

THE INITIAL RHYTHMIC ACCENT IN FRENCH: ACOUSTIC DATA AND PERCEPTUAL INVESTIGATION

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ABSTRACT

Recent models of French accentuation hypothesize the existence of a Rhythmic Word Initial (RWI) accent distinct from emphatic or pragmatic (word-initial) accents. This paper presents acoustic correlates (f₀ and duration) characterizing the RWI accent and also describes a perceptual investigation designed on the basis of these data. This investigation aims at testing hypotheses concerning the existence of an underlying accentual representation specifically associated with the initial syllable of lexical items and concerning the rhythmic motivations of the actualization of this representation. In an accent detection task we varied the Onset duration of a syllable so as to induce the perception of an accent. This syllable was localized in various positions inside a lexical item and embedded into two different rhythmic contexts (defined in terms of syllabic inter-accentual distance). Results show significantly higher detection rates in word initial position and for wide inter-accentual intervals.

1. INTRODUCTION

On the basis of results from experimental research on the acoustic properties of the initial rhythmic accent in French, we propose to verify some hypotheses on the role played by this accent in the metrical representation of French through a perceptual experiment.

Recent studies [8, 11, 13] have brought to light the emergence of a word-initial accent in French, the origin of which is difficult to evaluate precisely (cf. [6] for a discussion). Although it is found in different discourse types, the initial accent is more frequent in TV- and Radio-News Broadcast, as well as in conferences. It is however complementary to final accentuation which remains a major characteristic of French prosody. The initial accent has often been interpreted as an emphatic accent with an expressive [16] or didactic function [12]. For some authors however it represents an essential metric component of the phonological representation of French prosody [9, 14]. In an attempt to model French accentuation, Di Cristo [6] considers that the initial accent belongs to an intermediate underlying representation of the word in French. This potential accent can be projected onto the level of the surface structure either as :

- a rhythmic (word-initial) accent (RWI), motivated by the tendency to favor eurhythmy, as in "des souliers noirs" (*Black shoes*);
- an emphatic (word-initial) accent (EWI), also called accent of insistence, as in "c'était fantastique" (*it was fantastic*);
- or as a pragmatic (word-initial) accent (PWI), intended to signal the beginning of word groups that the speaker wishes to highlight within his message, as in "... car c'était des

personnalités étrangères qu'il avait rencontrées" (*because he had met foreign personalities*)

It would be interesting to see how far these three types of accents possess distinctive phonetic characteristics. In this study however, we shall only be concerned with the acoustic, rhythmic, and perceptual properties of the *Rhythmic Word-Initial* (RWI) accent.

Section 2 presents the results of an extensive multi-style analysis of RWI accents [2]. It appears from this study that, although this type of accent has long been typically considered a "pitch accent" [17], duration correlates are relevant in the description of RWI accents. Indeed, a closer look at the distribution of lengthening across the different syllabic constituents (Onset, Nucleus and Coda) reveals that RWI accents are characterized by a typical lengthening strategy, extremely robust throughout speaking-styles, that contributes to distinguishing RWI accents from word-final accents.

On the basis of these duration characteristics of RWI accents, Section 3 is designed to test the following 2 hypotheses from a perceptual point of view:

- H1: the RWI accent belongs to the phonological representation of French prosody.
- H2: the actualization of this representation is motivated by eurhythmic constraints.

2. ACOUSTIC PROPERTIES OF THE RHYTHMIC WORD-INITIAL ACCENT (RWI)

Results in this section are extracted from Astésano [2], who investigates the physical parameters of accentuation in French.

2.1. Material and experimental procedure

Our investigation was carried out on 10 minutes of connected speech, consisting of three speaking styles ((a) reading, (b) radio news broadcast, (c) interview), each involving two speakers. Our speakers are all native speakers of educated standard French.

The choice of 3 different speaking styles allows us to bring to light the potential duration invariance as well as the part of variability imputable to the difference in encoding procedures (read vs. spontaneous speech).

The recordings were transcribed without punctuation. An expert was asked to locate all perceived prominence, to mark emphatic accents and non-terminal and terminal Intonation Unit boundaries. The syllables were classified into 6 categories: Emphatic Word-Initial (EWI), final in a Non-Terminal Intonation Unit (IU-NT), final in a Terminal Intonation Unit (IU-T), Rhythmic Word-Initial (RWI) and Word-Final (WF). The remaining syllables were labeled as unaccented (UN). Our corpus totals approximately 2600 syllables.

The excerpts were digitized at 16 kHz and labeled phonemically and in syllables by hand. In order to analyze the duration parameters, each constituent of the syllable was then coded as Onset, Nucleus or Coda. The duration of the different syllable constituents was measured and the raw data was normalized using the Z transform method [5], with the phonemic means and standard deviations calculated separately for each speaker.

The fundamental frequency was modeled with a quadratic spline function using an automatic modeling algorithm [10] with manual corrections. The modeled f_0 is represented by a sequence of target points $\langle \text{ms}; \text{Hz} \rangle$ corresponding to relevant local variations. A set of three target points defines the tonal configurations (typically rise-fall configurations), capturing their dynamic aspects.

The results presented below are mainly concerned with the acoustic invariant in terms of f_0 and duration, common to the 3 speaking styles.

2.2. F0 correlates

As far as f_0 variations are concerned, it appears that rhythmic initial accents (RWI) can be distinguished from word final accents (WF) on the basis of the general shape of their tonal configurations. Indeed, initial accents exhibit asymmetric configurations, whereas they are symmetric for final accents, the slope of the fall (right slope) being less abrupt for the former than for the latter. Moreover, tonal configurations associated with RWI accents spread over many syllables (largest syllabic span of all accent categories), meaning that no major f_0 variations occur in their close vicinity. This may indicate that RWI accents occur when 2 major accents are separated by many unaccented syllables, thus confirming that the actualization of the RWI accent is motivated by eurhythmic constraints (see [3] for more details).

2.3. Duration correlates

As a general tendency, RWI and WF accents have similar global syllable duration, which is quite unexpected considering that the RWI accent has been described as a 'pitch accent' and WF as an 'accent of duration'. This tendency is robust to changes in speaking styles. What distinguishes these two types of accents however is the distribution of the differential lengthening (p-value = 0.0366). Indeed, lengthening is distributed differently across the syllabic constituents (Onset and Rime) depending on whether the accent is word-initial or word-final: a greater lengthening of the Onset is characteristic of word-initial accents, whereas a greater lengthening of the Rime elements is more characteristic of word-final accents (Figure 1). This tendency is also robust to changes in speaking styles (see [1] for more details).

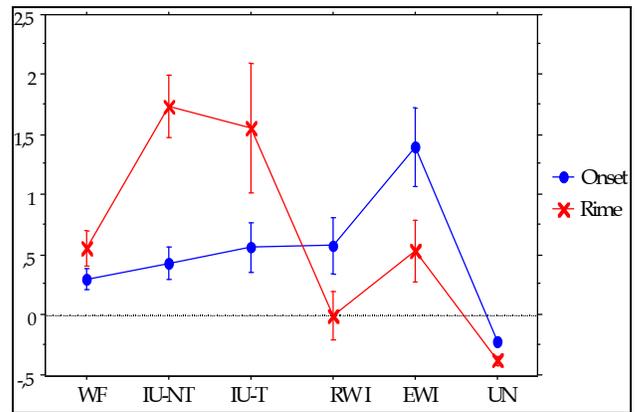


Figure 1. General tendencies of differential lengthening of syllabic constituents (Onset and Rime) across accent categories, for 3 speaking styles (Accent categories : WF = Word-Final; RWI = Rhythmic Word-Initial; IU-NT = final in a Non Terminal Intonation Unit; IU-T = final in a Terminal Intonation Unit; EWI = Emphatic Word-Initial). Duration is normalized in Z.

To summarize, the main results concerning the acoustic and rhythmic properties of the RWI accent, which prove speaking-styles independent, are twofold:

- the RWI accent occurs to favor eurhythmy;
- the RWI accent is characterized by a typical infra-syllabic lengthening strategy, which distinguishes it from WF accent type, the syllable lengthening being mainly supported by the Onset constituent.

The following experiment is designed to give perceptual support to these results.

3. PERCEPTUAL EXPERIMENT

3.1. Introduction

Hypotheses H1 and H2 developed in section 1 lead to the prediction that, within an accent detection task, an increase of the Onset duration should involve a better accent detection for a syllable in a Word-Initial position than for a syllable located in another position. It is also predicted that the longer the distance between this initial syllable and the subsequent phrase final accent, the stronger this effect should be. Our aim is to verify these predictions and thus the hypotheses from which they are inferred.

3.2. Material and procedure

3.2.1. Introduction. The experiment described below is an accent detection task. This task is carried out on a *Target Syllable* (TS) under various experimental conditions. Three factors determine these experimental conditions:

- *Step* factor (S): the duration of the TS Onset is taken from a range of increasing steps covering the typical values observed for unaccented syllables until the most important values observed for RWI accents.
- *Position* factor (P): the TS can be either the Initial (I), Middle (M) or Final (F) syllable of a lexical word. The Initial position is expected to be associated with a phonological representation of accentuation involving an increase of the Onset

duration, while the Final position would rather involve an increase of the Rime duration. The Middle position is not expected to be associated with any accentuation representation. This factor is designed to test hypothesis H1.

- the *Rhythmic Context* factor (RC): the distance between the TS and the following phrase final accent can be of one unaccented syllable (Narrow RC) or of two unaccented syllables (Wide RC). This factor is designed to test hypothesis H2.

3.2.2. Material. The experimental material is thus constituted of 6 phrasal conditions (Table 1) in which Position (P) and Rhythmic Context (RC) factors are crossed.

For each condition, the duration of the Target Syllable's (TS) Onset varies from 70 ms to 123 ms by 16 steps of 5% increase rate (Step factor). The Nucleus of the TS has a constant duration of 63 ms. All other syllables have constant characteristics: unaccented syllables have an Onset duration of 70 ms and a Nucleus duration of 63 ms; phrase final accented syllables have a duration of 90 ms for the Onset consonant, of 120 ms for the Nucleus and of 95 ms for the Coda consonant. Provided the disparities of intrinsic duration between macro-classes of segments and the co-intrinsic variations, the first /l/ had to be shortened to 50 ms [15]. The lexical item carrying the TS (i.e. "toccata") was chosen so as to minimize that kind of constraint.

Melodic factors were neutralized as much as possible. The f0 curve was built on three values linked by a linear interpolation, 105 Hz, 100 Hz and 80 Hz respectively assigned to the initial, penultimate and final syllables of each phrase. The duration and f0 values of the phrase final accented syllable are typical characteristics of an intonation unit terminal boundary.

The duration and f0 values used in this study are taken from the data of [1, 2, 3].

The 96 stimuli (16 Steps * 3 Positions * 2 Rhythmic Contexts) were synthesized using the diphone synthesis MBROLA [7].

	Position	Rhythmic Context	Phrasal conditions
IN	Initial	Narrow	la <u>to</u> cca T A
IW	Initial	Wide	la <u>to</u> cca T A RUSSE
MN	Middle	Narrow	la <u>to</u> cca T A RUSSE
MW	Middle	Wide	la <u>to</u> cca T A de BACH
FN	Final	Narrow	la <u>to</u> cca T A de BACH
FW	Final	Wide	la <u>to</u> cca T A pol ONAISE

Table 1. Phrasal conditions used in the accent detection experiment ("the {Ø; Russian; Bach; Polish} toccata"). Bold, underlined characters indicate the Target Syllable; bold, capital characters indicate the phrase final accented syllable.

3.2.3. Procedure. Stimuli were presented in an accent detection task in a "Yes/No" paradigm. The assessment test software ASTEC [4] was used to present stimuli and record answers.

For each trial, one of the 6 phrasal conditions was presented on a computer screen, the Target Syllable being capitalized. The corresponding stimulus was presented after 2 seconds through headphones. The subject then had to judge

whether the TS was accented or unaccented. No stimulus repetition was allowed.

A training session involving 12 trials was presented. The 12 trials comprised the different phrasal conditions, as well as the lowest, median and highest steps (namely steps 01, 09 and 16).

The test was composed of 3 blocks of 96 randomized presentations (that is to say 288 presentations per session). Each session was about 25 minutes long, and two pauses were allowed between blocks. 16 subjects (8 students in phonetics and 8 non phonetician students or staff members) individually took part to the experiment. A preliminary analysis indicated that the answers of one non phonetician subject significantly differed from all other subjects' answers and were discarded.

3.3. Results

ANOVAS were carried out on the 4320 answers collected. Two major results emerge: 1. the accent detection rate varies as a function of the Position of the Target Syllable; 2. the accent detection rate varies as a function of the *combination* of the Position and Rhythmic Context factors.

3.3.1. Effect of the Position factor on the accent detection rate.

In a three-way ANOVA, at a 5% threshold, the Step factor is significant (p-value < 0.0001). This analysis indicates that the rate of accent detection increases as a function of the TS Onset's lengthening. The Position factor is also significant (p-value < 0.0001). This analysis indicates that the rate of accent detection in Initial position is 22.2% higher than in Middle position (p-value < 0.0001) and 23.4% higher than in Final position (p-value < 0.0001). The detection rate for the Middle position is 1.2% higher than the one for the Final position and this difference is not significant (p-value = 0.4913). The Rhythmic Context factor is not significant (p-value = 0.5969) but the interaction between the RC and Position factors is significant (p-value = 0.0073). We therefore performed 3 two-way ANOVAS (Step * Rhythmical Context) in order to test the influence of the RC in each Position condition (Initial, Middle and Final).

3.3.2. Effect of the Rhythmic Context on the accent detection rate for each Position condition.

The Step factor remains significant in any position (p-value < 0.0001). In Initial position, the Rhythmic Context factor is significant (p-value = 0.0131), the rate of accent detection being 5.4% higher in Wide RC than in Narrow RC. In Final position, the Rhythmic Context factor is not significant (p-value = 0.4512). In Middle position, the Rhythmic Context factor is also significant (p-value = 0.0398), the rate of accent detection being 5,1% higher in Narrow RC than in Wide RC. These results call for a comment: it may seem awkward that the RC factor should be significant for this position, since accentuation in a Middle position is not phonological in French (cf. section 3.2.1.). However, this effect is low (detection rate: 53,5% for MN, compared to 70,4% for IN, and 75,8% for IW).

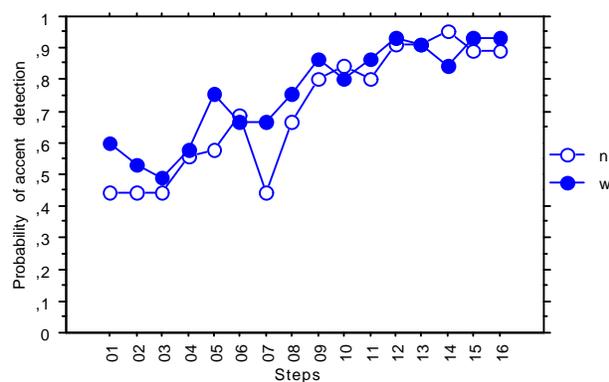


Figure 2. Accent detection probabilities in Initial position by steps of increasing duration and Rhythmic Context.

3.4. Discussion

These results globally confirm the predictions inferred from hypotheses H1 and H2. Subjects showed better performance of accent detection for Onset lengthening in Word-Initial position than in Middle or Final position (Figures 2 and 3). The more distant the Word-Initial syllable from the subsequent accented syllable, the more reinforced this effect.

However, as shown in Figure 2, subjects tend to detect an accent in Initial position with a probability around 0.5 even for null (Step 01) or negligible duration increases (Steps 02 or 03 for instance). This probability corresponds to answers given at random, indicating that hearers expect to find an accent in this position. This expectancy may thus be interpreted as phonological.

4. CONCLUSION

In this study, we presented acoustic data highlighting the specific characteristics of the RWI accent. These data emphasize the relevance of duration parameters, namely differential lengthening across the syllabic constituents, in the characterization of RWI accents and its distinction from word-final accents.

On the basis of these results, a perception experiment was carried out to test 2 hypotheses concerning the phonological status of the RWI accent. The results lead us to interpret the strong probability of detection of an accent in initial position (even for lowest steps of Onset lengthening) as the consequence of an expectancy on the part of the hearer. This expectancy is consistent with the hypothesis of a mental representation of the initial accent in French. It is also consistent with the fact that the actualization of initial accentuation is motivated by eurhythmic constraints. Thus, these results tend to confirm the existence of a proper *rhythmic* function of Word-Initial accents in French, distinct from emphatic or pragmatic expressions of initial accentuation.

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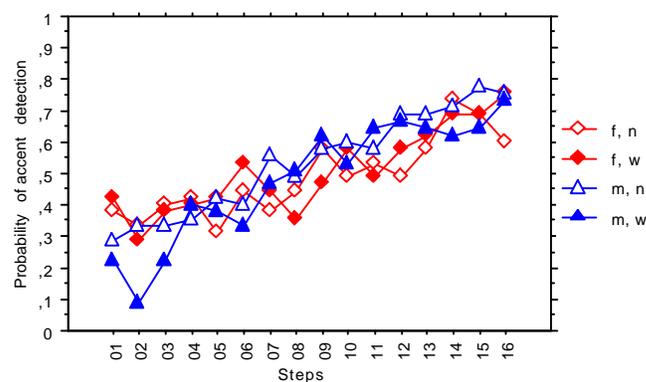


Figure 3. Accent detection probabilities in Middle and Final positions by steps of increasing duration and Rhythmic Context.

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