LAXING HARMONY IN LAURENTIAN FRENCH: COARTICULATION OR PHONOLOGICAL PROCESS?

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ABSTRACT

In Laurentian French, high vowels are laxed in certain closed syllables, and several sources report that this laxing can optionally spread to preceding high vowels in open syllables. A past articulatory study suggested that this laxing harmony may be (at least partially) a coarticulatory phenomenon, although the study only analyzed words where harmony could apply just one step. We collected ultrasound data for chains of potential harmony targets and found that some speakers maintain an intermediate or complete degree of laxing throughout such chains, suggesting that such iterative harmony is phonological. We additionally observed a speaker who applies harmony in a somewhat non-local manner, harmonizing penultimate vowels only if they can also harmonize a word-initial antepenultimate vowel in the same word.

1. BACKGROUND

Laurentian French (henceforth LF) encompasses the varieties of French spoken in Ontario and Quebec, excluding other Canadian varieties such as Acadian French, which is spoken in the Maritime provinces. The LF dialect is well-known for a process of allophonic laxing that affects the high vowel phonemes /i/, /y/, and /u/ when they appear in certain closed syllables, and this process serves as the base for a reported case of vowel harmony [1, 2, 3, 4, 5] which is the focus of this paper. Examples of each process are given in (1) and (2). We start by summarizing some work on the distribution and acoustics of closed-syllable laxing before discussing the harmony pattern.

(1) Closed syllable laxing in a final syllable
- /pəti/ → [pə.tˢi] ‘small (masc.)’
- /pətit/ → [pə.tˢɪt] ‘small (fem.)’

(2) Harmonic laxing of a non-final vowel
- /minyt/ → [mɪ.nʏt] ‘minute’

All sources agree that laxing occurs before codas other than voiced fricatives (/v/, /z/, /ʒ/) and rhotics (/ʁ/), which are sometimes grouped together under the label of *lengthening* consonants in the LF literature. Some sources additionally claim that voiced fricatives and/or rhotics either trigger laxing or diphthongization. All the varying claims regarding lengthening codas are summarized in Table 1. Furthermore, the process is reported to be obligatory for closed final syllables but optional for non-final closed syllables [5].

/ʁ/ coda	/v/ coda	/z/ coda	/ʒ/ coda	Sources
L	L	L	L	[6, 7]
N	L	L	L	[8]
L	N	N	N	[9, 10]
N	N	N	N	[11, 4, 12]
D	D	D	D	[3, 13, 14, 15] [16, 17, 18]

Table 1. Claims regarding lengthening codas. L = laxing, D = diphthongization, N neither

As for the process’s acoustics, every acoustic study of LF laxing finds that laxed vowels have a significantly higher first formant (F1) than their regular tense counterparts, and most acoustic studies find that laxed front vowels have significantly lower second formant (F2) and that laxed back vowels have significantly higher F2 [19, 20, 11, 6, 21, 7]. A minority of studies, however, find no F2 differences [22, 17, 18]. Based on these formant differences, we expect a lower tongue position (since F1 is negatively correlated with vowel height) and a more central tongue position (since F2 is negatively correlated with backness), although the single existing articulatory study by [22] saw only tongue lowering.

Normally, we expect laxing only on high vowels in closed syllables, although several sources report that high vowels in open syllables can take on a lax quality if followed by a laxed vowel under certain circumstances [1, 2, 3, 4, 5]. The most in-depth investigation of this harmony process was done by [5], who classified speakers into categories based on their answers to an acceptability judgment task. Given a word with a chain of 4 high vowels like /similityd/ ‘similarity’, there are 8 logical possibilites for laxing placement, but only 4 of these are

accepted by the LF speakers that [5] examined: absence of harmony (3a), local non-iterative harmony (3b), local iterative harmony (3c), and non-local harmony (3d). The location of secondary non-final laxing is underlined for clarity.

(3) Accepted types of harmony [5]
   a. Absent [si.mi.li.tˢʏd]
   b. Local, non-iterative [si.mi.l̲ɪ.tˢʏd]
   c. Local, iterative [s̲ɪ.m̲ɪ.l̲ɪ.tˢʏd]
   d. Non-local harmony [s̲ɪ.mi.li.tˢʏd]

(4) Unaccepted types of harmony [5]
   a. [si.m̲ɪ.li.tˢʏd]
   b. [si.m̲ɪ.l̲ɪ.tˢʏd]
   c. [s̲ɪ.mi.l̲ɪ.tˢʏd]
   d. [s̲ɪ.m̲ɪ.li.tˢʏd]

The other experimental investigation of LF harmony was done by [2]. Collecting acoustic and ultrasound data for disyllabic words, he found that penultimate high vowels which have potentially undergone harmony (as determined impressionistically) are articulated midway between fully lax and fully tense. He interpreted his results to mean that the spreading of LF laxing is less than harmony but more than co-articulation, representing an intermediate stage in the synchronic development of a true vowel harmony system.

While the findings for disyllabic words in [2] can certainly be interpreted to mean that LF harmony is not a fully phonological process, they do not necessarily preclude the possibility that harmony is fully phonological but causes an intermediate result. If laxing harmony is (partially) a phonetic process of co-articulation, we expect to observe a diminishing degree of laxing as we get further from the final syllable. Our study builds on that of [2] by including trisyllabic words with two goals:

- Ascertain whether laxing due to harmony is weaker in antepenultimate syllables
- Gain acoustic and articulatory evidence for the 4 types of speakers reported by [5]

2. METHODS

We analyze data collected from 7 native speakers of LF French (6 female) who read a word list aloud in a soundproof booth using a Micro ultrasound system with a Telemed MC4-2R20S-3 convex probe that was stabilized with a helmet. Ultrasound and audio data were collected simultaneously using Articulate Assistant Advance software [23], with the ultrasound probe recording at a framerate of approximately 82 Hz. Following the experiment, participants completed a basic demographic questionnaire. Data were collected from 4 additional people, but they were excluded from analysis because they spoke a different dialect of French (2 female), because their tongue imaged poorly (1 male), or because the recording session ended early (1 male).

The word list consisted of 58 words in total and was constructed for use in several experiments including the present one. The list was repeated 6 times, with a different randomization for each repetition. This randomization was the same across all participants. Of the 58 words, 12 were analyzed in the present experiment: /maʒi/ ‘magic’, /beni/ ‘blessed’, /avi/ ‘opinion’, /pɛʁmi/ ‘permit’, /bazilik/ ‘basil’, /ɑ̃piʁik/ ‘empirical’, /imyn/ ‘immune’, /sɔlityd/ ‘solitude’, /ʁidikyl/ ‘ridiculous’, /disimyl/ ‘conceal’, /pʁimitif/ ‘primitive’, and /miʁifik/ ‘fabulous’. This gave us 4 instances of each of the categories in (5). Note that we distinguish penultimate instances that begin a chain of high vowels (5c) from those that are in the middle of such a chain (5d). All vowels analyzed were instances of /i/ in order to make comparing tongue shapes across conditions more straightforward.

(5) Types of /i/ analyzed:
   a. Open final
      /maʒi̲/
   b. Closed final
      /bazili̲k/
   c. Chain-initial open penult
      /bazi̲lik/
   d. Chain-medial open penult
      /miʁi̲fik/
   e. Chain-initial open antepenult
      /mi̲ʁifik/

Using Praat [24], we marked the beginning and end of each vowel by hand, using these points to calculate the midpoint of each vowel as well as its duration. We then normalized duration values on a speaker-by-speaker basis using z-scores. Finally, tongue tracing was done by hand with Articulate Assistant Advance software [23], using the frame closest to the calculated vowel midpoint.

3. RESULTS

We began our analysis by inspecting tongue shape across syllable types. For each participant, a Smoothing Spline Analysis of Variance plot (SSANOVA: [25]) was created using the extracted

tongue splines. These plots used a polar coordinate system, as this makes comparisons roughly perpendicular to the tongue surface and thus easier to see and interpret [26]. For all but one participant (F06), final closed syllables were produced with a lower tongue body/blade and a more retracted tongue root than in final open syllables, as we would expect from the formant differences observed in the existing literature on LF laxing.

Speaker F06's tongue shape did not differ across any of the conditions. Visual inspection of her formant values showed higher F1 and lower F2 in final laxed syllables only, which would be indicative of a lower tongue body/blade and a more retracted tongue root. We thus tentatively classify this speaker as a non-harmonizer, although with the mismatch between her acoustic and audio data, it is not fully clear whether she truly laxes high vowels in final closed syllables.

The majority of participants (5 of 7) exhibit what we interpret to be local iterative behaviour. Speakers M01, F02, F03, and F07 displayed tongue splines that were intermediate between a fully open and fully laxed shape for both chain-initial and chain-medial penultimate open /i/, as was observed by [2]. Furthermore, speakers M01, F02, F03, and F06 produced antepenultimate open /i/ with the same intermediate shape as they did penultimate open /i/. Speaker F04 displayed a nearly laxed tongue shape for both types of penultimate open /i/. Speaker F04 also extended her penultimate behaviour to antepenultimate syllables, producing them with a fully lax tongue shape. To illustrate, Figure 1 provides the SSANOVA plots for speaker M01 (left) and speaker F04 (right).

The remaining speaker, speaker F05, displayed what we interpret to be a type of non-local behaviour. Her antepenultimate instances of open /i/ had a fully laxed tongue shape, as were her chain-medial penultimate instances. Crucially, her chain-initial penultimate /i/ displayed only a partially laxed tongue shape, suggesting that her harmony system will spread through a chain of high vowels specifically when it can reach the word-initial syllable. The intermediate tongue shape in chain-initial penults would, in this scenario, be coarticulatory in nature. It could also be driven by the word /imyn/ 'immune', where the chain-initial /i/ also happens to be in the first syllable; in all other words the chain-initial /i/ was in the second syllable.

To analyze the normalized duration values, we ran a mixed effects model in R [27] using the lme4 package [28]. Estimated p-values were obtained with the lmerTest package [29]. Each model included a fixed effect of syllable type, with final open syllables as the reference level. For random effects, we included by-participant intercepts and by-participant slopes for syllable type. To include by-item intercepts, each syllable of each word was treated as a different item (so, for example, the three vowels in /miʁifik/ 'fabulous' are considered to be three different items).

The duration model revealed that final closed syllables were shorter than final open syllables ($\beta = -0.98$, $t = -2.78$, $p = 0.012$). Penultimate syllables were even shorter, both for chain-initial instances ($\beta = -1.28$, $t = -2.82$, $p = 0.012$) and chain-medial instances ($\beta = -1.84$, $t = -5.14$, $p = 0.0000587$). Antepenultimate syllables were shorter than final closed syllables and longer than penultimate syllables ($\beta = -1.26$, $t = -3.06$, $p = 0.0064$). Figure 3 illustrates these differences. In light of the small number of participants, a reviewer suggested we do a post-hoc power analysis, although we chose not to do so since [30] advise that such analyses do not change the interpretation of the p-values.

4. DISCUSSION AND CONCLUSION

In his ultrasound study, [2] argued that the intermediate degree of laxing on penultimate open instances of /i/ meant that the process of LF laxing harmony was at least partially a phonetic process of coarticulation. If this were true, we would expect the degree of laxing to diminish when it spreads to antepenultimate syllables, although this is not what we found in our data. For three of the speakers that we categorized as local iterative harmonizers (following the terminology in [5]), the intermediate degree was maintained throughout the chain of high vowels, and for one speaker the entire chain exhibited complete or near-complete laxing.

One possibility here is that laxing harmony is indeed phonological, although it may create intermediate results for some speakers. Another possibility, though, is that the vowel space may be reduced in non-final syllables due to their shorter duration, making non-final /i/ inherently less high and front. In this latter scenario, what has been reported as harmony could in fact be a perceptual phenomenon whereby non-final /i/ is inherently lower and more central due to vowel space reduction and gets perceived as laxed when followed by an actually laxed vowel. The fact that non-final laxing was always complete for one of the iterative speakers (F04) suggests that her harmony at least is not due solely to a reduced vowel space, but to mediate conclusively between the possible explanations, a future study will compare non-final instances of open /i/

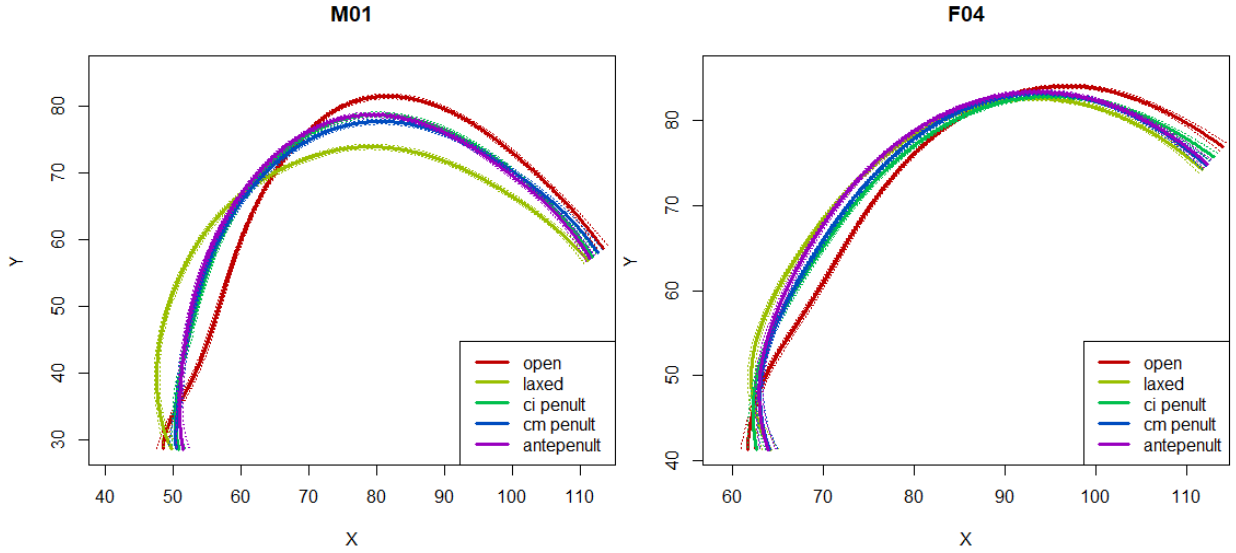

Figure 1. SSANOVA plots for speakers M01 (left) and F04 (right), ci = chain-initial and cm = chain-medial

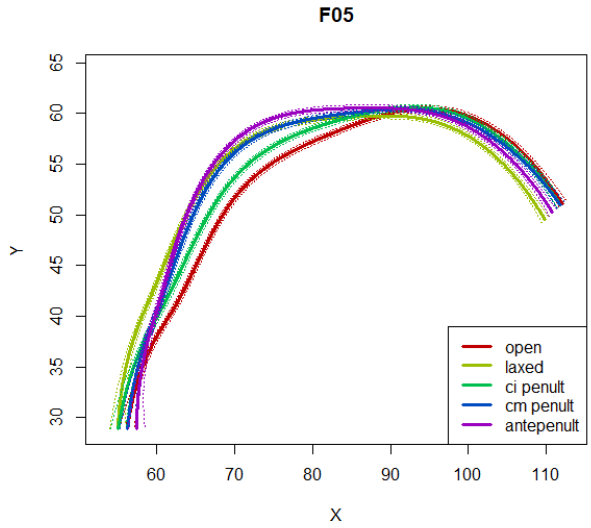

Figure 2. SSANOVA plot for speaker F05, ci = chain-initial and cm = chain-medial

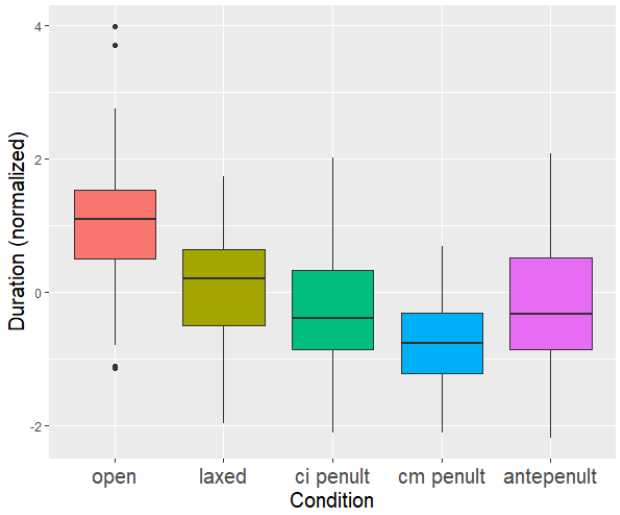

Figure 3. Duration by syllable type, ci = chain-initial and cm = chain-medial

that are followed by a laxed high vowel (e.g., /i̱myn/ 'immune') to those which are not (e.g., /si̱zo/ 'scissors').

That being said, one of our speakers exhibited non-local behaviour that would be difficult to explain as entirely due to a reduced vowel space in non-final syllables. This participant laxed penultimate instances of /i/ specifically when they could also lax word-initial antepenultimate /i/. This is not exactly as we would expect from past descriptions of non-local LF harmony [3, 5], though it is reminiscent of a pattern from Tutrugbu, where non-high prefix vowels undergo leftward [+ATR] harmony only when the leftmost prefix is also non-high [31].

To conclude, the main contributions of our study are that it provides:

- articulatory evidence that LF harmony is a phonological phenomenon which may produce an intermediate result for some speakers
- articulatory evidence for local iterative and non-local harmonizers described in [5]

We plan to collect more data from LF speakers in order to confirm and expand our findings.

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