk	pr. name <Zurich>
vɪ . zɪt	‘visit’	fɪ . zɪk	‘physical’
pʊ . ʁɪt	‘rotten, fem.’	sɪ . vɪk	‘civic’
fʁɪ . ʒɪd	‘frigid’	kʊ . ʁʊs	‘anger, v.’
lɪ . vɪd	‘livide’	dʒɪ . vɪn	‘divine’
lɪ . ʁɪk	‘lyrical’	ʏ . ʁɪn	‘urine’

These data only support the tautosyllabicity condition if we assume that pre-fricative tensing is ordered after harmony. A non-tautosyllabic version of the rule is workable if we assume instead that pre-fricative tensing is ranked *before* harmony as in (9), but the assumption is not valid:

(9)

[+high] → [+ATR] / _[+vce, +cont] mʏ . zɪk

Harmony⁵¹ mʏ . zɪk

The assumption is not valid because pre-fricative tensing renders harmony opaque, in which case we must assume they are ordered in a counter-bleeding sequence. The opaque interaction is illustrated in (10) and is the topic of section 3:

⁵¹ The harmony rule will be defined in the following section.

(10) *Opaque interaction of harmony and pre-fricative tensing*

Laxing	mi . s <u>I</u> v
Harmony	m <u>I</u> . s <u>I</u> v
Pre-fricative	m <u>I</u> . s <u>i</u> v

Pre-fricative tensing masks the conditioning environment for harmony, yet harmony applies anyway. If pre-fricative tensing and harmony are in counterbleeding order, then pre-fricative tensing must be formulated tautosyllabically. The tautosyllabic formulation of this rule is important for the discussion of opacity in section 3.1.

It is possible that the quality of [+high] vowels before voiced fricatives is due to tongue root advancement caused by the difficulty of maintaining voicing for the length of the fricative. Voicing necessitates a pressure differential between the sub-laryngeal and supra-laryngeal cavities (Perkell 1969, Halle & Stevens 1969, 1971, Stevens 1998: 32). Constriction in the supra-laryngeal cavity may cause the pressure differential to neutralise, compromising the voiced quality of the fricative. The tongue root may be advanced to increase the volume of the supra-laryngeal cavity and actively counter this effect. Though volume expansion is most often effectuated by the passive compliance of the vocal tract walls (Stevens 1998: 466), active expansion by the articulators has also been observed. Progressive and anticipatory consequences of this effect have been observed on neighbouring vowels, causing phonologised co-articulation effects (see Trigo 1991 and Vaux 1996, 1998 for these effects in varieties of Armenian and Turkic, as well as other languages, e.g. Madurese, Buchan Scots English). Kohler (1981, 1984) also observes that voiced segments cause neighbouring vowel sounds to have lowering F_1 and raising F_2 formants near the vowel-consonant boundary, suggesting a displacement of the tongue body upwards and forwards in the supra-glottal cavity, possibly caused by advancement of the tongue root. This possibility has been proposed for CF in Poliquin (2004).

I will now turn to the relationship that exists between pre-fricative tensing and lengthening, which I have mentioned in the phonetic discussion above. Most previous authors have assumed that the tense quality of [+high] vowels before voiced fricatives is a synchronic consequence of the latter's lengthening effect on preceding vowels (see Dumas 1981, 1987, McLaughlin 1986, Ostiguy 1993, Walker 1984). Indeed, in final syllables, [+high] vowels that precede voiced fricatives are not only tense, but long as well:

(11)

sa.li:v	'saliva'	*sa.liv
ve.zy:v	pr. name	*ve.zyv
a.pɸu:v	'approve'	*a.pɸuv
e.gli:z	'church'	*e.gliz
e.kly:z	'locks'	*e.klyz
pœ.lu:z	'lawn'	*pœ.luz
vɛɸ.t ^s i:ʒ	'vertigo'	*vɛɸ.t ^s iʒ
de.ly:ʒ	'flood'	*de.lyʒ
ɸu:ʒ	'red'	*ɸuʒ
de.li:ɸ	'delirium'	*de.liɸ
se.ɸy:ɸ	'door lock'	*se.ɸyɸ
bõ.ʒu:ɸ	'hello'	*bõ.ʒuɸ

The assumption that tensing is related to lengthening is based on the fact that, cross-linguistically, there exists a correlation between length and tenseness: [+ATR] vowels tend to be long, while [-ATR] vowels tend to be short. The correlation only partially holds in CF however, which argues against the idea that such a correlation is encoded in the synchronic grammar. Firstly, a subset of CF [-high] vowels can surface before tautosyllabic voiced fricatives and are long, but not tense:

(12)

e.lɛ:v	‘pupil’	*e.le:v
e.pʁœ:v	‘test’	*e.pʁø:v
e.lo:ʒ	‘praise’	*e.lo:ʒ
i.no:v	‘innovate’	*i.no:v

Secondly, in non-final syllables, [+high] vowels must be [+ATR], but not long:

(13)

uz.bɛk	‘Uzbek’	*uz.bɛk	*u:z.bɛk
syz.rɛ̃	‘feudal lord’	*syz.rɛ̃	*sy:z.rɛ̃
iʁ.syt	‘hirsute’	*iʁ.syt	*i:ʁ.syt
fyz.laʒ	‘fuselage’	*fyz.laʒ	*fy:z.laʒ
iz.ra.ɛl	pr.name	*iz.ra.ɛl	*i:z.ra.ɛl

For these reasons, I maintain that lengthening and pre-fricative tensing are separate processes warranting separate rules whose conditioning environments are partially overlapping:

(14) a. *Pre-fricative tensing rule* (repeated from (7))
$$[+high] \rightarrow [+ATR] / _ [+vce, +cont]]_o$$

b. *Lengthening rule*

[-cons] → [+long] / _[+vce, +cont]#

2.3 Vowel harmony: one rule, two parameters

2.3.1 Data overview and formalisation of the vowel harmony rule

As mentioned in section 2.1, vowel harmony occurs in CF when a [+high] vowel in a non-final open syllable projects a [-ATR] autosegment. Non-final [+high] vowels may only project a [-ATR] autosegment if the final vowel within the same word projects a [-ATR] autosegment as a result of closed syllable laxing. This is illustrated in (1) repeated here as (15):

(15) a. *Autosegmental representation of CF vowel harmony*

[-ATR]	[-ATR]
fɪ.	lɪp

b. *Characteristics of CF vowel harmony*

Harmonic feature:	[-ATR]
Trigger:	Word final [+high] vowels in closed syllables
Target:	Non-final [+high] vowels in open syllables.
Domain:	Word

I have intentionally described CF vowel harmony in an atypical manner. Typically, vowel harmony is conceptualised as ‘spreading’ of a harmonic feature from a trigger vowel to a target vowel. I will argue here that CF vowel harmony is more appropriately conceived of as the result of a ‘feature copying rule’ à la Nevins (2004). Using the disyllabic word in (15) as an example, a non-final [+high] vowel copies the [-ATR] feature of the final [+high] vowel by projecting a [-ATR] feature of its own. The reason for conceiving of harmony this way is that CF vowel harmony can occur non-locally, and intriguingly, across intervening

[+high] vowels that are otherwise appropriate feature-bearing units: e.g. $\underline{i} . l i . s \underline{i} t$ (notice that the medial vowel is [+high], but has not undergone harmony). The formalisation of the harmony rule is given here:

(16) *Vowel harmony rule*

$$[+high] \rightarrow [-ATR] / _]_{\sigma} . (\sigma_0) . [+hi, -ATR] C(C)]_{\sigma} \#^{52}$$

There exists variation among speakers of CF as to how the harmony rule is applied. Application of the rule depends on the settings for two parameters: iterativity and directionality. Iterativity refers to whether or not a rule may apply more than once within the domain of application. Directionality refers to whether the rule starts applying from the left edge of the domain going towards the right, or whether it starts immediately to the left of the trigger and continues applying towards the left edge of the domain. I will expand on these concepts below.

This variation is only observable on words of three syllables or more. However the parameters are set, surface effects are the same for disyllabic words. In a word like [fɪ . lɪp], there is only one non-final vowel, so that if the iterativity parameter is turned off, its effects are not observable; again, whether direction of the rule's application is

⁵² I include a word boundary in the vowel harmony rule. I assume that the harmony trigger is always a final [+high] vowel that is obligatorily lax. Implicitly, I also assume that a [+high] vowel that is lax by optional closed non-final syllable laxing cannot trigger harmony. The assumption is only tentative, and reflects the fact that I have not tested words with this configuration, simply for lack of forms. To my knowledge, CF contains no morphologically simplex forms such as /iniɫme/, where a medial vowel can be optionally lax and thus be a potential trigger for harmony. The word must be morphologically simplex, because we know that harmony is possible in a morphologically complex word such as [t^sɪ . mɪd . mā] ('timidly'), where harmony can be applied in the stem: [t^sɪ . mɪd] ('timid'). It is also possible that learners might generalise the harmony rule from morphologically complex words to morphologically simplex ones, in which case the word boundary in my formalisation of the rule is unnecessary. I am open to any substantiated modification.

rightward or leftward makes no difference: however harmony applies, it will produce [fɪ. lɪp]. The different parametrisations on how the harmony rule is applied in CF allows us to extract the subset of attested grammars from the superset of logically possible grammars that may exist.

Let us look at the different patterns for trisyllabic words attested in chapter 2. In trisyllabics with only [+high] nuclei, speakers will vary as to which (and how many) non-final syllables will undergo harmony. There are three logically possible patterns, and all three are attested. Some speakers will lax all vowels in the word, producing forms like [ɪ. lɪ. sɪt]; I informally refer to this pattern as the ‘*across-the-board*’ pattern. Other speakers will only lax the leftmost [+high] vowel in the word, producing patterns like [ɪ. li. sɪt]; I will refer to these speakers as ‘*non-local*’ speakers. Thirdly, there are speakers who will only lax the [+high] vowel that is most adjacent to the ‘trigger,’ producing forms like [i. lɪ. sɪt]; I will refer to this pattern as the ‘*adjacent non-iterative harmony*’ pattern. Finally, since the harmony rule can be suppressed, there exists a fourth pattern where none of the non-final vowels harmonise: [i. li. sɪt]; this pattern will be referred to as the ‘*no harmony*’ pattern. The four patterns are illustrated with more examples below:

(17) *Four patterns of harmony: trisyllabic examples*

<i>No harmony</i>	<i>Across-the-board</i>	<i>Non-local</i>	<i>Adjacent</i>	
ʒy. ʁi. dʒɪk	ʒ <u>y</u> . ʁ <u>ɪ</u> . dʒɪk	ʒ <u>y</u> . ʁi. dʒɪk	ʒy. ʁ <u>ɪ</u> . dʒɪk	‘judicial’
si. ʁi. liɪk	s <u>ɪ</u> . ʁ <u>ɪ</u> . liɪk	s <u>ɪ</u> . ʁi. liɪk	si. ʁ <u>ɪ</u> . liɪk	‘cyrillic’
ny. tʁi. t ^s ɪf	n <u>y</u> . tʁ <u>ɪ</u> . t ^s ɪf	n <u>y</u> . tʁi. t ^s ɪf	ny. tʁ <u>ɪ</u> . t ^s ɪf	‘nutritional’
dʒi. si. plɪn	dʒ <u>ɪ</u> . s <u>ɪ</u> . plɪn	dʒ <u>ɪ</u> . si. plɪn	dʒi. s <u>ɪ</u> . plɪn	‘discipline’
li. mu. zin	l <u>ɪ</u> . m <u>u</u> . zin	l <u>ɪ</u> . mu. zin	li. m <u>u</u> . zin	‘limousine’

d ^z i.si.mɪl	d ^z <u>ɪ</u> .s <u>ɪ</u> .mɪl	d ^z <u>ɪ</u> .si.mɪl	d ^z i.s <u>ɪ</u> .mɪl	‘dissimulate’
i.ly.mɪn	<u>ɪ</u> .l <u>ɪ</u> .mɪn	<u>ɪ</u> .ly.mɪn	i.l <u>ɪ</u> .mɪn	‘illuminate’

In the case of trisyllabics, the number of attested patterns is equal to the number of logically possible patterns. In chapter 2, I showed that this is not the case for tetrasyllabics, suggesting that the grammar is constrained somehow. In a tetrasyllabic word like [si.mi.li.t^sɪd] ‘similarity,’ because there is one more non-final [+high] vowel in an open syllable, there are three potential target for harmony, which increases the number of potential patterns of harmony from three to seven. If we include the ‘no harmony’ pattern, there are eight logically possible patterns of harmony. Yet only four are attested, as illustrated here (‘✓’ indicates an attested pattern, while ‘✗’ indicates an unattested pattern):

(29) *Logically possible patterns of harmony for tetrasyllabics*

a. no harmony	si.mi.li.t ^s ɪd	✓
b. across-the-board	s <u>ɪ</u> .m <u>ɪ</u> .l <u>ɪ</u> .t ^s ɪd	✓
c. non-local	s <u>ɪ</u> .mi.li.t ^s ɪd	✓
d. adjacent (non-iter)	si.mi.l <u>ɪ</u> .t ^s ɪd	✓
e. local 2 iterations	si.m <u>ɪ</u> .l <u>ɪ</u> .t ^s ɪd	✗
f. non-local non-initial	si.m <u>ɪ</u> .li.t ^s ɪd	✗
g. non-local non-initial iterative	s <u>ɪ</u> .m <u>ɪ</u> .li.t ^s ɪd	✗
h. non-local & local non-iterative	s <u>ɪ</u> .mi.l <u>ɪ</u> .t ^s ɪd	✗

In chapter 2, I showed that the patterns attested for tetrasyllabics are the same as those attested for trisyllabics: ATB, non-local and adjacent non-iterative. Other patterns were judged unnatural by speakers of CF. I also showed in chapter 2 that speakers were consistent

in their preferences, suggesting that speakers' grammars are stable in their preferences, despite inter-speaker variation. Speakers who had a preference for the ATB pattern in trisyllabics maintained that preference for the ATB pattern in tetrasyllabics, and similarly for the non-local and adjacent non-iterative patterns. Just from these two types of words, we can see that there are two parameters according to which the harmony rule can apply. Firstly, there is clearly an iterativity parameter that separates ATB speakers from non-local and adjacent non-iterative speakers. Secondly, it appears that some speakers allow harmony to operate non-locally (non-local speakers) while others only allow harmony to be strictly local (adjacent non-iterative speakers). Judging only by tri- and tetrasyllabic words, it is not clear whether ATB speakers apply harmony from left to right ($[\rightarrow \text{I} . \rightarrow \text{I} \text{I} . \text{SIT}]$) or from right to left ($[\text{I} \leftarrow . \text{I} \text{I} \leftarrow . \text{SIT}]$). Parametrising one way or another brings about the same result for tri- and tetrasyllabics, but makes different predictions when we consider words whose medial vowel is neutral ([-high]).

For some CF speakers, harmony can also occur across transparent medial vowels. All [-high] vowels are potentially transparent, so that the non-final [+high] vowel in a word like <inéдите> can harmonise: $[\underline{\text{I}} . \text{ne} . \text{d}^{\text{Z}} \underline{\text{I}} \text{t}]$. I will argue however that transparency is not due to the nature of the vowel or to a gap in the phonological inventory — [-high] vowels can be [-ATR] in CF— rather, I will argue that the transparency effect is a result of different parametrisations for the harmony rule. My analysis is reminiscent of the one found for transparency effects in Wolof proposed in Archangeli & Pulleyblank (1994: 225-239). The transparency effect is illustrated in (30):

(30) *Harmony across transparent [-high] vowels*⁵³

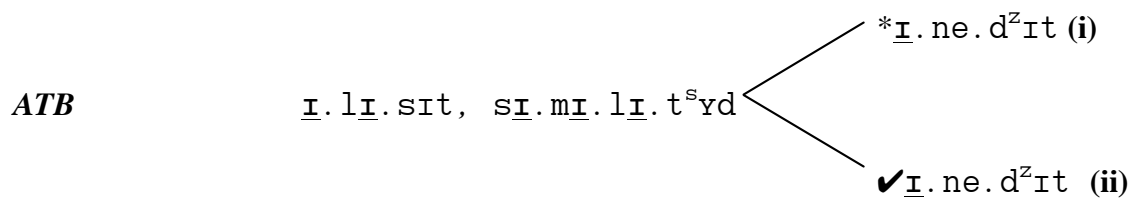
⁵³ The medial vowels used here are the only ones that are contrastive in this position.

gl <u>l</u> .se.ɸɪd	‘glycerid’	t ^s <u>l</u> .ɸa.nɪk	‘tyrannical’	<u>l</u> .pɔ.lɪt	pr. name
<u>l</u> .be.ɸɪk	‘Iberian’	bɸ <u>l</u> .ta.nɪk	‘British’	b <u>ɸ</u> .kɔ.lɪk	‘bucolic’
ʃ <u>l</u> .me.ɸɪk	‘chimerical’	kl <u>l</u> .ma.t ^s ɪk	‘climatic’	<u>l</u> .dɸɔ.lɪk	‘hydrolic’
n <u>ɸ</u> .me.ɸɪk	‘digital’	d ^z <u>ɸ</u> .ɸa.t ^s ɪf	‘durative’	<u>l</u> .ɸɔ.nɪk	‘ironic’
s <u>l</u> .ne.t ^s ɪk	‘kinetics’	fɸ <u>l</u> .ka.t ^s ɪf	‘fricative, masc.’	<u>ɸ</u> .tɔ.pɪk	‘utopian’
l <u>l</u> .be.lɪl	‘dragon-fly’	v <u>l</u> .bɸa.t ^s ɪl	‘vibratory’	pl <u>ɸ</u> .tɔ.nɪk	‘plutonian’
<u>ɸ</u> .te.ɸɪs	‘uterus’	k <u>ɸ</u> .ɸa.t ^s ɪf	‘curative’	<u>l</u> .pɔ.gɸɪf	‘hippogriff’

In chapter 2, I showed that all non-local speakers allowed non-final laxing in *inédite*-type words, whereas none of the adjacent non-iterative speakers, for whom harmony must operate strictly locally, allowed non-final laxing in *inédite*-type words. ATB speakers were split evenly with respect to these data, suggesting that across-the-board harmony may apply locally or non-locally.

In total, we have three attested patterns for trisyllabics and the same for tetrasyllabics, and two patterns for *inédite*-type words. If speakers’ behaviours were truly random, we should expect to find as many grammars as there are combinations of patterns. Though there are 32 logically possible combinations of patterns, only four are attested. I will assume that these four attested patterns are the only possible grammars of CF relative to harmony. The four attested patterns are given here:

(20)



Non-local $\underline{i}.li.s\dot{I}t, s\underline{i}.mi.li.t^s\dot{Y}d$ ————— ✓ $\underline{i}.ne.d^z\dot{I}t$ (iii)

Adj. non-iter. $i.l\underline{i}.s\dot{I}t, si.mi.l\underline{i}.t^s\dot{Y}d$ ————— * $\underline{i}.ne.d^z\dot{I}t$ (iv)

I assume that rules apply ‘directionally’ as opposed to ‘simultaneously.’ Simultaneity is the mode of rule application assumed in Chomsky & Halle (1968), viz. a rule applies simultaneously to all its targets within a string at the same time. Simultaneity is opposed to directionality, a mode of application by which a rule applies to one target at a time in a given direction (right-to-left and left-to-right). Simultaneity was first disputed in Johnson (1972) and Howard (1972). Johnson and Howard point out that simultaneity makes incorrect predictions in the case of some rules, and that some rules cannot be simultaneous if they are to be descriptively adequate. For example, Eastern Ojibwa (Algonquian) has a process of prevocalic glide formation (see Johnson 1970 and Bloomfield 1956) whereby /o/ and /i/ become [w] and [j] respectively before vowels. From an underlying form like /e.ni.ni.o.ak/, the glide formation rule must apply from right to left to derive the surface form [e.ni.ni.wak]. If the rule applied simultaneously (or from left to right), we would obtain the unattested output *[e.ni.njwak], since both the rightmost /i/ and the /o/ are prevocalic in the underlying form. Definitions of simultaneity and directionality are provided here:

(21) *Definition of simultaneity*

A rule R operating on string S applies simultaneously if all targets of R undergo R at the same time.

b. *Definition of directionality*

A rule R operating on string S applies in direction $X \rightarrow Y$, $X \neq Y$, and X and Y being the edges of a domain (e.g. word, phonological phrase, foot) if for segments S_x and S_y , S_x coming before S_y relative to $X \rightarrow Y$, R applies to S_x before S_y .

It should be noted that problems with simultaneous rule application can also be solved in an OT-type framework. My main reason for adopting a directional mode of rule application is the fact that it allows us to derive non-local harmony very easily. If we assumed that vowel harmony applied simultaneously to all potential target vowels we could only differentiate between the ATB and non-local patterns by positing two different rules of harmony. With the harmony rule I assume here (see (16)), a simultaneous application of the rule would target all non-final [+high] vowels in open syllables, producing the ATB pattern. The non-local pattern could not be derived if we assume only the rule in (16) and simultaneous rule application, because there would be no way to prevent the application of harmony to the medial vowel. The medial vowel could not be excluded from application on the basis that it is not an appropriate feature-bearing unit, since [+high] vowels can clearly be [-ATR] in this language. One could not exclude the medial vowel on the basis of Structure Preservation either (Kiparsky 1985, Itô & Mester 1986). Structure Preservation is a constraint on rule application which prevents a rule from applying if it introduces a non-contrastive segment⁵⁴. But even in the non-local pattern, the fact that the initial vowel has undergone harmony shows that the rule can violate Structure Preservation. My only argument is that if we are to use a rule-based framework, then we should assume that rules apply directionally. In and of

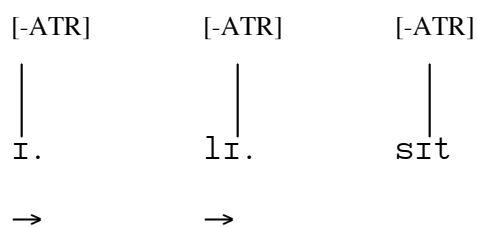
⁵⁴ For such an analysis of harmony in Khalkha Mongolian, see Steriade (1987a).

itself, the fact that rules can apply directionally does not constitute an argument against OT. I will argue however, that there exist a range of OT constraints that cannot account for the CF harmony facts specifically ('Agree,' 'Spread').

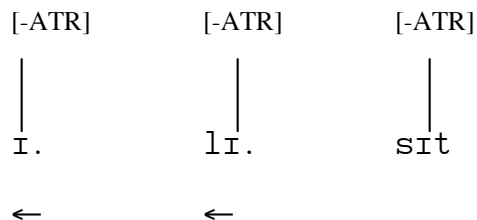
I will now illustrate how the harmony rule can apply given different settings of the iterativity and directionality parameters. Let us first assume that the rule applies iteratively, which yields the two ATB patterns, whether the rule starts applying from the left edge of the domain going right, or going left from the trigger:

(22) *ATB patterns*

a. *Going left to right*



b. *Going right to left*

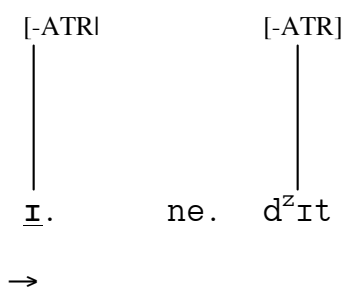


Since the final [+high] vowel projects a [-ATR] feature as a result of closed syllable laxing, the vowel harmony rule can apply. If the rule is parametrised to apply from left to right as in (22)a, the rule first identifies the leftmost [+high] vowel as a target, and applies by inserting a [-ATR] feature. Because the rule is [+iterative], it moves on to find the next target, and inserts a [-ATR] feature on the medial vowel as well. If the rule is parametrised to apply

from right to left, then it first applies to the medial vowel and moves on to the next until all vowels have undergone the rule.

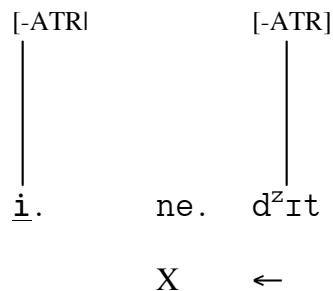
As mentioned above, though right-to-left or left-to-right application of an iterative vowel harmony rule produces the same outputs for tri- and tetrasyllabics, the different parametrisations make different predictions as *inéдите*-type words are concerned. If the rule applies from left to right, we expect the initial [+high] vowel to lax:

(23) *Left-to-right application in 'inéдите'-words*



If the rule applies from right to left however, it first encounters a neutral vowel, and does not move on to the next potential target, even though it is iterative:

(24) *Right-to-left application in 'inéдите'-words*



I am assuming that the vowel harmony rule scans the [-cons] tier, and, when it encounters a [-high] vowel, that the rule simply ‘gives up’ searching for a target. This is a constraint on rule application which I will henceforth call the ‘all-or-nothing’ principle of rule application. Informally, the principle states that, if a rule is to apply, it cannot have failed to apply

previously. In the case of an iterative rule, the iterative application of a rule depends on previous successful application. In (24), the right-to-left harmony rule cannot apply to the first vowel it encounters on the [-cons] tier because it is [-high]. Since the rule cannot apply, it stops applying altogether, even though there are appropriate targets to the left of the neutral vowel. The principle is formally stated here:

(25) *The ‘all-or-nothing’ principle of rule application*

A rule R can apply to a segment S_y iff it meets either of the following conditions: a) it has not applied before, or b) it has successfully applied to a segment S_x coming before S_y relative to direction $X \rightarrow Y$.

The all-or-nothing principle makes some precise predictions concerning some types of data⁵⁵. For instance, for a word like [i . l e . ʒ i . t^sɪm] (‘illegitimate’), which contains a medial neutral vowel flanked by two non-final [+high] vowels, I predict that an ATB speaker who applies harmony from left to right (✓ɪ . lɪ . sɪt , ɪ . n e . d^zɪt), should produce [ɪ . l e . ʒɪ . t^sɪm], but not *[ɪ . l e . ʒɪ . t^sɪm]. Even though the speaker will lax all potential targets for harmony in tri- and tetrasyllabics, as well as *inédite*-words, it is predicted that, by the all-or-nothing principle, a word like *illégitime* should be an exception to that general fact about left-to-right ATB outputs. If this is true, then ATB speakers of this type only apply harmony ‘across-the-board’ to a point. Similarly, right-to-left ATB speakers should accept only [i . l e . ʒɪ . t^sɪm] and not *[ɪ . l e . ʒɪ . t^sɪm]. As far as this could be checked with the two ATB speakers, HRZ and JB, this appears to pan out. In this case,

⁵⁵ The ‘all-or-nothing’ principle proposed here is similar to the ‘defective intervention principle’ proposed in Nevins (2004: 117). Using Nevins’s terminology, the medial vowel in CF is a ‘defective intervener,’ in that it fails to meet the precondition on CF harmony targets that they be [+high]. As a result, the search for an appropriate target terminates in failure. The ‘defective intervention principle’ is formulated in such a way that defective interveners are assumed to be inappropriate ‘sources of valuation’ (roughly, harmony triggers). In the present case, the defective intervener is assumed to be an inappropriate target for harmony. Essentially, I am assuming that the ‘all-or-nothing’ principle and the ‘defective intervention principle’ are one and the same, but applying to the search for potential targets and triggers, respectively.

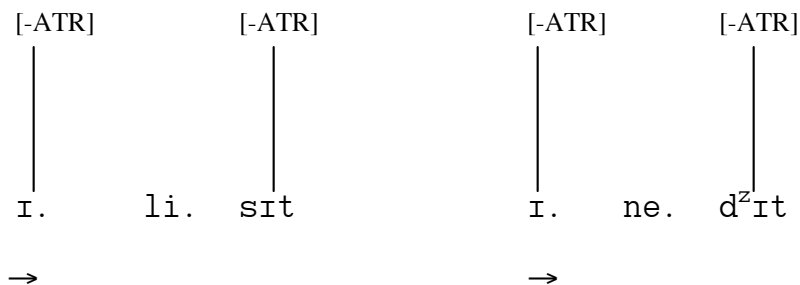
we are faced with a minor empirical problem however. To my knowledge, *illégitime* is the only word with this configuration in the language. This hypothesis could only be tested with the help of nonce words. This is to be the topic of further investigation.

It should be stated that the all-or-nothing principle does not make the prediction that all intervening segments to which a rule cannot apply are necessarily grounds for a rule to stop applying, or for a search for a particular target or trigger to end in failure. There are some well-known cases of transparency (see Finnish, Hungarian) where two vowels can harmonise though they are separated by a neutral, transparent vowel. Whether a search for a trigger or target will end in failure depends on how the rule is formulated. Following Nevins (2004), a Finnish suffix vowel is underspecified for the feature [back], and ‘inherits’ its value for [back] from the closest stem vowel that is contrastive for [back].

Let us now turn to the two non-iterative patterns. These patterns share a negative value for the iterativity parameter, but are differentiated on the basis of directionality. Non-local speakers apply the harmony rule from left to right, while adjacent non-iterative speakers apply the rule from right to left, as illustrated here:

(26)

a. *Left to right [-iterative] speakers (non-local)*



b. *Right to left [-iterative] speakers (adjacent non-iterative)*



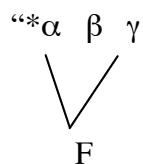
i.	li.	sit	i.	ne.	d ^z it
		←		X	←

In the case of non-local speakers, harmony first applies to the initial vowel, and because it is non-iterative, does not apply to the medial vowel, which retains its [+ATR] quality. I assume that [+high] vowels are underlyingly [+ATR] based on the cross-linguistically motivated hypothesis that [+ATR] is the default value for [ATR] as [+high] vowels are concerned (see Archangeli & Pulleyblank 1994: 175). As for adjacent non-iterative speakers, the rule applies to the target word most adjacent to the trigger, and also stops applying because it is [-iterative], yielding the adjacent non-iterative pattern. Again, the all-or-nothing principle of rule application comes into play. Conceivably, adjacent non-iterative speakers could lax the initial vowel in *inédite*, since it is the most adjacent target to the trigger. Assuming that the rule scans for targets on the [-cons] tier, it encounters the medial [-high] vowel and fails to apply. Because it has failed to apply, it cannot apply to the initial vowel by the all-or-nothing principle.

2.3.2 On locality in terms of directionality

In terms of locality, CF vowel harmony essentially shows two patterns. On the one hand, there are the ATB and adjacent non-iterative patterns, which can be assumed to operate under the principle of locality. I will assume that a structure satisfies ‘locality’ if it does not exhibit a ‘gapped structure.’ I will assume the definition of ‘gapped structure’ provided in Ni Chiosain & Padgett (2001), provided below:

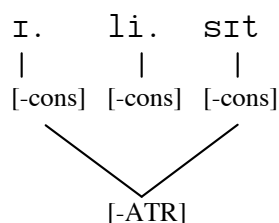
(27) *Gapped structures*



A featural event F is convex [gapped] iff it satisfies the following condition: For all segments α , β , γ , if α precedes β , β precedes γ , α overlaps F and γ overlaps F, then β overlaps F.” (Ni Chiosain & Padgett 2001: 127)

This is of course assuming that vowel harmony only operates on the [-cons] tier, in which case, only vowels are relevant. Intervening consonants do not ‘count’ as intervening β -elements as in (27). Even if we assume that vowel harmony operates only on the [-cons] tier, a form of the non-local pattern represents a gapped structure:

(28)



One option would be to simply modify such a locality constraint, or subject it to parametric variability. Choosing this option would result in some serious consequences however. As Archangeli & Pulleyblank’s entire (1994) work (henceforth, A&P) shows at length, the existence of this constraint is very well motivated cross-linguistically. As they also point out though, some languages do seem to exhibit gapped structures; these surface when medial vowels appear to be transparent to ‘spreading’ effects like harmony. Rather than proposing that locality constraints be modified or weakened, A&P propose that harmony processes can produce structures that are marked, but do not violate locality conditions.

A&P (1994: 225-239) make this case for Wolof, in which [+high] vowels are transparent to a harmony process targeting [-high] vowels. In Wolof, [-high] vowels agree for [ATR]. Only [-high] vowels exhibit alternations in [ATR]. Wolof has the following surface vowels. With

the exception of [+high] vowels, vowels are grouped in pairs differentiated only by their value for [ATR]. These vowels exhibit conditioned alternations:

(29) *Wolof surface vowels*

	[high]	[low]	[back]	[ATR]
i	+	-	-	-
u	+	-	+	-
e	-	-	-	+
ɛ	-	-	-	-
o	-	-	+	+
ɔ	-	-	+	-
ə	-	+	-	+
a	-	+	-	-

The following examples in (30), adapted from A&P (1994: 227) show that mid vowels within a word must share the same value for [ATR]:

(30) *[+ATR] harmony in Wolof [-high] vowels*

[-high, +ATR]. . . [-high, +ATR]

- | | |
|-----------|--------------------|
| a. jəndəl | ‘buy for’ |
| b. leebəl | ‘tell stories for’ |
| c. footəl | ‘do laundry for’ |
| d. gənə | ‘be better in’ |
| e. reere | ‘be lost in’ |

f. doore	‘hit with’
g. bëggoon	‘wanted’
h. reeroon	‘was lost’
i. nowwon	‘came’

(31) *[-ATR] harmony in Wolof [-high] vowels*

[-high, -ATR] . . [-high, -ATR]

a. waxal	‘speak for’
b. bëyal	‘cultivate for’
c. wooral	‘fast for’
d. xamε	‘know in’
e. dεmε	‘go with’
f. xoolε	‘look with’
g. takkoon	‘tied’
h. rεεroon	‘had dinner’
i. joxoon	‘gave’

In Wolof, the initial [-high] vowel’s value for [ATR] determines the value for [ATR] of all [-high] vowels to its right. [+high] vowels, which are always [+ATR], are transparent to this process. This is illustrated in the following examples:

(32) *Transparent [+high] vowels in Wolof*

[+ATR] . . [+high] . . [+ATR]

a. gεstuleen	‘do research!’
--------------	----------------

- b. toxilenn ‘go & smoke!’
 c. tərīwoon ‘went & slept’
 d. yobbujinə ‘he went to bring’

[+ATR]...[+high]...[+ATR]

- e. tɛkkilɛɛn ‘untie!’
 f. mɔytulɛɛn ‘avoid!’
 g. sɔppiwulɛɛn ‘you have not changed’
 h. yɛbbijina ‘he went to unload’

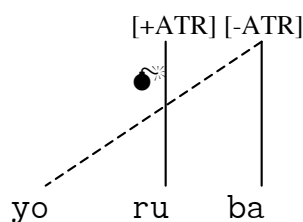
[+high] vowels do not alternate for [ATR], but do not prevent [-high] vowels on either side of them to share the same value for [ATR]. The Wolof case contrasts with Yoruba, in which [+high] vowels block the spreading of [ATR]. As in Wolof, Yoruba [-high] vowels in the word domain typically agree for [ATR]. In Yoruba though, it is the final vowel that determines the value for [ATR] of the vowels to its left. [+high] vowels, like in Wolof, are always [+ATR], but unlike in Wolof, they block leftward spreading of [-ATR] (Yoruba examples also adapted from A&P (1994: 242)):

(33) *Opaque [+high] vowels in Yoruba*

- a. odidɛ ‘Grey Parrot’ *ɔdidɛ
 b. yoruba ‘Yoruba’ *yɔruba
 c. elubɔ ‘yam flour’ *ɛlubɔ
 d. ojiya ‘Daniellia Ogea’ *ɔjiya

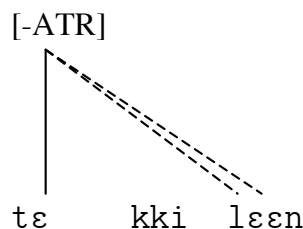
A&P report that the autosegmental accounts for these phenomena involve specification. Opacity in Yoruba is accounted for by assuming that the medial [+high] vowel projects a [+ATR] feature, which blocks the [-ATR] feature from spreading leftward:

(34) *Autosegmental account of Yoruba*



In Wolof on the other hand, transparency is accounted for by assuming that the medial [+high] vowel does not project a [+ATR] feature, thus allowing spreading of the initial [ATR] feature to spread:

(35) *Autosegmental account of Wolof*



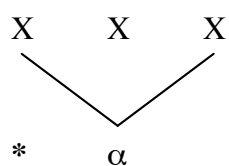
As A&P point out however, such an account crucially relies on the independent motivation that Yoruba [+high] vowels are specified for [+ATR], while Wolof [+high] vowels are not. On the one hand, they report that there is ample evidence that in fact, Yoruba [+high] vowels do not project an [ATR] feature at the stage of the derivation where harmony is applied (Pulleyblank 1988). Conversely, Wolof underspecification of [+high] vowels is only motivated insofar as it correctly predicts these transparency effects. In short, A&P argue that not all cases of neutrality can be accounted for by stipulating conditions on representation, since these are not necessarily independently motivated. A&P propose instead that neutrality can be derived by *contextual conditions on rules*. My account of the different CF grammars

is largely inspired by this approach, as it predicts the existence of all three harmony patterns found in CF. It should be noted that A&P's approach does not exclude the possibility that neutrality effects can be accounted for using the autosegmental approach. Surface neutrality effects, they argue, can be derived differently from language to language. In the case of Wolof and CF harmony, neutrality effects can be derived using conditions on 'insertion' rules⁵⁶, since the underspecification of [+high] vowels cannot be independently motivated.

According to A&P's proposal, there exist five possible types of autosegmental representations, four of which are well formed (A&P 1994: 35):

(36) *Logically possible autosegmental representations*

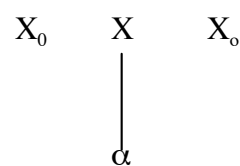
a. *Gapped structure*



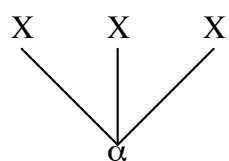
b. *Floating*



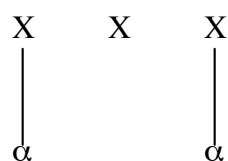
c. *Linked*



d. *Plateau*



e. *Twin Peaks*

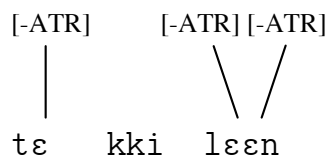


Among these structures, the gapped structure is avoided at all cost. Other structures can be said to have a sort of implicational relationship. A twin peaks structure is well formed, but will only be formed if multiple linking of the α -element results in a gapped configuration.

⁵⁶ 'INSERT/F-ELEMENT' in A&P's terminology.

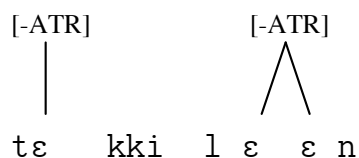
In Wolof, an iterative insertion rule can insert a [-ATR] feature on every [-high] vowel starting from the left. So, at a certain level, we get the following representation for the word ‘untie!’:

(37)



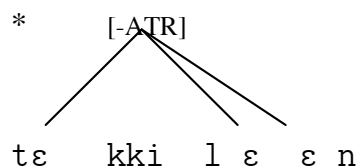
This structure is well formed to the extent that it is not gapped, but to use an OT term, it is not ‘optimal.’ The optimal structure is for the [-ATR] autosegments to the right to conflate, producing the following twin peaks structure:

(38)



Had all [-ATR] conflated, we would have obtained a gapped structure, which is ill-formed:

(39)



The Wolof thus operates under a number of conditions:

(40) *Conditions on Wolof insertion rule*

- a) The rule only targets [-high, -low] vowels.
- b) The rule inserts a [-ATR] feature.
- c) The rule is fully iterative.
- d) The rule operates from left to right.

e) The rule cannot result in a gapped structure (universal)

The analysis I propose for CF harmony is largely similar, though the conditions are somewhat different:

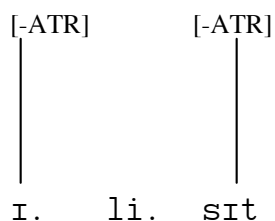
(41) *Conditions on CFVH insertion rule (non-local pattern)*

- a) The rule only targets [+high] vowels.
- b) The rule inserts a [-ATR] feature.
- c) The rule is not iterative.
- d) The rule operates to the left of a final [+high, -ATR] vowel.
- e) The rule operates from left to right.
- f) The rule cannot result in a gapped structure (universal).

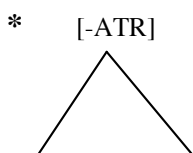
Given an input like /ilɪsɪt/, the vowel harmony rule applies after closed syllable laxing has applied to the final vowel. Since closed syllable laxing has applied, condition d) is met, and vowel harmony can apply, starting from the left edge of the domain (condition e)). We obtain the following twin peaks structure in (42)a:

(42)

a.

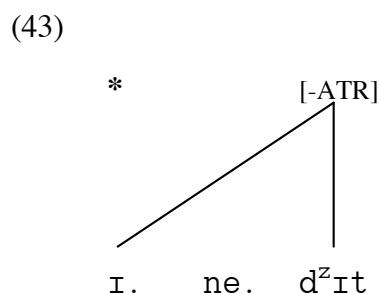


b.



ɪ. li. sɪt

Like in Wolof, the insertion does not result in a gapped structure, which I assume are universally banned ((42)b). Instead we obtain a twin peaks structure, which yields the non-local output. As mentioned above, A&P's model does not preclude the existence of 'spreading' rules, which essentially amount to creating association links between a single feature and more than one segment. Spreading rules thus differ from insertion rules, in that spreading rules will never result in the production of a twin peaks structure. This is because they assume only one autosegment, not the insertion of multiple autosegments which may or may not conflate thereafter. This makes the correct prediction as to how adjacent non-iterative speakers handle *inédite* words. Going from right to left, if an association link were created between the [-ATR] autosegment and the initial vowel in this case, the resulting structure would be gapped:



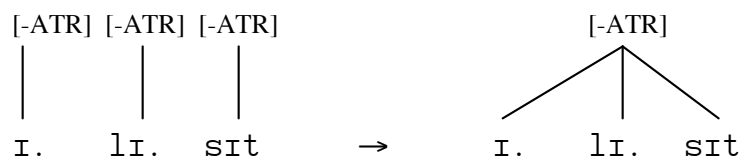
This predicts that adjacent non-iterative speakers should not accept non-final laxing in *inédite* words, which is true to fact.

A&P's model also predicts that the same pattern can be obtained on the surface by two different kinds of rules. This is illustrated by the two ATB patterns. I remind the reader that ATB speakers are divided with respect to their acceptance of non-final laxing in *inédite*-type words. We expect ATB speakers to accept non-final laxing in *inédite* words if harmony is an

insertion rule. In this case, ATB speakers insert [-ATR] autosegments iteratively on all [+high] vowels. [-ATR] features can then conflate, producing a plateau structure as in (44)a. In the case of *inéдите* words, conflation into a plateau structure would produce a gapped structure, so that the resulting structure is of the twin peaks variety ((44)b):

(44) *Insertion rule ATB speakers*

a.



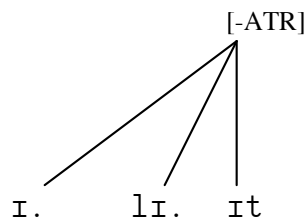
b.



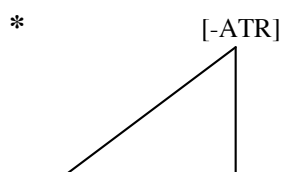
The ATB pattern can also be obtained by a spreading rule, but in this case, we expect such speakers not to accept non-final laxing in *inéдите* words, since the resulting structure would be gapped:

(45) *Spreading rule ATB speakers*

a.



b.



ɪ. ne. dʒɪt

The essential difference between my analysis and A&P's is the fact that they would attribute the difference between the two ATB patterns to the application of different types of rules, rather than to directionality of application.

Importantly, A&P's model correctly that some tetrasyllabic patterns should be unattested. Attested and unattested patterns are repeated here:

(46) *Logically possible patterns of harmony for tetrasyllabics*

a. no harmony	si.mi.li.t ^s ɪd	✓
b. across-the-board	s <u>ɪ</u> .m <u>ɪ</u> .l <u>ɪ</u> .t ^s ɪd	✓
c. non-local	s <u>ɪ</u> .mi.li.t ^s ɪd	✓
d. adjacent (non-iter)	si.mi.l <u>ɪ</u> .t ^s ɪd	✓
e. local 2 iterations	si.m <u>ɪ</u> .l <u>ɪ</u> .t ^s ɪd	✗
f. non-local non-initial	si.m <u>ɪ</u> .li.t ^s ɪd	✗
g. non-local non-initial iterative	s <u>ɪ</u> .m <u>ɪ</u> .li.t ^s ɪd	✗
h. non-local & local non-iterative	s <u>ɪ</u> .mi.l <u>ɪ</u> .t ^s ɪd	✗

A&P's model predicts that the unattested patterns for tetrasyllabics should never surface.

This is provided we assume that conditions on rules are equivalent to bivalent parameters. If a rule is iterative, it will iterate until it runs out of targets. If it is not, it will apply only once. If a rule applies in a given direction $X \rightarrow Y$, it can only apply in direction $X \rightarrow Y$, not $X \leftarrow Y$.

Y and $Y \rightarrow X$ at the same time. At root, A&P's model is therefore not different from my proposal in its predictions, but different in its notation. The parameters that I assume, [iterative] and [LR, RL], are essentially conditions on the application of single rule. In this sense, the proposal that I make is perhaps more economical insofar as I assume only one kind of rule. The harmony rule I assume for all speakers, from A&P's perspective, is an insertion rule. The difference in behaviour is predicted by the two settings for the directionality parameter.

One important difference between A&P's framework and my own is due to the differences in the languages we consider. In their analysis of Wolof, A&P assume that all mid vowels in a word like [tɛkki lɛɛn] project a [-ATR] feature by the same rule. A&P take for granted that, to apply non-locally, a rule must be iterative. They thus make the prediction that, in a word with the configuration $XYZ_1Z_2Z_3$, where Y is not a bearer of some feature α , that, if X and Z_1 bear the feature α , then so should Z_2 and Z_3 . If Y is transparent, then both X and Z_1 inherit α by an insertion rule. Since both X and Z_1 bear α as a result, the rule is iterative, and if the rule is iterative, then it should apply to Z_2 and Z_3 as well, since we know Z elements are bearers of α . I believe A&P's prediction to be correct, insofar as I maintain iterativity comes in only two values. Iterativity is never partial. A&P do not consider however that the α -element can be projected by X as a result of a preceding rule, in which case the rule by which Z_1 inherits its α -element need not be iterative. This is the case in CF: I do not consider that, for the adjacent non-iterative pattern ([i . lɪ . sɪt]), that the medial vowel and the final vowel project a [-ATR] feature by the same rule, since two rules can be independently motivated. Since this is so, it is possible to obtain a string like $XYZ_1Z_2Z_3$, where only X and Z_1 project α by a given rule.

Importantly though, A&P's analysis of the Wolof data predicts that a pattern like non-local harmony should be possible, a prediction that is verified by CF. A&P remark that insertion

rules are more marked than spreading rules, leading them to predict that such a pattern should be less common, a prediction that is also verified.

2.3.3 On Nevins (2004) and predictions for Hungarian and Finnish harmony

This section will provide a general overview of the common points and differences that exist between the general account of harmony processes proposed in Nevins (2004) and the present account for CF harmony. I will show that the present account of CF harmony assumes some of the same theoretical mechanisms as assumed in Nevins (2004), and thus makes the same predictions for Yoruba and Wolof, but also Hungarian- and Finnish-type harmony systems. I will also show that the present account includes a key addition to Nevins's theory, one that allows us to predict CF harmony of the non-local type.

Nevins (2004) proposes a 'target-centric' theory of harmony (and dissimilation), in which targets are seen as segments underspecified for a given feature-value, and 'in need' of valuation. Targets are marked for needing valuation, and the harmony rule, like in the present account, is assumed to be a feature-copying rule. Application of the feature-copying rule initiates a search for the closest 'source of valuation' from which the target obtains a value for the (dis)harmonic feature. I say '(dis)harmonic' because the rule may copy the feature-value of the source of valuation, which results in harmony between target and source, or the *opposite* value of the feature, which results in dissimilation. This is one of the advantages of Nevins's proposal: harmony and dissimilation share the same formal mechanisms, thus capturing the fact that they share similar behaviours. These mechanisms, namely, the search for a source of valuation and feature-copying, are well illustrated by a simple example from Finnish (drawn from Nevins (2004)). In Finnish, most suffix vowels assimilate the value for [back] of the vowel that immediately precedes them (unless that vowel is neutral, i.e. [i] and [e]). Most suffixes thus have two allomorphs, one with a [+back] vowel and one with a [-back] vowel, whose distribution is determined by the stem-

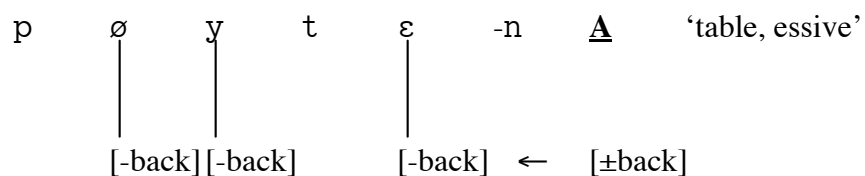
vowel that precedes them. Finnish has the following vowel system (symbols are from the International Phonetic Alphabet for internal consistency):

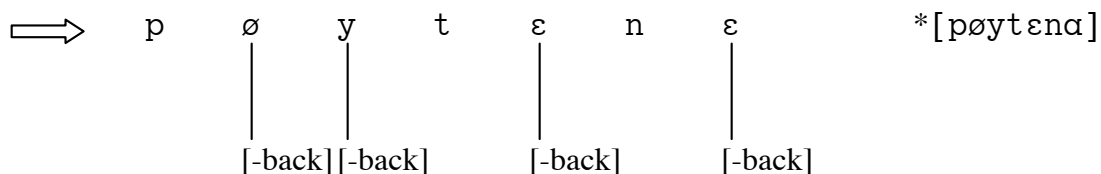
(47) *Finnish vowel system*

	[back]	[high]	[low]	[round]
i	-	+	-	-
e	-	-	-	-
ɛ	-	-	-	-
y	-	+	-	+
ø	-	-	-	+
u	+	+	-	+
o	+	-	-	+
ɑ	+	-	+	-

According to Nevins, the vowel of a suffix, like the essive suffix [nɑ] or [nɛ], has underlying representation that is underspecified for the feature [back]: ‘-nA.’ The value for [back] is copied from the closest source of valuation, which is the immediately preceding vowel in the stem. The feature-copying rule instigates a search for the closest source of valuation as follows:

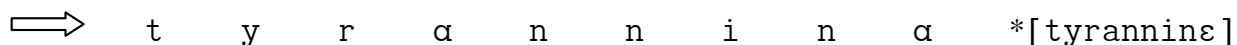
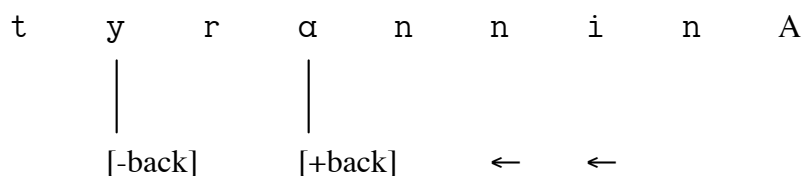
(48)





The suffix vowel in Finnish searches for a value for [back] and copies it from the closest source, which, in this case is the immediately preceding vowel. There are cases in Finnish though where the closest source is not the immediately preceding vowel. This occurs when the vowel immediately preceding the suffix is neutral, such as in the word [tyranni] ('tyrant'). As mentioned above, neutral vowels in Finnish are [i] and [e]. It just so happens that in Finnish, [i] and [e] are not contrastive for [back]. Nevins proposes that in Finnish, a potential source of valuation (a 'determinant') must be contrastive for the harmonic value in order to be an appropriate source of valuation. In the case of 'tyrant,' we get the following derivation:

(49)



The closest source of valuation is the vowel closest to the suffix vowel that is contrastive for back. The suffix vowel thus copies the feature [+back] from the medial [ɑ], though the vowel that is linearly closest to the suffix vowel is [-back], phonetically, but not contrastive for [back]. This predicts that if the closest vowel contrastive for [back] were a front vowel, then the suffix vowel should be [-back]. This prediction checks out. In the word for

‘martyr,’ [martyri], the medial vowel is contrastive for [back] and [-back]. In the essence, the resulting surface form is [martyriɛ], not *[martyriɔ]. The transparency of the neutral vowels in Finnish is encoded in the formulation of the harmony rule, which specifies that the search for a source of valuation only includes determinants which are contrastive for the harmonic feature. If the harmony rule specified that the search for a source of valuation included all determinants projecting the harmonic feature, regardless of the feature’s contrastive status, we would predict that /martyri/ and /tyranni/ would surface as [martyriɛ] and [tyranniɛ], respectively. If the search for a source ‘saw’ all instances of [back], the search would end with the immediately preceding vowel, which, in effect, would block the search from going any further.

It follows from Nevins’s account that transparency or opaqueness of neutral vowels stems from whether or not the feature-copying rule sees only contrastive features, or all features. Thus, the transparency of [+high] vowels in Wolof (see previous section) is accounted for by the assumption that the harmony rule in Wolof instigates a search only for contrastive values of [ATR]. When a trigger (or ‘source’) and a target are separated by a [+high] vowel ([+high] vowels are not contrastive for [ATR] in Wolof), as in [tɛkkilɛɛn] (‘untie!’), both trigger and target share the feature [-ATR]. In standard Yoruba though, the harmony rule instigates a search for all instances of [ATR], contrastive or not. So, in a word like /Odide/ (‘grey parrot’), where the initial vowel is unspecified for [ATR] (harmony is regressive in Yoruba), the initial vowel is [+ATR] on the surface, because the search for a source of valuation sees the [+high] vowel, even though it is not contrastive for [ATR]. The search for a source of valuation terminates in failure, and the resulting surface form for ‘grey parrot’ is [odide]. The initial vowel is not [+ATR] on the surface because the [+high] vowel is non-contrastively [+ATR], it is because, in the case of a failed search, the target inherits the default value of the feature by the Elsewhere condition.

The ontology of opacity and transparency in Nevins's account is different from the one they have in my account of CF neutral vowels, but the predictions for Yoruba and Wolof are the same. The reason for this is that the CF data presents a case of transparency that cannot be accounted for using Nevins's approach. Considering the non-local case of harmony in CF, where the initial and final [+high] vowels of a word like [ɪ . l i . sɪ t] share the feature [-ATR], we might consider that the initial vowel is the vowel in need of valuation; specifically, the target vowel must find the feature [-ATR]. Whether the harmony rule considers only determinants that are contrastive for [ATR], or all determinants, makes the same prediction. If the search considers only those determinants that are contrastive for [ATR], the search will terminate in failure since none of the vowels are contrastive for [ATR] in a word like /ilɪsɪt/. If the search considers all determinants, it will first consider the medial vowel and terminate in failure because the medial vowel is defective in not being [-ATR]. Since in both cases the search terminates in failure, we predict that the form [ɪ . l i . sɪ t] is impossible.

Building on Nevins's contribution, I propose that the ontology of opacity and transparency must be different in the CF case simply because the CF feature-copying rule differs from the one applied in the cases considered in Nevins (2004). The difference comes in one key respect. In the Finnish, Yoruba and Wolof cases, the harmony rule targets a specific segment (the segment in need of valuation, marked as such in the underlying representation), and initiates a search for a possible source. In a given string, there can be more than one logically possible source, but the actual source of valuation is found at the end of a principled search. The search is 'principled,' inasmuch as it always starts with the determinant that is closest to the target, at which point the search may or may not be successful. In the cases reviewed by Nevins, the search always targets a source of valuation. The target is always known, but the source is unknown. The situation happens to be the

reverse in CF. The source is known; the source of valuation is always a final [+high] vowel that is [-ATR] by derivation. What is unknown is the target. Given an appropriate source, the rule initiates a search for a target. Given the CF case, it appears that the search for a target need not start with the determinant that is closest to the source. But why?

I see three possible reasons with varying degrees of desirability:

1) Search for a source is always local, but search for a target can be non-local, a difference hard-wired into UG. This possibility is not desirable; I see no causal link between the nature of a target and a source, and the possibility for non-local search.

2) It is possible that there are non-local searches for sources of valuation, yet no such cases are attested. This possibility is more desirable, since it is consistent with the fact that both types of searches are highly marked. But it is unclear why it should be marked.

3) Non-local searches are possible in both cases, but only if the learner has reason to believe that a non-local search is possible; otherwise, the default option is that the search starts locally. What are those reasons? As mentioned in chapter 2 of this work, CF has a syncope process that targets medial [+high] vowels that are between two voiceless consonants: e.g. /d^zifisil/ → [d^zif.sɪl] ('difficult'). As a result of syncope, the initial vowel can be in a closed syllable, where it can lax: [d^zɪf.sɪl]. It is unclear in this case whether the initial vowel is lax as a result of optional non-final closed syllable laxing, or harmony. One way or another, the learner knows that in this case, without a doubt, the initial vowel can be lax, because s/he has evidence from other words that non-final closed syllable laxing is possible. Now, the learner is also aware of the non-syncoated version of such words from careful speech, where it surfaces as [d^zi.fi.sɪl]. Since the learner cannot tell whether the initial vowel is lax because of harmony or laxing in the syncoated version, the learner

can assume that initial vowels, in words that have an appropriate trigger for harmony, can be lax, but that the medial vowel is not lax. With this assumption, the learner can extend the rule to words where syncope is not possible: e.g. [sɪ.mi.li.t^sɪd] ‘similarity.’

Phonologically, this translates as searching for a non-local target. In summary, non-local searches are possible, but only if the PLD is such that the stimulus can be interpreted this way. For this interpretation to be possible, the PLD must meet a certain number of conditions (e.g. have enough forms that can be interpreted as displaying non-local harmony), the greater the number of conditions, the more unlikely the assumption, and the less likely the grammar.

At this point, I will not commit to any of these possible reasons. They are the topic of on-going research.

Still, the proposal that searches are inherently directional makes specific predictions about certain kinds of data, namely multisyllabic affixes that would be the target of harmony as found in Finnish or Hungarian. For example, let us take the word for ‘table’ in Hungarian, [ɑs.tɑl], and a hypothetical trisyllabic affix /-AtAkAk/, whose three vowels are underspecified for [back]. In Hungarian, much like in Finnish, suffixes take their value for [back] and [round] from the closest preceding contrastive value for [back] and [round]. For example, the plural suffix is [ok] for ‘tables,’ [ɑstɑlok], because [ɑ] is [+back, +round]. For [ɟ^jerək] (‘child’), the plural is [ɟ^jerəkək], because the stem-final vowel is [-back, -round]. For [iʃmərøʃ] (‘acquaintance’), the plural is [iʃmərøʃæk], because the stem-final vowel is [-back, +round]. What would happen in our hypothetical case, assuming the trisyllabic affix, like the Hungarian plural, has three allomorphs:

[ok]/[ek]/[æk]? Let us also assume that [+round] is the marked value for [round], and since there are no back unrounded vowels in this pseudo-Hungarian, the ‘default allophone’

is [ek]. Let us also assume that the domain of search for targets is the suffix, and search for a source always starts from the last identified target (in other words, we don't allow for non-local searches of sources of valuation).

In the hypothetical case, there are two unknowns. Firstly, there are multiple targets, and secondly, there are multiple sources. The derivation is illustrated here:

(50)

Directionality parameter setting for **target** search: L-to-R

Directionality parameter setting for **source** search: R-to-L

Target search 1: α s t α l -A t A k A k

→

Source search 1: α s t α l -A t A k A k

←

Valuation 1: α s t α l -o t A k A k

Target search 2: α s t α l -o t A k A k

→

Source search 2: α s t α l -o t A k A k

←

Valuation 2: α s t α l -o t o k A k

Target search 3: α s t α l -o t o k A k

→

Source search 3: α s t α l -o t o k A k

←

Valuation 3: α s t α l -o t o k o k
 Output: [αstαlotokok]

Assuming we start by searching for possible targets, we might start in one of two directions, given our directionality parameter. Starting from the left, we encounter the leftmost A, which needs valuation. We then look for the closest possible source of valuation, which in this case can be to the right or left. If we search for a source going towards the left, we find the stem-final [α], specified for [+back]. By the feature-copying rule, the leftmost target also becomes [α], yielding [αs . tα . lo . tA . kAk]. Now searching for a target, again, going towards the right. We find the medial A. Looking for the closest source of valuation, looking left, we find the first suffix vowel, an [o]. By the feature copying rule, we obtain [αs . tα . lo . to . kAk]. If the derivation proceeds in the same fashion, the final output will be [αs . tα . lo . to . kok], every search, for target and trigger having been successful.

If, again, we assume that target searches are made left-to-right, but we change the source search direction to be left-to-right as well, the operation yields a different result:

(51)

Directionality parameter setting for **target** search: L-to-R

Directionality parameter setting for **source** search: R-to-L

Target search 1: α s t α l -A t A k A k

→

Source search 1: α s t α l -A t A k A k

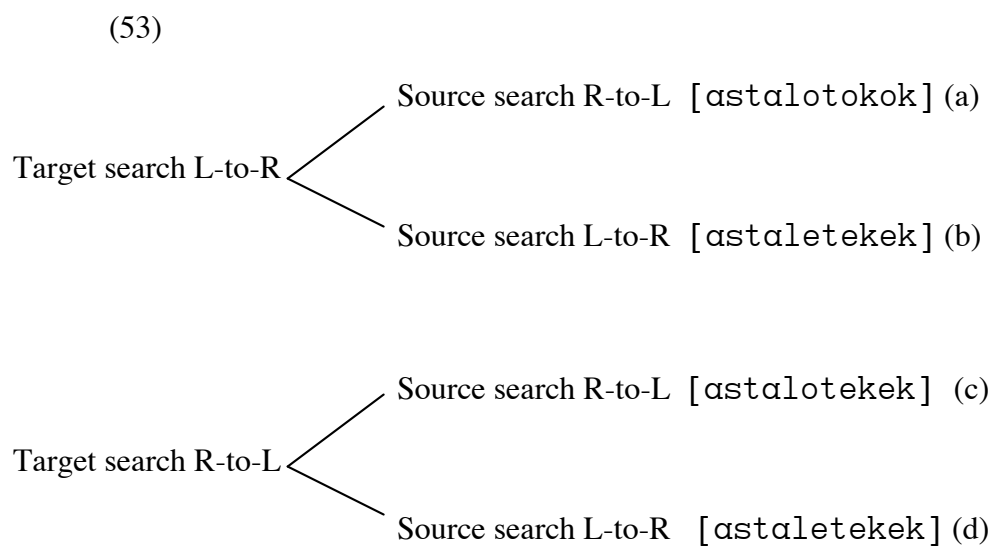
→

←

Valuation 3: α s t α l -o t e k e k

Output: [astalotekek]

The first two searches for a source of valuation terminate in failure, so that the first two targets going from the right are assigned the default value. When it comes to the third target from the right, the search for a source of valuation is successful and the target is assigned the [+back, +round] values. Given the two possible values for the directionality parameter, and the two kinds of searches, we obtain the following logically possible patterns:



Do languages really work this way? Languages with harmony of this type, like Finnish, Hungarian or Turkish, typically have mostly monosyllabic suffixes. Finnish has the reflexive suffix [utu]/[yty], where both vowels harmonise, suggesting Finnish operates using the grammar in (53)a. The same goes for Hungarian, which also has a few disyllabic suffixes where both vowels are non-neutral. They are listed here (see Rounds 2001, Siptár & Törkenczy 2000):

(54) *Hungarian disyllabic suffixes*

-αlom/-ελεμ	collective
-ασατ/-εσετ	agentive (English ‘-er’)
-ατλαν/-ετλεν	without
-ταλαν/-τελεν	without

The fact that each suffix has two allophones indicates that each vowel in the suffix harmonises with the stem. In other words, it seems as though Hungarian works according to the grammar illustrated in (53)a, where the search for targets proceeds from left-to-right, but the search for a source of valuation looks towards the left. Other grammars seem somewhat implausible: grammars (53)b and (d) essentially predict that we should find languages where there may be stem-internal harmony, but where suffixes never harmonise. Grammar (53)c predicts we should find grammars where only the initial vowel of a multisyllabic suffix will harmonise, but those coming after will not. Why and how is the grammar constrained then? A complete answers to this question will necessitate further research, but we can attempt a few speculations. Firstly, it is possible that the grammar is not as ‘dumb’ as the framework used here predicts it to be. I maintain that searches do proceed dumbly from one determinant to another, and sometimes fail. But there may be higher constraints on the grammar. For example, we might surmise that a rule that initiates a search will privilege looking towards the stem for a source of valuation rather than suffix-internally. In other words, when it comes to harmonising suffix vowels, a rule will look left rather than right, simply because it is more likely to find an appropriate source of valuation in that direction. When it comes to looking for a target within a multisyllabic suffix, a grammar is more likely to search from left to right because there is a propensity to harmonise all suffix vowels rather than one or none. How exactly these constraints are integrated into the language faculty is the topic of further inquiry.

Finally, I will like to add a note on the predictions of the ‘all-or-nothing’ principle proposed in (25). The all-or-nothing principle states that a rule cannot apply to a segment if it has failed to apply to a previous segment. This can be rephrased in terms of a search as well: a search cannot go on to a second segment if it has terminated in failure on a previous segment. It should be stated that the all-or-nothing principle does not make the prediction that all intervening segments to which a rule cannot apply are necessarily grounds for a rule to stop applying, or for a search for a particular target or trigger to end in failure. As shown above, there are some well-known cases of transparency (see Finnish, Hungarian) where two vowels can harmonise though they are separated by a neutral, transparent vowel. Whether a search for a trigger or target will end in failure depends on how the rule is formulated. Following Nevins (2004), a Finnish suffix vowel is underspecified for the feature [back], and ‘inherits’ its value for [back] from the closest stem vowel that is contrastive for [back]. When the rule searches for a source of valuation, it only ‘sees’ contrastive values. If an intervening vowel is not contrastive for [back], it does not count as a defective intervener, so that the search does not terminate in failure. In CF, because harmony is parasitic, the rule searches for a target that is [+high]. What is more, because [+high] vowels are not contrastive for [ATR], the rule sees *all* values for [ATR], not just those that are contrastive. If the search operates from right-to-left in an *inéдите*-type word, it will encounter a non-target that has a value for [ATR] but that is [-high]. By the formulation of the rule, and the all-or-nothing principle, the search terminates in failure. I am thus making a very important prediction concerning parasitic harmony. Unless a search can operate non-locally as in CF (a highly marked case), the all-or-nothing principle predicts that neutral vowels in parasitic harmony systems always block harmony. I expect parasitic harmony and the transparency of neutral vowels to be a very rare combination. To my knowledge, there exist no such systems aside from the case of CF.

2.3.4 Iterativity, optionality and the relative complexity of grammars

Given the two conditions on application of harmony—iterativity and directionality—it follows that CF grammars should produce the three patterns of harmony, and only these three patterns. We must assume another condition on the application of harmony, one which holds for all speakers. The condition on application has to do with optionality⁵⁷. As observed in Vaux (2002) and Vaux & Samuels (2006), optionality and iterativity can ‘interact’ in different ways. In CF, vowel harmony applies ‘optionally’ in the sense that it either applies or it does not. If it does apply, then a rule may or may not be iterative. In this sense, optionality and iterativity are independent of each other. In other languages however, it is possible for a rule to be optional at each iteration. This is illustrated in Vaux (2002) by the rule of flapping in English. In North American English, an intervocalic /t/ that follows a stressed syllable can ‘flap’: /t/ → [ɾ] / ¹V_V. The rule is iterative to the extent that it may apply several times within the same domain if there is more than one target. But it need not apply to all targets. We can thus obtain one of the following four outputs for the word ‘iterativity’:

(55) *Iterative optionality in English*

a) [ɪɾəɪət^hɪvəɾɪ]

b) [ɪt^həɪət^hɪvət^hɪ]

c) [ɪɾəɪət^hɪvət^hɪ]

d) [ɪt^həɪət^hɪvəɾɪ]

⁵⁷ I thank John McCarthy (p.c.) for raising this point.

For each target that it identifies, the rule can ‘choose’ to apply or not. From the attested patterns we have, this possibility does not appear to exist in CF. If harmony were optional at each iteration, we should be able to obtain all eight logically possible outputs, given a tetrasyllabic input (see (29)). In chapter 2, I have proposed an explanation for the variation we observe in CF. The hypothesis is that variation is due to an underdetermined analysis of the PLD. Given a majority of disyllabic data like *Philippe*. Otherwise, the learner has no information on whether or not the rule is iterative or strictly local. This leads to variation in how speakers set their parameters for iterativity and locality, the latter of which I have formalised in terms of directionality. But learners do not have any more information on whether optionality is available at each iteration or not. Since learners can freely parametrise for iterativity or directionality for lack of information, why should they not parametrise freely on optionality?

A few answers here are possible. The first possible answer is that speakers are indeed free to parametrise on optionality; given a larger sample of speakers we may very well find some speakers who accept, if not prefer, some of the yet unattested patterns for tetrasyllabics. This would suggest that optionality can also be parametrised for in different ways depending on the speaker. The second possible answer has been suggested in recent work by Nevins, Poliquin & Perfors (2006) and Poliquin & Nevins (2006). Grammars that would allow optionality to operate at each iteration are predicted to be computationally more complex by models such as finite state machines and Bayes’ rule. By assuming that variation is the result of an underdetermined analysis of PLD, we are supposing that learners, when faced with ‘uninformative’ data like a CF disyllabic word, can hold an infinite number of hypotheses regarding the relationship that exists between the harmonic target and trigger. Though the hypothesis space is infinite, the number of attested grammars is limited. For example, when encountering a datum like *Philippe*, the speaker can hold the following two hypotheses among an infinity of others: a) the target vowel must be adjacent to the trigger, or that b) the

harmonic vowel must be no more than one syllable away from the left edge of the word. Both hypotheses are logically possible, and both are consistent with the input. From the data I have gathered, it appears that speakers can hold hypothesis a), which results in an output like [sɪ . mi . lɪ . t^sɪd], (when given a tetrasyllabic input), but that speakers do not hold hypothesis b), which would result in the unattested output *[sɪ . mɪ . li . t^sɪd]. Why?

The model we propose is based on Bayes' rule, which states that the probability of a hypothesis being held by a learner is a function of the computational complexity of the resulting grammar G and G's fit to the PLD. In other words, though a learner may, in principle, hold hypothesis b), s/he is unlikely to do so because, a) the resulting grammar is computationally complex, and b) s/he encounters practically no data that confirms that this hypothesis is true. How is computational complexity determined however? This hypothesis is largely a work in progress, but so far, we have been assuming that the computational complexity of a grammar is a function of the number of 'states' and 'transitions' that are found in its output. For example, a fully iterative output like [sɪ . mɪ . lɪ . t^sɪd] includes only one 'state,' that is, all vowels are harmonised. It also necessitates only one type of 'transition,' that is, once the rule has applied to one vowel, it simply moves on to the next vowel. An output like *[sɪ . mi . lɪ . t^sɪd], on the other hand, includes three states (one vowel is harmonised, then a vowel is skipped, then another vowel is harmonised), and three types of transitions, so that it is the output of a grammar that is computationally more complex.

The advantage of this approach is that it is consistent with what patterns we find in CF. Since patterns (29)e-h are unattested for tetrasyllabics, it would be tempting to hypothesise that their impossibility is hardwired in UG. We could do this by saying that iterativity and directionality are the *only* contextual restrictions available for harmony in CF, if not for all languages. But this would not be prudent. Clearly, iterative optionality is possible in the

world's languages, and presumably, CF speakers could exhibit variation on this parameter as well. Rather than predicting that the patterns in (29)e-h are impossible, this approach predicts that they are possible, just unlikely. This approach also makes a prediction regarding flapping in English, namely, that the flapping patterns in (55)c-d should be less likely than the ones in (55)a-b. This is an empirical question to which I do not have an answer yet, but it is a reasonable prediction.

3 Opacity: on rule ordering and the 'Cycle'

3.1 Harmony counterbled by pre-fricative tensing

Since I adopt a traditional rule-based framework to account for vowel harmony, my account for derivational opacity is very straightforward, and does not go beyond the assumptions of Chomsky & Halle (1968) on extrinsic rule ordering. I will give a brief review of the facts here, which the previous chapter has examined in more depth. The treatment of this type of opacity in other frameworks will be the topic of the following chapter.

I simply propose that pre-fricative tensing forces all [+high] vowels to be [+ATR] before tautosyllabic voiced continuants, which masks the conditioning environment for harmony.

The derivation is illustrated here:

(56) *Deriving opaque vowel harmony in CF*

UR	/mɪsɪv/	'letter'
Syllabification	mɪ.sɪv	
Laxing rule	mɪ.sɪ̃v	
Vowel harmony	mɪ̃.sɪ̃v	
Pre-fricative tensing	mɪ̃.sɪ̃v	

Lengthening	mɪ . sɪ : v
Output	[mɪ . sɪ : v]

Opacity may occur in both disyllabics and trisyllabics⁵⁸. In the case of trisyllabics, opacity may occur for all parametrisations of the vowel harmony rule. More disyllabics are shown in (57), while trisyllabic patterns are given in (58):

(57) *Disyllabics featuring opacity*

kɪ . vɪ : v	‘alert’
ɪ . ʁɪ : z	‘to make iridescent’
lɪ . t ^s ɪ : ʒ	‘litigation’
fɪ . nɪ : ʁ	‘to finish’
bʁɥ . ly : ʁ	‘burn’
tʊ . ʒu : ʁ	‘always’
vɪ . tʁy : v	pr. name
d ^z ɪ . fy : z	‘diffuse’
pɪ . ky : ʁ	‘vaccine’
ʁɥ . sɪ : z	‘russify’
sɥ . bi : ʁ	‘to undergo’
pʊ . sɪ : v	‘lazy, fem.’
sʊ . mi : z	‘submitted, fem.’
ʁʊ . sɪ : ʁ	‘to redden’
ɥ . mu : ʁ	‘humour’

⁵⁸ Tetrasyllabics with opacity were not tested for this study.

mu.ɰy:ɤ ‘die, pret.’

(58) *Trisyllabics featuring opacity*

<i>No harmony</i>	<i>Across-the-board</i>	<i>Non-local</i>	<i>Adjacent</i>	
fy.ʒi.t ^s i:v	f _ɣ .ʒ _ɪ .t ^s i:v	f _ɣ .ʒi.t ^s i:v	fy.ʒ _ɪ .t ^s i:v	‘fugitive, fem.’
py.ni.t ^s i:v	p _ɣ .n _ɪ .t ^s i:v	p _ɣ .ni.t ^s i:v	py.n _ɪ .t ^s i:v	‘punitive, fem.’
mi.ni.mi:z	m _ɪ .n _ɪ .mi:z	m _ɪ .ni.mi:z	mi.n _ɪ .mi:z	‘minimise’
y.t ^s i.li:z	ɣ.t ^s _ɪ .li:z	ɣ.t ^s i.li:z	y.t ^s _ɪ .li:z	‘use, v.’
i.my.ni:z	ɪ.m _ɣ .ni:z	ɪ.my.ni:z	i.m _ɣ .ni:z	‘immunise’
vi.ɸi.li:z	v _ɪ .ɸ _ɪ .li:z	v _ɪ .ɸi.li:z	vi.ɸ _ɪ .li:z	‘to make virile’
nu.ɸi.t ^s y:ɤ	n _u .ɸ _ɪ .t ^s y:ɤ	n _u .ɸi.t ^s y:ɤ	nu.ɸ _ɪ .t ^s y:ɤ	‘food’
t ^s y.by.ly:ɤ	t ^s _ɣ .b _ɣ .ly:ɤ	t ^s _ɣ .by.ly:ɤ	t ^s y.b _ɣ .ly:ɤ	‘piping’
fi.ni.sy:ɤ	f _ɪ .n _ɪ .sy:ɤ	f _ɪ .ni.sy:ɤ	fi.n _ɪ .sy:ɤ	‘finishing’

For the trisyllabic cases, I propose that, at the intermediate representation which precedes application of pre-fricative tensing, harmony can apply under any of the parametric conditions imposed by iterativity and directionality, leading to our three familiar patterns for the opaque case as well.

3.2 Cyclicity: ‘Strict Cycle Condition’ effects in CF and Javanese

CF has another productive⁵⁹ pattern of opacity involving vowel harmony. In a stem in which harmony has applied, like [mʏ . zɪk] (‘music’), if the final syllable is resyllabified by the concatenation of a vowel initial suffix, the stem-final vowel is obligatorily tense, though the stem-initial vowel may retain its lax quality inherited from harmony: mʏ . zɪk → mʏ . zɪ̄ . kəl, *mʏ . zɪ̄ . kəl, *mʏ . zɪ̄ . kəl (‘musical’). I will propose that harmony is a cyclic lexical rule that is counterbled by an open syllable tensing rule that is subject to the Strict Cycle Condition (‘SCC’; Chomsky 1973, Mascaro 1976, Halle 1978). I will also show that all the rules proposed for CF apply at the word level. This level is split into two sublevels, characterised by the application of different sets of rules, and the concatenation of different suffixes. I will provide a similar analysis for an identical pattern in Javanese (Dudas 1976).

So far, I have proposed five rules with which we can derive all the phenomena that determine the distribution of [+high] vowel allophones in CF⁶⁰. These are closed syllable laxing, vowel harmony, open syllable tensing, pre-fricative tensing and pre-fricative lengthening. I will show that all five of these rules operate at the word level.

Closed syllable laxing is obligatory in final syllables. Here are a few examples:

(59) *Obligatory final closed syllable laxing*

ɛɪɔ̃	*ɛɪɔ̃	‘rich’
nʏl	*nʏl	‘null’
fɪn	*fɪn	‘nice, fem.’

⁵⁹ On the productivity of this pattern, see section 3.2 of chapter 3.

⁶⁰ I have also proposed a dissimilation rule and a diphthongisation rule. Since these are not relevant to the phenomena accounted for in this section, I will not discuss them.

o . kʏn	*o . kʏn	‘none, fem.’
y . na . nɪm	*y . na . mɪm	‘unanimous’

If closed syllable laxing applied at the stem level, we would expect its effects to be conserved once a non-resyllabifying suffix was concatenated. If a suffix is consonant-initial, it does not force resyllabification, so that the stem-final [+high] vowel is still in a closed syllable, in which case there is no reason for it to lose its lax quality. Closed syllable laxing should thus be obligatory, even though closed syllable is no longer final. The fact is however, that when we concatenate such a suffix, laxing is no longer obligatory. Compare forms in (59) with those in (60):

(60)

ʁɪŋ . mǎ	ʁiŋ . mǎ	‘richly’
nʏl . mǎ	nyl . mǎ	‘not at all’
fɪn . mǎ	fin . mǎ	‘nicely’
o . kʏn . mǎ	o . kʏn . mǎ	‘not at all’
y . na . nɪm . mǎ	y . na . mɪm . mǎ	‘unanimously’

In (60), we see that laxing is optional. This is consistent with the fact that the closed syllable is non-final, as if the laxing rule only applied once the word was formed. For this reason, I will assume that laxing occurs at the word level. By rule ordering, since laxing feeds vowel harmony, it should follow that vowel harmony also applies at the word level. This is indeed consistent with the behaviour of vowel harmony.

Harmony can apply in a morphologically complex word like [t^sɪ . mɪd . mǎ]

(‘timidly’). In this case, one could propose that optional closed syllable laxing, which applies at the word level, feeds (optional) vowel harmony, which would correctly

produce [t^sɪ.mɪd.mã]. I will argue however that there are two word levels, and that the input to the first is [t^si.mid], at which point laxing is obligatory, because the stem-final [+high] vowel is in word-final position. The suffix is only concatenated at the second word level. Both these approaches make the following correct predictions however: that laxing of the non-stem-final vowel is not allowed if the stem-final vowel is not lax: *[t^sɪ.mɪd.mã]. It is possible however to lax only the stem-final vowel: [t^si.mɪd.mã]. Naturally, since all these processes apply optionally, both vowels can remain tense: [t^si.mid.mã]. More examples are provided here:

(61) *Cyclical effects of harmony*

- | | | | | |
|----|-------------------------|---|----------------------------|--------------------------|
| a. | SY.bɪt | → | SY.bɪt.mã | ‘sudden’; ‘suddenly’ |
| b. | fɸɪ.ʒɪd | → | fɸɪ.ʒɪd.mã | ‘frigid’; ‘frigidly’ |
| c. | ɸɪ.ʒɪd | → | ɸɪ.ʒɪd.mã | ‘rigid’; ‘rigidly’ |
| d. | st ^s ɻ.pɪd | → | st ^s ɻ.pɪd.mã | ‘stupid’; ‘stupidly’ |
| e. | lɻ.sɪd | → | lɻ.sɪd.mã | ‘lucid’; ‘lucidly’ |
| f. | d ^z ɪ.vɪn | → | d ^z ɪ.vɪn.mã | ‘divine’; ‘divinely’ |
| g. | ʒɻ.ɸɪ.d ^z ɪk | → | ʒɻ.ɸɪ.d ^z ɪk.mã | ‘judicial’; ‘judicially’ |
| h. | ʒɻ.ɸi.d ^z ɪk | → | ʒɻ.ɸi.d ^z ɪk.mã | |
| i. | ʒy.ɸɪ.d ^z ɪk | → | ʒy.ɸɪ.d ^z ɪk.mã | |

In the case of trisyllabics, again, different patterns of harmony are possible:

(62) *Cyclicity effects in trisyllabic stems and complex words*

<i>Across-the-board</i>		<i>Non-local</i>		<i>Adjacent</i>		
<u>ɪ</u> .l <u>ʏ</u> .m <u>ɪ</u> n	<u>ɪ</u> .l <u>ʏ</u> .m <u>ɪ</u> .ne	<u>ɪ</u> .ly.m <u>ɪ</u> n	<u>ɪ</u> .ly.m <u>ɪ</u> .ne	i.l <u>ʏ</u> .m <u>ɪ</u> n	i.l <u>ʏ</u> .m <u>ɪ</u> .ne	‘illuminate/illumination’
d ^z <u>ɪ</u> .s <u>ɪ</u> .pl <u>ɪ</u> n	d ^z <u>ɪ</u> .s <u>ɪ</u> .pl <u>ɪ</u> .ne	d ^z <u>ɪ</u> .si.pl <u>ɪ</u> n	d ^z <u>ɪ</u> .si.pl <u>ɪ</u> .ne	d ^z i.s <u>ɪ</u> .pl <u>ɪ</u> n	d ^z i.s <u>ɪ</u> .pl <u>ɪ</u> .ne	‘discipline/to discipline’
ʁ <u>ɪ</u> .d ^z <u>ɪ</u> .k <u>ʏ</u> l	ʁ <u>ɪ</u> .d ^z <u>ɪ</u> .k <u>ʏ</u> .li.ze	ʁ <u>ɪ</u> .d ^z i.k <u>ʏ</u> l	ʁ <u>ɪ</u> .d ^z i.k <u>ʏ</u> .li.ze	ʁi.d ^z ɪ.k <u>ʏ</u> l	ʁi.d ^z <u>ɪ</u> .k <u>ʏ</u> .li.ze	‘ridicule/to make ridicule’
d ^z <u>ɪ</u> .s <u>ɪ</u> .m <u>ʏ</u> l	d ^z <u>ɪ</u> .s <u>ɪ</u> .m <u>ʏ</u> .le	d ^z <u>ɪ</u> .si.m <u>ʏ</u> l	d ^z <u>ɪ</u> .si.m <u>ʏ</u> .le	d ^z i.s <u>ɪ</u> .m <u>ʏ</u> l	d ^z i.s <u>ɪ</u> .m <u>ʏ</u> .le	‘hide/to hide’
m <u>ʏ</u> .n <u>ɪ</u> .s <u>ɪ</u> p	m <u>ʏ</u> .n <u>ɪ</u> .s <u>ɪ</u> .pal	m <u>ʏ</u> .ni.s <u>ɪ</u> p	m <u>ʏ</u> .ni.s <u>ɪ</u> .pal	my.nɪ.s <u>ɪ</u> p	my.n <u>ɪ</u> .s <u>ɪ</u> .pal	‘city/municipal’

It is not clear from these examples that vowel harmony *must* apply at the word level. So far, this type of example only shows that vowel harmony *can* apply at the word level.

There is strong evidence however that vowel harmony is a word level rule if we consider morphologically complex tetrasyllabics. Consider the following derivation for the word *illuminisme* (‘illuminationism’), where adjacent non-iterative harmony and closed syllable laxing apply at the stem level. I assume *illuminisme* is composed of the following morphemes⁶¹: /ilymin/ + /ism/:

(63) *Derivation of ‘illuminisme’ with vowel harmony applying at stem level***Stem cycle**

Input	/ilymin/
Syllabification	i.ly.min
Laxing	i.ly.m <u>ɪ</u> n
VH	i.l <u>ʏ</u> .m <u>ɪ</u> n

⁶¹ All tetrasyllabics are morphologically complex.

Word cycle

Input	/i.lɿ.mɪn/ + /ɪsm/
Syllabification	i.lɿ.mɪ.nɪsm
Laxing	i.lɿ.mɪ.nɪsm
VH	vacuously satisfied
Output	*[i.lɿ.mɪ.nɪsm]

If harmony occurs at the stem level, the stem-medial vowel should undergo harmony, and maintain its lax quality throughout the derivation. This results in an unattested pattern for trisyllabics. It is interesting to note that, though this pattern is unattested in CF, it is derivationally possible to obtain. It should therefore not be ruled out as an impossible pattern in the world's languages; we might expect an asymmetry between morphologically complex words that would allow such a pattern, and morphologically simplex words that would not. As for CF though, the pattern is not attested, whether a word is morphologically complex or not. Vowel harmony is thus sensitive to the word boundary.

There exists somewhat contradictory evidence from *musical*-type words, mentioned above. In these words, harmony appears to have applied at the stem. The stem-initial vowel can conserve its lax quality, which can only be attributed to harmony. The stem-final vowel must be tense however. Some examples are provided here:

(64) *Cyclicity effects in disyllabic stems and complex words*

d^zɪ.sɪp d^zɪ.sɪ.pɛ 'dissipate/to dissipate'

<u>ɪ</u> .m <u>ɪ</u> t	<u>ɪ</u> .m <u>i</u> .t <u>e</u>	‘imitate/to imitate’
<u>ɪ</u> . <u>ʁ</u> <u>ɪ</u> t	<u>ɪ</u> . <u>ʁ</u> <u>i</u> .t <u>a</u> .s <u>ʝ</u> õ	‘irritate/irritation’
p <u>ʏ</u> .bl <u>ɪ</u> k	p <u>ʏ</u> .bl <u>i</u> .s <u>i</u> .t <u>e</u>	‘public/publicity’
m <u>ɪ</u> .n <u>ɪ</u> m	m <u>ɪ</u> .n <u>i</u> .m <u>a</u> l	‘minimal/minimal’
d ^z <u>ɪ</u> .v <u>ɪ</u> n	d ^z <u>ɪ</u> .v <u>i</u> .n <u>a</u> .s <u>ʝ</u> õ	‘divine/divination’
<u>ʏ</u> . <u>ʁ</u> <u>ɪ</u> n	<u>ʏ</u> . <u>ʁ</u> <u>i</u> .n <u>w</u> æʁ	‘urine/urinal’
<u>ʁ</u> <u>ʊ</u> .t ^s <u>ɪ</u> n	<u>ʁ</u> <u>ʊ</u> .t ^s <u>i</u> .n <u>ʝ</u> e	‘routine, n./routine, adj.’
s <u>u</u> .l <u>ɪ</u> n	s <u>u</u> .l <u>i</u> .n <u>e</u>	‘underline/to underline’
<u>ʒ</u> <u>ʏ</u> .b <u>ɪ</u> l	<u>ʒ</u> <u>ʏ</u> .b <u>i</u> .l <u>e</u>	‘jubilate/to jubilate’
s <u>ɪ</u> .v <u>ɪ</u> l	s <u>ɪ</u> .v <u>i</u> .l <u>i</u> .t <u>e</u>	‘civil/civility’
s <u>ɪ</u> .m <u>ʏ</u> l	s <u>ɪ</u> .m <u>ʏ</u> .l <u>a</u> .s <u>ʝ</u> õ	‘simulate/simulation’
<u>ʁ</u> <u>ɪ</u> . <u>ʒ</u> <u>ɪ</u> d	<u>ʁ</u> <u>ɪ</u> . <u>ʒ</u> <u>i</u> .d ^z <u>i</u> .t <u>e</u>	‘rigid/rigidity’
l <u>ʏ</u> .s <u>ɪ</u> d	l <u>ʏ</u> .s <u>i</u> .d ^z <u>i</u> .t <u>e</u>	‘lucid/lucidity’

If vowel harmony were sensitive to the word boundary, we should not expect harmony in *musical* words at all, since the stem final vowel is in an open syllable, and *obligatorily* tense. To conciliate the *illuminisme* and *musical* facts, we must divide the word level of the phonology into two sublevels, each of which is defined by the application of different suffixes. Vowel harmony only applies at the first of these word levels, at which all suffixes susceptible of conditioning harmony are concatenated (*-isme*, *-iste*, *-ite*, *-ule*, *-cule*). I am assuming for lack of counter-evidence, that all other suffixes are concatenated after the first level of lexical rule application.

I propose that the stem-final vowel in *musical* words is subject to an open-syllable tensing rule formalised here:

(65) *Open-syllable tensing rule*

$$[+high] \rightarrow [+ATR] / _]_o$$

Formalised as such, the rule makes erroneous predictions. Because it must be ordered after harmony, we would expect it to ‘re-tense’ any vowel that has undergone harmony, since they are all in open syllables. I propose that the rule is in fact subject to the ‘Strict Cycle Condition,’ which ensures that cyclical rules apply only to segments at the cyclical boundary or, segments that constitute ‘new information’ in that they were subject to a rule on the current cycle. I provide the following definition, cited from Kenstowicz (1994: 208), which follows the formalisation proposed in Halle (1978):

(66) *Strict Cycle Condition*

“A cyclic rule may apply to a string x just in case either of the following holds:

- a) The rule makes crucial reference to information in the representation that spans the boundary between the current cycle and the preceding one.
- b) The rule applies solely within the domain of the previous cycle but crucially refers to information supplied by a rule operating on the current cycle.”

The open-syllable tensing rule operates under condition b) of the SCC as formulated in (66)⁶². The stem-final vowel is the only vowel in an open syllable that has undergone a rule on the cycle at which *-al* is suffixed. The suffix causes resyllabification, which I assume operates on every cycle. Because the stem-final vowel has undergone the syllabification rule, it is subject to any other rule on that cycle, including open-syllable tensing. The stem-initial vowel however, is not affected by resyllabification, so that it is not ‘re-tensed.’

These assumptions predict the correct result for *illuminisme* and *musical facts*:

(67)

Word Level 1

<i>Input</i>	i.ly.min + ism	my.zik
Syllabification	i.ly.mi. <u>nism</u>	vacuously satisfied
Laxing	i.ly.mi.n <u>ism</u>	my.z <u>ik</u>
Harmony	i.ly.m <u>i</u> .nISM	mY.ZIk

Word Level 2

<i>Input</i>	i.ly.mI.nISM	mY.ZIk + al
Syllabification	vacuously satisfied	mY.ZI. <u>kal</u>
Open-σ tensing	-----	mY.z <u>i</u> .kal
<i>Output</i>	[i.ly.mI.nISM]	[mY.zi.kal]

⁶² The SCC has seen different formulations in Mascaró (1976), Halle (1978), Kiparsky (1982) and Kiparsky (1985). I include a discussion of why I choose this particular formulation of the SCC in the appendix to this chapter.

I am not assuming that open-syllable tensing is a level 2 process simply because it must be ordered after harmony. If it were to apply at the same level as harmony (level 1⁶³), it could, by the SCC, re-tense all the vowels that have undergone harmony⁶⁴. Consider the following derivation where ATB harmony is applied:

(68) *ATB harmony applied with open-syllable tensing applying at the same level as harmony.*

Word Level 1

<i>Input</i>	i.ly.min + ism
Syllabification	i.ly.mi. <u>nism</u>
Laxing	i.ly.mi.n <u>ism</u>
Harmony	<u>i</u> .l <u>y</u> .m <u>i</u> .nISM
Open-σ tensing	<u>i</u> .l <u>y</u> .m <u>i</u> .nISM
<i>Output</i>	[i.ly.mi.nISM]

I thus assume two different sub-levels of rule application within the word level of the phonology. These levels are characterised by the concatenation of two classes of suffixes, those that contain a harmony trigger, and those that do not. A list of suffixes for both classes is provided here (taken from Bosquart 1998):

(69)

a. *Suffixes containing harmony trigger (level 1)*

⁶³ We know they could not apply both at level 2, where *-al* is suffixed, since we could not get harmony in the stem of *musical*.

⁶⁴ It should also be noted that we cannot assume that open-syllable tensing is a post-cyclic rule since it is subject to the SCC. The SCC only applies to cyclic rules. I am assuming this for theory-internal consistency; to my knowledge, there is no evidence one way or another that open-syllable tensing is cyclic or post-cyclic.

-ISM	state/doctrine (n.)
-IST	state/doctrine (adj.)
-IT	disease
-YL/-KYL	diminutive
-IBL	possibility
-I.SIM	superlative
-IK	adjective
-I. t ^s Yd, -t ^s Yd	state

b. *Suffixes not containing harmony trigger (level 2)*

-ad	action, succession, product
-aʒ	whole/collection, action, state
-ε	plantation, diminutive
-aj	instrument, result
-ε. zō	action, result
-ās	action, result
-o, -œ. ʁo, -œ. to	diminutive
-e	content, quantity
-œ. ʁI	quality, action, place
-εs	quality, fault
-oz	disease
-te, -œ. te, -i. te	quality, state
-sjō, -i. sjō, -a. sjō	action, state

-abl	possibility
-al	adjective
-aɤ	pejorative
-ɑtɤ	approximative, pejorative
-ɛsk	quality
-ø, -y.ø	quality
-a.je	pejorative action
-i.fje	transformative action
-i.ze	causative action
-o.te	pejorative action
-wa.je	action
-mã	adverb

The question now is, why does the learner know to distinguish these two classes of adjectives? Aside from outputting the correct results, what evidence does the learner have there exist two classes of suffixes, whose concatenations are ordered differently with respect to the application of vowel harmony? In one case, we have a class of words where harmony could potentially apply in the morphological base (meaning the morphologically simplex primitive), but only applies once the suffix containing a trigger for harmony is concatenated. In other words, in this case, harmony, as it could apply in the morphological base, is not carried over to the derivative. In the other case, harmony applies in the morphologically simplex base, and is carried over to the derivative. This is the *musical* case. This is perhaps suggestive of a stronger conceptual relationship between the base and the derivative in the *musical* case, and a weaker one in the *illuminisme* case. The relationship I am suggesting is semantic in nature. One could argue that there is a closer semantic link between *musique* and *musical* than between

commune ('commun' or 'common, fem.')

commune ('commune' or 'common, fem.')

communiste ('communist').

The weaker semantic relationship would not impede the learner from assuming that the word *commune* ('commune' or 'common, fem.')

and the stem [kɔ . mʏn]-, the stem on which the word *communiste* is formed, are separate morphological bases with different entries in the lexicon. This sort of argument could be tested, but before any tests are done, there is reason to believe that this argument would need some refinement. For example, this could hardly be argued for *riche* ('rich') and *richissime* ('richest, very rich'), in which case the semantic link is very transparent. What we might expect is a greater tendency for open-syllable tensing of the medial syllable in a word like *richissime* than for *communiste*, in which case the application of harmony would not really depend on the suffixes themselves, but on the nature of the semantic relationship between the morphological base and the derivative. This would mean that some suffixes could be associated with each of the two different levels, depending on what morphological base they are suffixed to, and the relationship that exists between the base and the resulting derivative. I leave these issues to further investigation.

The *musical* pattern is almost identical to one found in Central Javanese (Dudas 1976: 57-60). In Javanese like in CF, [+high] vowels (/i, u/) in final closed syllables surface as [-ATR] by an allophonic rule identical to the one I propose for CF. In all other environments, [+high] vowels surface as [+ATR] (all Javanese examples adapted from Dudas 1976, except where noted):

(70) *Closed syllable laxing in Javanese*⁶⁵

- | | | |
|--------------|-------------|------------|
| a. a . pɪq | 'good nice' | *a . pik |
| b. dʒa . mur | 'mushroom' | *dʒa . mur |

⁶⁵ Notice that [+high] vowel harmony does not apply in this variety of Javanese reported in Dudas (1976). High vowel harmony is only reported for Eastern Javanese in Schindwein (1988).

c. mu. rɪt	‘student’	*mu. rɪt
d. tan. duq	‘actions’	*tan. duk

(71) *Open syllable tensing in Javanese*

a. bu. ri	‘back, rear’	*bu. rɪ, *bu. rɪ, *bu. ri
b. i. bu	‘mother’	*ɪ. bu *i. bu *ɪ. bu

Like in CF, closed syllable laxing is cyclic, since laxing of stem-final [+high] vowels is conserved when a non-resyllabifying suffix is concatenated:

(72) *Cyclicality of Javanese closed syllable laxing*

Stem		Derived
a. a. pɪq	‘good nice’	a. pɪq. ku, a. pɪq. mu
b. dʒa. mur	‘mushroom’	dʒa. mur. ku, dʒa. mur. mu
c. mu. rɪt	‘student’	mu. rɪt. ku, mu. rɪt. mu
d. tan. duq	‘actions’	tan. duq. ku, tan. duq. ku

But when a resyllabifying suffix is concatenated, only the [+ATR] allophone of the stem-final [+high] vowel can surface:

(73) *Re-tensing in Javanese*

Stem		Derived	
a. apɪq	‘good, nice’	a. pɪ. qe	3 rd pers. poss.
b. dʒu. puq	‘go get’	ndju. pu. qo	imperative
c. klu. wun	‘rainbow’	klu. wu. nge	<i>no gloss provided</i>

d. tu. l <u>i</u> s	‘write’	nu. l <u>i</u> . so	imperative
e. wi. w <u>i</u> t	‘beginning’	wi. w <u>i</u> . tan	substantive

In Javanese, open-syllable tensing counterbleeds a dissimilation process, yielding the same opacity effect that we observe in CF. In Javanese, stem-initial mid vowels in open syllables must have the opposite value for [ATR], relative to the stem-final vowel (Dudas only provides disyllabic roots). So, if a mid vowel precedes a [+high] vowel that is in a final closed syllable, the mid vowel must be [+ATR], because the [+high] vowel must be [-ATR] by closed syllable laxing:

(74) *[ATR] dissimilation in Javanese*

a. klɛ. ru	‘mistaken’
b. kɔ. pi	‘coffee’
c. mɛ. ri	‘envious’
d. wɔ. lu	‘eight’
e. e. dum	‘shady, sheltered’
f. to. mis	‘rice-accompanying dish’
g. be. ring	‘unbalanced’
h. ko. dʒur	‘bad luck’

In examples (74)a-d, the initial mid vowel is lax, because the final [+high] vowel is tense. In examples (74)e-h, the initial mid vowel is tense, because the final [+high] vowel is lax. If we concatenate the suffix *-(n)e* (3rd pers. poss.), the lax [+high] vowels in (74)e-h must be tense, but the mid vowel retains its tense quality, see (75)e-h (the suffix surfaces as *-e* in this case). When we concatenate the same suffix to vowel-final stems like (74)a-d, the

mid vowel stays lax, and the final [+high] vowel retains its tense quality because it is still in an open syllable (the suffix surfaces as *-ne* in this case):

(75) *'Musical'-type opacity in Javanese*

a. klɛ . ru . ne	'mistaken'
b. kɔ . pi . ne	'coffee'
c. mɛ . ri . ne	'envious'
d. wɔ . lu . ne	'eight'
e. e . d <u>u</u> . me	'shady, sheltered'
f. to . m <u>i</u> . se	'rice-accompanying dish'
g. be . r <u>i</u> . nge	'unbalanced'
h. ko . d <u>ɜ</u> . re	'bad luck'

This pattern is easily derivable using the analysis I propose for CF. From the data that Dudas provides, there is no evidence that laxing or dissimilation are not stem-level phenomena. For this reason, I will assume that laxing and dissimilation are stem level phenomena in Javanese and that the derivation includes only one word level (for simplicity's sake):

(76)

Stem Level

<i>Input</i>	/kleru/	/edum/
Syllabification	kle . ru	e . dum
Laxing	-----	e . d <u>u</u> m
Dissimilation	klɛ . ru	vacuously satisfied

Word Level

<i>Input</i>	klɛ . ru + ne	e . dum + e
Syllabification	klɛ . ru . ne	e . du . me
Open-σ tensing	-----	e . <u>du</u> . me
<i>Output</i>	[klɛ . ru . ne]	[e . du . me]

The account is more straightforward for Javanese because the open-syllable tensing rule need not apply only at the word level. One could also assume that it applied vacuously at the stem level. The initial mid vowel does undergo syllabification at the stem level, in which case we would expect the open-syllable tensing rule to undo the effects of dissimilation. But there is evidence that in Javanese, the open-syllable tensing rule only targets [+high] vowels. Dudas seems to only provide one example showing this (no gloss is provided): kə . tɛq > kə . tɛ . qe. Mid vowels are also subject to a laxing rule in final closed syllables, but retain that lax quality when resyllabified. In contrast, CF applies the open-syllable tensing rule to mid vowels as well. In CF mid front unrounded vowels must be lax in closed syllables: *ke . bək, ✓ke . bək ('Quebec'), but *ke . bɛ . kwa, ✓ke . be . kwa ('Quebecois')⁶⁶. If the rule only applies to [+high] vowels in Javanese, then the SCC is not needed either, since the rule will only target the [+high] vowel.

The framework in which Dudas works does not use the notion of cycle, so that these facts can only be accounted for by positing a complicated rule. Dudas proposes a rule by

⁶⁶ Just from my personal experience, I believe that extension of the open-syllable tensing rule to mid vowels is subject to regional variation. Though I apply the rule to mid vowels as well as [+high] vowels in my idiolect, it is my feeling that the rule only applies to [+high] vowels in certain Franco-Ontarian dialects with which I am familiar. Ironically, the current premier of Quebec does not extend the rule to mid vowels.

which mid vowels become [-ATR] before all stem final [+high] vowels in open syllables: [-high, -low] → [-tense] / $_.$ [+high]]_{stem}. Given an input like /k_leru/, the final [+high] is in an open syllable, so that the preceding mid vowel will be [-tense]. Given an input like /edum/, the final [+high] is in a closed syllable, so that the rule does not apply. The mid vowel thus surfaces as tense. Without the notion that rules apply cyclically, Dudas is forced to abandon the generalisation that mid vowels are subject to a process of dissimilation. Positing this kind of rule opens the door to a wide range of processes, which I suspect are unattested. There is no reason why mid vowels should become [-tense] rather than any other feature (e.g. [+round]).

Interestingly, Schlindwein (1988) reports that Eastern Javanese extends the harmony pattern to include mid and [+high] vowels (reported in A&P 1994: 137-142):

(77) *Eastern Javanese [+high] vowel harmony*

mu.rɪt	‘student’	*mu.rɪt
pli.pɪr	‘edge’	*pli.pɪr
tu.mɪs	‘side dish’	*tu.mɪs

[-ATR] harmony can only hold across two vowels of the same type: *ɪ.jɛn, ✓i.jɛn ‘alone.’ As [+high] vowels are concerned, the pattern in Eastern Javanese is the same as for CF. Unfortunately, no tri- or tetrasyllabic data are provided in Dudas (1976) or A&P (1994) in their report of Schlindwein’s findings⁶⁷. The Eastern Javanese pattern is interesting nonetheless, because it shows that, not only does open-syllable tensing only affect [+high] vowels in this language, thus differing from CF, but that the SCC does not hold. Consider the following forms:

⁶⁷ Schlindwein’s dissertation was unavailable for consultation at the time of writing.

(78) *No SCC in Eastern Javanese*

- a. tu.mi.sɛ ‘side dish’ tu.mi.se ‘this side dish’
 b. bo.bot ‘weight’ bo.bot.te ‘this weight’

In (78)a, we see that, when the demonstrative suffix is concatenated, all [+high] vowels must be tense. Under the present analysis, this would suggest that the open-syllable tensing rule applies to all [+high] vowels, not only the [+high] vowel that has undergone resyllabification. Schlindwein and A&P propose that there exist two rules of closed syllable laxing (or ‘[-ATR] insertion’ in A&P’s terminology): the first targets only mid vowels before suffixation of the demonstrative, and the second targets only [+high] vowels after suffixation of the demonstrative. In other words, mid vowel laxing would occur at the stem level, but [+high] vowel laxing would only apply at the word level. Because laxing occurs before suffixation in the case of mid vowels, the mid vowel in (78)b is lax, and vowel harmony can apply. Vowel harmony cannot apply in the case of [+high] vowels however, because suffixation bleeds the [+high] vowel laxing rule of its conditioning environment:

(79) *A&P and Schlindwein (1988) analysis of [+high] and mid vowel asymmetry*

<i>Input</i>	/bobot/	/tumis/
Mid vowel laxing	bo.bot	-----
Suffixation	bo.bot.te	tu.mi.se
[+high] vowel laxing	-----	-----
Harmony	bo.bot.te	-----
<i>Outputs</i>	[bo.bot.te]	[tu.mi.se]

Though Schindwein and A&P's account predicts the Eastern Javanese facts, the present analysis does away with the redundancy of having two identical laxing rules with different targets. The present analysis simply assumes that the open-syllable tensing rule does not extend to mid vowels in Javanese (Eastern and Central), something that seems to fit with the sort of regional variation found within CF. What is more, it appears from A&P's report of Eastern Javanese that mid vowel [ATR] dissimilation also holds in this dialect. But we know from the dissimilation data that [+high] vowel laxing must apply *before* suffixation, so that A&P's analysis is not consistent with the whole range of facts. By assuming an open-syllable tensing rule and a single laxing rule, we can account for both Javanese and CF facts. Crucially however, we must assume that the Strict Cycle Condition does not apply in Javanese. Rather than proposing that the SCC be subject to parametric variation, we may be able to propose that open-syllable tensing is post-cyclic in Javanese. The data set in my sources for Javanese is not rich enough to test this hypothesis unfortunately. A full comparison of the CF and Javanese facts remains the topic of further inquiry.

4 A note on metaphony

The CF harmony facts are somewhat reminiscent of 'metaphony' processes that exist in Spanish and Italian. Metaphony generally involves assimilation in height of a word-internal vowel with a word-final vowel. There exists a wide range of such phenomena on which there is a very rich literature. I refer the reader especially to Kaze (1989) and volume 10. 1 of *Rivista di Linguistica* (1998), entirely devoted to metaphony, and which includes some seminal articles by Calabrese, Hualde, and Cole, as well as some interesting comparisons with like phenomena in German and Scandinavian. Of interest are also Hualde (1989) and McCarthy (1985). The purpose of the present section is not

to review all aspects of this phenomenon, which is not clearly typologically related to CF harmony. There are enough similarities however to warrant a few key remarks.

In his survey of over 90 Spanish and Italian dialects, Kaze (1989: 172) identifies four types of metaphony in terms of the feature that is spread from an unstressed final vowel (up) to a stressed non-final vowel. Kaze identifies systems that spread a) the feature [+high], b) the features [+high] and [-back], c) [-ATR] and d) the feature [low]. A typical case is well illustrated by the Italian dialect of Servigliano (Kaze 1989: 62). In Servigliano, stressed tense and lax mid vowels raise by one degree of height when followed by [+high] final vowel:

(80) *Metaphony in Servigliano*

a. métto	‘I put’	mítti	‘you put’
b. krédo	‘I believe’	krídi	‘you believe’
c. kwésto	‘this, neuter’	kwístu	‘this, masc. sg.’
d. pésa	‘heavy, fem.sg.’	písu	‘heavy, masc. sg.’
e. modésta	‘modest, fem. sg.’	modéstu	‘modest, masc. sg.’
f. péttene	‘comb’	péttini	‘combs’
g. sgwéza	‘sinister, fem. sg.’	sgwézu	‘sinister, masc. sg.’
h. fjóre	‘flower’	fjúri	‘flowers’
i. spósa	‘wife’	spúsu	‘husband’
j. spróta	‘pedantic, fem. sg.’	sprótu	‘pedantic, masc. sg.’

k. móre ‘he dies’ móri ‘you die’

There are two things to observe in Servigliano. Firstly, tense mid vowels become [+high] when the final vowel is [+high] ((80)a-d, h-i), while lax mid vowels become tense mid vowels in the same environment ((80)e-g, j-k); in other words, vowels raise one ‘degree of height’ under the influence of a final [+high] vowel. Secondly, only the vowels up to the stressed vowel and including the stressed vowel undergo metaphony. Vowels that precede the stressed vowel do not undergo harmony (see specifically (80)e).

Kaze and Hualde (1989, 1998) describe two cases of metaphony that involve spreading a [-ATR] feature from a final vowel to a non-final vowel, a pattern reminiscent of CF vowel harmony. The two cases are Pasiego Montañés and Tudanca Montañés, both dialects of Spanish spoken in the Santander province of Spain. [-ATR] metaphony is illustrated here using data adapted from Hualde (1998):

(81) *Tudanca Montañés*

a. sekálu	‘to dry it, masc. sg.’	sekalo	‘to dry it, mass’
b. késu	‘a cheese’	késos	‘cheeses’
c. tʃíku	‘boy’	tʃíkos	‘boys’
d. óhu	‘eye’	óhos	‘eyes’
e. θúrdu	‘lefthanded, masc. sg.’	θúrdos	‘lefthanded, masc. pl.’

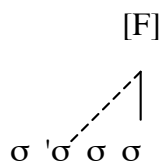
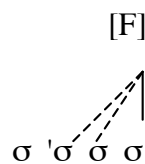
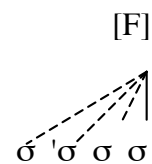
(82) *Pasiego Montañés*

a. málu	‘bad, masc. sg.’	mála	‘bad, fem. sg.’
b. lixíru	‘light, masc. sg.’	lixéra	‘light, fem. sg.’

c. lɪmpjʊ	‘clean, masc. sg.’	límpja	‘clean, fem. seg.’
d. flúxu	‘loose, masc. sg.’	flóxa	‘loose, fem. sg.’
e. súθju	‘dirty, masc. sg.’	súθja	‘dirty, fem. sg.’

In the Montañés case, the harmonic feature is [-ATR], but the spreading pattern is different between the two cases. In Tudanca, only the stressed vowel assimilates in [-ATR] with the final vowel, while in Pasiego, we have an ATB pattern; all vowels undergo metaphony. So, metaphony can involve different harmonic features, but also different patterns of spreading. Hualde (1989) and Walker (2005) identify three basic types illustrated here:

(83)

a. *Stress-targeted*b. *Post-tonic extension*c. *Maximal extension*

In the stress-targeted pattern, only the stressed vowel assimilates to the final vowel. In the post-tonic extension pattern, only the stressed vowel and the vowels that follow it assimilate, and finally, in the maximal extension pattern, we have our familiar ATB pattern, where every vowel assimilates.

The first question is, can the patterns of harmony in CF be reduced to the patterns that Hualde and Walker have identified for metaphony? The stress targeted pattern produces some ‘long-distance’ effects, that, aside from transparency effects, are rather rare in the realm of vowel assimilation phenomena. Might this not be equated to the non-local pattern we find in CF? I have argued that the non-local pattern in CF is cross-

linguistically rare, though perhaps expected given certain models of assimilation. After all, the initial vowel in CF does bear secondary stress. Though this analysis is possible, and I do not wish to discount it, it is unclear that the non-local pattern in CF is really stress-targeted. As a non-local speaker, I accept harmony in the words [de. fɪ. ni. t^sɪf] ('definitive, masc.') or [kɔ̃. tʁɪ. by. t^sɪf] ('contributive, masc.'), and I have found that most non-local speakers I have had access to agree with these judgments. The vowel targeted by the non-local harmony pattern is unstressed in *définitif* words, it is simply the leftmost vowel in a string of [+high] vowels that may or may be continuous. If this is so, it is not clear that this is truly a stress-targeted pattern. We must leave that possibility open though. It is entirely possible, given my approach, that a learner analyses the non-final vowel in a word like *Philippe* as being 'the secondarily stressed vowel,' in which case we would expect this speaker not to accept harmony in words like *définitif*. This is entirely possible, but fundamentally does not change my analysis of this pattern, and the predictions that I make. Such a speaker would behave the same way with regards to tetrasyllabics, and *inédite* words. The only difference would be *définitif* words.

Walker (2005) argues that metaphony, among other vowel assimilation effects, has a functional purpose in providing maximal salience to a perceptually weak feature in a perceptually weak position. Maximal salience or exposure is achieved by spreading the weak feature onto other segments, and preferably other segments that are in a perceptually prominent position. The idea is based on the analysis of harmony systems by Kaun (1995). What is true for CF is that [-ATR] is a perceptually weak feature, in the sense that tense and lax [+high] vowels are only differentiated by a few hundred Hertz difference in F₁ and F₂ (see chapter 2). There are two main conflicts however between the CF data and what is proposed in Walker (2005). Firstly, the harmonic feature is not in a perceptually weak position, since the trigger bears primary stress. One could argue

though that maximal exposure is still the goal, because the feature can spread to the secondarily stressed vowel (if that is what's going on), or it can spread to every vowel, ensuring maximal extension. This may be true for the non-local and ATB patterns, but the [-ATR] feature certainly gains nothing by spreading to the medial vowel in the case of the adjacent non-iterative pattern, since the medial vowel is unstressed and is the vowel most likely to be reduced.

The second conflict is that there is not much to gain from maximal salience anyway. [+high] vowels are [-ATR] as a result of allophony. [+high] vowels in CF do not contrast for [ATR]. In Spanish and Italian, the functional argument can be well motivated; vowel differences can carry some important semantic information about number, person and gender. In fact, in some dialects of Italian (e.g. Calvello), the final vowel has been historically reduced if not deleted, in which case differences in gender are now borne by non-final vowels, as a result of a historical process of metaphony. There is no such motivation in CF. One could argue perhaps that the [-ATR] feature carries some information to the extent that it signals word boundaries. Spreading the feature from the final syllable to the initial syllable flags the harmony domain as a separate morphological unit. This could be perhaps be argued for the non-local and ATB patterns, in which case CF may fit into Walker's analysis. Tying the CF facts to Walker's proposal would require an empirical investigation that is beyond the scope of the present thesis.

5 Conclusion

This chapter has provided an account for all types of CF vowel harmony and all processes that interact with it. My account of harmony and the processes that render its conditioning environment opaque was couched in the rule-based framework of Lexical Phonology. My choice of framework is justified by the fact that Lexical Phonology, with its use of extrinsic rule ordering and cyclic rule application, can account for the full range

of facts surrounding harmony, including the non-local application of the process. This is not to say that OT-based frameworks cannot account for any of these facts. I will show in the next chapter that most OT-based frameworks can account for a certain range of the CF facts, but never all of them.

Appendix: On the different formulations of the Strict Cycle Condition

The formalisation of the SCC has evolved throughout the literature. This version is intermediary between the first version proposed in Mascaró (1976) and the revised version proposed in Kiparsky (1982, 1985). The first version proposed by Mascaró (1976) essentially stipulated that cyclic rules apply only to derived environments. In short, this was proposed to account for the fact that certain rules apply only to derived environments and not otherwise. One such rule in English is the Trisyllabic Shortening rule, whereby initial vowels that are long become short when they are followed by two or more vowels, the first of which is unstressed: e.g. *opaque* → *opacity*, [o . pe^jk] → [o . pa . sɪ . ri]. The rule applies to the word *opacity*, but not to words like *nightingale*: *[nɪ . tən . ge^jl]. This is because *opacity* is derived from the concatenation of the stem *opaque* plus the suffix *-ity*; *nightingale* on the other hand is morphologically simplex. Kiparsky (1982) points out the following problem with this formulation: if we assume that both *opacity* and *nightingale* undergo cyclic stress-assignment and syllabification rules, then both constitute derived environments, in which case we must assume that the Trisyllabic Shortening rule should apply to both forms. The prediction is of course wrong. Kiparsky proposes to fix this problem by deriving the SCC from the Elsewhere Condition, thereby also remedying the stipulative nature of the SCC. Kiparsky assumes that a “lexical entry constitutes an identity rule whose structural description is the same as its structural change” (Kiparsky 1982: 159). In other words, a lexical entry is associated with an identity rule such that /najtənge^jl/ → [najtənge^jl]. The trisyllabic word *nightingale* is a one-member subset of all trisyllabics, which are subject to the Trisyllabic Shortening rule. By the Elsewhere Condition then, the Trisyllabic Shortening rule will apply to all trisyllabics, except *nightingale* since it is associated with an identity rule by virtue of having a lexical entry.

Since *opacity* does not have a lexical entry, it is not subject to an identity rule, and by the Elsewhere Condition, it will undergo Trisyllabic Shortening.

So far, neither Mascaró's original formulation nor Kiparsky's (1982, 1985) revision capture the CF facts. The reason I assume the SCC is because we must account for why the open-syllable tensing rule applies to the stem final [+high] vowel in a word like *musical*, but not to the stem initial [+high] vowel: [mʏ . zɪ . kəl]. Both [+high] vowels get their [-ATR] value by derivation. By Mascaró's formulation, both should be subject to the open-syllable tensing rule. Now, if we used Kiparsky's (1982, 1985) formulation, we would also have to assume a different formulation for the open-syllable tensing rule, according to which it would apply by the Elsewhere Condition. Essentially, the open-syllable tensing rule would tense all [+high] vowels unless they had undergone laxing by another previous rule (that is, by disjunctive ordering with the laxing rules, i.e. closed syllable laxing and vowel harmony). But then, this predicts the opposite of what Mascaró's formulation predicts, namely, that neither [+high] vowel should undergo tensing: *[mʏ . zɪ . kəl].

The formulation I adopt from Halle (1978) and Kenstowicz (1994: 208) is one that is slightly more precise than Mascaró's. I repeat it here:

(84) *Strict Cycle Condition*

“A cyclic rule may apply to a string *x* just in case either of the following holds:

- a) The rule makes crucial reference to information in the representation that spans the boundary between the current cycle and the preceding one.

- c) The rule applies solely within the domain of the previous cycle but crucially refers to information supplied by a rule operating on the current cycle.”

This version of the SCC says that a cyclic rule can apply if it refers to information already referred to by a rule operating on the current cycle, not to all derived environments. This allows us to distinguish between the stem-final [+high] vowel and the stem-initial [+high] vowel. Only the stem-final [+high] vowel is referred to on the level 2 cycle because it is affected by resyllabification. The stem-initial vowel is not.

The fact that I assume that vowel harmony and open-syllable tensing apply on different cycles (for independent reasons) also allows us to bypass the *opacity* versus *nightingale* problem. Again, in English, the problem is this: if we assume that both *opacity* and *nightingale* undergo a stress assignment rule, then they both constitute derived contexts, and they should both undergo Trisyllabic Shortening. In CF, if we assumed that laxing, vowel harmony and open-syllable tensing applied on the same cycle, then both *illuminisme* and *musical* should undergo open-syllable tensing, effectively undoing the effects of laxing and harmony (that is, crucially, if we assume Halle’s SCC, not Kiparsky’s version derived from the Elsewhere Condition, which would produce the wrong result anyway). If we assume that laxing and harmony apply on a first cycle, and open-syllable tensing on a second cycle, the derived context in which open-syllable tensing is allowed to apply is the one provided by resyllabification, not laxing and harmony. The same strategy might be used in English. If we assume that there is a stress-assignment rule that operates on every cycle, but that Trisyllabic Shortening only applies on the second cycle, then the problem is solved:

(85) *A very simplified version of English phonology*⁶⁸

UR	/ope ^j k/	/najtənge ^j l/
Cycle 1		
Syllabification	o.pe ^j k	naj.tən.ge ^j l
Stress	o.'pe ^j k	'naj.tən. ,ge ^j l
Cycle 2		
Input	/o.'pe ^j k/ + /ɪri/	/'naj.tən. ,ge ^j l/
Syllabification	o.'pe ^j .kɪ.ri	vacuously satisfied
Stress	o.'pe ^j .kɪ.ri	vacuously satisfied
Trisyllabic Shortening	o.'pa.sɪ.ri	n/a

Of course, this only works if we assume that stress affects the entire string. Between *opaque* and *opacity*, the location of the primary stress does not change, in which case one might say that the string *opacity* satisfies the stress rule vacuously, in which case Trisyllabic Shortening should not apply. But it is plausible that stress assignment is recomputed taking the whole string into account, since stress can shift : e.g. *cycle* → *cyclicity*.

Undoubtedly, there are many more issues to be solved when it comes to the Strict Cyclicity Condition, which is beyond the scope of the present work. What CF clearly shows however, is that, as Kiparsky (1985) points out, any theory of phonology that includes the notion of cycle (and I argue any theory of phonology must include this notion) must have something like the SCC. Its final formulation is the topic of further investigation.

⁶⁸ I am ignoring rules such as 'velar softening' and 'flapping.'

Chapter 5: On the insufficiencies of non- and semi-derivational models of phonology

1 Chapter overview

The previous chapter shows how we can account for the three main problems of CF vowel harmony using the framework of Lexical Phonology (Kiparsky 1982a, 1985), which assumes surface forms are derived from underlying representations using ordered sets of rules. The three main problems of CF vowel harmony are: 1) accounting for different patterns of CF that vary in terms of locality parameters, 2) accounting for derivational opacity, and 3) accounting for cyclicity effects.

Though Lexical Phonology offers straightforward solutions to these problems, these are by no means the only potential solutions. In this section, I will show that assuming Lexical Phonology- or at the very least, any rule-based framework- is necessary to account for the CF phenomena, for the simple reason that all purely constraint-based frameworks fail to account for one or more of the CF facts. The constraint-based frameworks that are reassessed in this section all incorporate at least a subset of the assumptions laid out in Prince & Smolensky's (1993/2004) seminal monograph on Optimality Theory (OT)⁶⁹. I will henceforth refer to a framework that incorporates the totality of their assumptions with no modifications as 'classical OT.'

Subsection 2 defines the 'over-evaluation' problem and shows how classical OT frameworks fail to solve it. Subsection 2.2 shows how this problem can be partially solved if we assume constraints that are highly specific in their targets and very limited in

⁶⁹ The classical OT framework also incorporates assumptions proposed in later works, e.g. generalised alignment (McCarthy & Prince 1993), and faithfulness and identity proposed in McCarthy & Prince (1999).

the repair options that they allow; these are ‘Match’ constraints, proposed in McCarthy (2003). Though the problem is partially solved, Match constraints over-generate when it comes to tetrasyllabic forms in CF.

Subsection 3 briefly shows how classical OT fails to make the correct prediction when it comes to opaque CF vowel harmony. Subsection 3.2 is specifically devoted to ‘targeted constraints’ (Bakovic 2000; Wilson & Bakovic 2001; Wilson 2003). I show that targeted constraints are successful in overcoming the over-evaluation problem, but that they also fail to account for the opacity facts of CF. Subsection 3.3 takes a look at the ‘Sympathy’ version of OT proposed in McCarthy (1999, 2002, 2003). Though these frameworks are specifically designed to account for cases of non-paradigmatic opacity (as in Tiberian Hebrew), I show that accounting for the CF facts leads to a major theory internal problem for these frameworks. Because CF vowel harmony is allophonic, we must abandon the Richness of the Base hypothesis to account for opacity within this framework (see Prince & Smolensky 1993/2004). This is a theoretical shift that is inconsistent with the other assumptions of Sympathy.

Subsection 3 looks at frameworks that are successful in accounting of the opacity facts, but fail to account for the cyclicity data of CF. The first framework to be reassessed here is ‘Turbidity,’ proposed in Goldrick (2000). Turbidity is a version of OT that assumes direct mapping of inputs to outputs, but assumes that outputs can include some ‘covert structure’ which might account for the opacity facts. The framework is successful in doing so in the case of CF, but ultimately fails to account for the cyclicity facts. Finally, I show in subsection 3.6, that stratal OT, and specifically the version of stratal OT proposed in Kiparsky (2000) and Bermudez-Otero (1999, in preparation), is also successful in accounting for opacity facts, but cannot account for cyclicity at all.

2 The ‘over-evaluation’ problem

OT assumes that the phonological component can be modeled as a function that maps an input string to an output string. The output is selected from among a set of candidates, each of which is evaluated in relation to a constraint hierarchy. Constraints essentially dictate that a given phonological structure is prohibited on the surface of any language. Constraints are all potentially violable however. The candidate that incurs the least grave violations, i.e. violates only constraints that are the most lowly ranked in the language, is selected as the winner. When a candidate string is evaluated in relation to the constraint hierarchy, it is assumed that the entire string comes under evaluation. There is no sense in which only a particular segment or subset of the string is visible to the constraint hierarchy at any given time. It is assumed that evaluation with respect to all constraints in the hierarchy is performed simultaneously.

Moreover, if a given input structure violates a constraint or set of constraints within the hierarchy, it is not assumed that this structure is repaired in a ‘piecemeal’ fashion. So, if an input structure S_1 violates constraints C_1 and C_2 , it is not assumed that S_1 first undergoes the range of repairs that are possible for C_1 , and then undergoes the set of repairs that are possible for C_2 . Instead, it is assumed that the ‘generator’ (‘Gen’) generates an infinite set of candidates without referring to the input or the constraints which S_1 might violate. One of the candidates in the set generated by Gen will necessarily be the candidate that incurs the least grave violations. In other words, among the infinite set of candidates, there will be a candidate that satisfies more of the highly ranked constraints than another candidate. On the surface, this winning candidate will give the appearance that the input was repaired in ways that are the least constrained in

the language. Thus, constraints do not specify any particular repair operations or set of repair operations, and these operations are never effectuated in relation to the input.

In the next subsection I will provide the set of constraints necessary to account for transparent harmony in disyllabics, which classical OT can account for. I will show that this system undergenerates when we look at words of more than two syllables. The fact that it undergenerates is due to over-evaluation. ‘Over-evaluation’ refers to the fact that if a candidate C_1 has n violations with respect to a certain constraint Con_x , then only candidate C_2 , that has a $n-1$ violations is more harmonic than C_1 with respect to Con_x . In other words, if a violation V can be repaired without incurring violations of more highly ranked constraints, then all instances of V will be repaired. This predicts that certain processes that are iterative, but optional at each iteration, are impossible (see Vaux 2002 for examples such processes from French, Dutch, and North American English).

2.1 Classical OT

I will assume that closed syllable laxing and pre-fricative tensing are each forced by a context-dependent markedness constraint defined below:

(1) *Closed syllable laxing and pre-fricative tensing constraints*

- a. $*[+hi, +ATR]/_C]_\sigma$ In closed syllables, [+high] vowels are not [+ATR]
- b. $*[+hi, -ATR]/_Z]_\sigma$ In syllables closed by voiced fricatives (‘Z’ = voiced fricatives), [+high] vowels are not [-ATR].

The laxing constraint is justified by the cross-linguistic markedness of [+high, +ATR] vowels in closed syllables. This prohibition is observed in Pasiego Montañés (Picard 2001, Hualde 1989), Palestinian Arabic (Shahin 2002) and Kalɔŋ (Hyman 2002).

The pre-fricative tensing constraint is justified by the fact that tensing is a cross-linguistically common enhancement of lengthening (and vice versa; see Ladefoged & Maddieson 1996). Tensing of [+high] vowels in this environment is probably historically linked to their lengthening, though I choose to maintain lengthening and tensing as two separate processes in the synchronic grammar of CF (see discussion in section 2.2.3 of chapter 4). $*[+hi, +ATR]/_C]_{\sigma}$ is violated by any word in which pre-fricative tensing applies so that $*[+hi, -ATR]/_Z]_{\sigma} \gg *[+hi, +ATR]/_C]_{\sigma}$.

Both of these markedness constraints are ranked above a faithfulness constraint forcing segments to have the same value for [ATR] in the output as in the input. This is Ident-IO[ATR], which is an input-output correspondence constraint (see McCarthy & Prince 1995):

(2) *Faithfulness constraint*

Ident-IO[ATR] Output correspondents of an input $[\alpha ATR]$ are also $[\alpha ATR]$.

For the purposes of this subsection, I will not formalise the markedness constraint responsible for vowel harmony. The specific formalisation of this constraint can partially solve the over-evaluation problem, and I will treat this in the next subsection (2.2). I will simply assume that this constraint exists, and that it forces laxing of non-final [+high] vowels when the final [+high] vowel in the word is [-ATR]. I will refer to the constraint as ‘VH.’ The assumption that a similar constraint exists in the universal inventory is motivated by the existence of a similar phenomenon in Palestinian Arabic (Shahin 2002), where a [-ATR] feature can spread from final to non-final segments.

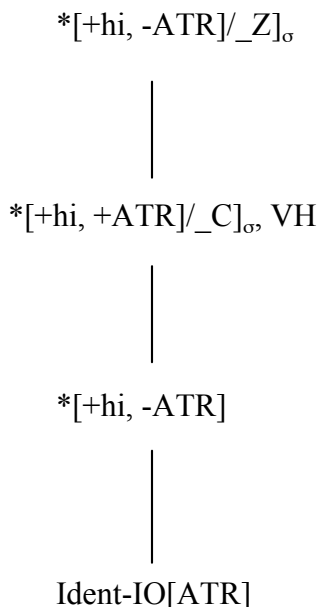
Finally, I also assume a context-free markedness constraint that prohibits [+high] lax vowels from surfacing at all. The existence of this constraint is justified by the cross-

linguistic markedness of [+high, -ATR] vowels (see Calabrese 1988, Archangeli & Pulleyblank 1994). The constraint is outranked by the laxing and harmony constraints, which are responsible for CF outputs having these vowels. The constraint outranks Ident-IO[ATR] however, since [+high] vowels do not contrast for [ATR]. The constraint is defined in (3), while the overall hierarchy is provided in (4):

(3) *Context-free markedness constraint*

*[+hi, -ATR] [+high] vowels are not [-ATR].

(4) *Constraint hierarchy*



I will assume that lengthening is forced by a highly ranked markedness constraint that forces all CF vowels to be long before tautosyllabic voiced fricatives: *[-long] / _[+vce, +cont]]_σ. *[-long] / _[+vce, +cont]]_σ is ranked above its corresponding faithfulness constraint Ident-IO[long]. I define the constraints below. Because lengthening is not

relevant to the present discussion, I will omit these constraints from all future tableaux. In those candidates that feature pre-fricative tensing, I will assume that lengthening ‘comes for free,’ but this is just for notational convenience:

(5) *Lengthening constraints*

- a. *[-long]/_[+vce, +cont]]_σ Vowels before tautosyllabic voiced fricatives are not short.
- b. Ident-IO[long] Output correspondents of an input [αlong] are also [αlong].

This constraint hierarchy predicts the correct output as far as disyllabic transparent cases are concerned, as illustrated in the following tableau. I am omitting the pre-fricative tensing constraint here, since it is not relevant. Assuming Richness of the Base, for any input, the hierarchy in (4) will always predict the correct output⁷⁰:

(6)

	*[+hi, +ATR]/_C]σ	VH	*[+hi, -ATR]	Ident-IO[ATR]
a. si.vil	*!			
Ⓢb. si.vil			**	
c. si.vil	*!	*	*	
d. si.vil		*!	*	

Though our constraint hierarchy predicts the correct output for disyllabics, I will show in the next section that this is not the case for words of more than two syllables.

⁷⁰ The correct output is [si.vil] ‘civil.’

2.2 Classical OT and the use of highly specific constraints (McCarthy 2003)

This subsection will argue that the ‘over-evaluation’ problem can be partially solved by hypothesising highly specific constraints. I assume that a constraint is highly specific if it has either or both of the following characteristics:

(7) *Characteristics of highly specific constraints*

- a. A constraint is highly specific if it targets one and only segment.
- b. A constraint is highly specific if the set of repairs that will satisfy the structural description of the constraint is limited to one.

Subsection 2.2.1 will show that non-specific constraints such as ‘Agree’ and ‘Spread’ constraints fail to predict some of the possible outputs of harmony under any ranking. Subsection 2.2.2 shows that ‘Match’ constraint offer a solution to this problem for trisyllabics, but ultimately overgenerates when it comes to tetrasyllabics.

2.2.1 Non-specific constraints: ‘Agree’ and ‘Spread’ constraints

Bakovic (2000) proposes an Agree family of constraints that can account for CF harmony in disyllabics. Agree constraints are given a general definition in (8)a, and a more specific definition in (8)b adapted to the CF case:

(8) a. *Agree[F]*

Agree[F] Adjacent segments must have the same value for the feature [F].

b. *Agree[+hi, -ATR]*

Agree[-ATR] [+high] vowels adjacent to a [+high, -ATR] vowel on the [-cons] tier has the same value for [ATR].

Violation marks are assigned to every pair of segments that do not share the feature [F].

Spread constraints (e.g. Padgett 1995, Kaun 1995) have a different definition but make the same prediction because of the way in which they assign constraint violations. This is spelled out in the definition below:

(9) a. *Spread[F]*

Spread[F] Assign one violation mark to every segment in domain D that is not mapped to autosegment [F].

b. *Spread[-ATR]*

Spread[-ATR] Assign one violation mark to every [+high] vowel in the word not mapped to a [-ATR] autosegment.


The following tableaux show that in the case of disyllabics, these constraints can predict the correct output (tableaux are essentially the same as the general tableau given in (6)):

(10) *Agree constraints predicting the correct output for transparent disyllabics*

	*[+hi, +ATR]/_C] _σ	Agree[-ATR]/[+hi]	*[+hi, -ATR]	Ident-IO[ATR]
a. si.vil	*!			
☞ b. si.vil			**	
c. si.vil	*!	*	*	

d. si.vil		*!	*	
-----------	--	----	---	--

(11) *Spread constraints predicting the correct output for transparent disyllabics*

	*[+hi, +ATR]/_C] _σ	Spread[-ATR]	*[+hi, -ATR]	Ident-IO[ATR]
a. si.vil	*!			
[-ATR] /  b. si.vil			**	
[-ATR] c. si.vil	*!	*	*	
[-ATR] d. si.vil		*!	*	

Both Agree and Spread constraints predict that, under any ranking, a candidate in which every segment agrees with the final [+high] vowel for [-ATR], or in which every segment is mapped to a [-ATR] autosegment, will always win over a candidate that has at least one segment that does not comply with the harmony constraint.

Problems for non-local CF harmony are very clear, since Agree assumes strict locality of spreading. A candidate such as [ɪ.li.sɪt], with non-local harmony could never win over a candidate like [ɪ.li.sɪt], where all [+high] vowels agree for [-ATR]. As shown in the tableau below, the candidate with ATB harmony can be the only surviving candidate, since all others incur one or more violations of Agree.

(12)

	Agree[+hi, -ATR]
a. i . l i . s i t	*
● [*] b. ɪ . l ɪ . s i t	
c. ɪ . l i . s i t	**
d. i . l ɪ . s i t	*

Under any ranking with respect to *[+hi, -ATR], non-local and adjacent harmony candidates will always lose out to the ATB candidate, which incurs no violation of Spread [-ATR]:

(13)

	Spread[-ATR]
a. i . l i . s i t	**
● [*] b. ɪ . l ɪ . s i t	
c. ɪ . l i . s i t	*
d. i . l ɪ . s i t	*

The problems with these constraints are only circumscribed if we assume, like McCarthy, that the constraints forcing harmony in CF target one specific segment, and not all eligible segments (i.e. all [+high] vowels).

The more general problem is ‘over-evaluation.’ Eval considers every relevant segment in a given candidate to see if it complies with a specific constraint. If we assume these constraints, we predict that there is no grammar that will select [ɪ . l i . s i t] over [ɪ . l ɪ . s i t] as its output.

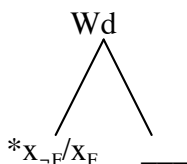
2.2.2 Highly specific constraints: ‘Match’ constraints

Since in an output like [ɪ . l i . sɪ t] or [i . lɪ . sɪ t] it is crucial that one and only one [+high] vowel undergo harmony, we must hypothesise constraints that see only one vowel. This is possible if we assume ‘Match’ constraints, proposed in McCarthy (2003). McCarthy (2003) proposes Match constraints as an alternative to Align constraints, the latter of which are used to account for autosegmental spreading in many authors’ works (see Pulleyblank 1996, Orié 2001, 2003). The gradient nature of Align constraints leads to unverified predictions, e.g. satisfaction of an Align constraint forcing harmony should block suffixation (Wilson 2003). McCarthy points out however, that, setting the interaction that may exist between spreading and suffixation aside, the relative harmony of candidates with respect to Align constraints predicts the correct outputs in most spreading cases. It is thus for broader theoretical reasons that an alternative to Align constraints is desirable. However, non-gradient alternatives such as Spread (Padgett 1995b) and Agree (Bakovic 2000) make incorrect predictions as to the range of possible patterns of spreading (see McCarthy 2003). These problems are the result of the autosegmental nature of Spread constraints and the assumption of iterativity (Agree). McCarthy thus proposes Match constraints, which force two or more segments within a given prosodic domain to agree with respect to a certain feature, but do not assume that they are mapped to the same autosegment, and do not assume that segments need be adjacent one to the other. Candidates thus have the same relative harmony for Match constraints as they do for Align, but without making the same predictions as their alternatives. Match constraints are defined as follows, where F is a feature or tone, and *x* is a segment or syllable:

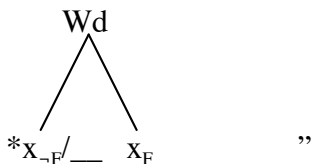
(14) *Match constraints*⁷¹

“The constraints Match-R(F) and Match-L(F) demand agreement in F-value between a segment or syllable and any preceding/following segment (in the case of features) or syllable (in the case of tones). They are defined as follows, where F is a feature or tone and *x* is a segment or syllable:

a. Match-R(F)



b. Match-L(F)



-McCarthy (2003)

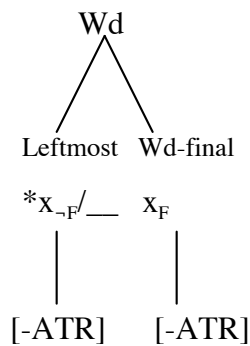
The advantage of Match constraints over Align, Spread or Agree, is that the formalism allows to target a segment that is in a specific position with respect to the harmonic trigger. The match constraint forcing non-local harmony is then defined as follows:

(15) *Constraint forcing non-local harmony*Match-L(-ATR) *leftmost*

The leftmost [+high] vowel in a sequence of [+high] vowels is not [+ATR] if the word-final vowel in the sequence is [+high, -ATR].

⁷¹ I remind the reader that McCarthy defines Match constraints *non-autosegmentally* despite the appearances of the formalism quoted here, which links both matching segments to a Word node. This ‘branching node’ formalism is only meant to indicate that the two matching segments are in the same prosodic domain.

Abbrev. Match-Leftmost



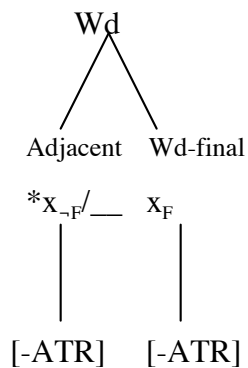
Similarly, the constraint forcing adjacent harmony would be defined as such with some minor adjustments regarding the relationship between the target and trigger:

(16) *Constraint forcing strictly local harmony*

Match-L(-ATR) adjacent

A [+high] vowel adjacent to a word-final [+high, -ATR] vowel is not [+ATR].

Abbrev. Match-Adjacent



I assume that the constraints forcing harmony are ranked at the same level as $*[+hi, +ATR]/_C]_{\sigma}$ which, when $Ident[ATR]$ is lowly ranked, forces closed syllable laxing. $Ident[ATR]$ will not appear in the upcoming tableaux for simplicity's sake. Match constraints do crucially interact with $*[+hi, -ATR]$ ⁷² in differentiating outputs corresponding to the non-final and ATB patterns. The following tableaux show how the different rankings of Match-Leftmost, Match-Adjacent and $*[+hi, -ATR]$ successfully account for all the possible *trisyllabic* outputs:

(17)

a. No harmony

	$*[+ATR]/_C]_{\sigma}$	$*[+hi, -ATR]$	Match-Leftmost	Match-Adjacent
☞ a. i.li.sIt		*	*	*
b. I.lI.sIt		***!		
c. I.li.sIt		**!		*
d. i.lI.sIt		**!	*	

b. ATB

	$*[+ATR]/_C]_{\sigma}$	Match-Leftmost	Match-Adjacent	$*[+hi, -ATR]$
a. i.li.sIt		*!	*	*
☞ b. I.lI.sIt				***
c. I.li.sIt			*!	**
d. i.lI.sIt		*!		**

c. Non-local

	$*[+ATR]/_C]_{\sigma}$	Match-Leftmost	$*[+hi, -ATR]$	Match-Adjacent
a. i.li.sIt		*!	*	*
b. I.lI.sIt			***!	
☞ c. I.li.sIt			**	*
d. i.lI.sIt		*!	**	

⁷² See chapter 1 where these constraints are defined.

d. Adjacent non-iterative

	*[+ATR]/_C] _σ	Match-Adjacent	*[+hi, -ATR]	Match-Leftmost
a. i.lɪ.sɪt		*!	*	*
b. ɪ.lɪ.sɪt			***!	
c. ɪ.lɪ.sɪt		*!	**	
☞d. i.lɪ.sɪt			**	*

Crucially, the rankings in (17)b-d also predict that correct outputs for disyllabics, as shown by the tableaux in (18):

(18)

a. ATB ranking

	*[+ATR]/_C] _σ	Match-Leftmost	Match-Adjacent	*[+hi, -ATR]
a. fi.lɪp		*!	*	*
☞b. fɪ.lɪp				**

b. Non-local ranking

	*[+ATR]/_C] _σ	Match-Leftmost	*[+hi, -ATR]	Match-Adjacent
a. fi.lɪp		*!	*	*
☞b. fɪ.lɪp			**	

c. Adjacent non-iterative

	*[+ATR]/_C] _σ	Match-Adjacent	*[+hi, -ATR]	Match-Leftmost
a. fi.lɪp		*	*	*
☞b. fɪ.lɪp			**	

So far so good, but as mentioned at the beginning of this subsection, even constraints that are as specific as ‘Match’ eventually overgenerate. It is necessary to hypothesise two separate Match constraints since there are two possible targets for harmony, the leftmost vowel and the most adjacent vowel. The necessity of this assumption is the cause of Match constraints’ overgeneration. Recall that in the case of tetrasyllabics, we must account for three patterns of harmony- the same number as in the trisyllabic case- and the impossibility of four other patterns. They are relisted here:

(19)

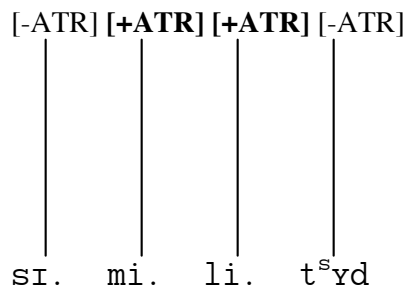
a. *Attested patterns of harmony in tetrasyllabics*

- | | | |
|---|------------------------|--------------|
| A. s <u>ɪ</u> . m <u>ɪ</u> . l <u>ɪ</u> . t ^s ɪd | across-the-board | ‘similarity’ |
| B. s <u>ɪ</u> . mi. li. t ^s ɪd | non-local | |
| C. si. mi. l <u>ɪ</u> . t ^s ɪd | adjacent non-iterative | |

b. *Unattested patterns of harmony in tetrasyllabics*

- | | | |
|--|------------------------------------|--|
| D. si. m <u>ɪ</u> . l <u>ɪ</u> . t ^s ɪd | local 2 iterations | |
| E. si. m <u>ɪ</u> . li. t ^s ɪd | non-local non-initial | |
| F. s <u>ɪ</u> . m <u>ɪ</u> . li. t ^s ɪd | non-local non-initial iterative | |
| G. s <u>ɪ</u> . mi. l <u>ɪ</u> . t ^s ɪd | non-local & Adjacent non-iterative | |

The non-local and adjacent patterns are easily accounted for by the rankings in (17)c and (d). The across-the-board pattern can be accounted for if we assume a constraint that forces all non-final [+high] vowels to be [-ATR] if the leftmost vowel projects a [-ATR] feature. This essentially amounts to a constraint that bans ‘gapped’ structures such as the one here:

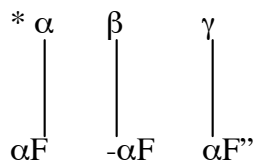
(20) *Gapped structures*

I will refer to the constraint prohibiting such structures as ‘NoGap,’ it is defined here in the words of Ni Chiosain & Padgett (2001):

(21) *NoGap*

“NoGap

Where α , β , and γ are segments, α is not αF if γ is αF and there is an intervening β that is $-\alpha F$.



The assumption that ‘across-word’ spreading is due to spreading being strictly local and iterative follows from the assumption that gapped structures are prohibited (highly ranked ‘NoGap’ constraint prohibits all non-local spreading; see Flemming 1995a, Gafos 1996, Walker 1998). The ‘across-the-board’ pattern can be generated if we assume the following ranking:

(22)

	Match-Leftmost	NoGap	*[+hi, -ATR]	Match-Adjacent
a. si.mi.li.t ^s yd	*!		*	*
↳ b. sɪ.mɪ.lɪ.t ^s yd			****	
c. sɪ.mi.li.t ^s yd		*!	**	*
d. si.mi.lɪ.t ^s yd	*!		**	
e. sɪ.mɪ.lɪ.t ^s yd	*!		***	
f. sɪ.mɪ.li.t ^s yd	*!	*	**	*
g. sɪ.mɪ.li.t ^s yd		*!	***	*
h. sɪ.mi.lɪ.t ^s yd		*!	***	

Because we assume only Match-Leftmost, Match-Adjacent and NoGap, under no ranking will we be able to generate candidates (e), (f) or g, so that this system works up to a point. For the purposes of the dissertation, I will assume that the unattested status of the outputs is due to the UG-based unavailability of a constraint like ‘Match-Second Vowel from the left edge.’ If this constraint were ranked above *[+hi, -ATR], the following outputs would be possible: e (if NoGap >> *[+hi, -ATR]), and g (if *[+hi, -ATR] >> NoGap). The availability of this constraint would also allow us to generate candidate g as an output, under the following ranking: Match-SecondVowel, Match-Leftmost >> *[+hi, -ATR] >> NoGap, Ident-IO[ATR]. Though I assume only Match-Leftmost and Match-Adjacent are the only constraint that are hardwired in UG, I only assume it for temporary lack of a better theory. Nevins, Poliquin & Perfors (2006) propose that patterns (19)b:(d-g) are unattested because their production involves greater computational complexity. As

such, their proposal is that these patterns are not necessarily impossible by virtue of UG 'being just so' but because their production is cognitively more difficult.

Though the account involving Match constraint accounts for this to a certain degree, it is possible to generate pattern (19)b: (g) (below as (23)h):

(23) *ATB ranking: non-autosegmental formulation of Match constraints.*

	Match-Leftmost	Match-Adjacent	*[+hi, -ATR]
a. si.mi.li.t ^s yd	*!	*	*
↖b. SI.MI.LI.t ^s yd			****!
c. SI.mi.li.t ^s yd		*!	**
d. si.mi.li.t ^s yd	*!		**
e. si.mI.li.t ^s yd	*!		***
f. si.mI.li.t ^s yd	*!	*	**
g. SI.MI.li.t ^s yd		*!	**
●h. SI.mi.li.t ^s yd			***

The only way to get around the over-evaluation problem in classical OT is to make constraints as precise as possible in the segment that they evaluate and the repair that they prescribe. Match constraints in this sense constitute a procedural instruction that highly resembles a rule. Even so, the fact that constraints can be ranked freely predicts that a pattern such as (23)h should be attested just as much as the pattern in (23)a (for example). The prediction is incorrect however, and for this reason, classical OT is an inadequate framework as far as CF vowel harmony is concerned.

Now, it is possible to exclude candidate (h) using Match constraints. One could reformulate Match-Adjacent, so that [+high] vowels need not match an adjacent [+high] vowel that is final, as I have formulated it. With such a formulation, candidate

(h) would violate Match-Adjacent and candidate (b) would be selected as the winner. With such a constraint though, under no ranking could the adjacent non-iterative pattern be outputted, since it would incur a violation of Match-Adjacent in this case.

2.2.3 Headed Spans

I will conclude section 2 with a brief note on ‘Headed Spans’ (HS) proposed in McCarthy (2004), and amended in O’Keefe (2005) (see also Key 2005). HS is a theory of featural association proposed in McCarthy (2004) as a solution to the two problems of ‘pro-spreading’ constraints (Agree/Spread) which constitute the problem of ‘over-evaluation’ as I have termed it: 1) pro-spreading constraints cannot predict outputs where spreading is not ‘across-the-board,’ 2) pro-spreading constraints over-generate in predicting unattested patterns, such as a highly ranked spreading constraint blocking epenthesis or suffixation (see Wilson 2001, for a thorough discussion of these problems).

HS constitutes an amendment to classical OT with respect to the ‘Gen’ component of the grammar. HS proposes that Gen parses all candidates into ‘feature spans.’ Feature spans are phonological domains headed by a single segment S_H whose value for a feature [F] (or tone T) determines the value for [F] of all other segments within the span headed by S_H . So, in CF, the final [+high] vowel of a word would be head of a [-ATR] span, since it determines the value for [ATR] of other [+high] vowels in the word. The across-the-board pattern would thus be represented as [ɪ . lɪ . sɪt]_[-ATR], where the bold underlined segment is the head of the span.

HS is similar to the ‘Optimal Domains Theory’ of Cole & Kisseberth (1994) and Cassimjee & Kisseberth (1998), as well as to the ‘Headed Feature Domains’ theory of Smolensky (2005). These all face the same problems when it comes to the CF data. HS

is couched within the framework of OT and assumes five ‘families’ of markedness constraints. I will define these five families first and provide an account for Wolof transparent vowels using HS (taken from O’Keefe).

The first family of constraints essentially force across-the-board spreading, in that it prohibits adjacent spans of the same feature: *A-Span(F). It is defined here in the words of Key (2005);

(24) *A-Span(F)

*A-Span(F) Assign a penalty [violation mark] for each pair of adjacent spans of [F].

The second family of constraints force particular segments to be heads. This is the ‘Head’ family of constraints:

(25) *Head constraints*

Head([βG, γH, . . .], [αF]) Every [βG, γH, . . .] heads a [αF] span.

Thirdly, it is assumed that languages can parametrise for the position of heads within a span (i.e. whether a span is right-headed or left-headed). This is the ‘SpHd’ family of constraints:

(26) *SpHd constraints*

SpHd {L,R}(αF) The head of an [αF] span is initial/final in that span.

HS also assumes a family of faithfulness constraints $FthHdSp(\alpha F)$, which forces each segment that is a feature-bearing unit for $[F]$ in a given input to head its own span for $[F]$:

(27) *FthHdSp*(αF)

$FthHdSp(\alpha F)$ If an input segment S_I is $[\alpha F]$ and it has an output correspondent S_O , then S_O is the head of an $[\alpha F]$ span.

Finally, there is also a family of constraints that force all segments within a span to share the same value $[\alpha F]$ with the head of the span. F , G , and H are features; Greek letters are feature values (taken from O’Keefe 2005):

(28) *AssociateHead*

AssociateHead($[\beta G, \gamma H, \dots], [F]$): Every $[\beta G, \gamma H, \dots]$ must share the value of the head of the F -span in which it is located.

In Wolof, suffix vowels surface with the same value for $[ATR]$ as stem vowels, and $[+high]$ vowels are transparent to harmony (see ch. 4 for discussion on Wolof). For example, if we take a monosyllabic stem like $[sɔŋg]$ (‘attack’), in which the vowel is $[-ATR]$, the vowel in the reciprocity suffix ($/-o/$ ‘reciprocal’) will have value for $[ATR]$:
 ✓ $[sɔŋgɔ]$ ✗ $[sɔŋgɔ̄]$. $[+high]$ vowels are transparent to harmony, meaning that harmony in $[-ATR]$ between a stem vowel and a suffix vowel also holds across a $[+high]$ vowel; $[+high]$ vowels are always $[+ATR]$: e.g. $[bɔkk]$ + $[ulɛ:n]$ ‘be part of’ + ‘2nd plural, neg.’ → ✓ $[bɔ.ku.lɛ:n]$, ✗ $[bɔ.ku.lɛ̄:n]$.

O'Keefe accounts for this pattern by proposing that the string [bɔ.ku.lɛ:n] forms a single [-ATR] span, but that the medial vowel is not laxed (to [ʊ]), i.e. not every segment within the span shares the value of the head of the F-span in which it is located. This is because Wolof has a highly ranked constraint banning [+high, -ATR] vowels from surfacing: *[+hi, -ATR]. O'Keefe assumes the following constraints for Wolof:

(29) *HS Constraints in Wolof*

- | | |
|----------------------------------|--|
| a. *A-Span(ATR) | Assign a penalty [violation mark] for each pair of adjacent spans of [ATR]. |
| b. Head([-high], [-ATR]) | Every [-high] vowel heads an [-ATR] span. |
| c. Head([-high], [+ATR]) | Every [-high] vowel heads a [+ATR] span. |
| d. SpHd {R}(ATR) | [ATR] spans are left-headed. |
| e. FthHdSp(α ATR) | If an input segment S_1 is [α ATR] and it has an output correspondent S_0 , then S_0 is the head of an [α ATR] span. |
| f. AssociateHead([+high], [ATR]) | Every [+high] vowel must share the value of the head of the ATR-span in which it is located. |
| g. *[+hi, -ATR] | [+high] vowels are not [-ATR] |

Harmony is forced by ranking *A-Span(ATR) >> FthHdSp(α ATR). This ensures that any string will have the minimal number of spans for [ATR]. Constraints (29)b and (c) are highly ranked and ensure that all [-high] vowels head an [ATR] span. Constraint (29)d is also highly ranked and ensures that harmony applies rightward. Finally, constraint (29)f, which forces all [+high] vowels to share the same value for [ATR] as the head of the span, is outranked by *[+high, -ATR] ((29)g). If the head of the span is [-ATR], complying with AssociateHead would incur a violation of the more highly ranked *[+high, -ATR]. The transparent candidate is the winner because it has a minimal number of [ATR] spans, yet does not violate the highly ranked *[+high, -ATR]. For simplicity's sake, I am leaving out constraints (29)b-d, since they are not crucial to the present point⁷³:

(30)

bokule:n	*[+hi, - ATR]	AssocHead	*A-Span	FthHd
a. (bokule:n) _[-ATR]		*		*
b. (bokule:n) _[-ATR]		**!	*	*
c. (bokule:n) _[-ATR]	*!			*
d. (bokule:n) _[-ATR]	*!			*

HS thus provide one way of accounting for transparent vowels within OT, and hence their interest for CF, which also has a case of transparency. The case is peculiar though, in that the transparent vowel is by definition non-neutral in non-local harmony:

⁷³ Also for simplicity's sake, I am only considering those candidates that feature one featural span, because all others would lose out anyway, since they would incur more than one violation of *A-Span.

[ɪ . l i . sɪt] ‘illicit.’ I will show that HS can only account for this pattern with difficulty. It should be noted that HS is not the only OT-based framework that can account for Wolof-type opacity. A similar pattern in Ife Yoruba, which involves [-ATR] harmony and [+high] transparent vowels, is accounted for with ‘pro-spreading’ constraints, and using the same assumptions, namely, that [+high] vowels cannot harmonise because of a highly ranked *[+high, -ATR] constraint (see Olika Orié 2003).

Constraint interaction in HS can be illustrated for the CF grammars for which this theory does work. Assuming HS, let us define the following constraints, which can account for some patterns of harmony in CF:

(31) *HS constraints in CF*

- | | |
|---------------------------|--|
| a. *A-Span(ATR) | Assign a penalty [violation mark] for each pair of adjacent spans of [ATR]. |
| b. Head([+high], [ATR]) | Every [+high] vowel heads an [ATR] span. |
| c. SpHd {R}(ATR) | [ATR] spans are right-headed. |
| d. FthHdSp(α ATR) | If an input segment S_I is [α ATR] and it has an output correspondent S_O , then S_O is the head of an [α ATR] span. |

Non-local and across-the-board harmony are each predicted by a different hierarchy, as illustrated in the following tableaux (I am assuming that the head and SpHd constraints are not violated by any of the candidates, so I do not include them here):

(32) *HS predicting adjacent and across-the-board harmony*⁷⁴

⁷⁴ The theory predicts that, in principle, outputs like (i . i)_[+ATR] · (ɪ)_[-ATR] and (i)_[+ATR] · (i)_[+ATR] · (ɪ)_[-ATR] should be identical. Only the former representation will ever surface however, since the latter would always incur one more violation of *A-Span[ATR], no matter the ranking.

a. Non-local harmony

	FthHdSp(α ATR)	*A-Span(ATR)
a. (i . i) _[+ATR] · (ɪ) _[-ATR]	*!	*
b. (ɪ . ɪ . ɪ) _[-ATR]	***!	
c. (ɪ) _[-ATR] · (i) _[+ATR] · (ɪ) _[-ATR]		***
d. (i) _[+ATR] · (ɪ . ɪ) _[-ATR]	*!	*

b. Across-the-board harmony

	*A-Span(ATR)	FthHdSp(α ATR)
a. (i . i) _[+ATR] · (ɪ) _[-ATR]	*!	*
b. (ɪ . ɪ . ɪ) _[-ATR]		***
c. (ɪ) _[-ATR] · (i) _[+ATR] · (ɪ) _[-ATR]	***!	
d. (i) _[+ATR] · (ɪ . ɪ) _[-ATR]	*!	*

We see that HS can predict the non-local pattern, as illustrated in (32)a. The non-local pattern of harmony wins because it has the most [ATR] spans and thus fully satisfies FthHdSp(α ATR). If we permute the two constraints, then the across-the-board pattern wins because it has limited the number of [ATR] spans to a single one, and thus incurs no violation of *A-Span(ATR).

There are two major problems however. The first major issue is theory-internal: implicitly, the non-local pattern can only be predicted if we assume that each vowel is specified for a value of [ATR] in the input. Because vowel harmony is allophonic, this contradicts Richness of the Base (ROTB). The second issue is empirical: as is evident

from the tableaux in (32), under no ranking could we differentiate the ‘no harmony’ pattern from adjacent harmony. Each incurs one faithfulness violation, since not every [ATR] feature-bearing unit heads its own span, and each incurs one markedness violation because it has more than one [ATR] span. The two candidates are thus impossible to differentiate.

Now, it would be possible for the non-local pattern to win, if we assumed that the output constituted only one featural span: [ɪ . l i . sɪ t]_[-ATR]. Although the string constitutes only one featural span, the medial vowel clearly does not agree with the head (i.e. the final vowel). This could only be the case if, as in Wolof, an AssociateHead constraint was violated. But this can only be done if complying with AssociateHead would incur a violation of a more highly ranked constraint that would prevent medial vowels from harmonising. Clearly, that constraint cannot be *[+high, -ATR], as in Wolof, because we know it is not highly ranked. The only way would be to posit an *ad hoc* constraint banning medial vowels from being [-ATR]. The solution would predict the correct results, but it is not clear what explanatory advantages it would have.

To conclude, HS overcomes the problem of over-evaluation in that it allows us to constrain spreading in ways that could not be done with pro-spreading constraints. In this sense, the theory represents a marked improvement. The CF facts still remain out of its analytical reach however.

3 Opacity

This subsection will look at how OT-based frameworks fail to account for opacity. The opacity problem is well covered in the literature: see among others Bermudez-Otero 1999, in preparation; Idsardi 1997, 1998, 2000; Kiparsky 2000, in preparation; McCarthy 1999a, 2003; Itô & Mester 2001, 2003a, for discussions on modeling opacity in an OT

framework. Opaque CF vowel harmony shows specifically that a purely parallelist solution to the opacity problem fails to account for non-paradigmatic opacity of the CF type. This has been pointed out before in the work of Itô & Mester (2001, 2003) and is confirmed by the CF data in subsection 3.3. The main focus of this subsection however will be on the framework of ‘Targeted Constraints’ (TC) proposed in Bakovic & Wilson 2001 and Wilson 2003. I will show in subsection 3.2 that TC offer a workable solution to the over-evaluation- essentially by virtue of being rule-like procedural instructions- but that they ultimately fail in accounting for opacity. Their failure in this respect is due to the OT assumption that constraints must be ranked. I will the present subsection by showing where traditional OT fails in accounting for non-paradigmatic opacity.

In this entire subsection I will assume the constraint set outlined in subsection 2.2, ignoring the over-evaluation problem. Also, for the most part in this subsection, I will be ignoring the variation data, since every point made herein is valid for all grammars of CF. The variations in locality will be relevant to the discussion on TC however.

3.1 Classical OT

As the tableaux illustrate in (17), the following hierarchy predicts harmony in CF (again, I am ignoring the different patterns of harmony). For our purposes here, I am assuming ‘Match’ forces every [+high] vowel to harmonise:

(33)

Match, * [+hi, +ATR] / _C]_o

|

* [+hi, -ATR]

|

Ident-IO[ATR]

We also know that the laxing constraint is violable, since [+high] vowels must be [+ATR] before tautosyllabic voiced fricatives. Consequently, $*[+hi, -ATR]/_Z]_{\sigma}$ dominates $*[+hi, +ATR]/_C]_{\sigma}$. Given this ranking, it is impossible to account for *missive*-type words, in which vowel harmony over-applies:

(34)

	$*[+hi, -ATR]/_Z]_{\sigma}$	Match	$*[+hi, +ATR]/_C]_{\sigma}$	$*[+hi, -ATR]$	Ident-IO[ATR]
a. mi.si:v			*		
b. mI.SI:v	*!			**	
c. mI.si:v		*!	*	*	
d. mi.SI:v	*!	*		*	

The opaque candidate will always lose out because it is not harmonic. The problem lies in the conflict between the assumption that OT constraints are formulated on the basis of surface conditions, and the fact that the correct output is not surface-true.

3.2 Targeted Constraints (Bakovic 2000; Wilson & Bakovic 2001; Wilson 2003)

TC are proposed as an alternative to pro-spreading constraints, which predict unattested effects, such as the blocking of unbounded feature spreading by epenthesis. Wilson (2001, 2003) illustrates these predictions using an example from Johore Malay that I will briefly review here, simply to introduce TC. Johore Malay has an unbounded spreading process whereby [+nasal] spreads rightward from a [+nasal] segment to all [-obs] segments. [+obs] segments block spreading (obstruents in Johore Malay cannot be [+nasal], assuming a highly ranked *NasObs constraint):

(35)

/pəŋawasan/ → [pəŋāwāsan] *[pəŋāwāšān] ‘supervision’

Assuming that this process is forced by a pro-spreading constraint like Spread-R([+nas], PrWd)⁷⁵, Wilson points out that we should expect interactions with a cluster simplification process, which Johore Malay also exhibits. Johore Malay breaks up word-final CC clusters by epenthesising schwa. Wilson assumes this is forced by *CC#. The two constraints conflict, as shown by the following tableau⁷⁶, adapted from Wilson (2003):

(36)

	Spread[+nas]	*CC#
a. nāwākasət	*****!	
☞ b. nāwākast	****	*

The tableau in (36) shows that epenthesis should be blocked by the higher ranked spreading constraint. Conversely, if the constraints were reranked, nasal spreading should be blocked by epenthesis. Under no ranking can we generate the expected

⁷⁵ Where PrWd = Prosodic Word = the morphological domain in which the nasal spreading process applies.

⁷⁶ /nawakast/ is a nonce word used in Wilson (2003) to illustrate this interaction.

output where spreading and epenthesis co-occur: /nawakast/ → [nãwãkasət].

Wilson (2001) shows at length that there exist many other potential conflicts like this⁷⁷, and that none of them are attested. The conflict problem is essentially a variation of the over-evaluation problem. In this case, like for CF harmony, Eval sees all segments that do not undergo spreading, including the epenthetic vowel, and this causes Eval to assign one too many violations to [nãwãkasət], the otherwise licit output.

To solve this problem, Wilson proposes that constraints should be able to encode one and only one repair, since feature spreading constraints, however they are formalised, force only one kind of repair: spreading⁷⁸. The TC framework thus solves two problems: it solves the conflict problem by allowing markedness constraints to specify one and only repair (δ), and it solves the over-evaluation problem by allowing constraints to specify only one *locus of violation*⁷⁹ (λ) (term borrowed by Wilson from McCarthy 2003). As Wilson points out, the resulting formalism is not very different from rules.

In the TC framework, evaluation proceeds as follows: a given markedness constraint evaluates all candidates generated by Gen, and assigns a violation mark for each locus of violation it identifies. A violation mark is removed however, if the locus of violation is repaired using the repair specified in the constraint. Wilson also assumes that each constraint evaluates the candidates in turn, in the order specified by the hierarchy (top to bottom). Once a constraint is done evaluating the candidates, the winner of the evaluation becomes the input to the next constraint's evaluation

⁷⁷ Among them conflicts between spreading and reduplication, allomorph selection, affix positioning, stress placement, etc.

⁷⁸ This of course would be formalised as a natural rule in the framework of Calabrese (2005).

⁷⁹ 'Locus of violation' is essentially the focus of evaluation of a given constraint, much like the focus of a rule (see Anderson 1974; Howard 1972).

process. This is the way in which the TC framework can model iterativity. If we are to account for unbounded spreading, and we assume that constraints identify only one locus of violation per evaluation, we must allow constraints to evaluate more than once so that a feature may spread to more than one segment. Wilson thus assumes that constraints can be parametrised to be iterative or not. It is also assumed that targeted spreading constraints are parametrised for whether they operate from right to left or left to right.

We thus assume the following targeted constraints⁸⁰ for Johore Malay:

(37) *Targeted constraints for nasal spreading in Johore Malay*
(adapted from Wilson 2003)

- | | |
|--------------------------------|--|
| a. T: *NasObs | <p>λ: Obstruents that are [+nasal]</p> <p>δ: [+nasal] \rightarrow [-nasal]</p> |
| b. T: Spread-{L}{[+nas], PrWd} | <p>λ: A [-nasal] segment immediately to the right of a [+nasal] segment in the same prosodic word.</p> <p>δ: [-nasal] \rightarrow [+nasal]</p> |

Let us see how the output [pəŋãwãsan] is derived. I will give a simplified run-through, starting with the spreading constraint. Assuming that the output of T: *NasObs is /nawakast/, the targeted Spread constraint will identify one locus of violation: [nawakast] and assign a violation mark to this candidate. Now, out of all possible

⁸⁰ Targeted constraints are identified with a ‘T.’

candidates, we also have [nāwakast], which is repaired in accordance with δ . The violation mark is removed for this candidate, and it becomes the input to the second iteration of T: Spread-{L}{(+nas), PrWd}. This time the constraint will identify the glide as the locus of violation, and if there is a candidate [nāw̄akast], where the violation is repaired according to δ , the violation mark will be removed, and [nāw̄akast], becomes the input to the iteration, and so on until we have the output of the fourth iteration, which is [nāw̄ākast]. Now, [nāw̄ākast] violates T: *NasObs, which is more highly ranked. So, between the candidate for which the violation mark for T: Spread-{L}{(+nas), PrWd) is removed, and the candidate for which it is not removed, the grammar selects the latter ([nāw̄ākast]) as the input to the next constraint.

Now, if the next constraint were T: *CC#, and its output were [nāw̄akasət], this output would not violate any more highly ranked constraints, since adding an epenthetic vowel does not correspond to any of the highly ranked constraints' specified loci of violation. We thus eventually obtain an output that features both nasal spreading and epenthesis.

Two assumptions are very important in the TC framework: 1) derivation occurs one constraint at a time in the order specified by the hierarchy, and 2) constraints are ordered in a hierarchy. The first assumption is necessary to encode iterativity while the second is necessary to prevent over-generation. I will now show that though the TC constraint successfully overcomes the over-evaluation problem for CF, these assumptions lead to the TC framework's ultimate failure with respect to opacity.

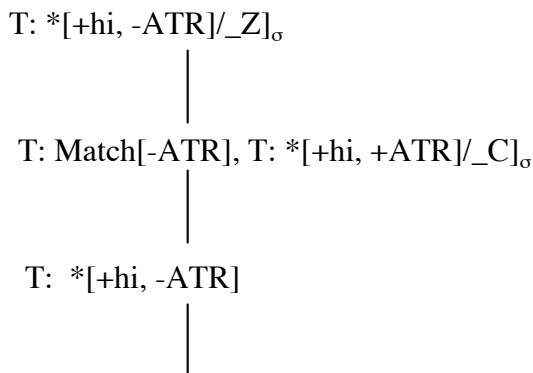
Let us assume the following targeted constraints for CF:

T: Match[-ATR] is non-iterative and starts with the leftmost locus of violation, and the adjacent pattern if T: Match[-ATR] is specified as non-iterative and going from right to left. Assuming these are the only parameters available from UG, we obtain only three possible patterns of harmony for tetrasyllabics as well. As for *inédite*-type words, it is unclear how we would account for the fact that speakers who prefer the adjacent pattern [i . lɪ . sɪt] do not like [ɪ . nɛ . dʒɪt]. Assuming that these speakers have parametrised T: Match[-ATR] to operate from right to left, the constraint would encounter the initial [+high] vowel as its first (and only) locus of violation. The TC framework would output [ɪ . nɛ . dɪt] for these speakers as well, which is incorrect.

Though the TC framework over-generates in this respect, it is possible to generate the harmony patterns attested in CF, which are not predicted by traditional pro-spreading constraints. Over-generation by the TC framework is potentially fixed if we introduce the notion of wide versus narrow scope. I will not concern myself with this sort of amendment here, since the TC framework has a graver flaw relative to opacity, and I will treat this issue instead.

Targeted constraints in CF have the same hierarchy as their non-targeted constraints in a traditional framework:

(39)



Ident-IO[ATR]

Let us assume that the targeted version of the pre-fricative tensing constraint has the following definition:

(40) *Targeted pre-fricative tensing constraint*

T: *[+hi, -ATR]/_Z]_σλ: A [+high] vowel that is [-ATR] in a syllable closed by a voiced fricative.

δ: [-ATR] → [+ATR]

If this is the case, then the output of the pre-fricative tensing constraint should be [mɪ . sɪ : v], or [mɪ . sɪ : v], depending on the original input (we are still assuming ROTB). If these are the only potential inputs to T: Match[-ATR], then the vowel harmony constraint is simply irrelevant. If the original input is /mɪsɪv/, then the TC framework simply cannot produce the opaque form, since pre-fricative tensing ensures that vowel harmony does not apply; in other words the pre-fricative tensing constraint bleeds the vowel harmony constraint. If the input is /mɪsɪv/, the output of the pre-fricative tensing constraint will be [mɪ . sɪ : v]. Again, harmony won't apply.

[mɪ . sɪ : v] may well correspond to the desired opaque output, but it cannot be the final output. In this case, T: *[+hi, -ATR] will apply and identify the non-local [+high] vowel as a locus of violation, which by δ will become [+high, +ATR], obtaining [mɪ . sɪ : v] as the eventual final output. The same happens if the input is /mɪsɪv/. Pre-fricative tensing will only apply vacuously, so that vowel harmony will not apply yet again, and T: *[+hi, -ATR] will ensure that the word has no [+high, -ATR] vowels, thus producing

[mi . si : v] as the final output. The derivation is almost identical if the original input is /mi si v/, except that in this case, pre-fricative tensing does not apply vacuously.

By virtue of its most fundamental assumptions, the TC framework simply cannot generate the opaque form under any circumstance. Though targeted constraints work almost exactly like rules, it is the OT assumptions (the fact that constraints are ordered and apply in that order) that lead to its ultimate downfall.

3.3 Sympathy (McCarthy 1999, 2003)

Assuming Richness of the Base (ROTB; Prince & Smolensky 1993/2002), it is assumed that [+high] vowels can be specified for either [\pm ATR]. Itô & Mester (2001) argue that assuming ROTB precludes an analysis of allophonic opacity facts in a strictly parallelist version of OT designed to accommodate opacity such as ‘Sympathy’ (McCarthy 1999, 2003). Sympathy⁸¹ extends correspondence theory (McCarthy & Prince 1995a) in such a way that output strings can be faithful to other candidates as well as to inputs. The output [mɪ . si : v] would thus exhibit the effects of complying with Match[-ATR] out of faithfulness to another candidate for which Match[-ATR] is relevant: [mɪ . si v], the ‘sympathetic’ candidate. A correspondence constraint acting as the ‘Sympathy’ constraint (represented by a \otimes) ensures this inter-candidate faithfulness. The sympathetic candidate is singled out by a faithfulness constraint called the ‘selector’ (represented by a

⁸¹ This discussion of Sympathy uses the assumptions of McCarthy (1999), where the sympathetic candidate is selected using a specially designated ‘selector’ constraint. The predictions of the modified version of Sympathy (McCarthy 2003) are identical. The 2003 version of Sympathy assumes that the sympathetic candidate is selected by constraints that ensure that it has fewer faithfulness violations relative to the input than the output. This is to avoid ‘Duke-of-York’ derivations, in which $A \rightarrow B \rightarrow A$. This modification to Sympathy may have been unnecessary however given Rubach (2003) and Odden (to appear), who show that Duke-of-York derivations may actually exist in Polish and Bantu, respectively.

☆). In the case of opaque CF harmony, the only available faithfulness constraint for acting as both Sympathy and selector constraint is Ident-IO[ATR]. It is therefore marked with both ☆ and ⌘ in the tableau below. Assumption of ROTB is represented by the multiple inputs, representing only the inputs relevant here, i.e. those showing varying combinations [±ATR] [+high] vowels:

(41)

a. mi. si:v	*[+hi, -	*[+hi,	Match[-ATR]	*[+hi, -	☆ ⌘ Ident-IO[ATR]
b. mI. si:v	ATR]/_Z]σ	+ATR]/_C]σ		ATR]	
c. mI. si:v					
d. mi. si:v					
⊙1. mi. si:v		*			**b, *c, *d
⌘2. mI. si:v	*!			**	**a, *c, *d
⊕3. mI. si:v		*		*!	*a, *c, **d
4. mi. si:v	*!		*	*	*a, *b, **c

As can be seen in the tableau, even if one extends correspondence theory to include Sympathy constraint, because the selector constraint is ranked below *[+hi, -ATR], the actual output (candidate 3) is not selected as the winner because it incurs a violation of *[+hi, -ATR], while its competitor, candidate 1 does not. Candidate 1 is wrongly selected as the winner.

There is another broader issue however pointed out by Itô & Mester (2001). Even if we do not assume $*[+hi, -ATR]$, the system makes the wrong prediction. This is illustrated in the tableau below, identical to (41), but with $*[+hi, -ATR]$ removed:

(42)

a. mi . si : v	$*[+hi, -$	$*[+hi,$	Match[-ATR]	$\star \otimes$ Ident-IO[ATR]
b. mI . SIV	ATR]/_Z]o	+ATR]/_C]o		
c. mI . si : v				
d. mi . SIV				
①1. mi . si : v		*		**b, *c, *d
②2. mI . SIV	*!			**a, *c, *d
③3. mI . si : v		*		*a, *c, **d
4. mi . SIV	*!		*	*a, *b, **c

The selector constraint selects the sympathetic candidate, which must be the candidate whose [ATR] specifications are most like those of the input. Candidate 2 is pointed out with a \otimes as the intended sympathetic candidate. In actual fact however, all four candidates could be selected as the sympathetic candidate. Candidate 1 is most faithful in this respect to input a, so that it could be selected as the \otimes -candidate if we knew the input to be /mi . si : v/. Similarly, candidates 3 and 4 could be the \otimes -candidates if the inputs were c and d, respectively. So Sympathy theory can only predict the correct output if candidate 2 is the \otimes -candidate, and consequently if b is the only input. However, by

ROTB, there is no reason to believe that *b* is the only input (/mɪ . sɪv/), so that

Sympathy theory is incompatible with ROTB.

Using a similar example from German involving opacity and allophonic variation, Itô & Mester (2001) point out that abandoning ROTB to uphold Sympathy leads to negating the divide that exists between contrasts and non-contrasts, a base for any theory of phonology. Rejecting ROTB, we must assume an input restriction theory limiting the input to /mɪ . sɪv/ to obtain the opaque output [mɪ . sɪ : v]. Given that a potential input like /mi . sɪv/ would produce a different output, then we predict that /mɪ . sɪv/ potentially contrasts with /mi . sɪv/. In other words, we predict that [+high] should in fact contrast for [ATR], which we cannot motivate otherwise.

Sympathy also makes the incorrect prediction if we assume that ✱-candidates can be selected with a markedness constraint. If we assume that this is possible, the ✱-candidate would be the candidate for which Match[-ATR] is relevant and which fully complies with Match[-ATR] (that is, the fully harmonic candidate [mɪ . sɪ : v]). Again, I am assuming ROTB. In the following tableau, the cells under Ident-IO[ATR] are divided into two parts. On the left hand side, I indicate the violations that the different candidates incur with respect to the inputs; these are irrelevant in this case, since selection of the ✱-candidate does not depend on its faithfulness to the input. On the right hand side, I indicate the violations that the different candidates incur with respect to the sympathetic candidate (marked with a '2').

(43)

a. mi . si:v	*[+hi, -	*[+hi,	★Match[-ATR]	*[+hi, -	⊗Ident-IO[ATR]	
b. mI . si:v	ATR]/_Z]o	+ATR]/_C]o		ATR]		
c. mI . si:v						
d. mi . si:v						
● ¹ . mi . si:v		*			**b, *c, *d	2**
⊗ ² . mI . si:v	*!			**	**a, *c, *d	
⊗ ³ . mI . si:v		*		*!	*a, *c, **d	2*
4. mi . si:v	*!		*	*	*a, *b, **c	2*

Even if we assume that the sympathetic candidate can be selected using a markedness constraint, this changes nothing about the fact that the correct output (#3) has one too many violations of *[+hi, -ATR] over candidate 1 ([mi . si:v]), which is chosen as the output. Sympathy could only select the correct output if we did away with *[+hi, -ATR], but this is an undesirable option, if we maintain the goal of designing an explanatorily

adequate model of the phonological component. Archangeli & Pulleyblank (1994) attest the fact that [+high, -ATR] vowels are cross-linguistically less common in the world's languages than their [+ATR] counterparts, and that vowel inventories that include the [+high, -ATR] vowels also include their [+ATR] counterparts, as is the case in English, Pasiego Spanish, German and CF (among others).

3.4 Optimality Theory with candidate chains (McCarthy 2006a, forthcoming 2006b)

McCarthy (2006a, forthcoming 2006b) addresses the problem of opacity in OT directly by proposing a synthesis of OT principles and derivations. In OT with candidate chains, henceforth OT-CC, McCarthy models the predictive power of derivations by making the following modification to the original OT framework: rather than assume that candidates produced by Gen are potential surface forms, McCarthy proposes that candidates are in fact series of forms called 'candidate chains.' Chains are composed of an underlying form that is fully faithful to the input and a form equivalent to the output. Candidate chains model derivations insofar as they can also include the intermediate forms that link the underlying form to the surface form. Candidate chains must meet three well-formedness conditions:

- a) the first member of a chain is fully faithful to the underlying form ('faithful initiation');
- b) each form in a candidate chain must be minimally divergent from the previous form ('gradual divergence'), in other words, a candidate chain member can only have incurred one more violation of a faithfulness relative to the previous member in the chain;
- c) a chain member is always more harmonic relative to the constraint hierarchy

than the previous member in the chain ('harmonic improvement')

This amendment to the original OT framework can account for most types of derivational opacity, including counterbleeding opacity. McCarthy illustrates this with an example from Bedouin Arabic in which syncope counterbleeds palatalisation. In Bedouin Arabic /k/ and /g/ palatalise to [k^j] and [g^j] respectively when adjacent to the front vowel [i]. In some cases however, [i] syncopates, obscuring the conditioning environment for palatalisation on the surface:

(44) *Counterbleeding opacity in Bedouin Arabic*

UR	/ħa:kim-in/	'ruling, masc. pl.'
Palatalisation	ħa:k ^j imi:n	
Syncope	ħa:k ^j mi:n	
Surface form	[ħa:k ^j mi:n]	

McCarthy proposes the following constraints:

(45)

- a. *ki There are no sequences of non-palatalised velars and front vowels.
- b. *iCV There are no short high vowels in non-final open syllables.
- c. Max Segments in the input are represented by segments in the output.

- d. Ident(back) Segments in the input with a specification for [back] have the same specification in the output.

Since palatalisation and syncope are clearly active in this language, constraints (45)a-b dominate constraints (45)c-d. But this constraint hierarchy cannot predict the correct result in classical OT (the incorrect winner is designated with a ‘✖’; the correct winner is marked with a ‘☑’):

(46)

/ħa:kimi:n/	*iCV	*ki	Max	Ident(back)
✖*a. ħa:kmi:n			*	
☑b. ħa:k ^j mi:n			*	*!
c. ħa:kimi:n	*!	*!		
d. ħa:k ^j imi:n	*!			*

Given the principles of candidate chain well-formedness, the following candidate chains are possible in OT-CC (the eventual winner is marked with a ‘☑’):

(47) *Possible candidate chains in Bedouin Arabic*

- <ħa:kimi:n>
- <ħa:kimi:n, ħa:k^jimi:n >
- <ħa:kimi:n, ħa:kmi:n >
- <ħa:kimi:n, ħa:k^jimi:n, ħa:k^jmi:n > ☑

The output cannot be derived directly from the input using the candidate chain <ħa:kimi:n, ħa:k^jmi:n > because the chain would violate the principle of gradual divergence. The output incurs two faithfulness violations, so that it is not minimally

divergent from the chain member equivalent to the input. For gradual divergence to be satisfied, we must elongate the chain with an intermediate chain member, so that the changes are effectuated one at a time. If we evaluate these candidate chains relative to the constraint hierarchy in (46), we still obtain the wrong result:

(48)

$/\text{ħa:kimi:-n}/$	*iCV	*ki	Max	Ident(back)
a. $\langle \text{ħa:kimi:n} \rangle$	*!	*		
b. $\langle \text{ħa:kimi:n}, \text{ħa:k}^j\text{imi:n} \rangle$	*!			*
☛c. $\langle \text{ħa:kimi:n}, \text{ħa:kmi:n} \rangle$			*	
☞d. $\langle \text{ħa:kimi:n}, \text{ħa:k}^j\text{imi:n}, \text{ħa:k}^j\text{mi:n} \rangle$			*	

The reason chain (d) loses is owed to the fact that the output member violates two faithfulness constraints, while the output member of chain c has only one. Chain d could win, but only if we could the violation of Ident(back) to precede the violation of Max. McCarthy ensures this result by proposing ‘Prec’ constraints (for ‘Precedence’). These constraints ensure that specific violations happen ‘in order.’ They are defined here, citing McCarthy (2006a):

(40) *Precedence constraints: definition*

Prec(A,B)

Let A' and B' stand for forms that add violations of the faithfulness constraints A and B, respectively.

To any chain of the form <X, B', Y>, if X does not contain A', assign a violation mark, and

to any chain of the form <X, B', Y>, if Y contains A', assign a violation mark.

To the correct output for Palestinian Arabic can be obtained if Prec(Id(back), Max) outranks Id(back). The constraint ensures that the intermediate chain member violates Id(back) before Max is violated. With this hierarchy, we obtain the correct result:

(41)

<i>/ħa:kimi:n/</i>	<i>*iCV</i>	<i>*ki</i>	<i>Max</i>	<i>Prec(Id(back), Max)</i>	<i>Ident(back)</i>
<i>a. <ħa:kimi:n></i>	<i>*!</i>	<i>*</i>			
<i>b. <ħa:kimi:n, ħa:k^jimi:n></i>	<i>*!</i>				<i>*</i>
<i>c. <ħa:kimi:n, ħa:kmi:n></i>			<i>*</i>	<i>*!</i>	
<i>d. <ħa:kimi:n, ħa:k^jimi:n, ħa:k^jmi:n></i>			<i>*</i>		<i>*!</i>

There are a number of problems if we try to apply this analysis to the CF *missive* case.

One of these problems is rooted in the framework's assumption of ROTB. Given ROTB, we have four possible inputs: /mi.siv, mI.siv, mI.siv, mi.siv/. We also have four-member chains, three-member chains, two-member chains and one-member chains. Given the four possible inputs, this gives a total of 64 logically possible chains. Not all of them are well-formed however given the principles of OT-CC listed above ('faithful initiation' etc.), so that they will not be produced by Gen. The total number of well-formed chains is 25, but only seven of these will have the correct output, so that we need not consider the rest. The seven are listed here:

(42)

a. <mI.siv>

b. <mi.siv, mI.siv>

c. <mI.SIV, mI.siv>

d. <mi.SIV, mI.SIV, mI.siv>

e. <mi.SIV, mi.siv, mI.siv>

f. <mI.SIV, mi.SIV, mi.siv, mI.siv>

g. <mi.siv, mi.SIV, mI.SIV, mI.siv>

Given the four possible inputs, we have four possible ‘evaluation scenarios’ (not to say ‘derivation’). Each input has a number of chains associated with it by faithful initiation, i.e. given an input I, only those chains that have an initial member M such that $M = I$ are under evaluation. The four evaluation scenarios are given below in the form of four tableaux:

(43)

a. *Input* = /mi.siv/

/misiv/	*[+hi, - ATR]/_Z] _σ	Match	*[+hi, +ATR]/_C] _σ	*[+hi, - ATR	Ident- IO[ATR]
a. <mi.siv, mI.siv>		*	*	*	*
b. <mi.siv, mi.SIV, mI.SIV, mI.siv>		*	*	*	*

b. *Input* = /mI.SIV/

/mISIV/	*[+hi, - ATR]/_Z] _σ	Match	*[+hi, +ATR]/_C] _σ	*[+hi, - ATR	Ident- IO[ATR]

a. <MI.SIV, mi.siv>		*	*	*	**
b. <MI.SIV, MI.SIV, mi.siv, MI.SIV>		*	*	*	**

c. *Input = /mISiv/*

/mISiv/	*[+hi, - ATR]/_Z] _σ	Match	*[+hi, +ATR]/_C] _σ	*[+hi, - ATR	Ident- IO[ATR]
a. <MI.SIV>		*	*	*	**

d. *Input = /miSIV/*

/miSIV/	*[+hi, - ATR]/_Z] _σ	Match	*[+hi, +ATR]/_C] _σ	*[+hi, - ATR	Ident- IO[ATR]
a. <mi.SIV, MI.SIV, MI.SIV>		*	*	*	**
b. <mi.SIV, mi.siv, MI.SIV>		*	*	*	**

For each scenario, we notice the same problem. Each candidate chain incurs the same violations. Essentially, the problem is this: the only well-formed chains that have the output as its final member are all convergent, no matter what the input is. Convergent chains are chains that have the same input and the same output. McCarthy points out that Prec constraints do not address the problem of convergent chains, so that the different chains in each case could not be differentiated by privileging some unfaithful mapping

orders over others. McCarthy (2006a: 12) points out that: “the empirical claim is that chain convergence isolates and eliminates all orders of noninteracting unfaithful mappings.” The empirical claim seems falsified by the CF example: no matter what the input is, we always obtain a situation where we have convergent chains. The only exception is if the input is /mɪ.sɪv/, in which case we only have one well-formed candidate chain. But the exception is of no help. To assume that only one input is possible amounts to abandoning ROTB. Essentially, the conflict between allophony and ROTB is reminiscent of the one that exists for Sympathy.

The impossibility of using Prec constraints in this case is very clear. Even if, theoretically speaking, we had evidence that there was a single possible input, the different possible chains would still be convergent, but one chain might win over another with the help of a Prec constraint. But the problem is evident: Prec constraints take as their arguments two *different* faithfulness constraints. In the case of CF, we can only really motivate the existence of a single one: Ident-IO[ATR]. Thus, there would be no way to specify a precedence relation, since all harmonic improvements in this case involve violations of the same constraint. Now, even if we consider the possibility of that there exists two faithfulness constraints: Ident-IO[+ATR] and Ident-IO[-ATR], the problem remains unsolved. If we assume /mɪsɪv/ or /mɪsɪv/ as inputs, the two possible Prec constraints, Prec(Id[-ATR], Id[+ATR]) and Prec(Id[+ATR], Id[-ATR]), do not make any difference. If we look at the corresponding tableaux in (43)a and (b), we see that the only possible candidate chains involve harmonic improvements that are violations either of Ident-IO[+ATR] only (in the case of (43)a), or Ident-IO[-ATR] only (in the case of (43)b). If we assume /mɪsɪv/ as the input, the only allowable chain is a one-member chain, in which case both Prec constraints are irrelevant. The only remaining option is to posit /mɪsɪv/ as the input, in which case either chain could win, depending on the ranking of the two Prec constraint relative to each other:

(44) a. $Prec(Id[-ATR], Id[+ATR]) \gg Prec(Id[+ATR], Id[-ATR])$

/miSIV/	$Prec(Id[-ATR], Id[+ATR])$	$Prec(Id[+ATR], Id[-ATR])$	*[+hi, -ATR]/_Z] σ	Mat ch	*[+hi, +ATR]/_C] σ	*[+hi, -ATR]	Ident- IO[ATR]
a. <mi.SIV, mI.SIV, mI.siv>	*!			*	*	*	**
b. <mi.SIV, mi.siv, mI.siv>		*		*	*	*	**

b. $Prec(Id[+ATR], Id[-ATR]) \gg Prec(Id[-ATR], Id[+ATR])$

/miSIV/	$Prec(Id[+ATR], Id[-ATR])$	$Prec(Id[-ATR], Id[+ATR])$	*[+hi, -ATR]/_Z] σ	Mat ch	*[+hi, +ATR]/_C] σ	*[+hi, -ATR]	Ident- IO[ATR]
a. <mi.SIV, mI.SIV, mI.siv>		*		*	*	*	**
b. <mi.SIV, mI.SIV, mI.siv>	*!			*	*	*	**

<mi . sIV,							
mi . sIV,							
mI . sIV>							

There are two obvious problems here: 1) we have to abandon ROTB, since the convergent chain problem can only be solved with Prec constraints by assuming one specific input; 2) even if the learner has evidence that there is only one possible input (which is not really possible given that all the processes here are allophonic), how would the learner rank the Prec constraints?

Though OT-CC offers a compelling solution to the opacity problem in OT, like Sympathy it cannot account for opacity involving allophony.

3.5 Turbidity (Goldrick 2000)

Where McCarthy's Sympathy framework proposes a modification of Con to solve the opacity problem, Goldrick (2000) proposes to modify the representation of output forms. Goldrick's 'Turbidity' framework assumes (like in classical OT) that 1) inputs are mapped to outputs in one optimisation (as opposed to stratal OT see subsection 3.6) that there exist only input-output correspondences. In other words, there are no constraints that ensure correspondence with other (failed) candidates like in Sympathy, or constraints that ensure correspondence with other outputs (e.g. Output-Output constraints proposed in Benua 1995 to account for paradigmatic opacity). In Goldrick's framework, output representation can contain 'turbid' structure that is 'covert.' Turbid structure is "unpronounced material which can influence the 'surface' - the portion of the output which is pronounced." (Goldrick 2000: 2). Turbid structure is structure that is 'projected' by surface material but not 'pronounced.'

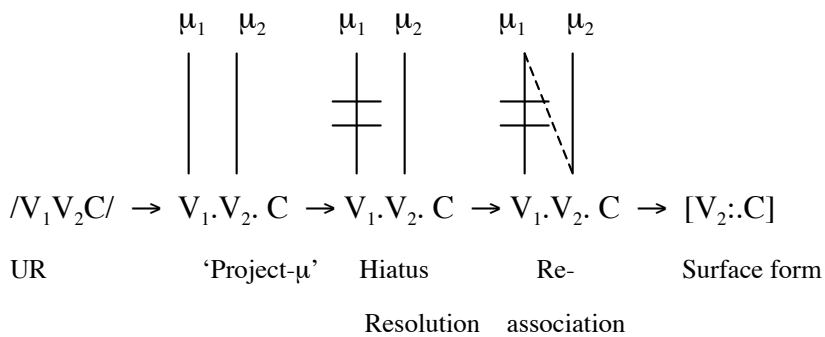
With these assumptions, Goldrick can account for a case of surface opacity in Luganda. I will summarise his account drawing only from Goldrick's work, with Luganda data originally coming from Clements (1986), Rosenthal (1994) and Wiltshire (1992, 1999). Vowel length in this language is generally contrastive, but can still be predictable in some cases: e.g. vowels are always long when preceding vowels are deleted:

(45) *Synchronic compensatory lengthening in Luganda*

- a. /ka/ + /tiko/ → [katiko] 'mushroom'
 b. /ka/ + /oto/ → [ko:to] 'fireplace (dim.)'
 c. /ka/ + /ezi/ → [ke:zi] 'moon (dim.)'

In a rule-based framework, this can be analysed as follows:

(46) *Rule-based analysis of Luganda compensatory lengthening*



Goldrick analyses this case as an instance of opacity because the length of the stem vowel on the surface does not correspond to its underlying length without any surface motivation for the lengthening. In a rule-based framework, the opacity would be accounted for by making the hiatus resolution rule counter-bleed the 'Project- μ ' rule, which forces vowels to associate with moraic structure.

As mentioned above, Goldrick assumes two types of structural relations. The first is called ‘projection,’ which is an abstract structural relationship between the mora and the vowel, and which is exemplified by the cancelled association line in (46). The second is called ‘pronunciation,’ which is an output relationship accounting for the surface realisation of a segment. The relation is exemplified by the dashed line representing re-association above. Crucial to Goldrick’s account is the assumption of a ‘Reciprocity^{X_Y}’ constraint (‘ R^X_Y ’), which forces projected structure to also be pronounced. Naturally, the constraint is violable. R^X_Y is defined below in Goldrick’s words:

$$(47) \quad R^X_Y \quad \text{“If Y projects to X, then X must pronounce Y.”}$$

According to Goldrick’s analysis, Luganda has a highly ranked constraint that prohibits hiatuses (*VV), but also has a highly ranked constraint that forces all morae to be pronounced (Pronounce- μ). By R^X_Y , μ_1 should be pronounced on V_1 , because it is projected by V_1 . This would incur a violation of *VV however. Because *VV is more highly ranked than R^X_Y , and because all morae must be pronounced (by Pronounce- μ), the optimal repair is to pronounce μ_1 on V_2 , thus making V_2 longer on the surface. Goldrick also assumes an undominated Max constraint, which ensures that the illicit structure is not simply repaired by deletion.

The Turbidity framework will account for the CF opacity facts. To do this, we must assume that the laxing and vowel harmony constraints both force a projection relation between a [+high] vowel and a [-ATR] feature. To indicate that a constraint forces a projection relation, I will follow Goldrick’s notation by using an up arrow: ‘ \uparrow .’ We thus assume the same laxing and vowel harmony constraints as before, only that we indicate what kind of projection they impose: *[+hi, +ATR]/_C] \uparrow , Match[-ATR] \uparrow . We must

also assume a Reciprocity constraint that forces segments projecting a [-ATR] feature to pronounce that feature this is $R^{[-ATR]}_{[-cons]}$, which is defined here:

$$(48) \quad R^{[-ATR]}_{[-cons]} \quad \text{If [-ATR] projects to [-cons], then [-cons] must pronounce [-ATR].}$$

$R^{[-ATR]}_{[-cons]}$ is violable however because when a vowel is tense by pre-fricative tensing, the [-ATR] feature on that vowel is not pronounced. I assume that the pre-fricative tensing constraint also forces a projection relation: $*[+hi, -ATR]/_Z]_{\sigma}\uparrow$. So, a [+high] vowel that is in a syllable closed by a voiced fricative projects both a [-ATR] and a [+ATR] feature but only pronounces the [+ATR] feature. The pronunciation relation is indicated with a downwards arrow:

$$(49)$$

[-ATR] [-ATR] [+ATR]

mɪ . sɪ : v

What forces that [+high] vowel to pronounce the [+ATR] feature instead of the [-ATR] feature? I assume that there exists another Reciprocity constraint that outranks $R^{[-ATR]}_{[-cons]}$ and forces vowels to pronounce a [+ATR] feature if they project one. This is $R^{[+ATR]}_{[-cons]}$:

$$(50)$$

$R^{[+ATR]}_{[-cons]}$

If [+ATR] projects to [-cons], then [-cons] must pronounce [+ATR].

We must also assume a highly ranked ‘Pronounce_[+ATR]’ constraint to ensure that the conflict between $R^{[-ATR]}_{[-cons]}$ and $R^{[+ATR]}_{[-cons]}$ is not resolved by simply disassociating the final [+high] vowel from the [+ATR] feature. We thus obtain the following tableau (I am not including *[+hi, -ATR] and Ident-IO[ATR] for simplicity’s sake though I still assume them):

(51)

	$R^{[+ATR]}_{[-cons]}$	Pronounce _[+ATR]	*[+hi, -ATR]/[_Z]σ↑	*[+hi, +ATR]/[_C]σ↑	Match[-ATR]↑	$R^{[-ATR]}_{[-cons]}$
[+ATR][+ATR] ↑ ↑ mi. siV				*!		
[-ATR] [-ATR] ↑ ↑ mi. siV			*!			
[-ATR] [-ATR] [+ATR] ↑ ↑ ↗ mi. siV						*
[+ATR][-ATR] ↑ ↑ mi. siV			*!		*	

The constraint hierarchy selects the correct output. The key innovation of this framework is that it allows us to assume that the opaque candidate covertly projects a [-ATR] feature. The covert [-ATR] feature makes vowel harmony possible. Because the Reciprocity relation between a segment and a [+ATR] feature has precedence over the relationship between the same segment and a [-ATR] feature, it is the [+ATR] feature projected by the final vowel of the opaque candidate that is pronounced. Opacity is thus accounted for by assuming that structural harmony constraints such as the pre-fricative tensing constraint can outrank Reciprocity constraints like $R^{[-ATR]}_{[-cons]}$.

Though Turbidity allows us to account for opacity, it ultimately fails to account for cyclicity. The reasons for this are very straightforward. For one, the Turbidity framework's *raison d'être* is to account for opacity in a version of OT that maintains strict parallelism. In other words, there is no room for a notion of cycle. Let us briefly recall the cyclicity facts: in CF, if we add a suffix to a stem like [mʏ . zɪk] ('music') where both laxing and vowel harmony have occurred, the suffix causes resyllabification, and the stem final vowel must 'lose' its lax quality: [mʏ . zɪk] → [mʏ . zɪ . kal] ('musical'). The non-stem-final vowel- the target of harmony- may retain its lax quality however. In a sense, this is a case of paradigmatic opacity. Because the stem-final vowel in [mʏ . zɪ . kal] is neither lax nor in a closed syllable, there is no reason for the non-final [+high] vowel to be lax- harmony should not apply, hence, the conditioning environment for vowel harmony is not surface-apparent. So, if we were to account for this in the Turbidity framework, we would assume that the stem-final vowel projects a [-ATR] feature but pronounces a [+ATR] feature. It is not clear how we should justify this however, since the stem-final vowel is in an open syllable. There is the undesirable option of going back on Goldrick's original plan not to modify Con as it is formulated in Prince & Smolensky (1993/2004), and adopting Output-Output-constraints. The non-stem-final vowel would be lax out of OO-faithfulness to the stem, but then it is not clear

why the stem-final vowel should not also obey such a constraint. There is a potential way around this if we say that the initial vowel obeys a sort of ‘positional’ OO-faithfulness constraint: only initial vowels are faithful to the stem-initial value for [ATR] because of some sort of greater prominence. This approach is not promising in the least however, since it is clear from the examples in (44) (repeated here as (52)) that faithfulness to the stem cannot be justified by position; in trisyllabics, non-initial (i.e. non-prominent) vowels can also retain their lax quality inherited from vowel harmony:

(52)

<i>Across-the-board</i>		<i>Non-local</i>		<i>Adjacent</i>		
<u>ɪ</u> .l <u>ʏ</u> .m <u>ɪ</u> n	<u>ɪ</u> .l <u>ʏ</u> .m <u>ɪ</u> .ne	<u>ɪ</u> .l <u>ɪ</u> .m <u>ɪ</u> n	<u>ɪ</u> .l <u>ɪ</u> .m <u>ɪ</u> .ne	i.l <u>ʏ</u> .m <u>ɪ</u> n	i.l <u>ʏ</u> .m <u>ɪ</u> .ne	‘illuminate/illumination’
d ^z <u>ɪ</u> .s <u>ɪ</u> .pl <u>ɪ</u> n	d ^z <u>ɪ</u> .s <u>ɪ</u> .pl <u>ɪ</u> .ne	d ^z <u>ɪ</u> .s <u>ɪ</u> .pl <u>ɪ</u> n	d ^z <u>ɪ</u> .s <u>ɪ</u> .pl <u>ɪ</u> .ne	d ^z i.s <u>ɪ</u> .pl <u>ɪ</u> n	d ^z i.s <u>ɪ</u> .pl <u>ɪ</u> .ne	‘discipline/to discipline’
ɸ <u>ɪ</u> .d ^z <u>ɪ</u> .k <u>ʏ</u> l	ɸ <u>ɪ</u> .d ^z <u>ɪ</u> .k <u>ʏ</u> .li.ze	ɸ <u>ɪ</u> .d ^z i.k <u>ʏ</u> l	ɸ <u>ɪ</u> .d ^z i.k <u>ʏ</u> .li.ze	ɸi.d ^z ɪ.k <u>ʏ</u> l	ɸi.d ^z <u>ɪ</u> .k <u>ʏ</u> .li.ze	‘ridicule/to make ridicule’
d ^z <u>ɪ</u> .s <u>ɪ</u> .m <u>ʏ</u> l	d ^z <u>ɪ</u> .s <u>ɪ</u> .m <u>ʏ</u> .le	d ^z <u>ɪ</u> .s <u>ɪ</u> .m <u>ʏ</u> l	d ^z <u>ɪ</u> .s <u>ɪ</u> .m <u>ʏ</u> .le	d ^z i.s <u>ɪ</u> .m <u>ʏ</u> l	d ^z i.s <u>ɪ</u> .m <u>ʏ</u> .le	‘hide/to hide’
m <u>ʏ</u> .n <u>ɪ</u> .s <u>ɪ</u> p	m <u>ʏ</u> .n <u>ɪ</u> .s <u>ɪ</u> .pal	m <u>ʏ</u> .n <u>ɪ</u> .s <u>ɪ</u> p	m <u>ʏ</u> .n <u>ɪ</u> .s <u>ɪ</u> .pal	my.n <u>ɪ</u> .s <u>ɪ</u> p	my.n <u>ɪ</u> .s <u>ɪ</u> .pal	‘city/municipal’

3.6 Stratal OT (Kiparsky 2000; Bermudez-Otero 1999, in preparation)

Lexical Phonology/Morphology-Optimality Theory (LPM-OT), proposed and elaborated in Kiparsky (2000, 2001, in preparation) and Bermudez-Otero (1999, in preparation) is a framework that modifies the parallelist assumption of Classical OT. The framework assumes that the phonological component is divided into two levels: the lexical and post-lexical levels, each of which is associated with different constraint rankings. The framework also allows for the lexical level to be sub-divided into two further levels: the stem level and the word level. It is thus assumed that each level of morpho-syntactic building is associated with a different constraint ranking called a ‘stratum.’ The output of

the first stratum (associated with the stem level), becomes the input of the second stratum and so on, until we obtain the final output of the phonological component. These intermediary outputs thus replicate the intermediate representations of rule-based models. In this sense, LPM-OT is not fully parallel, in that initial inputs are not directly mapped to outputs. Parallelism is not fully rejected however, since the framework assumes that parallelism holds level-internally. The framework can generate opaque outputs, since the reranking of constraints at a stratum S_n can mask the effects of a process that was forced at a previous level S_{n-1} , or the environment in which that process has applied.

LPM-OT can account for the opacity facts of CF if we assume that at stratum S_{n-1} , the pre-fricative tensing constraint is ranked lowly, so that only fully harmonic candidates are generated. Then at stratum S_n , the pre-fricative tensing constraint is reranked so that it outranks the vowel harmony constraint, and the output of stratum S_n features a [-ATR] non-final [+high] vowel and a final [+high] vowel that has undergone pre-fricative tensing: e.g. [mɪ . sɪ : v]. This is illustrated in (62). As can be seen in (62), it is crucial Ident-IO[ATR] be reranked so that the effects of vowel harmony are preserved in the output of S_n . This, ultimately, leads LPM-OT to make wrong predictions for cyclicity facts:

(53) *LPM-OT Derivation of 'missive' facts*a. Stratum S_{n-1}

	Spread[-ATR]/[+hi]	*[+hi, +ATR]/_C] _σ	*[+hi, -ATR]	*[+hi, -ATR]/_Z] _σ	Ident-IO[ATR]
a. mi . si : v		*!			
b. mI . SIV			**	*	
c. mI . si : v		*!	*		
d. mi . SIV	*!		*	*	

b. Stratum S_n

/mI . SIV/	*[+hi, -ATR]/_Z] _σ	Spread[-ATR]/[+hi]	*[+hi, +ATR]/_C] _σ	Ident-IO[ATR]	*[+hi, -ATR]
a. mi . si : v			*	**!	
b. mI . SIV	*!				**
c. mI . si : v			*	*	*!
d. mi . SIV	*!	*		*	*

LPM-OT predicts that the opaque candidate (53)c [mI . si : v] is predicted as the winner at stratum S_n . Candidate (53)a [mi . si : v] loses because it has one too many violations of Ident-IO[ATR].

Though LPM-OT can account for these facts, it cannot account for the CF cyclicity facts, precisely because reranking Ident-IO is so crucial to the account of opacity. Even if CF

did not have opacity, Ident-IO constraints must always be reranked in LPM-OT so as to preserve the effects of previous levels further down. The following derivation illustrates how this system makes the incorrect prediction for [mʏ . zɪk] → [mʏ . zɪ . kal]:

(54) *LPM-OT and Cyclicity Facts*

a. Stratum S_{n-1}

	Spread[-ATR]/[+hi]	*[+hi, +ATR]/_C] _σ	*[+hi, -ATR]	*[+hi, -ATR]/_Z] _σ	Ident-IO[ATR]
a. my.zɪk		*!			
b. mʏ.zɪk			**		
c. mʏ.zɪk		*!	*		
d. mʏ.zɪk	*!		*		



b. Stratum S_n

/mʏ.zɪk/ + /aɪ/	*[+hi, -ATR]/_Z] _σ	Spread[-ATR]/[+hi]	*[+hi, +ATR]/_C] _σ	Ident-IO[ATR]	*[+hi, -ATR]
a. my.zi.kal				**!	
b. mʏ.zɪ.kal					**

⊕c. mʏ . zi . kal				*!	*
d. my . zɪ . kal				*!	*

What selected the correct output for opacity now selects (54)b * [mʏ . zɪ . kal], the candidate with the fully harmonic stem, carried over from stratum S_{n-1} by full faithfulness to the input. The problem cannot be resolved by invoking positional faithfulness either (see Beckman 1997). One could assume that only the initial vowel remains lax because of a highly ranked positional faithfulness: Ident-IO[ATR]/ #(C)_. The fact is that all non-stem final vowels remain [-ATR] whether they are initial or not. This is observable in stems with three [+high] nuclei, where both non-final [+high] vowels have undergone harmony: [ɪ . lʏ . mɪn] → [ɪ . lʏ . mi . nɐ] ('illuminate' / 'to illuminate'). It would be difficult if not impossible to argue that the stem-medial vowel remains [-ATR] because it is in some kind of prominent position; the medial vowel in question is unstressed.

4 Conclusion

This chapter has shown that there are three key points which, in one way or another, must be modeled by a complete theory of phonology:

- 1) Not all prohibited structures are repaired. In CF, we have evidence that non-final [+high, -ATR] vowels in open syllables violate some sort of structural constraint, which is then repaired by making those [+high] vowels [-ATR]. But in certain varieties of CF, not all [+high, -ATR] vowels in this position are repaired. This can be attributed to various factors,

some of which can be modeled in OT. For example, it can be that a locus of violation must be repaired in a certain position, but not others. This is easily modeled in OT by making the structural description of a constraint more precise. The contribution of the present chapter in this respect was to show that the constraints that have been proposed in the literature to address this sort of problem in regards to harmony are not adequate when it comes to CF. As such, this point does not bear on fundamental principles of OT.

- 2) What does bear on the fundamental principles of classical OT is the question of opacity. Literature to date on this topic has thoroughly shown that derivational opacity is in direct contradiction with the fundamental principles of classical OT, something that has been corrected by a number of amendments to the original framework. The contribution I have made on this topic here, is that none of those amendments can take care of the CF facts. In short, derivations are necessary. As of yet, models of derivations in an OT framework still cannot predict a certain range of facts that are not peculiar to CF, namely, the issue of opaque allophony.
- 3) I have also shown that there exist clear interactions between the application of phonological processes and morphological structure building. A theory of phonology that is complete must account for what I think are meaningful generalisations in this regard.

I have proposed in this dissertation that, at this point in our development of theory of phonology, only a rule-based derivational theory of morphology that interacts directly with morphological structure building can account for the full range of facts in CF. Such a theory has already been proposed, and it is Lexical Phonology. Yet, this does not exclude the need for improvements to the theory of phonology in general. Certain aspects of phonological theory are well addressed by

a framework such as OT, namely, the role of typology in shaping phonological computation, which is the basis of the whole OT research program. It is only by clearly showing that typology plays no role in phonological computation that such a research program should be irrevocably abandoned. The present work does not aspire to do that. Rather, the aim of this work, and of the present chapter in particular, is to clearly highlight those aspects relevant to CF facts that are crucial to the completeness of a theory of phonology.

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