



HIGH VOWEL /i y u/ IN CANADIAN AND CONTINENTAL FRENCH: AN ANALYSIS FOR A TTS SYSTEM.

Marise Ouellet, Évelyne Tzoukermann, Lucie Ménard
Bell Laboratories - Lucent Technologies
600 Mountain Avenue, Murray Hill, NJ 07974
[marise, evelyne, lucie] @research.bell-labs.com

ABSTRACT

This paper deals with the treatment of high vowels /i y u/ in Canadian French Text-to-Speech system. Among significant differences in the structure of the vowel system, we focused on two aspects in which high vowels behave quite differently in the two dialects of French: 1) the tenseness rule according to which the three vowels are systematically contrasted by the tense/lax feature in Canadian French; 2) the reduction-deletion rule. Reduction and deletion are frequently observed at the phonetic level in Canadian dialect. Moreover, both variety of French exhibit some effects of devoicing and vowel shortening besides rule 2. In order to determine the effect of geographic origin and linguistic style on the phonetic features of /i y u/ we performed analysis on corpora recorded by two professional speakers in the two dialects of French. The outcome of the comparison allowed us to create a set of new rules for the treatment of high vowels in the Canadian version of the Bell Labs TTS system.

INTRODUCTION

The vowel system of Canadian French consists of 17 vowels. There are 8 intrinsically long vowels, that is four distinct nasal vowels, and four long oral vowels /ɑ ɛ: ɔ ø/. The vowel system also includes four short oral vowels /a ɛ ɔ œ/ and three high vowels /i y u/ as well as a central vowel: the schwa. High vowels are characterized, in Canadian French, by the extreme variability of their phonetic realizations. Besides the contextual variation between tense vowels [i y u] and lax vowels [I Y U], high vowels can, in some phonetic contexts, be devoiced, shortened, or deleted. The Canadian TTS system was developed from an already existing Continental French system and we needed to take into account the complexity of the Canadian French vowel system. [9] [10]

This study focuses on the occurrences of vowel tenseness variation and high vowels weakening (devoicing, shortening and deletion). Phenomena of high vowels weakening were mainly studied in the socio-phonetic research. [1],[2],[3],[6] Tenseness variation, attested for a long time in Canadian French, is characterized by an uncertain status at the phonological level [8]. Its origins are found in the French dialects of the XIVth century. [1]

Keeping in mind the development of the Canadian French TTS system, the well-known and studied phonetic variations modifying high vowels present an interesting problem:

1) what phenomena modifying high vowels can be found in a sample representative of a formal variety of Canadian French? 2) What properties should be modeled to preserve the Canadian pronunciation? 3) How should these phonetic properties be integrated into a TTS system?

We studied the occurrences of the rules of vowel tenseness and those related to the weakening of /i y u/ in the dialect of a Canadian professional speaker. The results obtained were compared to those of a Continental French speaker who participated in the creation of a Continental French TTS.

METHODOLOGY

Two speakers, one from Canada and the other from France, were asked to read a corpus of 102 sentences from *Le Monde* newspaper. The length of the recorded sentences varies from 12 to 34 syllables. Recordings were digitalized at 20 kHz then analyzed with the CSL software (Kay Elemetrics). For each speaker, measures of duration and F1 and F2 values in the middle of the vowel were taken on 396 high vowels appearing in the sentences (392 X 2 speakers: 792 occurrences). Information such as syllable structure (open or closed), identity of adjacent segments to the vowel, and position with regard to stress was also computed from the recordings.

The two corpora were originally recorded for studying phone durations. Therefore, even though the distribution of /i y u/ occurrences was not even (tokens:234; y:85; u:77), it allowed us to evaluate the high vowels variations in a standardized reading context.

ANALYSIS

The two phenomena that we studied appear mainly as variations in duration and variations in formant values. Weakening is systematically associated with vowel shortening whereas tenseness occurs in a centralization expressed by formant values. The presence of these phenomena in Canadian French allows us to anticipate a more important variation for these parameters in the Canadian corpus. The following figures enable us to

check this hypothesis: F1 and F2 values show a larger scattering of the /i y u/ realizations by the Canadian speaker.

Figure 1: F1-F2 Values for /i y u/ (Canadian French)

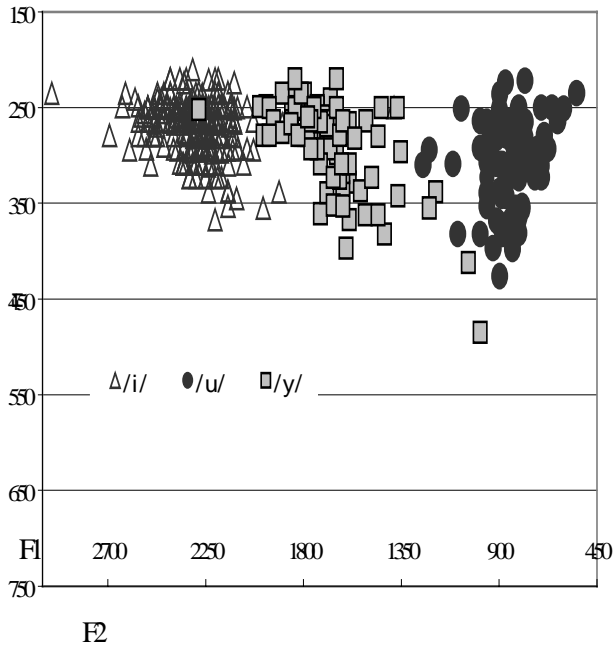
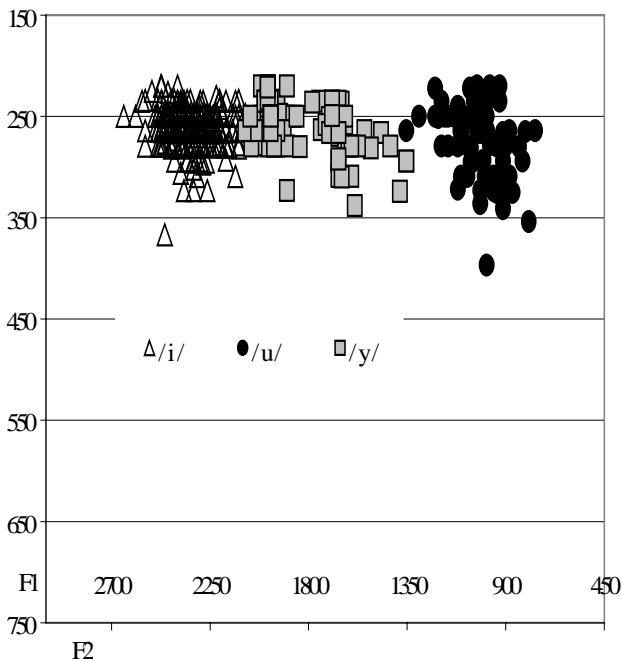


Figure 2: F1-F2 Values for /i y u/ (Continental French)



THE TENSE/LAX CONTRAST

In Canadian French, high vowels /i y u/ have tense variants [i y u] in the context of open syllables and syllables closed by lengthening consonants [z r v ʒ]. These tense realizations are longer and more closed than lax variants [I Y U] that occur in syllables closed by non-lengthening consonants. The laxing rule is compulsory in closed syllables with primary stress, but optional in unstressed syllables [1].

Research on the subject mention that lax variants [I Y U] are centralized and shorter than tense variants. At the acoustic level, the laxing effect should be expressed by an increase in the F1 value, showing the level of openness and, to some extent, by a reduction in the F2 value sensitive to the place of articulation, but also to the rounding feature. F1 and F2 variations with regard to reference values calculated in open stressed syllables allowed us to check the effect of stress and of syllable structure on formant values as well as the application of the tenseness rule shown by the Canadian speaker. As shown in Table 1, the open stressed syllable is chosen for the calculation of the reference value because of the limited effect of the consonant that follows the vowel and the maximum vowel duration preventing the formant undershoot.

The following table shows the average values obtained for F1 and F2 in the four types of syllables.

Table 1 : F1-F2 values according to stress level and syllable structure

Canadian French				
Open syl.	Stressed		Unstressed	
	F1	F2	F1	F2
I	267	2273*	263	2307
Y	284	1677*	269	1745
U	301	816*	295	868
Closed syl.				
i	280	2324	290	2278
y	313	1598	323	1612
u	309	848	327	901

Continental French				
Open syl.	Stressed		Unstressed	
	F1	F2	F1	F2
i	258	2329*	258	2344
y	252	1848*	261	1825
u	276	1059*	269	1047
Closed syl.				
i	268	2327	270	2321
y	269	1821	275	1694
u	296	960	278	981

* F1-F2 Reference value

Both speakers have a tendency to centralize high vowels in closed and/or unstressed syllables. The Canadian speaker's centralization is based on a systematic

modification of openness (F1) whereas the Continental speaker's centralization occurs in coordinated movements of F1 and F2. The syllable structure more than the stress level is associated by both speakers with the tendency to centralize vowels.

The variations of /i/ shown by both speakers are used to illustrate the effect of the rule of the tenseness rule. The quantity of occurrences and range of phonetic contexts found in the sentences of the corpus allow us to obtain the realizations of /i/: 1) in syllables closed by lengthening consonants (tense variants expected); 2) the realization in syllables closed by non-lengthening consonants (lax variants expected), and to compare them with our reference values.

Figure 3 : The lax/tense contrast for /i/

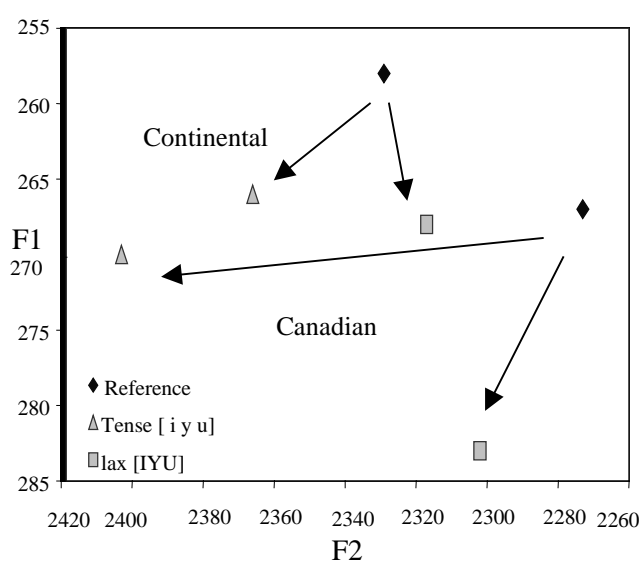


Figure 3 shows clearly for both speakers the tendency to centralize /i/ in closed syllables. However, our Canadian speaker follows the laxing rule and realizes and audible tense variant [i] in a syllable closed by a lengthening consonant and laxer variants [I] in front of other consonants. For vowels /y u/, the limited size of our sample and range of phonetic environments in closed syllables did not allow us to perform systematic observations with good averages. However, a comparison item by item between the speakers enables us to notice the maintenance of the tenseness rule with /y u/ by the Canadian speaker and the tendency to produce a little more centralized variants by the French speaker in environments where [Y U] would be expected.

HIGH VOWELS WEAKENING

High vowels weakening in Canadian French is observed through devoicing, shortening and deletion. Our observations, taking into account only the duration parameter will enable us to detect tendencies of vowels weakening in our speakers' dialect, if any.

Cedergren and Simoneau [2] define devoicing as the acoustic realization characteristic of a vowel without voicing. Although it is a phenomenon present in the continental variety of French and other languages, we took it into account in the more global perspective of the weakening process of /i y u/ in Canadian French [3]. Devoicing, shortening and deletion make up the three stages in the weakening process.

Devoicing appears as a total or partial reduction of the voiced section of the vowel, the only section we measured. The phenomenon occurs in unstressed closed or open syllables, when the vowel is located between two voiceless consonants or is simply followed by a voiceless consonant. Note that we did not come across a complete devoicing in the analyzed corpora.

Unlike devoicing, reduction can occur in voiced environment. We can observe the phenomenon in unstressed open syllables when the vowel is preceded or followed by a fricative consonant or when the vowel is followed by a voiceless occlusive consonant.

High vowel deletion is the more advanced stage of the weakening process. The vowel is, somehow, "absorbed" by the preceding consonant to which it transfers a part of its duration. The conditions favoring the vowel deletion are the same as those associated with shortening. Cedergren and Simoneau suggest a 30 ms threshold below which we consider vowel deletion. Our speakers did not reach this threshold, although some duration values came close.

Table 2: Vowel duration variations : Minimum and maximum values for / i y u/.

Canadian French		
Average	Minimum	Maximum
i : 82 ms	32 ms	226 ms
y: 78 ms	40 ms	256 ms
u: 94 ms	51 ms	296 ms

Continental French		
Average	Minimum	Maximum
i : 96 ms	31 ms	254 ms
y: 81 ms	33 ms	241 ms
u: 94 ms	52 ms	230 ms

Table 3 : Average duration for / i y u / according to stress level and syllable structure.

Canadian French				
Aver. ms	Stressed		Unstressed	
	Open syl.	Closed syl.	Open syl.	Closed syl.
i 82	93 ms	97 ms	73 ms	73 ms
y 78	80 ms	69 ms	85 ms	61 ms
u 94	107 ms	93 ms	82 ms	84 ms

Continental French				
Aver. ms	Stressed		Unstressed	
	Open syl.	Closed syl.	Open syl.	Close syl.
i 96	108 ms	121 ms	83 ms	86 ms
y 81	78 ms	76 ms	91 ms	66 ms
u 94	109 ms	99 ms	84 ms	78 ms

Except for the vowel average duration, slightly shorter, shown by the Canadian speaker, we cannot distinguish either speakers on the basis of the vowel duration variations (Table 2) or from the average duration according to stress level and syllable structure (Table 3).

To evaluate shortening signs linked to high vowels weakening, we compared the duration obtained in weakening and shortening environments with the average duration calculated in stressed open syllables (reference value). No deletion was found in the entire corpus.

Table 4: /i y u/ Duration in Devoicing and Reduction contexts

Canadian French			
Reference	Devoicing		Reduction
	U ---U	V ---U	Fricatives
i : 93 ms	52	73	81
y : 80 ms	79	66	95
u :107 ms	73	91	83

Continental French			
Reference	Devoicing		Reduction
	U ---U	V ---V	Fricatives
i : 108 ms	73	81	91
y : 78 ms	61	81	116
u :109 ms	80	112	87

U : voiceless consonants; V: voiced consonants

Results shown in Table 4 enable us to observe that environments favorable to devoicing induce systematic reductions of the vowel duration by the Canadian speaker. This reduction, shown by the French speaker, is systematic solely in vowels preceded and followed by a voiceless consonant (U---U). In the vowel reduction environment, we did not observe systematic shortening in all vowels; if present this shortening would have shown a weak position of the vowel.

As shown by our Canadian professional speaker, it appears that the more systematic tendency to shorten vowels duration in voiceless consonants constitutes the sole occurrence of the high vowels weakening phenomenon described in the literature.

DISCUSSION

This study aimed at determining the presence of phenomena described in the literature that modify high vowels /i y u/ in Canadian French. Note that the dialect of the professional speaker was in a formal speaking style. Formant values variations allowed us to evaluate the presence of a vowel tenseness variation. Segmental durations were used as signs of the weakening phenomenon.

The tenseness variation, attested by our Canadian speaker's dialect, leads to qualitative change in the vowel which is easy to model. Its occurrence is foreseeable and its distribution, limited to stressed syllables. The

lax/tense distinction attested in most Canadian French-speaking regions, is not socially marked, and is of common use in radio and television discourses. For these reasons we include the tenseness differences among the Canadian French features to be represented in the TTS system. The high vowels are thus represented by six phones, /i y u I Y U/, in the Canadian French TTS phonological database.

Weakening signs are generally less frequent in reading than in spontaneous discourse. Similarities of our speakers' productions encouraged us not to model devoicing, the only weakening sign in the corpus. This phenomenon is well represented by the Canadian speaker and the phonetic pronunciations of /i y u/ in voiceless contexts are well captured in the diphone and polyphone inventory of the Canadian French TTS system.

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