Regional Variations of Speech Rhythm in French:
In Search of Lost Times

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Abstract

This paper addresses the relevance of speech rhythm acoustic measures for the description of some standard, regional and contact varieties of French. First, the limitation of conventional speech rhythm measures (e.g. %V, ΔC or PVI) for the description of French regional variations is pointed out. Then, alternative acoustic measures of speech rhythm, based on supra-segmental characteristics associated with *timing* (regularity of accentual phrases) and *tempo* (articulation rate, speech rate) are introduced and discussed. A comparison with the conventional measures proves that long-term measures provide a classification which is more consistent with the expected classification, either in terms of continuous similarities or typological differences.

Index Terms: speech rhythm, rhythm metric, regional French, in-contact French, accentual phrase, articulation rate, speech rate.

1. Introduction

This study investigates 9 varieties of French spoken in Europe (France, Switzerland and Belgium) and in Africa (Central African Republic and Senegal), which correspond to 4 classes of French: standard, regional, and contact varieties.

- [FR-ST] includes to the varieties of French spoken in Paris (FR-75) and Lyon (FR-69), considered as "standard" varieties;
- [FR+] includes French spoken in Geneva (SW-GE) and Tournai (BE-TO), considered *weakly* regionally marked varieties of Switzerland and Belgium since they are very close to the French border;
- [FR-] includes French spoken in Neuchâtel (SW-NE) and Liège (BE-LI), considered as *strongly* regionally marked varieties since they are pretty far from the French border;
- [FR-CO] includes three contact varieties: French spoken in Neuchâtel by Swiss German L1 speakers (SW-GER), French spoken in Central African Republic (AF-CFA) by Sango L1 speakers and French spoken in Senegal by Wolof L1 speakers (AF-SN).
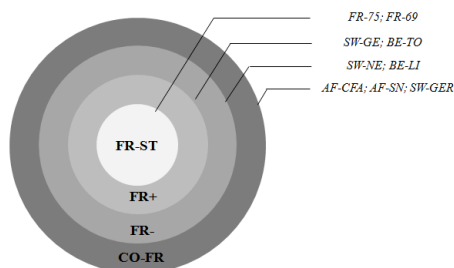

Figure 1: Regionality scale of French varieties

While a number of phonetic characteristics have been investigated for the description of regional French [1]-[3], the importance of prosodic characteristics has been introduced and discussed in recent studies [4]-[6]. In particular, the relevance of rhythmic measures such as %V/ΔC [7] and nPVI/rPVI [8] – *i.e.* temporal characteristics of vocalic and consonantal intervals – remains under discussion and has not been addressed for the description of French regional variation. On the one side, these short-term measures were originally developed to describe the variability of speech rhythm between rhythmic classes (i.e. stress-, syllable- and mora-timing; [10]). However, such concepts remain under question - from the study of rhythm-class differences in large speech databases [11] to the study of non-native French speakers with typologically different L1s [1]. On the other side, there is widespread evidence ([11], [12], [13]) supporting that long-term characteristics are relevant for the description of rhythm-class differences. Moreover, long-term characteristics may also be extended to the description of languages that are not easily attributable to auditory rhythm classes [14] – such as tone languages.

The varieties considered in this study would plausibly form groups with similar rhythmic characteristics, in the same manner as languages group into different rhythm classes (syllable-, stress-timed). In particular, the following classifications may be expected: first, standard varieties [FR-ST] may share the same rhythmic characteristics. Second, regional varieties [FR+ and FR-] may share similar rhythmic characteristics that are significantly different from standard varieties [FR-ST]. However, [FR+] and [FR-] varieties may present some substantial dissimilarities depending on their proximity to the standard varieties [FR-ST]. In particular, [FR+] may be expected to be closer to the standard varieties than [FR-]. Finally, contact varieties [FR-CO] can be expected to differ both from the standard and the regional varieties – due to transfers from the L1s [15]. Additionally, significant differences may exist between the contact varieties regarding the typological differences between the L1s.

This study addresses the relevance of various acoustic measures for the description of speech rhythm variations in regional French. First, limitations of conventional measures will be discussed. Then, long-term measures of speech rhythm will be compared, including speech rate measures and the extension of PVI measures to long-term segments, such as the Accentual Phrase (AP) – usually referred as a relevant unit for the description of speech rhythm in French [16]-[17]. This may be regarded, by analogy with music [18], as an attempt for a unified description of rhythm in terms of *timing* and *tempo*.

2. Speech Material

The speech material was collected from the "Phonologie du Français Contemporain" (PFC) speech database, which contains speech productions of thousands of speakers from French-speaking areas all around the world [19]. For each of the 9 varieties studied in this paper, we selected the recordings of the same text read by 4 speakers (two male and two female, two young speakers, 20-30 and two older speakers, 40-50). The text contains 398 words that are phrased into 22 sentences, and is 130-second long in average. The speech database used has a total duration of 78 minutes. Speech samples were transcribed orthographically in PRAAT [20], and automatically aligned with EasyALign [21], which provides a 3-layer segmentation in phones, syllables and words. The automatic alignments were manually corrected by one of the authors. Prominent syllables and disfluencies (for instance hesitation or syntactic interruptions) were independently identified on perceptual bases by two of the authors, following the guidelines initiated by [22] ($\kappa = 0.65$, substantial agreement). Finally, the reference tier that will be further used was obtained as follows: syllables that present agreement were defined as the reference. In cases of disagreement, a third expert (one of the authors) determined the prominent status (+/- prominent) of the syllable. The text was also parsed in APs: a clitic group (one content word and its dependent functional words) right bounded by a prominence syllable in the reference tier was considered as the head of an AP. Sentences boundaries were aligned in a dedicated tier.

3. Analysis

3.1 Measures of Speech Rhythm

3.1.1 Segmental measures

Conventional measures aim to account for the syllable regularity which is traditionally used to classify languages into stress-based and syllable-based languages. This includes:

- (vocalic nPVI, intervocalic rPVI) [9] used to describe the variation in duration across consecutive speech segments (vocalic, intervocalic), with or without normalization for the speech rate (nPVI and rPVI, respectively). Vocalic nPVI stands for the measurement of vowel regularity (e.g., vowel reduction), while intervocalic rPVI stands for the consonant regularity.
- (%V, ΔC) [7], where %V denotes the proportion over which speech is vocalic; and ΔC denotes the standard deviation of inter-vocalic segments.

3.1.2 Supra-segmental measures

In order to address the use of long-term rhythm characteristics for the classification of varieties and languages, the following measures are introduced and will be compared – mostly focused on the segmentation of speech into APs – usually referred as a relevant unit for the description of speech rhythm in French.

- (AP rPVI, AP nPVI) is an extension of the PVI measure to assess the regularity in duration of consecutive long-term segments (here, APs).
- (articulation rate, speech rate) which correspond to the syllable rate over APs, with exclusion/inclusion of silent pauses, respectively.

Finally, each measure was determined and locally averaged – when necessary – over the sentence. Hence, each speaker is represented by a distribution of characteristics over the 22 sentences of the speech database.

3.2 Robust Statistics

The average characteristics (mean μ and standard deviation σ) of each variety were determined using a robust estimation:

$$\overline{\mu}_X \quad = \quad \text{median}(\mathbf{x})$$
$$\overline{\sigma}_X \quad = \quad 0.7413 \times \text{iqr}(\mathbf{x})$$

where: median(.) and iqr(.) denote the median and interquartile range, and $\mathbf{x}$ the vector of observed characteristics.

This estimation presents the advantage of being robust to outliers and eventually to speakers with markedly different characteristics from the other speakers of a variety.

4. Results

The relevance of acoustic measures for the description of speech rhythm variations in regional French will now be assessed, with regard to the extent to which the descriptive classification that is obtained is consistent with the expected classification. First, the relevance of conventional speech rhythm measures will be questioned (§4.1); then, the relevance of the proposed measured will be discussed and compared with the conventional measures (§4.2).

4.1 Limitations of Conventional Measures

The classification obtained with (%V, ΔC) measures (with reference to the classification obtained in [7] for various languages) is presented in Figure 2, and the classification obtained with (vocalic nPVI, intervocalic rPVI) measures (with reference to the classification obtained in [8] for various languages) is presented in Figure 3.
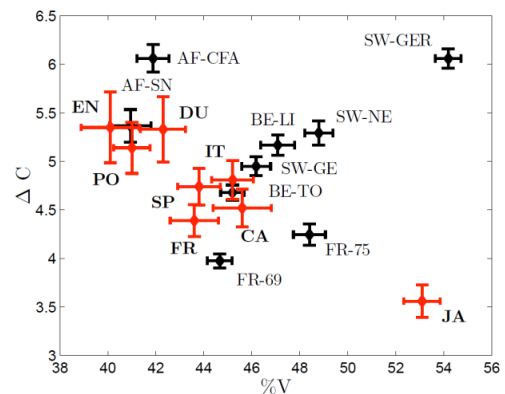

Figure 2: *Distribution of the 9 varieties of French and the languages studied in [7] over the (%V, ΔC) plane. Mean and standard error.*

In Figure 2, the distribution of standard and regional varieties is partially consistent. In particular, the dispersion of the standard varieties [FR-ST] is large compared to their distance to the regional varieties [FR+, FR-]. Additionally, the regional varieties [FR+] and [FR-] form a continuum over which no typological distinction can be observed. Also, the distribution of the contact varieties [FR-CO] is partially

consistent: on the one hand, the African varieties present consistent rhythmic similarities that stand close to the stress-based languages. On the other, the variety of French in contact with Swiss-German is clearly inconsistent – while however in agreement with measures reported in [12] for German with slow speech rate.
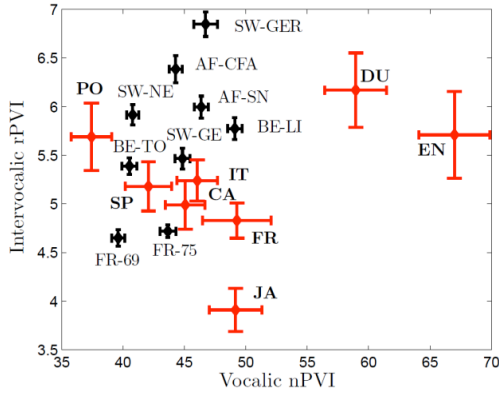

Figure 3: *Distribution of the 9 varieties of French and the languages studied [8] over the (vocalic nPVI, intervocalic rPVI) plane. Mean and standard error.*

In Figure 3, the standard varieties [FR-ST] form a more cohesive group, with a dispersion that is small with regard to the distance to the regional varieties [FR+, FR-]. Additionally, the contact varieties [FR-CO] are organized on a cohesive and consistent continuum. However, the distribution of the regional varieties [FR+] and [FR-] is inconsistent with the expected classification. In particular, the [FR+] and [FR-] varieties cannot be retrieved over the nPVI dimension. Moreover, some clearly unexpected similarities are observed (e.g., BE-LI appears close to AF-SN).

As a partial conclusion, none of the conventional measures conducts to a classification of the 9 French varieties that is consistent with the expected classification. This motivates the further search of reliable rhythm measures for the description of French regional variations.

4.2 In Search of Lost Times
The four figures below presents the comparison of articulation rate (Figure 4 and Figure 5) and speech rate (Figure 6 and Figure 7), with raw (rPVI) and normalized (nPVI) PVI measures over the AP segment.
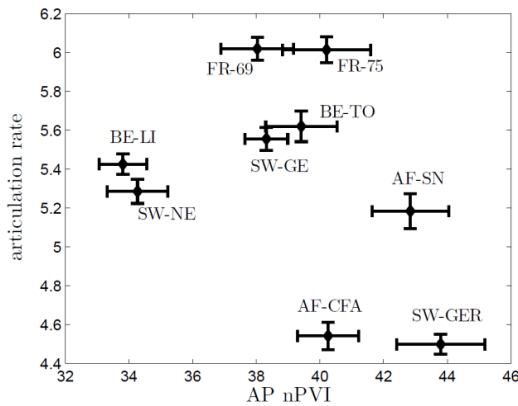

Figure 4: *Distribution of the 9 varieties of French over the (AP_nPVI, articulation rate) plane. Mean and standard error.*

The obtained classification appears globally more consistent with the expected classification, regardless to the measure considered. On the one hand, the varieties included in the non-contact varieties ([FR-ST, FR+, FR-]) are clearly grouped while substantially distant from the others. On the other hand, the contact varieties [FR-CO] are more heterogeneous and present a large dispersion compared to the non-contact varieties.
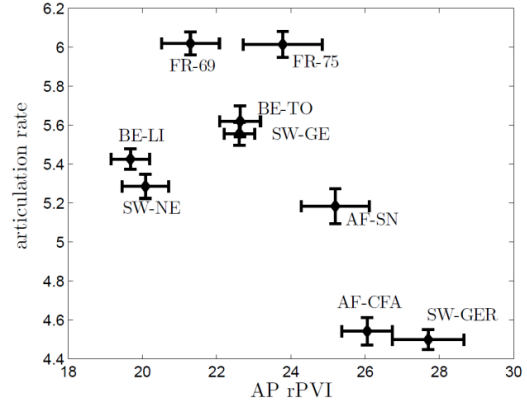

Figure 5: *Distribution of the 9 varieties of French over the (AP_rPVI, articulation rate) plane. Mean and standard error.*

The comparison of AP_rPVI and AP_nPVI does not conduct to substantial differences in the obtained classification - regardless of the rate measure (Figure 4 vs. Figure 5, Figure 6 vs. Figure 7). This may indicate that the normalization by the speech rate does not provide additional information for the description of regional variations.

The comparison of articulation rate and speech rate measures reveals substantial differences in classification. On the one hand (Figure 4 and Figure 5), articulation rate provides a cohesive classification of standard [FR-ST] and regional varieties [FR+, FR-], along with a disperse classification of contact varieties [FR-CO]. In particular, the AF-SN variety appears intermediate to the non-contact varieties ([FR-ST, FR+, FR-]) and the contact varieties, and substantially apart from the other contact varieties [FR-CO]. On the other hand (Figure 6 and Figure 7), speech rate provides a more cohesive classification of contact varieties [FR-CO], along with a more disperse classification of standard [FR-ST] and regional varieties [FR+, FR-].
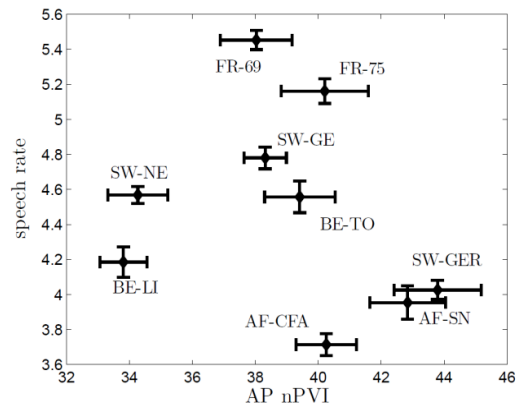

Figure 6: *Distribution of the 9 varieties of French over the (AP_nPVI, speech rate) plane. Mean and standard error.*
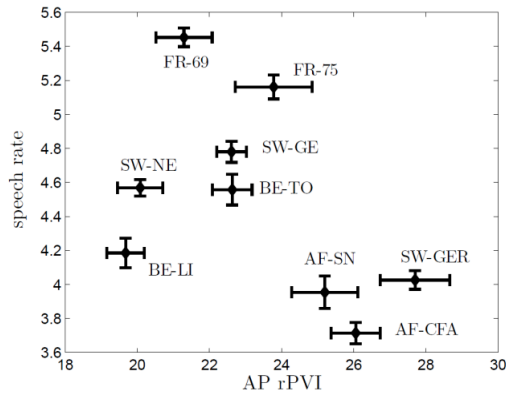
Figure 7: *Distribution of the 9 varieties of French over the (AP_rPVI, speech rate) plane. Mean and standard error.*

4.3 Discussion

The classification obtained proves the relevance of long-term measures for the description of speech rhythm variations in regional French (standard, regional, and contact varieties of French). First, the regional varieties present rhythmic similarities [FR+, FR-] that substantially differ from the standard varieties [FR-ST]. Second, regional varieties present noticeable differences depending on their proximity to the standard varieties. Third, contact varieties [FR-CO] stand significantly apart from the other varieties.

This suggests a continuum that may go from the standard varieties (fast tempo and moderately regular timing) to the regional varieties (slow tempo and regular timing). The contact varieties (slow tempo, irregular timing) stand typologically apart, probably due to the influence of the L1 language [18]. Finally, the comparison of speech rate/articulation rate and AP_rPVI/AP_n_PVI would require further investigations on the linguistic status of the language in contact considered, and the precise characteristics of SW-GER, AF-SN, and AF-CFA varieties.

5. Conclusions

This paper addressed the relevance of various acoustic measures for the description of speech rhythm variations in regional French (standard, regional, and contact varieties of French). First, the limitations of conventional measures such as %V, ΔC and PVI measures for the description of French regional variations were pointed out. Then, long-term acoustic measures related with speech *timing* (regularity of APs), and *tempo* (articulation rate, speech rate) were introduced and discussed. The proposed measures conducted to a classification consistent with the expected classification – either in terms of continuous similarities or typological differences.

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