Comparing intonation of two varieties of French using normalized F0 values

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Abstract

Normalized F0 values measured from a specific prosodic domain (the Accentual Phrase, AP) are used in order to compare readings from four female speakers of two varieties of French: two Canadians (Quebec City area) and two French (Vendée area). Comparisons are based on APs with similar internal organization (contour, number of syllables, contour-to-text timing) and identical position within an utterance. Normalized F0 values show greater inter-dialectal variation than intra-dialectal one for specific parts of the contours, namely the L tones of the LLH continuation contour and the first L and H tones of the LHL final contour. Perceptual experiments will be conducted later based on these findings.

1. Introduction: prosodic variation

1.1. Objectives and hypothesis

This paper deals with intonational variation between two dialects of French. Our long-term objective is to account for systematic prosodic variation between these dialects. In order to achieve this goal, we need both a theoretical and a methodological framework within which production and perceptual experiments will be conducted. The specific objective of this paper is to establish those frameworks. Our theoretical hypothesis is that such a study should be phonologically driven. Many analyses [1, 2] use measurements of phonetic parameters such as average F0 within utterance, F0 range, number of stressed or unstressed syllables and so on. We believe that before taking any measurements, one has to decide and motivate what to measure or, in other words, in the case of comparing varieties of a language, what to compare. To answer this question we look to the notion of prosodic similarity. We argue that the Accentual Phrases (APs) with identical internal prosodic organization (number of syllables, intonational contour, timing text-contour) and the same position in the utterance provide an excellent basis for comparison of different varieties of French (section 2.1.).

Another question then arises: how do we compare these similar prosodic productions once they have been identified? Our present attempt to provide an answer to this second question brings us to the normalization of F0 using a z-score procedure applied to APs sharing the same degree of prosodic similarity (section 2.2.). Then, the combination of prosodic similarity and normalized F0 values within a domain should lead us to identify recurrent variations between two or more dialects of French.

1.2. French intonation

A precise and detailed description of both phonological and phonetic aspects of French intonation is provided by Jun and Fougeron [3, 4]. They documented the many surface realizations of a single tonal melody LHLH which accounts for most contours encountered in declarative sentences of standard French. Our own studies on Canadian French showed that it is possible to describe this dialect using the same LHLH representation [5, 6]. For this study, we adopt their model and use their criteria in order to determine prosodic domains and contours.

In the model, the basic LHLH melody is phonetically realized in a prosodic domain called the Accentual Phrase, defined by an obligatory final stress and optional initial stress. Depending on the length (in syllables) of an AP, the lexical nature of the words (content words vs. functional words), and their morphological structure, the underlying LHLH melody can be realized differently [4]. The six most common surface contours found in our data are presented in Fig. 1.

![Figure 1: Six most common contours.](image-url)

In our corpus, HL and LHL usually express finality, while other contours indicate continuation, or non-finality.

The next section explains how we categorize the APs in order to compare them with each other.

2. Methodology

2.1. Prosodic similarity

Two APs are judged prosodically similar if they share the following parameters:

1. Relative position of an AP in the utterance: the phrases have the same place with respect to the declination line (final AP, penultimate AP, etc.). APs are counted backward from the last one of the utterance (tagged “POS1”) to the first one (e.g., POS2 is the penultimate AP, POS3 is the antepenultimate one, and so forth).

2. Surface tonal pattern: the tonal specification of the intonational contour of APs is the same.
3. Number of syllables: APs have the same number of syllables.
4. Timing: tone-to-text association is the same. For instance, a “134 LLH” means that the first L is associated with the first syllable, the second L with the third syllable, and the H with the fourth and last syllable of an AP.
5. Phrasing: the text is divided into APs in the same way (applies only to reading).
6. Position of an AP relative to pauses: since the AP is the minimal prosodic unit, this parameter is controlled in order to avoid melodic differences due to the presence of the higher prosodic levels associated with pauses.
7. Internal organization: because of the phrasal nature of French primary accent and rhythmical constraints governing secondary stress, the presence of functional words and the quantity of lexical words in an AP are relevant.

Thus, in the following examples taken from our corpus, the two underlined APs bearing the same contour, which is timed to the text in the same way, would be prosodically similar (same position in an utterance, same number of syllables, and so on).

Le village de Beaulieu est en grand émoi
Nous avons du soutien du village entier

2.2. Normalization

The normalization by z-score transformation eliminates individual variation between speakers (e.g. their F0 average and range values) and allows us to focus on pertinent differences. Applied first to the syllable domain, this approach established significant differences in the phonetic realization of tones in Mandarin Chinese [7]. In our study of the intonation of Canadian French and the French of France, we apply the z-score normalization to a larger prosodic unit – a phrase (AP) – since in French it is the domain of intonational contour.

The z-score for each F0 value of an AP is calculated in the following way:

$$z = \frac{(F0n - \text{aveF0})}{\text{stdF0}}$$

where $F0n$ is an F0 value, $\text{aveF0}$ is the average F0 of an AP, and $\text{stdF0}$ is the standard deviation for this average.

Figures 2 and 3 provide a comparison of original and normalized F0 values for two Canadian speakers.

![Figure 2: Original F0 values of the same AP pronounced by two Canadians.](image)

![Figure 3: Normalized F0 values of the same AP pronounced by two Canadians.](image)

Z-scores were calculated for an entire AP. However, since we adopt a tonal approach, which implies a tone-to-syllable association, we compared only the values of the normalized F0 at the tone targets, more precisely, in the middle of the syllable nuclei (or rhymes, in the case of sonorant codas) with which the tones are associated. We also calculated mean F0 values (Hz) and the range for each AP in order to make comparisons.

2.3. Data

This analysis is based on the data that come from the PFC project [8] database, which includes recordings of more than 500 speakers from all over the French-speaking world. For each speaker the recording consists of two sociolinguistic interviews and two readings: a list of words and a text. For this study we chose the text readings by four female speakers: two from Québec City, Canada (C1 and C2), and two from Vendée area, France (F1 and F2). As all subjects read the same text, the segmental content of the recordings is the same for all four speakers.

Our ultimate goal is the analysis of spontaneous speech, thus we are not likely to find the same segmental content for different speakers. This means that the internal organization and the phrasing parameters will not always be respected. Moreover, the presence of pauses and consequently of higher prosodic levels only changes the value of the final tone, not the intonation of the unit. Therefore, we adjusted our judgment of prosodic similarity, and retained only the first four parameters (see 2.1.). All data were coded for each of these parameters, and prosodically similar APs were compared using the normalization process.

In their readings of the text, the speakers produced between 154 and 169 APs (Table 1). Most of the phrases were realized with one of the six intonational contours shown in Fig. 1. Among them, the contours LLH and LHL were the most frequent (Table 1).

![Table 1: Number of APs for LLH and LHL contours.](image)

Note that the speaker F1 has a lower percentage of LLH contours and a higher percentage of LHL contours. This is accounted for by her particular reading style where she...
expresses continuation with both descending and rising intonation.

Our choice of contours was motivated not only by their numerical prevalence, but also by their location in relation to the declination line. In this way, we studied only LHL final contours (POS1) and LLH contours in penultimate (POS2) and antepenultimate (POS3) APs. Particularly, we retain the non-final LLH contour with the tone-to-syllable association 123 and 134, and the final LHL with the timing 124 and 135.

Table 2 shows that the total number of non-final LLH contours for the Canadian speakers is 25, and for the French speakers it is 23. As for the final LHL contours, French speakers produced 16 APs, and Canadians 12.

Table 2: Number of APs retained for the analysis

<table>
<thead>
<tr>
<th></th>
<th>LHL contour</th>
<th>LLH contour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>123 pos2</td>
<td>124 pos3</td>
</tr>
<tr>
<td>C1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>C2</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Can</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Tot</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>F1</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>F2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Fra</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td>Tot</td>
<td>23</td>
<td>16</td>
</tr>
</tbody>
</table>

3. Results

3.1. The LLH contour

We first discuss the results for the LLH contour expressing continuation. Recall that four conditions apply in this case: APs must be three or four syllables in length (timing 123 and 134), appearing in positions 2 and 3 in the utterance.

As we can see in Table 3, the average of F0 values and the range of F0 for the speakers within one dialect exhibit larger differences than between dialects. For example, the average F0 is closer for C1 and F1 (182 vs 184) than for C1 and C2 (182 vs 238) or for F1 and F2 (184 vs 227). The same is true for the speakers C2 and F2 (238 vs 227). As a result, the average F0 for Canadian and French speakers is very similar (204 vs 205).

The same situation is observed in the range values: C2 and F1 have a closer range (91 vs 95) than C1 and C2 (78 vs 91) or F1 and F2 (95 vs 67). In conclusion, raw F0 values tend to show more intra-dialectal differences than inter-dialectal ones.

Table 3: Mean F0 and range: LLH contour

<table>
<thead>
<tr>
<th></th>
<th>Average, Hz</th>
<th>Std</th>
<th>Range, Hz</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>181.58</td>
<td>14.13</td>
<td>77.93</td>
<td>22.58</td>
</tr>
<tr>
<td>C2</td>
<td>237.99</td>
<td>14.04</td>
<td>90.9</td>
<td>33.24</td>
</tr>
<tr>
<td>F1</td>
<td>184.02</td>
<td>13.97</td>
<td>95.25</td>
<td>18.28</td>
</tr>
<tr>
<td>F2</td>
<td>226.93</td>
<td>16.23</td>
<td>66.67</td>
<td>15.02</td>
</tr>
<tr>
<td>Can</td>
<td>204.15</td>
<td>31.4</td>
<td>83.12</td>
<td>27.45</td>
</tr>
<tr>
<td>Fra</td>
<td>205.47</td>
<td>26.45</td>
<td>80.96</td>
<td>21.93</td>
</tr>
</tbody>
</table>

Figures 4 and 5 present results for Canadian and French speakers respectively. They show average values of the normalized F0 for each target point associated with the tones and for the four variables under consideration. The main difference is found when comparing the first L tones. While Canadian speakers show values between 0 and +5, values for French speakers are concentrated between -5 and -1. Note that there is no overlap between the two varieties in the values for the first L tone. This is more or less also true for values related to the second L tone, even if the data are not distributed in different areas of the graphs.

Values for the H tone show much more variation within and between varieties. More analysis will be needed in order to provide a better picture of the behavior of this tone.

The next figure presents differences within and between varieties expressed in percentage. We compare average F0 and normalized values for both L tones of the LLH contour, with all the parameters considered together.

The normalization emphasizes inter-dialectal differences, while making the intra-dialectal variation less obvious.
3.2. The LHL contour

As we saw in Table 3 for the LLH contour, the average of the raw phonetic values of F0 and the range calculated for APs bearing LHL contour do not allow us to make clear distinctions between varieties. Table 4 displays similar results for the LHL contour.

Table 4: Mean F0 and range: LHL contour

<table>
<thead>
<tr>
<th>Varieties</th>
<th>Average, Hz</th>
<th>Std</th>
<th>Range, Hz</th>
<th>Std</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can135</td>
<td>203.45</td>
<td>24.9</td>
<td>99.25</td>
<td>21.6</td>
</tr>
<tr>
<td>Can124</td>
<td>189.28</td>
<td>21.7</td>
<td>95.57</td>
<td>28.48</td>
</tr>
<tr>
<td>Fra135</td>
<td>215.48</td>
<td>12.76</td>
<td>104.42</td>
<td>22.63</td>
</tr>
<tr>
<td>Fra124</td>
<td>179.2</td>
<td>11.5</td>
<td>115</td>
<td>16.7</td>
</tr>
</tbody>
</table>

The following figure introduces average normalized values for the two parameters (four syllables, timing 124 and five syllables, timing 135) under investigation for the LHL contour.

Figure 7: Mean z-score of the LHL contour.

The second L tone of the contour – the final one of the entire utterance – shows no difference at all between varieties. For the first L tone, the values of Canadian speakers are clearly positive, while the corresponding values for French speakers are clearly negative, so that the differential between Canadian L and French L is at least one std. As for the H tone, there is a clear difference between the values for both varieties with no overlap, but the differential is smaller.

Differences within and between varieties for the first L tone and the following H tone are shown in Fig. 8.

Figure 8: Differences between speakers of the same variety and between varieties: LHL contour.

Again, the z-scores show that there is more variation between varieties than within for the two first tones of the contour.

4. Discussion and Conclusion

Since this study adopted a phonological approach, we have presented the results for each discrete tonal unit of the contours under investigation. This allowed us to identify systematic differences in the phonetic realization of tone targets. If we try to characterize what makes the two dialects different, we can turn to the global contour of an AP and the way the phonetic interpolation happens between the targets. For the LHL contour, the lowest values are reached at the beginning of an AP for the French speakers, and right before the final rise for the Canadian speakers. In the case of the LHL contour, the initial L tone is clearly realized by the French speakers, while the Canadians produce the first part of the contour as a plateau. This suggests that the difference between the two dialects might be found in the implementation of the initial L tones of a contour.

Our results show that the comparison of normalized F0 values allows us to identify systematic points of variation in the phonetic realization of contours in two dialects of French. Building on these findings, our next step is to conduct perception tests.

5. Acknowledgements

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6. References