

Contrastive Analysis of Intonation Patterns in French and European Portuguese

Lurdes de Castro Moutinho¹, Rosa Lúcia Coimbra¹, Jean-Pierre Zerling²

¹Universidade de Aveiro, Portugal

²Université Marc Bloch à Strasbourg, France
pfonetica@dlc.ua.pt, zerling@umb.u-strasbg.fr

1. Introduction

The scope of this research is the study of three types of prosodic structures - declarative, interrogative, and imperative – in two Romance languages, i.e., French (FR) and European Portuguese (EP). With this objective, we elaborated a corpus which was recorded by native speakers. The experimental procedure adopted is described in the next section. After presenting the corpus and the methodology of analysis, results will be presented concerning the study of F₀, intensity and duration, for both speakers. Finally, some comments on these results will be made for each speaker and modality, and comparisons between them will be established.

2. Experimental procedure

2.1 The different steps

This research is organized in different steps. Thus, for each language, the following method was adopted:

- two sentences were chosen (one for Portuguese, another for French) in order to constitute the corpus;
- phonetic transcription of the sentences;
- recording of a native speaker for each language;
- prevision of lexical and rhythmic stresses;
- prevision of melodic variations, according to Delattre terminology (Delattre, 1966);
- observation of the variations and comparison with the previsions;
- comparison of the three melodic patterns;
- analysis of duration and vocal intensity.

Afterwards, and crossing data obtained for the two languages, we will try to determine the specificities of each language and the common aspects.

2.2 The corpus

In order to create the corpus of this research, two sentences were made so that their syntactic and phonetic structure might be as similar as possible:

<i>Pateta toca no café</i>	[pa"tEt6 "tOk6 nu ka"fE] ¹
<i>Petitout passe à la télé</i>	[p@"ti"tu pasalate"le]

¹ To make phonetic transcription easier, we use SAMPA phonetic alphabet for Portuguese (<http://www.phon.ucl.ac.uk/home/sampa/portug.htm>) and French (<http://www.phon.ucl.ac.uk/home/sampa/french.htm>).

As can be observed, these two sentences are ambiguous, so that only the prosodic variation when they are uttered will allow the meaning distinction for each of the chosen modalities: declarative, imperative and interrogative.

On the segmental level, these sentences are comparable, since both contain the same number of phonetic syllables. The syllables are open, with a CV structure, and in most cases the consonant present in the syllable is an unvoiced consonant, so that analysis is made easier. The basic differences between the sentences derive from the fact that the stressed syllable, in the case of proper names, does not coincide in the two languages and also the verb is disyllabic in Portuguese and monosyllabic in French. However, and with the objective of making the two sentences as similar as possible, an oxytone was chosen for the last word of the Portuguese sentence, stressed, therefore, on the last syllable, as it always happens in French words. Moreover, this option also prevents the elision of the last vowel of the Portuguese sentence, which is a very frequent phenomenon when the last word of the sentence is a paroxytone or a proparoxytone. In fact, previous studies (Delgado-Martins, 1982; Mira Mateus et al., 1982; Morais Barbosa, 1994) show that European Portuguese unstressed vowels often disappear when they are in syllable or sentence end. Our previous research (Moutinho et al., 2001) also proves this kind of phenomenon, especially in declarative type sentences.

2.3 The documents

For each language, the sentences are produced several times by the same native male speaker. Five utterances were selected for analysis, among those considered perceptually correct and representative of the modalities in study. Therefore, a total of $3 \times 5 = 15$ utterances of each sentence in each language were analysed.

Recordings were made, respectively in the phonetics laboratories of the universities of Aveiro (Portugal) and Strasbourg (France). The recorded signal was converted into “.wav” format, so that it could later be processed in a semi-automatic way. The segmentation of the signal, as well as the elaboration of graphs was done in Aveiro, using Matlab software with a scientifically tested methodology (Contini et al., 2002; Moutinho et al., 2001).²

The parameters analysed for each vocalic segment were duration, intensity, and three basic frequency values, measured in three distinct points: beginning, middle, and end of the vowel. The average values obtained for the five utterances of the same sentence for the same speaker, were then calculated and used for the analysis. Figures 1 to 5 represent, for each sentence, the average variations of the basic frequency F_0 for each prosodic pattern. These average variations of the melodic curve were then compared, both for two intonational patterns by same speaker, and for the same patterns in the two languages. Figures 6 to 11 show the comparison of variations in vowel duration. Table 1 presents, as a synthesis, the main common prosodic characteristics for the two speakers.

² Due to the involvement of Aveiro researchers in a project called AMPER (Atlas Multimédia Prosodique de l'Espace Roman), and the software available for that purpose, it was decided to adopt a similar analysis methodology, specially as far as the studied parameters were concerned..

3. Analysis

3.1 Study of melodic variations (F_0)

3.1.1 Declarative sentence (DEC)

- **expected melodic pattern**

The expected declarative intonational pattern is globally falling (patterns of "purpose", according to Delattre, 1966). However, the analysed sentences, include, *a priori*, two rhythmic groups and the first group can be rising. Moreover, it may even be expected other possible variations, related to lexical stress, for Portuguese, by using one or several of the three acoustic parameters: F_0 , duration or intensity.

- **French speaker (FS)**

The results reach our expectations: a melodic rise of 8 halftones (143-227 Hz) is observed in the first group. However, in spite of this rise, each vocalic segment is frequently declining. This fact is related to a micro-prosodic phenomenon, very frequent in French: the glottal attack is strengthened by the presence of an unvoiced consonant preceding the vowel. The culminating point (227 Hz) is reached in the 3rd syllable (end of the rhythmic group), and then a regular lowering is observed, almost linear, of 12.6 halftones (195-94 Hz). Concerning duration, it was observed that the last two syllables of the group are slightly longer than the others, specially the last one that almost reaches the double of the duration.

- **Portuguese speaker (PS)**

A rise is also observed in the first three syllables, but proportionally smoother than in French: 3.6 halftones (118-145 Hz). The high frequency on the final non-stressed vowel may seem surprising, but it confirms the role it plays on intonation, which also happens in French. The two syllables of *toca* remain high and at the same level. Afterwards there is a gradual decline of 7.7 halftones (142-91 Hz) in the last three syllables. The three stressed vowels are the longest, specially the last one with a duration 2 or 3 times higher than that observed for the shorter ones. However, and contrary to a legitimate expectation, the basic frequency does not allow to truly identify what would normally be considered as "tonic stresses".

- **Portuguese/French (PORT/FR) comparison**

Overlapping the representations of the obtained melodic curves clearly shows the similarity between two intonational patterns chosen in each language³. But we also notice, independently of differences in speaker's vocal range, that the rising of the first group is clearly higher in French. This type of performance is perfectly understandable, since the third syllable, in French, is simultaneously the carrier of the rhythmic stress and of the intonational pattern of movement continuation. In Portuguese, on the other hand, the presence of the stress on the second syllable makes it improbable on the third, because it might create a possible ambiguity.

³ We observe that in the graphs that present superposition of melodic curve movement the first line is used as a normalizing model, including to the horizontal scale. That is way the segment duration correspond to the duration of the French utterance and not the Portuguese one.

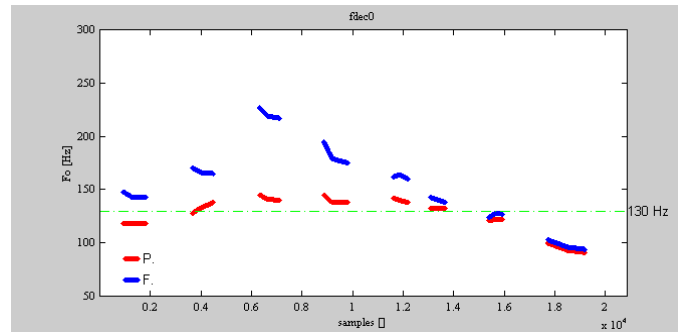


Figure 1. PORT/FR Declarative comparison

3.1.2 Imperative sentence (*IMP*)

• expected melodic pattern

The imperative sentence (order or "commandement", according to Delattre's terminology) generally follows a declining pattern. However, our sentences include two rhythmic groups, materializing two phrases that grammatically correspond to a vocative, followed by an imperative. The first element (vocative) could perfectly be uttered, either by a high or ascending movement (of the interrelative type), or by a descending movement (of the exclamative type).

• FS

Interesting relatively to our predictions, the melodic curve of the vocative segment is globally moving upwards by 4.3 halftones (130-167 Hz), but if the third vowel is marked by a raising attack, the pattern quickly inverts and the frequency clearly loses 2.1 halftones (167-148), which is possibly due to the long vowel duration. Everything is processed as if there was simultaneously, in this first group, a combined rise and fall of F_0 . The long duration of the third vowel also clearly reflects the end of the rhythmic group, more marked than in the declarative modality, which is also due to the fact that this group is followed by a silent pause.

We admit that this dropping plays a contrastive function, which also evidences the very high frequency attack on the first syllable of the imperative group. The brusque rising of 148 to 221 Hz is equivalent to 6.9 halftones, which is really considerable.

The second melodic group variation is typical of a declarative sentence, i.e., with a gradual lowering of 13.6 halftones (221-101 Hz).

• PS

This Portuguese speaker produced a vocative intonational group – 1st rhythmic group – that is simultaneously similar and different than the one observed for the French informer. If in French the melodic curve is globally rising with a final fall, for the Portuguese we may say that it is globally falling, with an intermediate up that is necessary to mark the tonic stress on the paroxytone *Pateta*. This fall is important, since it represents a difference of 4 halftones (120-95 Hz) between the beginning and the end of this rhythmic group. The different amounts to 7.1 halftones (143-95 Hz) if we take as starting point the most raised point of the 2nd vowel. This fall is important because it leads the melodic curve to its minimum point (95 Hz), which will only be found again at the end of the sentence.

The following group, as in French, appears after a pause (longer for this informer) and an attack even more marked than the one produced by the French speaker: 9.3 halftones higher (95-163 Hz). This fact is even more significant, since the Portuguese speaker uses less melodic variation than the French one. This tessiture ranges between 7.9 and 9.9 halftones. He

uses, in this particular situation, all his vocal capacities, since his basic frequency varies, practically, from its lower value to its higher value.

Similarly to what is observed for the declarative, the three stressed vowels are the longest. However, in this in case, it is the second vowel in *Pateta* that is the longest (about 4 times than the brief ones). Such a fact is understandable because the vocative is the important element. Contrary to what was observed for the declarative, the basic frequency plays, in this in case, a more important role, in allowing to detach the tonic stresses, twice through maximum points and once through the final drop.

• PORT/FR comparison

The overlapping of the two melodic curves clearly shows, considering the effect of vocal range differences between the two informants, the similarity of the intonational patterns in both languages. The first group presents a convex pattern, with its maximum value on the stressed vowel, depending on the language. Then, after a pause, the attacks on the second group present a very high basic frequency in both cases. The highest value in French is undoubtedly conditioned by the already high frequency of the last vowel of the preceding group. However, in terms of musical height, the beginning of this ascending movement is superior in Portuguese. The end of the sentence is, after that, gradually lowering, presenting almost an overlapping on the contour for the two speakers.

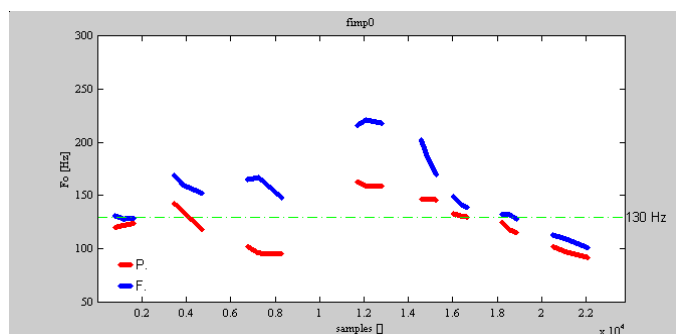


Figure 2. Comparison of PORT/FR imperatives

3.1.3 Interrogative sentence (INT)

• expected melodic pattern

In the syntactically ambiguous sentences that were analyzed, the intonation plays a necessarily determinant role. In this case, the global interrogative (a question, "question", according to Delattre), allows to predict a melodic rising, generally near the end of the sentence. This sentence is *a priori* constituted by two rhythmic groups, the first one being less predictable: it may be upwards or downwards, according to the adopted logic (ascending pattern of continuation, or falling pattern for a contrastive effect). The variation of stress already mentioned must also be taken into consideration.

• FS

As for the two preceding types of sentences, the basic frequency rises gradually on the three syllables of *Petitout*, with a vocal range of 3.5 halftones (125-153 Hz), similar to the imperative sentence but with a direction change less marked and a longer duration of the last vowel of the group. Then, and after an almost inexistent variation in the first half of the second group, there is a fast and abrupt rising of F_0 on the final vowel which presents a long duration: with a rise of 8.6 halftones (165-271 Hz), of which 5.3 (200-271 Hz) on the vowel

itself. The reached frequency is the highest of the three occurrences (271 Hz). This result confirms the final level considered by Delattre for the intonational pattern of a question.

• **PS**

The attack of the basic frequency is the highest of the three sentences produced by this speaker (161 Hz, in opposition to 118 and 120 Hz). It is practically higher than the maxima of the two preceding sentences (145 and 163 Hz). Afterwards, after a fast rise of 2.4 halftones (161-185 Hz) culminating on the tonic vowel, a gradual fall is observed, very slow, until the final vowel, which suffers an abrupt fall of 4.6 halftones (147-113 Hz). However, more or less at the middle of its duration, there is a movement inversion, with an increase of 1.4 halftones (108-117 Hz). This small up movement, connected to the inflection movement, may be enough and determinant in producing the desired effect: the perception of the final rise, which is characteristic of the question.

• **PORT/FR comparison**

The overlapping of the two melodic patterns clearly shows that the two speakers use two very different strategies when producing questions. In French, the attack is sufficiently low and there is a gradual rising until a very marked final contour. In Portuguese, there is a relatively high attack and a gradual fall until the moment of a fast inversion of the movement, followed by a final rise.

Globally, there are practically two symmetrical curves, relatively to the horizontal line, passing through the medium frequency of the vowels situated at the middle of the sentence. Despite the evidenced differences, there are some common points: at the beginning of the sentence, a rising attack in both languages and at the end, a final rise involving all or part of the last vowel.

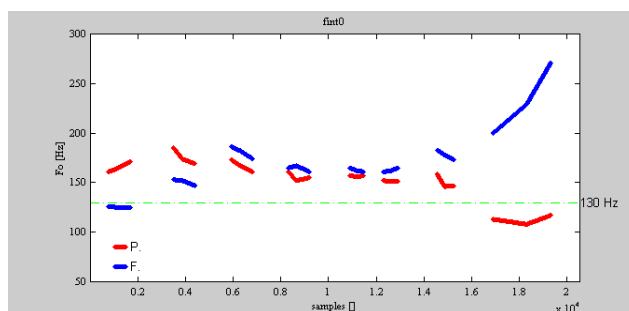


Figure 3. Comparison of PORT/FR interrogatives

3.2 Variations within the same speaker

The following graphs compare the variations of F_0 , for each speaker, not only between declarative and imperative sentences, but also between declarative and interrogative sentences.

Through the overlapping of the declarative-imperative contours, in both languages, a rather similar behaviour is observed, despite the marked individual differences. On the first part of the sentence, F_0 goes up in the declarative sentence, while it tends to go down or to invert in the imperative.

In the second rhythmic group, after an attack on the first vowel of the imperative, the curve goes down and is practically overlapped on the last four vowels.

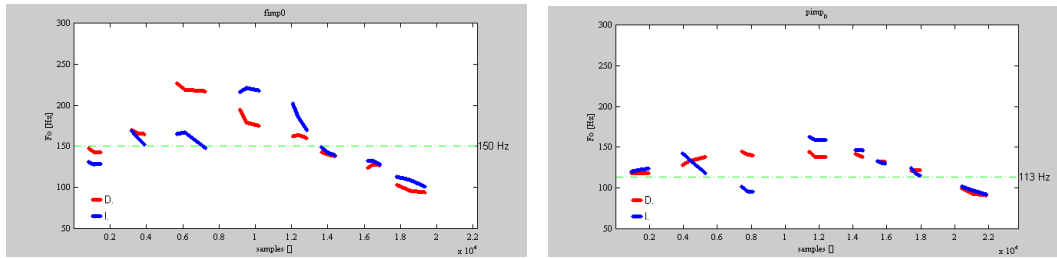


Figure 4. Dec and Imp comparison (FS left : *Petitout passe à la télé*; PS right: *Pateta toca no café*)

The overlapping of the declarative-interrogative sentences clearly confirms the preceding affirmations: the use of radically different strategies in the two languages, relatively to the interrogative:

- In French, the first rhythmic group goes up equally in the two cases, but with a slightly higher basic frequency value in the case of the declarative (of 2 to 3 halftones on the first three vowels). This phenomenon may be due to the fact that, in this case, the two elements of the sentence are more independent, on the syntactic point of view, while in the interrogative there is a bigger cohesion between the groups.
- In Portuguese, the global melodic curve of the two sentence types is almost parallel, but, here, with a F_0 systematically higher in all interrogatives (a maximum of 5.6 halftones (118/164 Hz), in the beginning and of 2.3 halftones (151/132 Hz) in the remaining portion of the utterance). The intonational distinction between the two sentence types seems to be essentially due to this height difference, specially in the initial attack and also in the small slope inversion on the last vowel in the interrogative sentence.

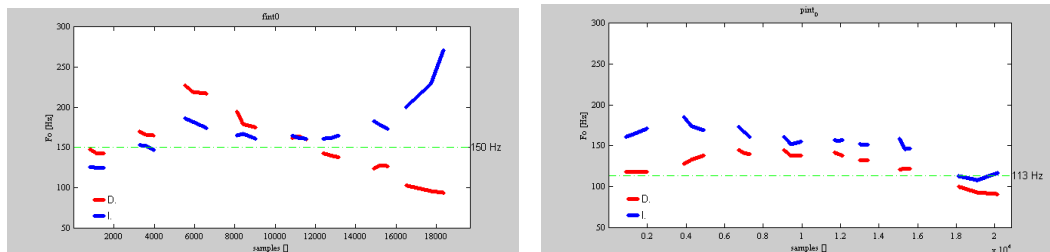


Figure 5. Dec and Int comparison (FS left : *Petitout passe à la télé*; PS right: *Pateta toca no café*)

Concerning the intonational pattern of the two rhythmic groups, it is observed that, in the two languages, the first group always presents a very distinct form, with the culminating point on the stressed syllable: the second, being tonic in Portuguese and the third rhythmic in French. A small violation of the rule is also observed, in the case of the Portuguese declarative, where the third non-stressed vowel of *Pateta* continues to be produced with raised F_0 . This phenomenon may be considered as an accentual effect, but mainly as an "echo" (in Delattre's sense).

We must however admit that some of the differences that were observed, specially for the interrogatives, may be due, besides the different strategies, to small subtleties in the ways to place the question; for example a rhetorical question of the type "Pateta toca no café, não é verdade?" ("Pateta touches the coffee, doesn't he?").

4. Study of vowel intensity and duration

4.1 Intensity

It is usually considered that the intensity parameter plays a minor role in French, when compared to other languages, namely to the so-called accentual languages. The observation of the graphs that illustrate the variation of this parameter shows that there is effectively no significant variation of the intensity, which would allow the clear detection of stresses or delimitation phenomena independently of sentence type.

In Portuguese, invariably, the intensity reaches a slight maximum point on the tonic vowels of *Pateta* and *toca*. After that, it decreases regularly on the last four syllables of the sentence, from 4 to 12 dB (103-95, 104-92, 103-99, depending on the sentence). The final vowel, although tonic, always suffers a fall in the intensity values (from 1 to 4 dB), relatively to the preceding vowel. We may thus conclude that for this speaker the variations follow a certain expected logic, characterised by stress reinforcement and a final weakness (Delgado-Martins, 2002). We also notice a bigger diversity of values in the Portuguese intonational standards.

In the present state of this research, in spite of the stability of the differences between the two languages, it seems difficult to be sure whether they present an important role on sentence production and perception.

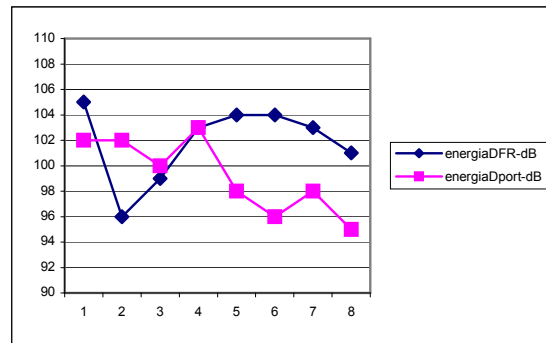


Figure 6. Comparison of vowel energy in PT/FR Declaratives

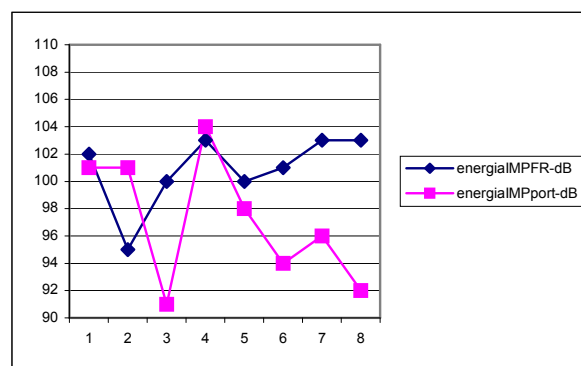


Figure 7. Comparison of vowel energy in PT/FR Imperatives

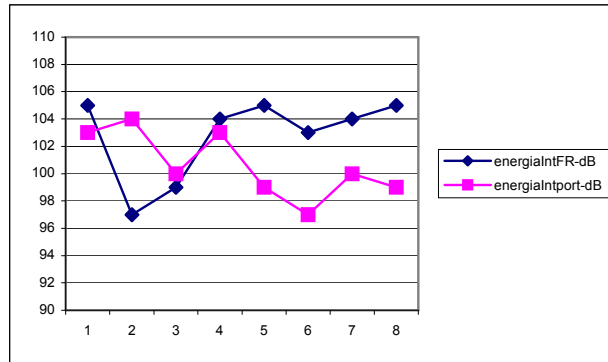


Figure 8. Comparison of vowel energy in PT/FR Interrogatives

4.2 Duration

Graphs made from the measured values allow to compare the three sentences in the two languages and to observe the way duration parameter is used. Moreover, they offer the possibility to verify if common points exist, both between different sentence types and between the two languages.

In the first place, the lowest vocalic durations reach approximately 40 ms for the French speaker, while for the Portuguese they are of 30 ms. This fact may seem surprising, since the speech rate of the former is slightly superior to the latter. This particularity is due to the fact that in Portuguese there is a tendency to reduce non-stressed vowels.

If we consider stress position in both languages, we observe that:

- The final vowel is always long or very long (from 80 to 150 ms): between 2 and 6 times longer than the short ones. This fact is certainly justified by its position at the end of the first rhythmic group of the sentence. As in Portuguese, besides its position in the rhythmic group, it also carries the tonic stress of the last word (paroxytone), and presents a bigger energy increase than in French.
- The non final vowels, expected as stressed or potentially stressed (lexical stress in Portuguese, rhythmic stress in French), also have a slightly superior duration: 1.3 to 1.8 ms in French and 1.8 to 2.7 ms in Portuguese.

Moreover, if we compare the two sentence types in the two languages, we notice that:

- The declarative sentence is distinguished essentially by the presence of a long final vowel (81 and 103 ms).
- The imperative also presents a long final vowel, with values similar to those obtained for the declarative: 82 and 113 ms. The stressed vowel of the first group is still longer, in both languages (108 and 136 ms). The vocative phrase is, in this way, still more prominent than the final part of the sentence that contains the order.
- In the interrogative sentence, the end is extremely long, for the two informants (150 and 153 ms, that is, respectively 3.6 and 5.8 ms superior to the values obtained for short vowels).

Relatively to the short vowels, the Portuguese speaker presents a bigger duration in stress vowels than the French speaker. This is somewhat surprising since it is considered that French privileges the duration parameter.

Moreover, the Portuguese speaker uses the variations of vocalic prolongation (relation between long and brief vowels) in a finer form than the French speaker. It is, undoubtedly, his way of compensating for his more monotonous intonation, which we have already mentioned previously.

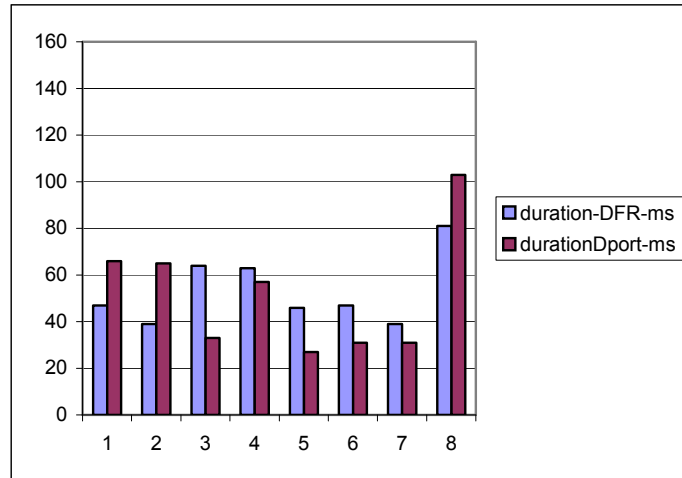


Figure 9. Comparison of vowel duration in PT/FR Declaratives

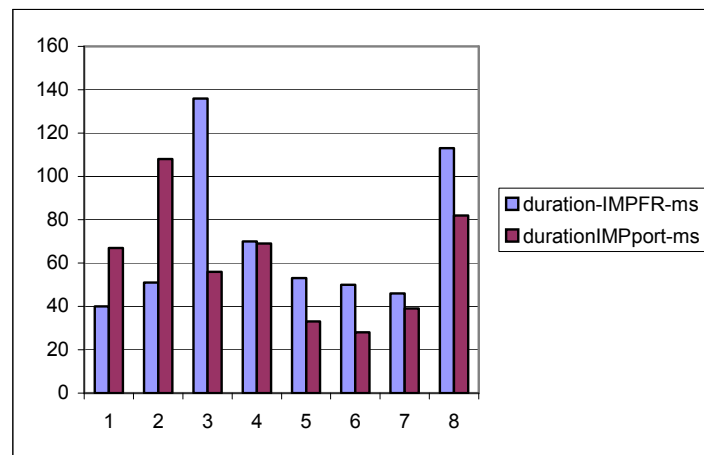


Figure 10. Comparison of vowel duration in PT/FR Imperatives

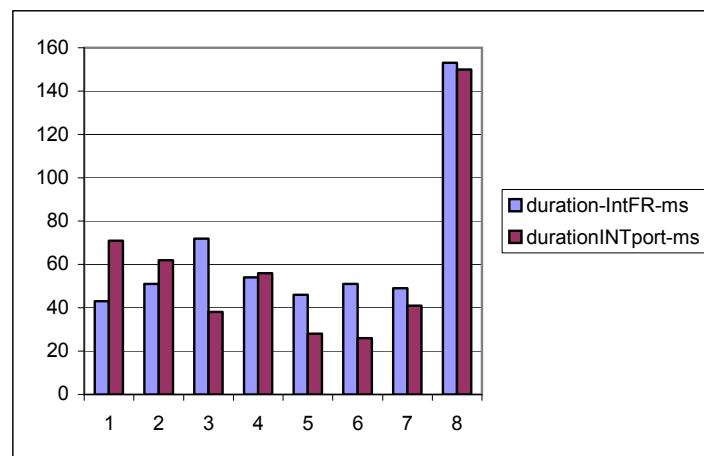


Figure 11. Comparison of vowel duration in PT/FR Interrogatives

5. Final remarks

Contrary to possible expectation, it was verified that the prosodic behaviour of the two languages, relatively to the two studied speakers, is very similar in the three studied sentence types: declarative, imperative and interrogative.

The first two present minimum differences and concern mainly the existing difference in stress position and the different role it plays in each language. The melodic patterns and duration variations seem to be very similar in both languages.

The major difference that could be observed concerns the two different melodic strategies used for the interrogative sentence, even if there are common points between the two languages, mainly at the beginning and at the end of sentences.

However, a doubt remains about the nuances of the message that each informer wanted, effectively, to transmit when formulating the question.

Intensity does not play a significant role in the distinction between the three types of sentences. It seems more subject to variation in Portuguese, slightly increasing for the stressed vowels and decreasing at the end, while in French it remains constant.

Contrary to a preconceived idea that French would mainly use the duration parameter to mark stress, while other languages would mainly use intensity and basic frequency (hence the denomination of "tonic stress"), our data tend to prove that it would rather be Portuguese that would privilege this parameter, especially in the case of the stressed vowels.

We must keep in mind, however, that the sentence chosen for French was not particularly favourable to the effect of vocalic elongation that is generally found in certain closed syllables.

On the other hand, global melodic variations are clearly superior for the French speaker. Unfortunately, our data do not allow to decide if this phenomenon can be generalized for the two studied languages or if it must be imputed to the speakers. The continuation of this research is indispensable to clarify this type of problems.

To conclude, the following table presents a synopsis of the main common prosodic characteristics of the two languages, for both informers.

Table 1. Main prosodic characteristics common to the two speakers

2 speakers	Declarative	Imperative	Interrogative
F0 attack	low	low	high
mean F0	-	-	+
melody	up	up-down	slightly up
group 1			/ strongly up ++(FR)
& group 2	\ down	\ down	/ down-up (PT)
maximum vocalic duration		++ stressed vowel 1st gr.	
	+ final vowel	+ final vowel	++ final vowel
Intensity		not significant	

This brief study on prosodic behaviour of French and European Portuguese, in spite of not being exhaustive, has the merit of presenting a methodology of analysis extendable to the study of other languages.

This research shows the necessity to complete these comparisons with other Romance or non Romance languages, such as Italian, English, German, and others.

The inclusion of a larger number of informers, more complex sentences and spontaneous speech (map task technique or other) in future research, would also be needed.

To conclude, we would like to point out the importance of basic research in the domain of Prosody, in general, and of rhythm and intonation, in particular. Besides increasing knowledge in this often neglected area, the results may also help to improve the quality of foreign language teaching.

References

- Contini, M., Lai, J.-P., Romano, A., Roullet, S., de Castro Moutinho, L., Coimbra, R. L., Pereira Bendiha, U., & Secca Ruivo, S. (2002). Un projet d'atlas multimédia prosodique de l'espace roman. *Proceedings of the International Conference Speech Prosody 200* (11-13 April 2002) (pp. 227-231). Aix-en-Provence, France.
- Delattre, P. (1966). *Studies in French and comparative phonetics*. Mouton, La Haye.
- Delgado-Martins, M. R. (1986[1982]). *Sept études sur la perception. Accent et intonation du portugais*, Lisboa: INIC.
- Delgado-Martins, M. R. (2002). *Fonética do português. Trinta anos de investigação*, Edit. Caminho, Lisboa.
- Hirst, D., & Di Cristo, A. (Eds.) (1998). *Intonation systems: A survey of twenty languages*. Cambridge: Cambridge University Press.
- Martin, P. (1987). Pour une théorie de l'intonation. In Rossi et al. 1981, 234-271.
- Mira Mateus, M. H. et al. (1982). *Gramática da língua portuguesa*. Almedina, Coimbra.
- Morais Barbosa, J. (1994). Entoação e prosódia. In G. Holtus et al. (Eds.), *Lexicon der Romanistischen Linguistik, Band VI* (2), 243-248.
- Moutinho, L. C., Coimbra, R. L., Ruivo, S., & Bendiha, U. (2001). Atlas prosódico multimédia: Curvas de uma trajectória. *Actas do XVI Encontro Nacional da Associação Portuguesa de Linguística* (pp. 387-391). Colibri.
- Rossi, M. (1999). *L'Intonation - Le Système du Français: Description et modélisation*, Ophrys, Paris.