Analysis of Global Pitch Contour Domains at Paragraph Level in Spanish Reading Text

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ABSTRACT
In this paper a study of F0 patterns at paragraph level is presented. The goals of this work are the search of a domain for the 'basic intonation unit' within the paragraph and the validation of the existence of an F0 pattern for the whole paragraph. The results suggest that it is necessary to define a special linguistic unit that covers the scope of these patterns. They also seem to indicate that there is some general tendency to a global declination in the paragraphs, specially in the bottomline, and that there exists some kind of partial reset working at the internal boundaries of the paragraph.

INTRODUCTION
Intonation[1] at paragraph level has been studied for different languages such as Danish (Thorsen, 1985) or English (Ladd, 1988) among others, but not for Spanish. This work presents the preliminary results of a study of paragraph intonation of Spanish text readings. It has been focused on two topics related to the intonation in paragraphs: a) how can paragraph F0 contours be split into smaller units, and b) whether it is possible to define a global paragraph F0 pattern.

Intonation units within the paragraph
The F0 contour of a whole paragraph can be seen as a series of one or several global F0 patterns, (henceforth **pitch contours**). Assuming that F0 contours have a general tendency to decline, **F0 resets** can be a cue to indicate the beginning of a new pitch contour. An F0 reset is found when the general F0 level of a contour is reset (placed at a higher level).

Each pitch contour has an associated domain in the paragraph, that we will call here **contour domain**. It is not clear yet, what is the nature of this domain. Some studies assume that pitch contours match syntactic units, mainly clauses or sentences. Recent studies in phonology (i.e. Selkirk 1984, Nespor & Vogel, 1986, among others) have noted the lack of an exact matching between syntactic and intonative units, and suggest a phonological unit, the 'intonational phrase' as the basic domain for pitch contours. A phonetic unit, the breath group, has also been proposed as a domain for intonational units in Spanish (Navarro, 1939). However, the results of recent studies suggest (Schuetze-Coburn *et al.*, 1991, for example) that there is not an exact matching between the position of pauses and the position of F0 resets in discourse. Breath groups would not be then always the domain for the pitch contours.

A F0 pattern for the whole paragraph
Several studies on intonation in paragraphs have reported the presence of some kind of global pattern through the different pitch contours of a paragraph. This pattern could be defined as a general 'supra-declination' line linking the onset of the initial pitch contour

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[1] Intonation is considered here as the evolution of the F0 contours at a non-local level (phrases, sentences and beyond).

and the offset of the final pitch contour in the paragraph (Thorsen, 1985). Thorsen's study shows that initial and final values of contours in paragraphs are kept quite constant independently of the length of the text, and that within the paragraphs, the starting values of each contour depend on the number of sentences and the length of each one.

Finally, it has also been hypothesized that the starting value of the pitch contours is also dependent on the degree of coherence between the syntactic components before and after the reset. According to this hypothesis, the reset will be higher if it is placed between two sentences (**total reset**) than if it is placed between two coordinated clauses, for example (**partial reset**).

GOALS AND METHOD

Goals
The goals of this work are following: 1) To find out the different pitch contours in a series of paragraphs, by looking for the different F0 resets; 2) to analyze the domain of these contours, in order to define which is the type of unit (syntactic, phonological, phonetic) underlying them; 3) to study the structure of these pitch contours, and to analyse its relation with the rest of contours in the paragraph, including the hypothesis of the partial reset.

Material
A corpus of 'real' speech material has been collected, including news and comments read by professional speakers (extracted from recordings of radio and TV news bulletins) and by non professional ones (readings of journal news). The chosen paragraphs have been labeled according to its duration in number of syllables (10 categories established), the number of sentences in the paragraph (6 categories), the type of speaker (professional/non professional) and the type of read text (news/comments of news). The combination of these labeling served to classify each paragraph.

The results presented in this study have been obtained only from a small part of this corpus. The analyzed paragraphs have been extracted from news read by professional speakers. The range of categories was also limited to a maximum of 4 sentences per paragraph (category 3), and a maximum of 326 syllables (category 6). An example of each category was selected for the analysis, giving a total of 11 paragraphs analyzed, ranging from 1 to 4 sentences, and from 51 to 287 syllables per paragraph. This is a rather small amount of analyzed material, so the results should have to be considered as preliminary.

Measurements and analyses
The presence of a F0 reset was detected if these three conditions were met: a) there was a boundary that could imply a reset (pause, syntactic boundary); b) the F0 value of the last F0 maximum before the potential boundary was lower than the F0 value in the first maximum after the boundary; c) the last F0 minimum before the boundary was lower than the corresponding value at the first minimum after the boundary. Minima and maxima were defined as points in syllabic nuclei that showed lower or higher F0 values, respectively, that their immediately preceding or following syllables.

Once a pitch contour was defined in this way, F0 and time values corresponding to its first maximum (IMax), the first minimum (IMin), the final maximum (FMax) and the final minimum (FMin) were taken. Duration of the contour was also calculated. Finally, the number and position of pauses in the contour, and the syntactic type of boundary were noted as well.

Initial and final maxima and minima were used to trace top and bottom lines for each contour and for each paragraph, in the way that can be observed in Figure 1. The difference between the first and the last maximum, on the one hand, and between the first and the last minimum, on the other, were computed, as well as the slope of these lines, in Hz/sec., both for each contour and for each paragraph as a whole.
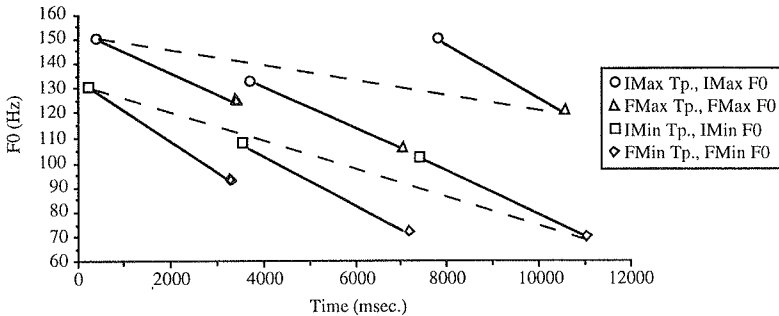
Figure 1. *Top and bottom lines calculated for the pitch contours of one of the analysed paragraphs. Solid lines correspond to the different pitch contours, and dashed lines to the whole paragraph.*

Finally, the level of reset in toplines was determined by subtracting the F0 value at FMax (last maximum before the reset) from the value at IMax (first maximum after the reset). The same procedure was used with FMin and IMin to calculate the level of reset in the bottomline.

RESULTS
The analysis of the 11 paragraphs led to its segmentation into 44 different pitch contours. The results of the analyses performed on these contours are summarized below.

Contour domains
The analysis of the relation between breath group and pitch contours led to the following results:

1) There is a clear tendency to find pauses at the end of the pitch contours (36 times, 81.81 % of the cases).
2) This does not mean that there exists a high degree of matching between breath groups and contour domains, because it is not rare to find domains containing more that one breath group (29.54 % of the cases presented 2 or more pauses in a single contour), or only a part of it (18.18 % of the contours showed no pause at all, even at the end of the contour).

The analysis of the relation between syntactic structure and contour domains showed that:

1) There is a tendency to find resets at the end of sentences (20 cases, 45.45% of the total), but more that 50% was found in other boundaries: before a verbal complement (6 times, 13.63% of the cases), at the end of a subordinate clause (5 times, 11.36%), between the Subject and the Predicate (11.36%), after parenthetical phrases (6.81%) after phrases moved to the front of the sentence (2 times, 4.54%), between two coordinate elements (4.54%) or between the verb and its object (1 time, 2.27%). These results show that there is a tendency in complex paragraphs to find the resets at the end of major syntactic boundaries (sentences or clauses), but it is also possible to find them at lower-level boundaries.
2) The analysis of the syntactic categories underlying the contours led to the conclusion that in a high number of cases (19 times, 43.18 % of the cases) it was not possible to find a syntactic structure that matched the domain of the pitch contour. When it was possible, this category was a Sentence or a Clause (17 times, 38.63%

together). There appeared other categories as NP Subject or VP Predicate (3 times each) with a lower percentage of occurrences.

Definition of a global paragraph unit
The analysis of the top and bottom lines for the whole paragraphs gave the following results:

1) There is a tendency to the declination in both the top and the bottom lines of the paragraphs (mean declining slope in both: -1.79 Hz/sec. for the topline and -3.4 Hz/sec. for the bottomline). This tendency is stronger in the bottom than in the topline, mainly due to the fact that some of the paragraphs showed a positive topline (maximum value: 1.53 Hz/sec. of rising slope). There is also less variation in the slope of the bottomline than in the slope of the topline, according to the standard deviation for each line (1.971 for the top and 1.803 for the bottom).
2) There is a high correlation (-0.805) between number of syllables in the paragraph and the slope of its bottomline: the longer the paragraph is, the steeper is the slope of its bottomline. This could indicate that initial and final values of the bottomline are more or less constant, while the slope is adapted to reach the same value at the end of the paragraph.

Finally, as far as the analysis of partial reset is concerned, there seems to be a certain degree of correlation between syntactic structure and level of reset in both the top and bottom lines. The differences in the mean values for the level of reset at sentence (40 Hz for the topline and 40.22Hz for the bottomline), clause (30.25 Hz for the top and 34.4 Hz for the bottomline) and Subject/Predicate (19.4 Hz for top and 26.8 Hz for bottom) boundaries seem to indicate that the weaker is the syntactic relation between the constituents at both sides of the reset, the higher is the level of reset at that boundary. The analysis of these means also suggests that the variation is higher in the top that in the bottom line.

DISCUSSION AND CONCLUSION
The results presented here, although preliminary, seem to indicate, on the one hand, the existence of a special prosodic unit that covers the domain of pitch contours. Position of pauses and syntactic structure seem to have an influence in the intonational parsing of paragraphs, but there is not a one-to-one relation. On the other hand, these results suggest too the existence of a global pattern for the whole paragraph, according to the findings of earlier studies (Thorsen, 1985), and a relation between syntactic structure and level of reset in the pitch contours within the paragraphs. Further research is being carried out to confirm and formalize these findings.

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