

Figure 6.25. Prosodic tree corresponding to the sentence 143 ('Commentaries' set), uttered by speaker A.R.

Similar structures have been proposed already in earlier works, as Nespor & Vogel (1986).

6.5.6. Summary

In this section, the existence of intermediate intonational units between the phonic groups and the sentence has been suggested. This intermediate unit has been called here 'intonational clause', and it has been defined as a set of several phonic groups within the same 'supra-lines' domain. It has also been proposed that the phonetic cue for 'intonational clause' boundaries is the presence of a 'total' reset.

Intonational clauses can also appear grouped in higher-level units. As in the case of 'intonational clauses', 'total' resets seem to be the phonetic cue to indicate the beginning and end of these higher-level units. They also have their associated 'supra-lines' pattern. These units can cover different parts of a sentence, and even the whole sentence. However, it seems that the sentence is not an obligatory domain for 'supra-lines' patterns.

A tendency to distribute the phonic groups of a sentence in two main 'supra-units' has been observed, although non-binary organizations seem also to be possible.

A hierarchy of units can be proposed for the intonational structure of sentences: phonic groups, one (or several) levels of intonational clauses, and sentence. This intonational structure can be represented as a prosodic tree,

and can be considered as the phonetic realization of a phonological structure, that organizes the contents of a utterance in prosodic units.

6.6. Linguistic factors determining the intonational structure at the sentence level

As was indicated in the first chapter, the analysis of the factors determining prosodic structure of sentences in Spanish is beyond the scope of this work: this type of analysis can be considered as a phonological problem, and the goal of this study is to describe exclusively the phonetic aspects of Spanish intonation. In addition, the material used here is not controlled enough to extract definitive conclusions about this question. In the following sections, however, some hypotheses are considered about the possible factors which can affect the structuring of the prosodic units in a sentence. Anyway, their definitive confirmation or rejection needs a more accurate experimental analysis.

6.6.1. The role of syntactic structure

6.6.1.1. Reset and syntactic structure

Previous studies carried out for languages other than Spanish have revealed that there seems to exist some relationship between resets and the syntactic structure of a sentence. These studies have focused on two main aspects: first, the presence or absence of reset in a boundary; second, the amount of reset appearing at each specific boundary.

The presence or absence of reset has been traditionally analysed at major syntactic boundaries, that is, sentence and clause boundaries. Resets have been detected at boundaries between sentences, in the limits between two coordinate clauses, and between a subordinate clause and its corresponding main clause.

As far as the amount of reset is concerned, Thorsen (1985, 1986) found some differences in the degree of reset affecting the second clause of a pair of coordinate clauses, and in the degree of reset between two complete sentences. According to Thorsen's findings, the reset is higher in the second case than in the first one. These results seem to indicate some relationship between the syntactic structure and the 'level of reset' of the corresponding intonational contour.

In the following sections, an analysis of the location and amount of reset related to the presence of specific syntactic boundaries is presented. The

data presented in section 6.5. about reset in the collected sentence sub-corpus have been used as basic material for this analysis.

6.6.1.1.1. Reset and syntactic boundaries

The goal of this first analysis is to check whether the presence or absence of a reset in the analysed material is related to specific syntactic boundaries. To do this, the percentage of top and bottom line resets for each syntactic boundary coinciding with the end of a phonic group (that is, a pause) has been computed. The inventory of syntactic labels considered here is the same used in the analysis of final local patterns presented in section 4.7.3.1 (see appendix 7, section 2, for a description of the analysed boundaries). A table included in appendix 7 (section 6.1) presents the results of this analysis.

An analysis of the data presented in that table shows no strong preferences for any specific syntactic boundary in the placement of an F0 reset. The percentage of resets found for the different boundaries compared to the total analysed boundaries is quite high in all cases.

However, some syntactic boundaries seem to show a slightly higher tendency to trigger resets than others. This is the case of the end of parenthetical elements (94.12% in the case of top line resets; 92% in the case of bottom line resets), or the beginning of non-restrictive elements (90% in the case of top line resets; 95.24% in the case of bottom line resets), which show the highest percentage of resets.

This data can be interpreted in the sense that there are no specific syntactic boundaries which favour the presence of a reset. When a pause is inserted, a reset is likely to occur, independently on the type of syntactic boundary associated to the pause. Resets can be considered as additional phonetic cues to detect the presence of intonation group boundaries, as advanced in section 6.5.1.

6.6.1.1.2. Amount of reset and syntactic boundaries

A second analysis was performed using this data to test whether the 'amount of reset' was related or not to the syntactic structure. Mean values for the 'amount of reset' were calculated for each syntactic boundary, taking into account exclusively those cases where a reset had been found. The results of this analysis are presented in a table included in appendix 7 (section 6.2).

The first conclusion that can be extracted from the observation of that table is that there is more variation in the amount of reset of top lines than of bottom lines, as already stated in section 6.5.1.

As far the relationship between amount of reset and syntactic boundary is concerned, there are no clear differences in the amount of reset at different types of syntactic boundaries. However, some boundaries show higher amounts of reset than others. The 'End of Parenthetical Element' boundary, for example, shows clearly higher resets in both speakers, on both top and bottom lines (for top lines, 31.56 Hz as mean in the case of speaker A.R., and 62.72 Hz in the case of speaker M.E.; for bottom lines, 35.54 Hz in the case of speaker A.R., and 36.6 Hz in the case of speaker M.E.). 'Asyndetic coordination' boundary also shows high reset values, although they are lower than in the previous cases (for top lines, 25.57 Hz as mean value in the case of speaker A.R., and 82 Hz in the case of speaker M.E.; for bottom lines, 21.55 Hz in the case of speaker A.R., and 30.5 Hz in the case of speaker M.E.).

According to these results, some special boundaries seem to favour higher amounts of reset than others. It is possible that these boundaries with a higher level of reset also present more cases of total resets. This possibility is explored in the following section.

6.6.1.1.3. Total reset and syntactic boundaries

An analysis similar to the one presented in section 6.6.1.1.1 has been carried out in this case. The number of times a total reset is found for each syntactic category has been computed, as well as the percentage relative to the total number of cases for each boundary. As in the rest of cases, the results have been included in a table that can be found in appendix 7 (section 6.3).

The results indicate that some types of syntactic boundaries seem to favour the presence of total resets. The 'End Parenthetical Element' category, for example, shows a top line total reset in 82.35% of the analysed cases, and a 84% of bottom line resets. In the case of the 'End of Non-Restrictive Element' category, 62.5% of the analysed cases showed a top line total reset, and 69.23% showed a bottom line reset. However, other boundaries show a poor percentage of total resets. This is the case, for example, of the 'Beginning of Noun Complement' category, which presents only a 28.57% of top line total reset, and a 11.11% of bottom line total resets.

These data seem to support the idea that the beginning of a new intonational clause, which was considered to be related to the presence of total resets (section 6.5.2), is favoured by the presence of specific syntactic boundaries.

The case of parenthetical elements is specially clear in the material handled in this work.

6.6.1.2. Prosodic structure and syntactic structure: the 'tension part'/'distension part' hypothesis revisited

As reviewed before (section 1.2.3.2), it has been suggested that the intonational structure of sentences in Spanish can be divided in two main parts, the 'tension' part and the 'distension' part. This hypothesis seems to agree with some of the results presented in this work (section 6.5.4): the sentences analysed in this study, even the most complex ones, tend to be organized in two main 'macro-units', each one with its own intonational pattern, although other structures have also been found.

It has also been suggested that the limit between these two parts tends to appear at specific syntactic boundaries. Canellada & Kuhlmann (1987) defined an inventory of syntactic boundaries where this limit is usually placed, which has been included in section 1.2.3.2. The analysis of the sub-corpus sentences organized in two 'macro-units' has revealed that the boundary tends to appear at those syntactic boundaries predicted by Canellada & Kuhlmann. One of the possible locations for this boundary, according to Canellada & Kuhlmann (1987), is the limit between a fronted element and the rest of the sentence. Several examples of this division have been found in the selected sub-corpus, as the one presented in figure 6.26.

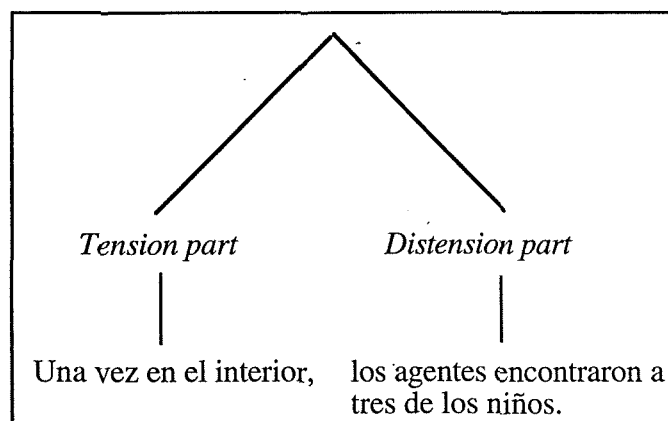


Figure 6.26. Prosodic tree corresponding to sentence 65 ('News' set), uttered by speaker M.E.

Examples of sentences showing the 'tension'/'distension' boundary between the subject and the predicate of the sentence have also been found. The prosodic tree presented in figure 6.27 illustrates this possibility.

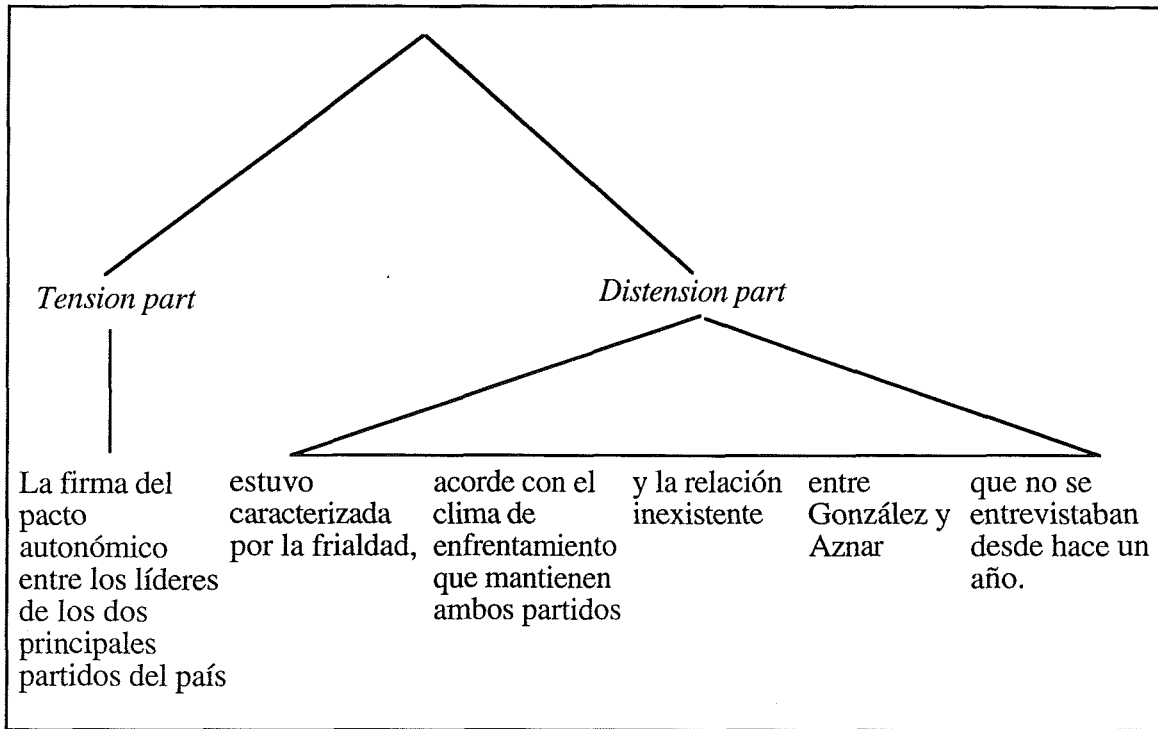


Figure 6.27. Simplified prosodic tree corresponding to sentence 24 ('News' set), uttered by speaker M.E.

A third case which has been recorded in the analysed sub-corpus is the one presented in figure 6.28. In this case, the boundary between the two parts has been placed in the syntactic boundary between two coordinate clauses:

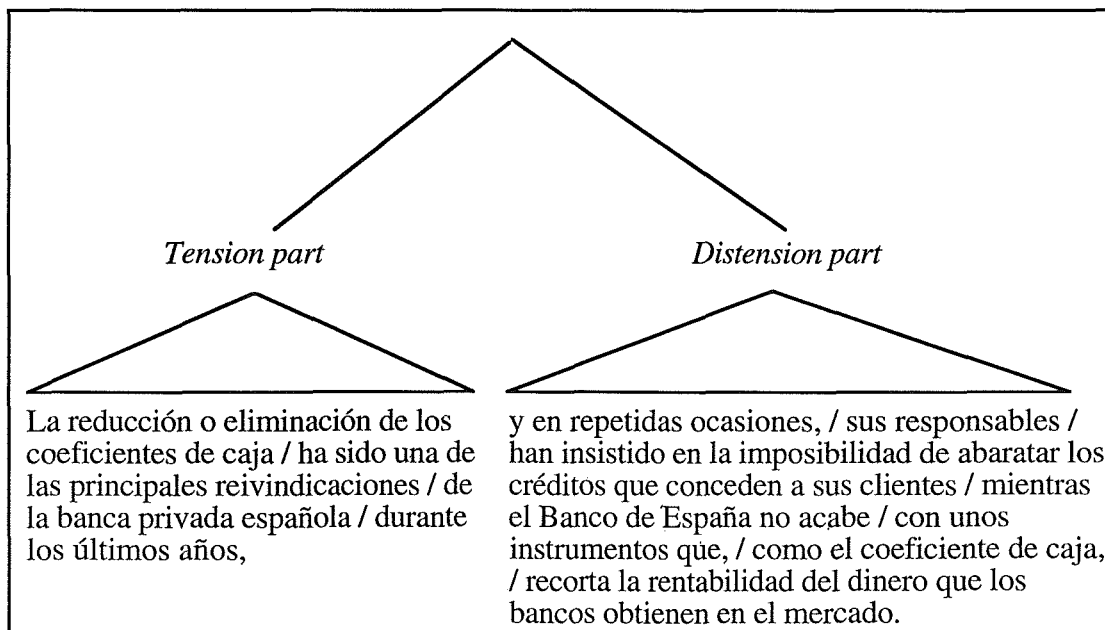


Figure 6.28. Simplified prosodic tree corresponding to sentence 104 ('News' set), uttered by speaker A.R.

The analysis of the sentence sub-corpus has also revealed that there are cases of boundary placement not predicted by Canellada & Kuhlmann's proposal. The example included in figure 6.29 presents a case in which the boundary between 'tension' and 'distension' part has been placed in the subject/predicate boundary of the subordinate clause.

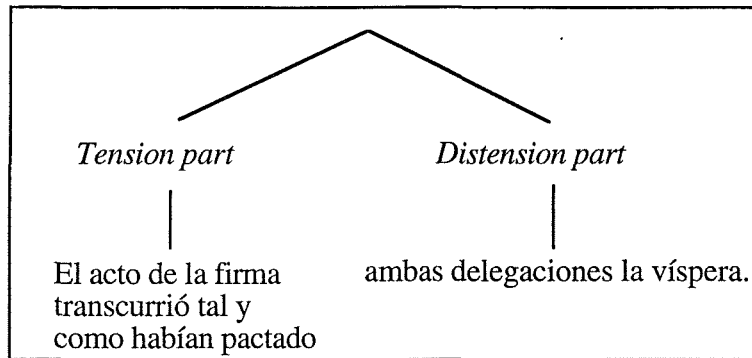


Figure 6.29. Prosodic tree corresponding to sentence 28 ('News' set), uttered by speaker M.E.

The hypothesized intonational structures corresponding to the prosodic trees presented in figures 6.26, 6.27, 6.28 and 6.29 can be found in appendix 7 (section 5).

The examples presented here seem to support the initial idea that, as predicted by Canellada & Kuhlmann (1987), the division of the sentences into 'tension' and 'distension' parts seems to be determined by syntactic factors. Some types of syntactic boundaries seem to be good candidates for the placement of this boundary. It has to be noted, however, that the intonational units forming these two parts of the sentence do not always coincide with syntactic units. The prosodic organization of the sentence presented in figure 6.29 illustrates this idea.

As reviewed in section 1.2.3.2, it has been traditionally considered that the main phonetic cue to indicate the 'tension'/'distension' boundary is the presence of a final rising movement at the end of the 'tension' part. However, the results presented in section 4.7.3.2 suggest that this rising movement is not a necessary cue at this boundary. According to the data presented here, it can be suggested now that the this limit is phonetically indicated by means of a 'total' reset, or at least a high amount of reset, signalling the boundary between the 'tension' and 'distension' intonational units.

6.6.2. The role of the new-given information distinction

Previous studies on Spanish intonation have hypothesized that the shape of the intonation contour of a sentence can be partially determined by

pragmatic factors. Canellada & Kuhlmann (1987), for example, suggested the idea that the division between 'tension' and 'distension' parts coincides with the boundary between the given and new information of a sentence. The data collected here seems to support this hypothesis.

It has been indicated before (section 6.5.4) that sentences in the analysed sub-corpus showed two frequent global patterns. The first possibility is that the two intonational clauses of the sentences appear grouped into a single higher-level pattern, as in the case of the figure 6.30. In these cases, the initial points of the lines or 'supra-lines' corresponding to the first part of the sentence is higher than the corresponding points at the beginning of the second part.

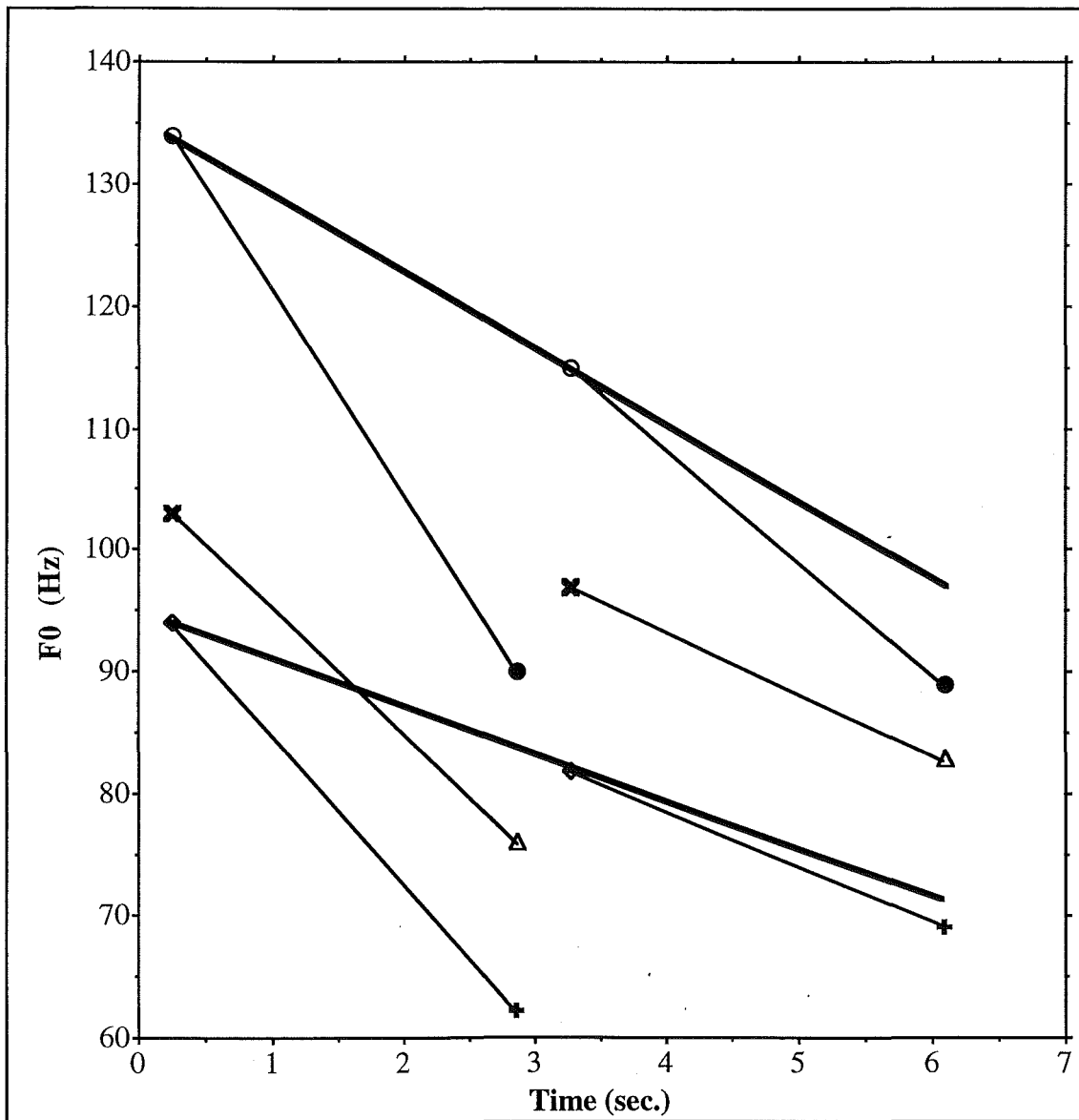


Figure 6.30. Top, mid and bottom lines of the phonic groups of sentence 10 ('News' set), uttered by speaker A.R.

It is also possible that the initial points of the lines or 'supra-lines' of the second part of the sentence show a higher initial level than the ones of the first part, as in the case presented in figure 6.31. In this case, the sentence does not show a single global pattern.

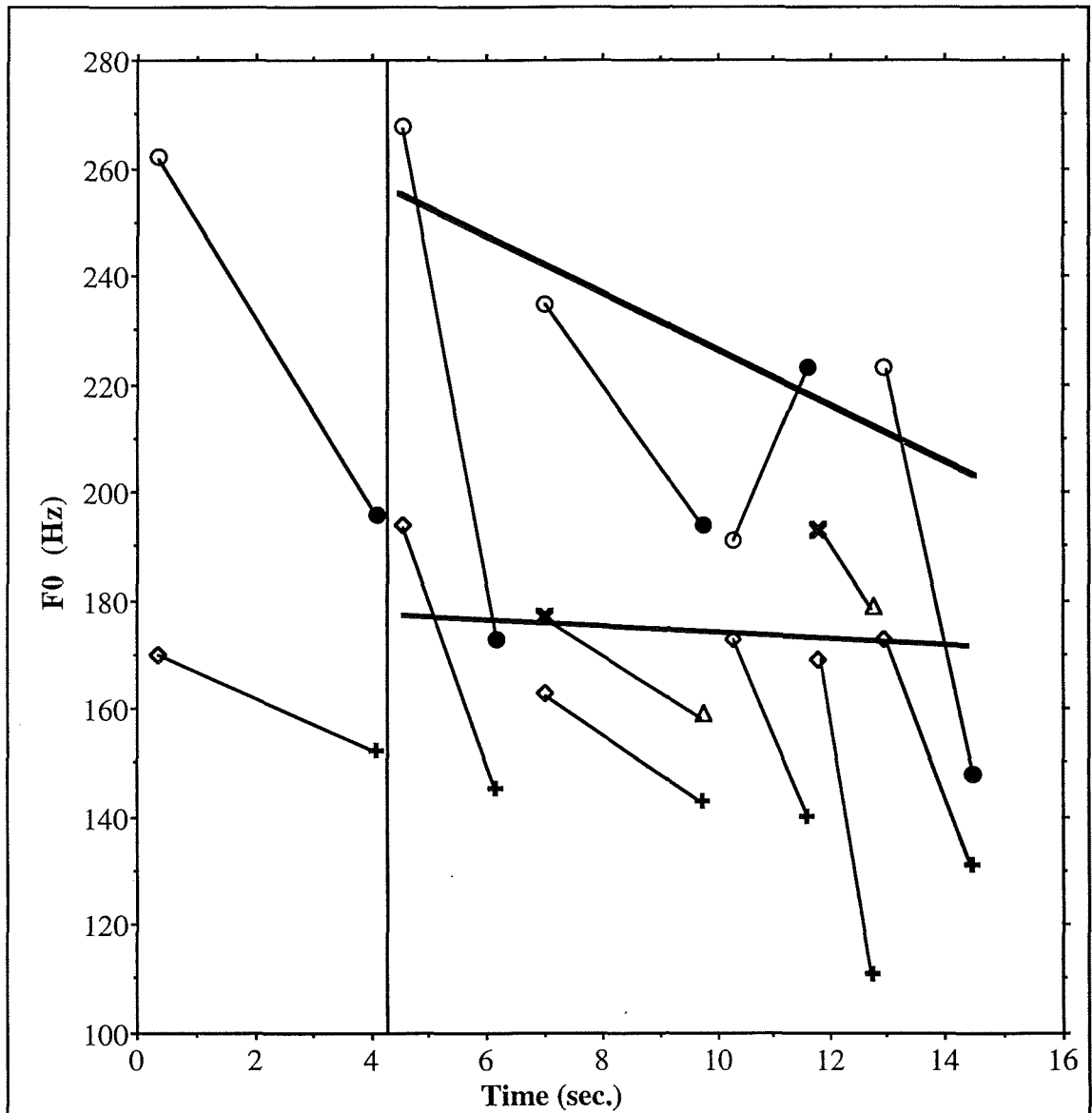


Figure 6.31. Top, mid and bottom lines of the phonic groups of sentence 24 ('News' set), uttered by speaker M.E.

One possible explanation for the choice of one or another scheme is related to the location of the beginning of the new information in the sentence. If the beginning of the new information is within the first intonational clause (the 'tension part') the highest F0 level is in this clause, and, accordingly, the second clause shows a lower level, as in the case of the figure 6.30. Figure 6.32 offers the prosodic tree corresponding to the sentence presented in figure 6.30.

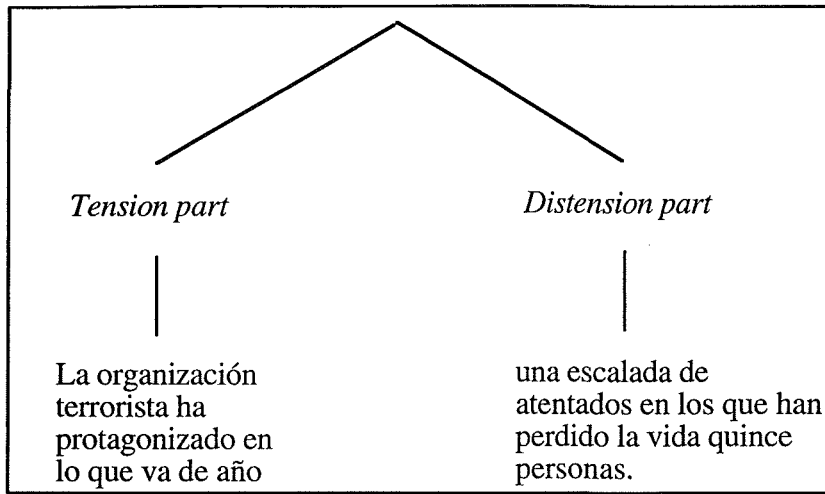


Figure 6.32. Prosodic tree corresponding to sentence 10 ('News' set), uttered by speaker A.R.

However, if the beginning of the new information coincides with the 'distension part', this one shows a highest initial level than the 'tension part', as in the case presented in figure 6.31. Figure 6.33 offers the prosodic tree corresponding to the sentence of figure 6.31.

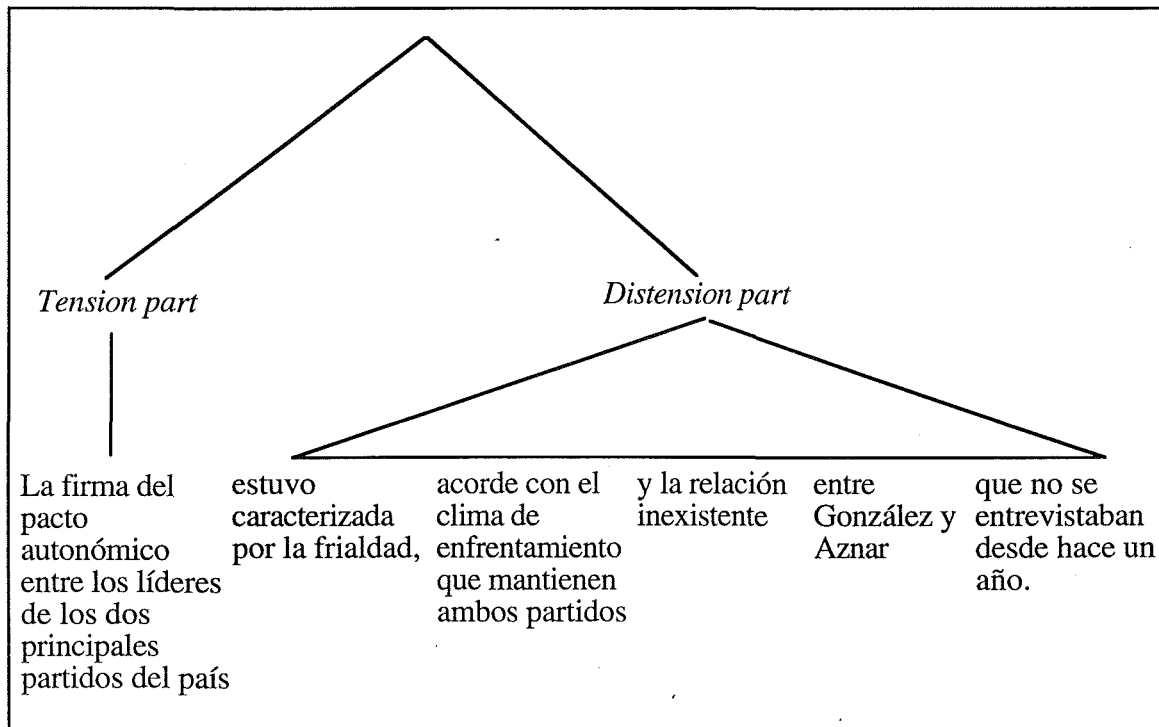


Figure 6.33. Simplified prosodic tree corresponding to sentence 24 ('News' set), uttered by speaker M.E.

According to these examples, it seems possible that the relative height of the intonational clauses within a sentence is at least partially determined by pragmatic factors. The point of highest F₀ level in the sentence tends to

coincide with the beginning of the new information. However, this hypothesis has not been checked in detail in this work.

6.6.3. Summary

In the previous sections, some of the factors that can determine the intonational structure of sentences have been briefly considered. Factors such as the length of the clauses have not been considered, but it is very likely that they are also involved in the process.

The data presented in section 6.6.1 suggests that the syntactic structure of a sentence plays an important role in the organization of its intonational structure. The boundaries between the different intonational clauses forming a sentence seem to coincide with specific syntactic boundaries. In this way, the predictions made by Canellada & Kuhlmann (1987) within the 'tension part' - 'distension part' framework seem to be quite adequate when applied to the material handled in this study.

The results also seem to indicate that the units forming the different-level intonational clauses of a sentence do not have to coincide with specific syntactic constituents. They show then the same tendency already reported for phonic groups, both for Spanish and other languages.

In section 6.6.2, the influence of pragmatic factors in the organization of the intonational structure has been briefly considered, confirming earlier suggestions made in previous work on Spanish intonation. The observation of the data obtained in this study seem to support this idea, but, as in the case of the syntactic factors, this issue has not been analysed in detail.

6.7. General summary

In this chapter, the analysis of intonation contours of a sub-corpus of sentences has been carried out. Three goals were established at the beginning of this chapter:

- a) the definition of a descriptive framework for the description of sentence intonation contours;
- b) the search of intonation units and patterns at the sentence level;
- c) the analysis of the variation of the defined patterns according to several factors.

A descriptive framework based on the 'topline-bottomline' approach, accepted already for phonic groups, has been proposed to model the 'supra-declination' phenomena detected in the intonation contours of the sentence

sub-corpus. A grid of six different 'supra-lines' has been suggested, three for the definition of the initial values of each line of the different phonic groups (high 'supra-lines'), and three for the control of the final values of the lines (low 'supra-lines'). Figure 6.34 shows an example of this structure.

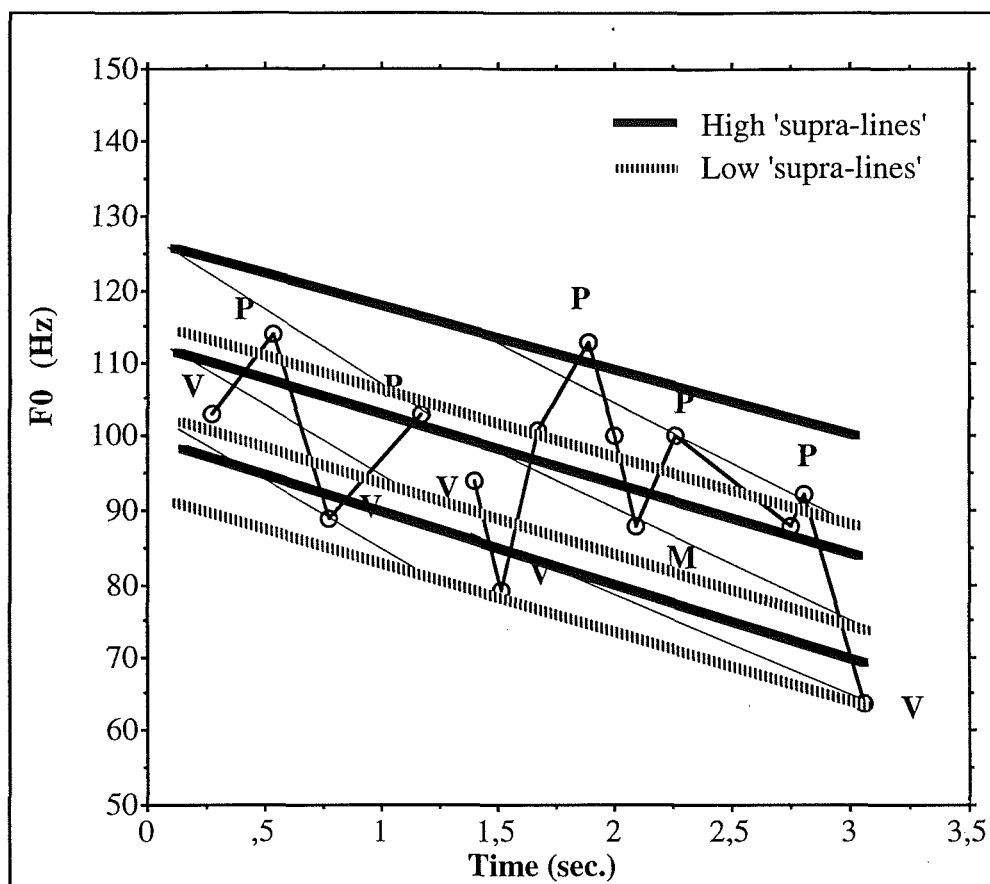


Figure 6.34. Top, mid and bottom lines and 'supra-lines' for the stylized contour of sentence 65 ('News' set), uttered by speaker A.R.

The concept of 'intonational clause' has been introduced to define the domain at which some 'supra-declination' phenomena seem to operate within sentences. The intonational structure of sentences seems to be made of one or several layers of intonational clauses, depending on the complexity of the sentence. According to the hypothesis suggested here, each of these intonational clauses is the domain of a 'supra-declination' pattern, that can be represented by their own top, mid and bottom 'supra-lines'. The existence of intonation units of scope larger than the intonation group but narrower than the sentence had already been suggested in previous works, as Ladd (1986) and Nespor & Vogel (1986). The data presented here can be interpreted as an additional evidence supporting this idea.

According to the data collected here, the definition of a single intonation pattern covering the whole sentence seems more controversial. Some of the

sentences show such a global pattern, while others seem to be formed by several ungrouped lower-level units. Sentences seem to be usually divided in two main intonational clauses, that can be identified with the 'tension' and the 'distension' parts proposed in Navarro (1994), but they can also show a different number of parts.

The notion of 'prosodic tree' has been introduced to represent the underlying phonological structure which seems to determine this hierarchical realization of the intonation contours at a phonetic level. The use of trees to represent the phonological structure of utterances has already been proposed in earlier works, as Nespor & Vogel (1986). The data of this work seems an additional evidence supporting the validity of these representations.

Finally, the issue of the different factors involved in the organization of the sentences into a hierarchical structure of intonational clauses has been briefly addressed. The observation of the data obtained in this study seem to indicate that some syntactic and pragmatic factors can determine this structuring. However, a detailed analysis of this question has been postponed for future research.

Chapter 7

SPANISH INTONATION CONTOURS AT THE PARAGRAPH LEVEL

The last level of analysis considered for this work is the paragraph. The paragraph, as in the case of the sentence, has been defined using orthographic criteria. As indicated in section 1.4.2.2, it has been considered here as 'paragraph' any portion of text, including one or more sentences, organized in such a way that its first sentence starts a new line of the text, and the end of the last sentence also determines the end of a line.

The following goals have been established for this last chapter:

- a) the application of the 'topline-bottomline' framework to the modelling of paragraph intonation, and the use of the 'intonational clause' approach to describe the structuring of paragraph contours;
- b) the analysis of the sentence and paragraph as intonation units;
- c) the study of the variation of paragraph intonation as a function of phonetic factors such as length.

Following the same procedure as in previous chapters, a descriptive framework has been selected first. The same 'topline-bottomline' framework defined in the previous chapter for sentences has been used to the description of the intonation contours of the paragraphs. Using this framework, paragraphs have been represented as sets of hierarchically-structured 'intonational clauses'.

The problem of the definition of the status of the sentence as an intonation unit is considered again in this chapter. The results presented in chapters 5 and 6 do not provide a definite answer to this question. For this reason, the

analysis of paragraphs has been used to obtain additional evidence about the behavior of the sentence as an intonational unit in the selected material.

This chapter also deals with the definition of intonational phenomena having the paragraph as a natural domain. The 'supra-declination' effects reported at lower-level domain in the previous chapters are also investigated at the paragraph level. The results presented in Garrido *et al.* (1993) for Spanish showed that this effect is present in controlled paragraphs. However, the results described in Garrido (1993) revealed that when 'less controlled' paragraphs (in the sense defined in section 2.1.1) are considered, the tendency to find global patterns becomes less general. Additional data about this issue is provided in this chapter.

Finally, the problem of whether the length of the paragraphs can affect the shape of intonational patterns is debated. The results obtained here are compared with those presented in previous studies, which showed a tendency to keep constant the values of the initial and final points of the paragraphs independently of their length.

Section 7.1 deals with the process of definition of the paragraph sub-corpus. Section 7.2 describes the analysis procedure applied to the paragraph contours. In section 7.3 the framework used for the modelling of the paragraphs is discussed. Section 7.4 considers again the question of the validity of the sentence as an intonational unit. Section 7.5 analyses paragraphs as the potential domain of intonational phenomena. Finally, section 7.6 analyses the variation of paragraph intonation depending of the length of the paragraphs.

7.1. Definition of the paragraphs sub-corpus

The procedure of definition and selection of the sub-corpus has been similar to the one used for the rest of the analysed levels. As in previous chapters, first the considered variables are reviewed, and second the selection procedure is described.

7.1.1. Variables

In this case, only two variables have been considered for the definition of the sub-corpus:

- a) **Length of the paragraph**, in number of syllables.

As indicated before, previous studies on paragraph intonation and declination (Thorsen, 1985, 1986 among others) have analysed the effect

of paragraph length on the shape of intonation contours. The variable 'length' has been included to analyse this effect on the sub-corpus.

b) **Number of sentences** of the paragraph.

The number of sentences of the paragraph is another factor that can theoretically determine the shape of its contour. This variable has also been considered in Thorsen's (1985, 1986) studies.

The length of the sentences within each paragraph has not been included as a controlling factor.

7.1.2. Selection and organization of the material

The values allowed for each variable were established in the same way as in previous chapters.

1) 'Length of the paragraph'

The length of all the paragraphs of the collected material was analysed first in order to establish the range of lengths to be analysed. Paragraphs containing from 8 to 538 syllables were found in this analysis. However, this range was considered too large to the scope of this work. For this reason, the maximum length considered here has been only 220 syllables. 4 different categories were established, including each one an equal range of duration in syllables:

1. 'Sil. 1': paragraphs between 8 and 61 syllables.
2. 'Sil. 2': paragraphs between 62 and 114 syllables.
3. 'Sil. 3': paragraphs between 115 and 167 syllables.
4. 'Sil. 4': paragraphs between 168 and 220 syllables.

2) 'Number of sentences'

A similar study was performed in order to establish the number of sentences contained in the paragraphs of the collected material. It was found that this number ranged from 1 to 11 sentences. However, this range was too large to be analyzed in this work. For this reason, the maximum number of sentences for a paragraph to be considered in this analysis has been limited to 3. Accordingly, three different categories were established for this variable:

1. 'Cat. 1': paragraphs containing 1 sentence.
2. 'Cat. 2': paragraphs containing 2 sentences.
3. 'Cat. 3': paragraphs containing 3 sentences

As in the previous analyses, the combination of these variables defined the 'feature grid' of the paragraphs to be found in the material. Only one case per combination of variables has been analysed, when available. The realizations of the two speakers have been considered for each paragraph. The total amount of paragraphs studied has been then 14 (7 x 2 speakers) in the case of the 'News' set, and 14 (7 x 2 speakers) in the case of the 'Commentaries' set, that is, 28 paragraphs in global.

The complete inventory of analysed paragraphs can be found in appendix 8, as well as two tables summarizing the contents of the sub-corpus.

7.2. Corpus analysis

The same analysis procedure used for sentences was applied to the selected paragraphs. After segmenting paragraphs into phonic groups (the results of this task are included in appendix 9, section 1), the stylized contour of each phonic group was post-processed and labelled as described in chapter 4. These annotated versions were used to calculate top, mid and bottom lines for each phonic group, using the same regression method as in the phonic group and sentence analyses (see section 5.2.2 for a more detailed description of this method). The lines obtained for every paragraph of the collected sub-corpus have been plotted for further analysis. The resulting figures have been included in appendix 9 (section 3). Figure 7.1 presents an example these representations. To facilitate the interpretation of the figure, the stylized contour has also been included. However, it does not appear in the figures of appendix 9.

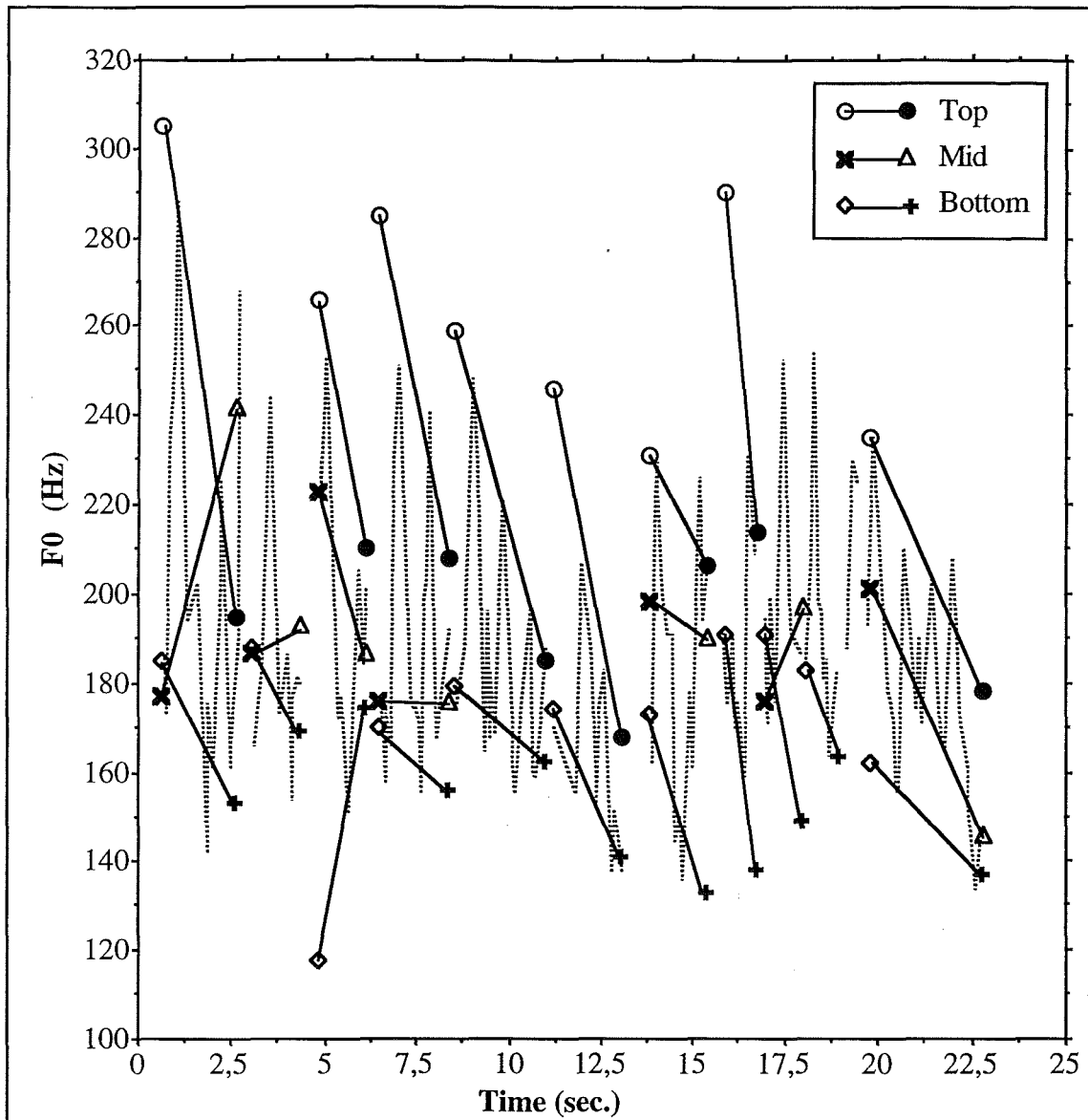


Figure 7.1. Obtained representation for the intonation structure of paragraph 18 ('Commentaries' set), uttered by speaker M.E. The dotted line indicates the evolution of the stylized contour. Solid lines indicate the calculated top, mid and bottom lines.

7.3. Definition of the framework

The same 'topline-bottomline' approach used for sentence modelling has been used here for paragraphs. According to this framework, the shape of the global intonation patterns can be modelled using six different 'supra-lines', three defining the evolution of the F0 values of the initial points in top, mid and bottom lines, or high 'supra-lines', and three defining the values for the final points of the lines, or low 'supra-lines' (see section 6.3.2 for details).

7.3.1. Approaching the shape of paragraph 'supra-lines'

A first attempt to define the shape of these 'supra-lines' has been carried out by calculating regression lines for all the values of the initial and final points in the phonic groups for each speaker. The results are presented in the following sections.

7.3.1.1. High 'supra-lines'

Regression lines for the initial points corresponding to the top, mid and bottom lines of all the phonic groups of the analysed paragraphs have been calculated separately for each speaker. The results of this analysis, including the data about the initial points, slope and R values of the obtained 'supra-lines', are presented in appendix 9 (section 2.1). Figure 7.2 presents the obtained lines in the case of speaker A.R.

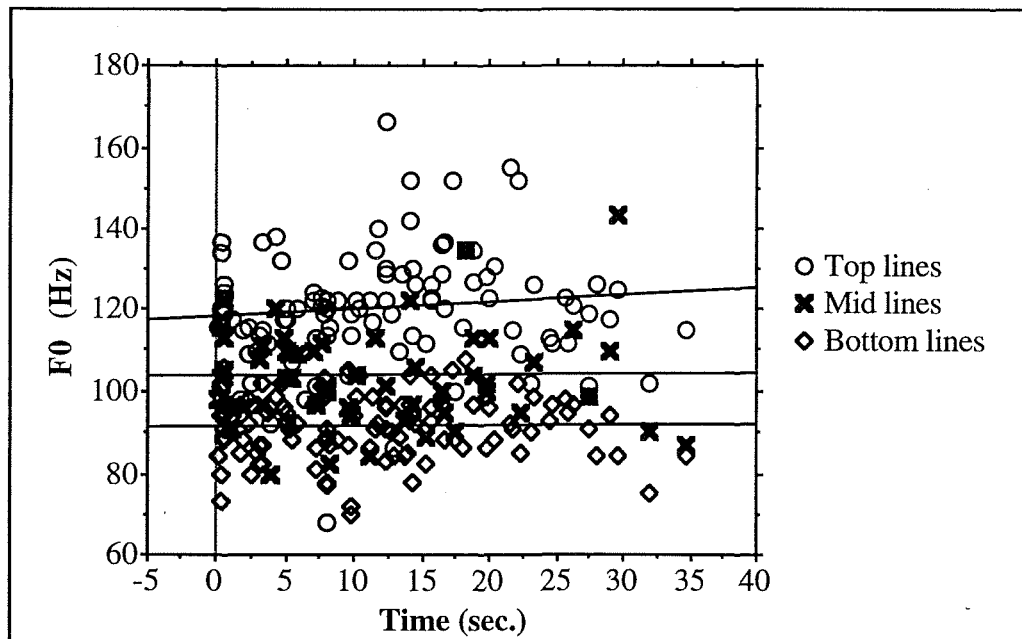


Figure 7.2. Regression lines for the initial points at top, mid and bottom lines of the phonic groups of speaker A.R.

A slightly rising tendency is observed in the three lines, specially in the case of the top lines. The obtained p value is under the significance threshold ($p=0.05$) in the three cases.

Figure 7.3 presents the obtained lines in the case of speaker M.E.

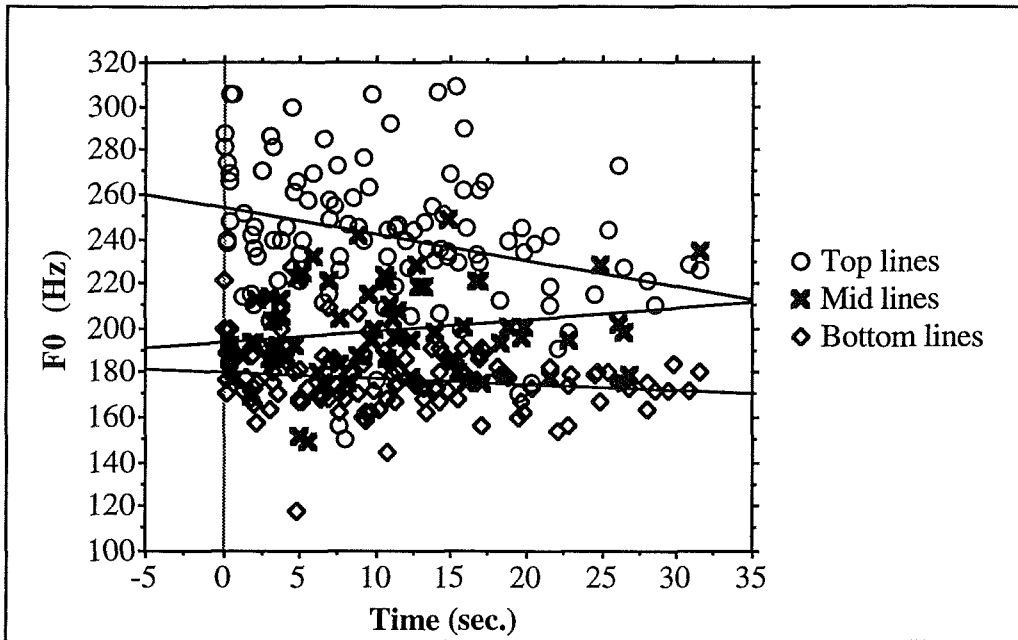


Figure 7.3. Regression lines for the initial points at top, mid and bottom lines of the phonic groups of speaker M.E.

In this case, the tendency is more similar to the results reported for sentences: falling for top and bottom lines, and rising for mid lines (see section 6.4.2 for comparison). The obtained p values are under 0.05 in the case of mid and bottom lines, and below this threshold ($p=0.025$) in the case of the topline.

7.3.1.2. Low 'supra-lines'

As in the case of the initial points, regression lines have been calculated separately for each speaker for the final points corresponding to the top, mid and bottom lines of all the phonic groups. Data about the initial points, slope and R values of these 'supra-lines' are presented in appendix 9 (section 2.2). Figure 7.4 presents the obtained lines for speaker A.R.

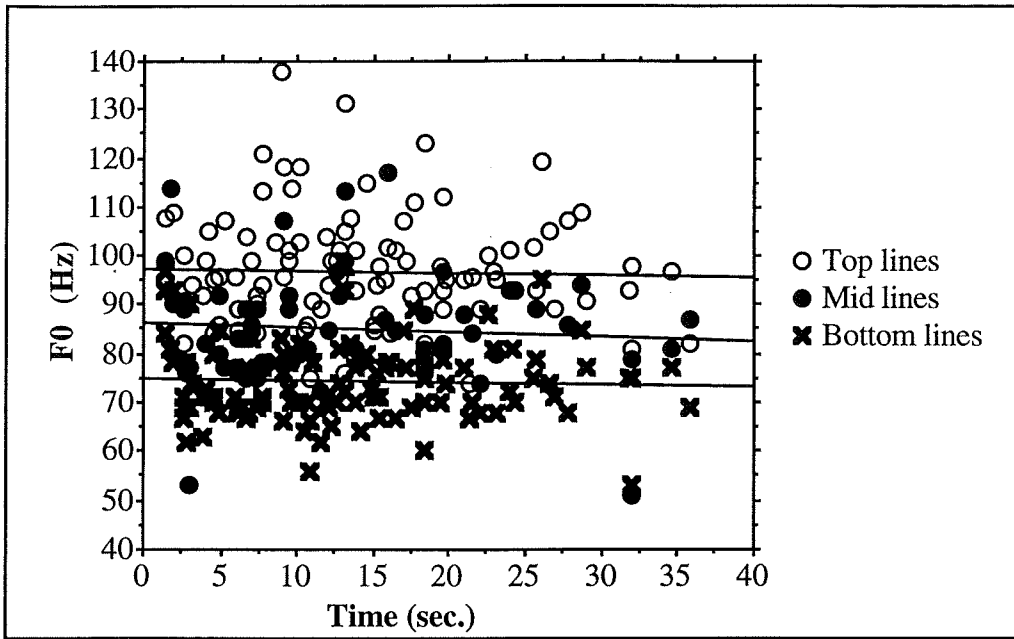


Figure 7.4. Regression lines for the final points at top, mid and bottom lines of the phonic groups of speaker A.R.

In this case, the three lines are falling, and almost parallel. As in the case of the high 'supra-lines' for this speaker, the obtained p value is under the significance threshold ($p=0.05$) in the three cases.

Figure 7.5 presents the obtained lines for the final points in speaker M.E.

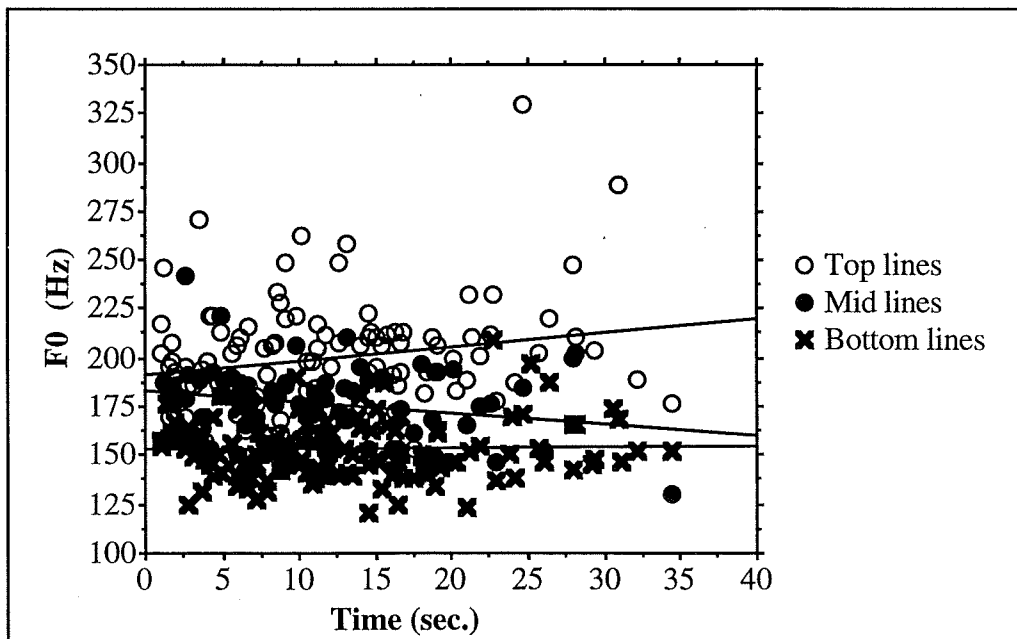


Figure 7.5. Regression lines for the final points at top, mid and bottom lines of the phonic groups of speaker M.E.

It can be observed that the lines corresponding to the top and bottom final points are rising, while the one corresponding to the mid final points is falling. The obtained p values are under 0.05 in the case of mid and bottom lines, and below this threshold ($p=0.04$) in the case of the topline, as was also observed for the high 'supra-lines' of this speaker.

7.3.1.3. Summary

The analysis of the shape of the obtained lines favour the idea that global patterns similar to the ones defined for phonic groups and sentences can be defined at the paragraph level. However, the results indicate that a linear regression model does not explain the considered data at a significant level. This can be related, as in the case of sentences, to specific characteristics of the intonational structure of the analysed paragraphs. For this reason, the problem of the definition of a global pattern for paragraphs is considered again in section 7.5.

7.3.2. Applying the 'intonational clause' approach to paragraphs

Using this framework, the segmentation of paragraphs into 'intonational clauses' has been attempted, following the same criteria than in the case of sentences. Figure 7.6 shows an example of the resulting representations, with the corresponding 'supra-lines' superimposed.

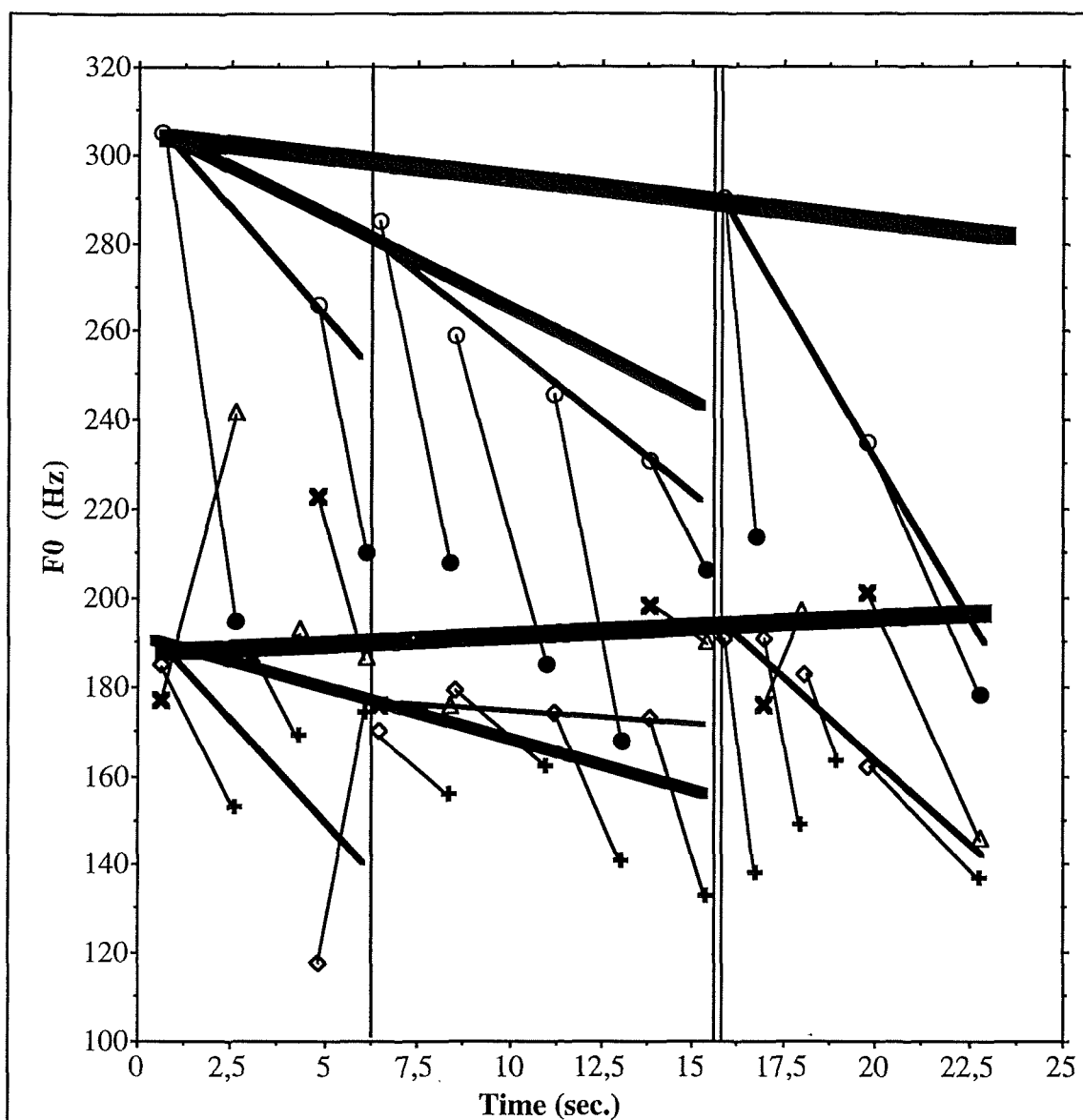


Figure 7.6. Top, mid and bottom lines and 'supra-lines' for paragraph 18 ('Commentaries' set), uttered by speaker M.E.

As in the case of sentences, the 'supra-lines' have been added by hand to the representations. Only high 'supra-lines' have been included here, in order to simplify the representations. The results of this analysis have been included in appendix 9 (section 3).

7.4. The status of the sentence as a global intonation unit: phonetic realization of sentence boundaries

The results obtained in chapters 5 and 6 are not conclusive about the recognition of intonation patterns for sentences. The data obtained in chapter 5 showed a general tendency of the F0 in the phonic groups to fall from the beginning to the end of sentences, which could be related to the

existence of a general global pattern covering the whole sentence. However, the analysis presented in chapter 6 indicated that the intonational patterns appearing at sentences can be more complex than a single falling pattern: they are usually divided in two main parts, which can (or can not) be grouped into a single intonation unit. These results lead to question the existence of obligatory global intonational patterns having the sentence as natural domain.

If the existence of a global 'supra-lines' pattern covering the whole sentence is not a necessary cue to detect its beginning and end, then other cues can contribute, apart from the final local movements, to indicate these boundaries. In this section, the use of reset as one of these additional cues which may be related to sentence boundary marking is analysed.

7.4.1. Total reset and sentence boundaries

As suggested in section 6.5.2, resets can be considered as a phonetic cue to indicate the beginning of a new intonation unit. According to the 'intonational clause' hypothesis, partial reset indicates the presence of an intonation (phonic) group boundary, while total reset indicates the beginning of a new intonation clause, or of a 'macro-unit' grouping several intonational clauses. If sentences actually are high-level intonation units, it should be expected then to find total resets at sentence boundaries. An analysis of the resets at sentence boundaries in the selected paragraphs has been carried out in order to check this hypothesis.

The number of sentence boundaries showing top and bottom line total resets was computed. Table 7.1. summarizes the results.

	Number of analysed cases	Number of cases showing total reset	Percentage of cases showing total reset
Topline	18	11	61.11%
Bottomline	22	16	72.73%

Table 7.1. Percentage of total resets at sentence boundaries in the analysed paragraphs sub-corpus

It can be observed that 61.11% of the sentence boundaries showed a total reset in the topline, and 72.73% in the bottom line. If these percentages are compared with the ones presented in the previous chapter for lower-level syntactic boundaries (see section 6.5.1.1.3 and the table of appendix 7, section 6.3, for comparison), it can be observed that they are in general higher than the ones obtained for the rest of analysed boundaries, with the exception of the 'End of Parenthetical Element' boundary, which shows higher percentages (82.35% for the top line and 84% for the bottom line).

These results seem to indicate that there is a strong tendency to find total resets at sentence boundaries, more frequently than at lower-level syntactic boundaries, but that its presence is not obligatory at all.

The observation of the material resulting from the 'intonational clause' analysis of the paragraphs (included in appendix 9, section 3) offers supplementary evidences for this hypothesis. The examples selected from this material and presented below show how the presence of total reset does not seem to be completely necessary for sentence boundary marking.

The first selected case represents an example of a clear marking of sentence boundaries by means of a total reset. Figure 7.7 presents the calculated top, mid and bottom lines corresponding to the paragraph 24 of the 'Commentaries' set, which includes three different sentences.

De la tormenta monetaria de hace un mes, que condujo a la salida de la libra y la lira del SME, a la devaluación de la peseta y al realineamiento del resto de divisas, ni una sola palabra. Sospechosamente, ni una mínima referencia. Como si no hubiera relación causa-efecto.

It can be observed in the figure how each sentence boundary coincides with top and bottom line total resets, indicated with vertical lines. In addition, 'supra-lines' covering the phonic groups of each sentence can be drawn in the three cases. This seems to indicate that each sentence of the paragraph constitutes a separate 'intonational clause'.

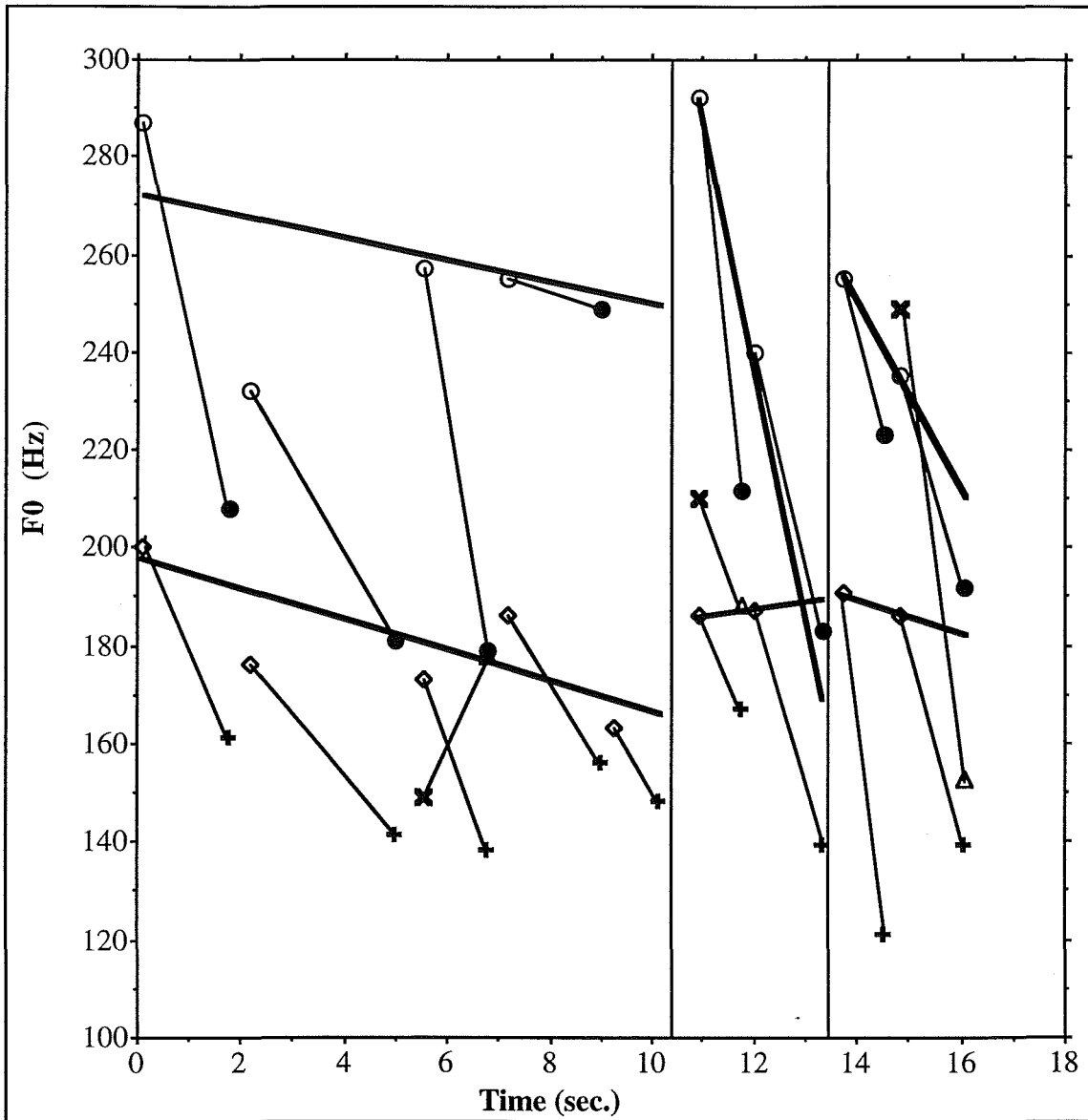


Figure 7.7. Top, mid and bottom lines of paragraph 24 ('Commentaries' set), uttered by speaker M.E. Vertical lines indicate the hypothesized 'intonational clause' boundaries.

In other cases, however, sentence boundaries are not so clearly marked. The example included in figure 7.8 shows a case in which the boundary is only marked with a top line reset (second vertical line). In this case, the figure represents the global lines corresponding to the paragraph 4 of the 'News' set, which contains two sentences:

La instrucción interna del secretario de Estado para la Seguridad fue transmitida a las Fuerzas de Seguridad del Estado el veintiuno de febrero, después del atentado que ETA realizó el pasado diecinueve de febrero en Santander. En el mismo murieron tres transeúntes e hirió a otra veintena, entre los que se encontraban varios agentes que viajaban en un furgón policial.

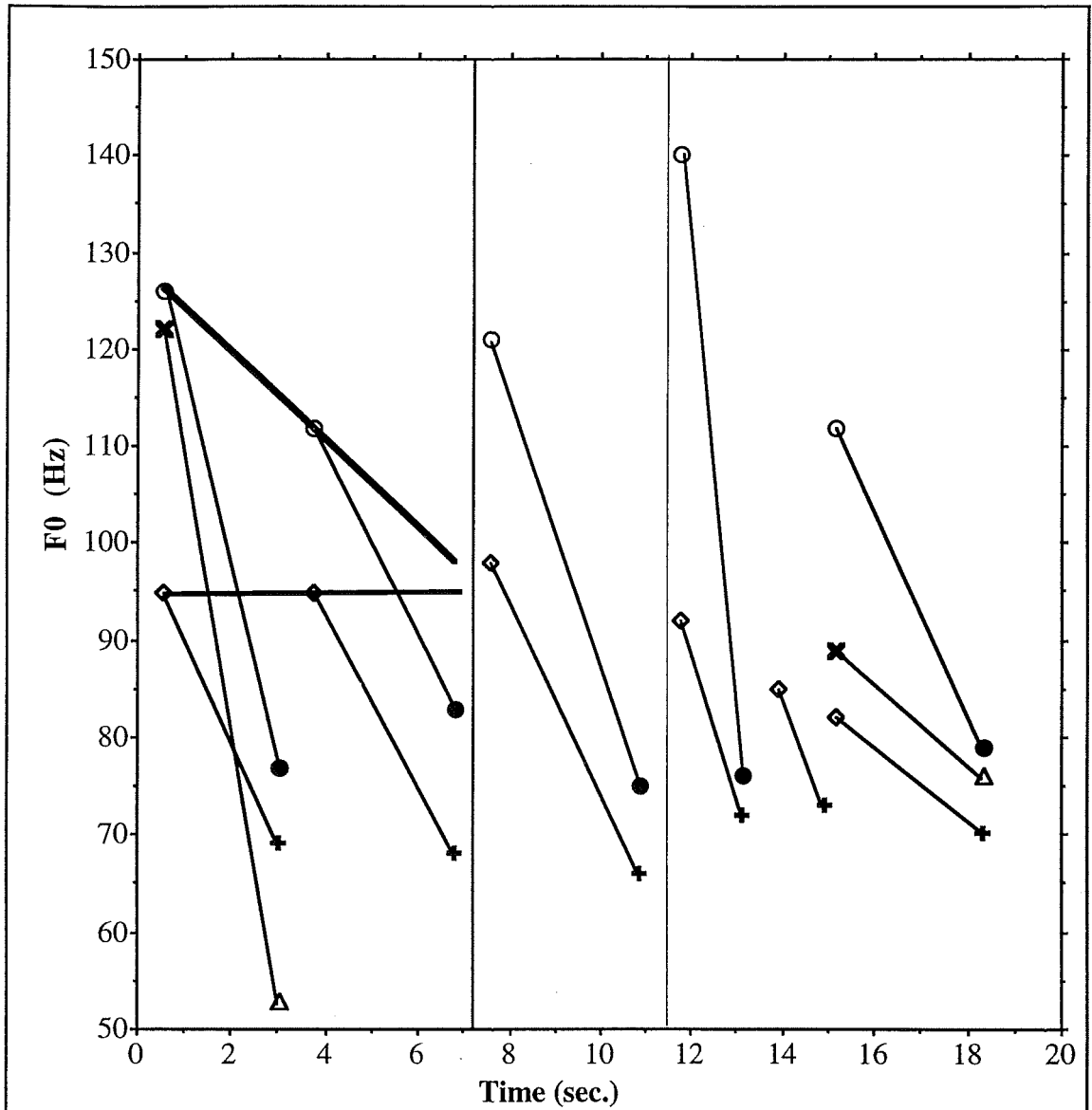


Figure 7.8. Top, mid and bottom lines of paragraph 4 ('News' set), uttered by speaker A.R. Vertical lines indicate sentence boundaries.

As can be observed, it seems that in this case a higher initial range has been used to indicate the beginning of the second sentence, instead of a clear total reset.

The third case illustrates the possibility of marking sentence boundaries only with a bottom line reset. In the example presented in figure 7.9, the sentence boundary, indicated by the vertical line, is only marked with a bottom line reset. It corresponds to the paragraph 8 of the 'News' set, which includes two sentences.

La organización terrorista ha protagonizado en lo que va de año una escalada de atentados en los que han perdido la vida quince personas. Por ello, Vera señala que por parte de los agentes "no cabe tolerar apatía alguna o dejaciones nunca permisibles del deber contraído frente a la sociedad".

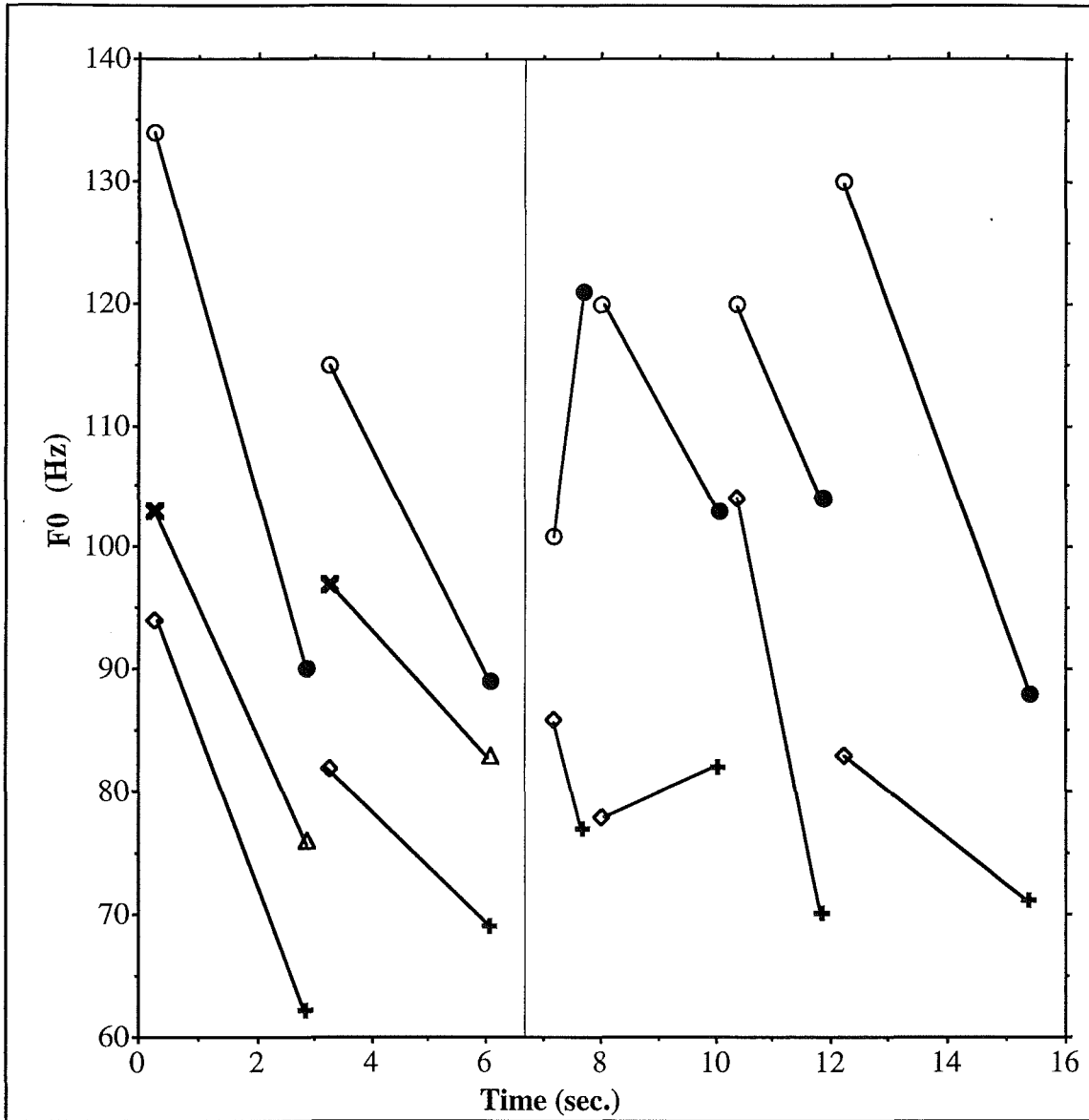


Figure 7.9. Top, mid and bottom lines of paragraph 8 ('News' set), uttered by speaker A.R. The vertical line indicates the sentence boundary.

Finally, there are cases in which sentence boundaries do not coincide with any total reset at all. Figure 7.10, which corresponds to the paragraph 24 of the 'Commentaries' set uttered by speaker A.R., illustrates this possibility.

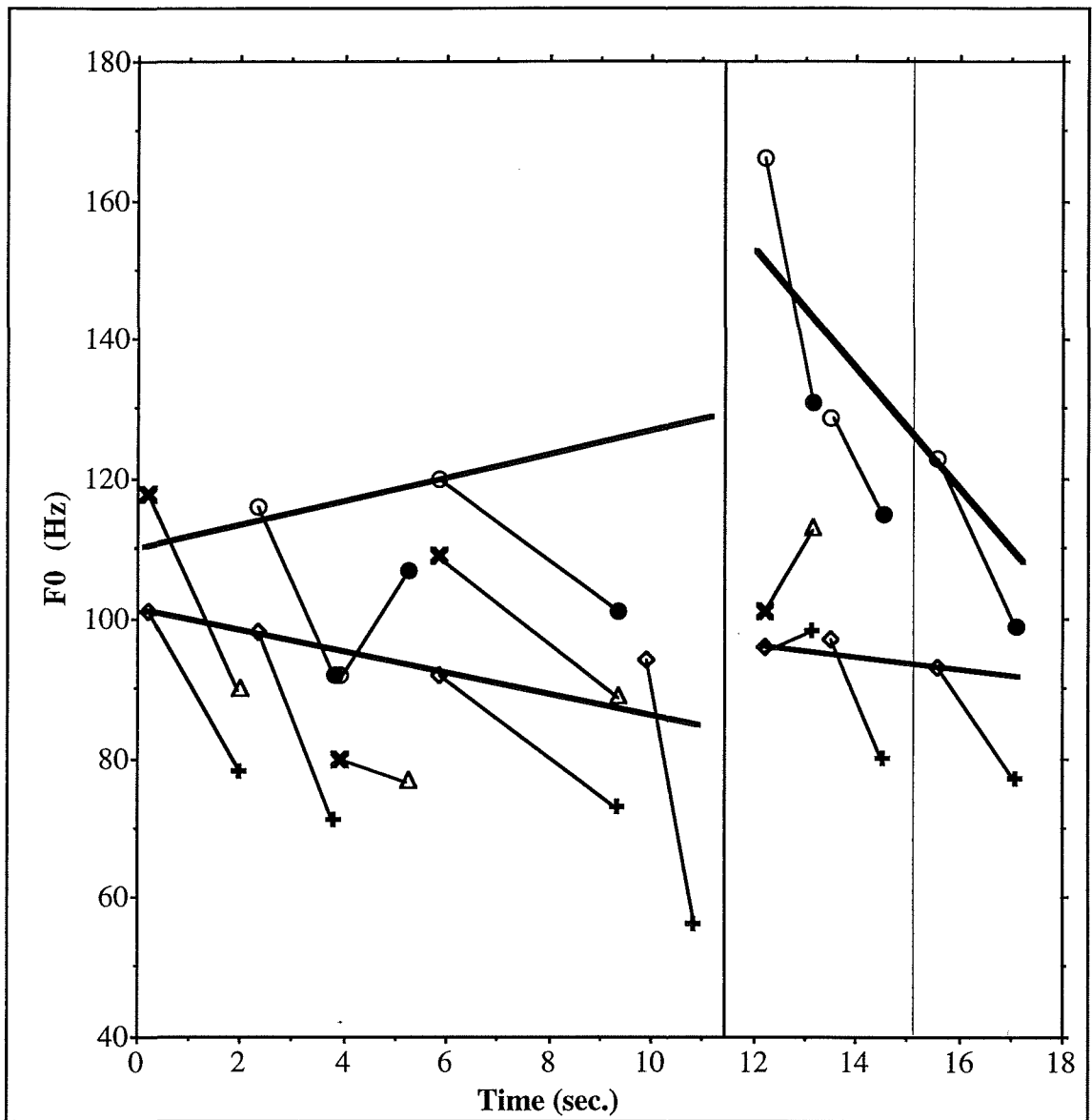


Figure 7.10. Top, mid and bottom lines of paragraph 24 ('Commentaries' set), uttered by speaker A.R. Vertical lines indicate sentence boundaries.

In this case, the second vertical line indicates the boundary between the second and the third sentence of the paragraph. No total reset, neither in the topline nor in the bottomline, can be observed at this boundary. The last two sentences should be then theoretically included in the same 'intonational clause'.

7.4.2. Amount of reset and sentence boundaries

A second possibility considered in this analysis is that sentence boundaries can be indicated with 'larger' resets than in the case of lower-level syntactic boundaries. In other words, the amount of reset would be higher in the case of sentence boundaries than in other minor syntactic boundaries. This idea

has already been suggested for French by Nicolas (1995). To check this hypothesis, the amount of reset for each sentence boundary in the paragraphs sub-corpus has been calculated.

The mean values obtained for the amount of reset at this boundary are presented in table 7.1. To calculate these values, only the cases at which reset is present have been taken into account.

Speaker	Amount of reset (Hz)	
	Topline	Bottomline
A.R.	34.6 (10 cases)	24.5 (12 cases)
M.E.	75.88 (8 cases)	44.6 (10 cases)

Table 7.2. Mean values (in Hz) for the amount of top and bottom line reset at sentence boundary for speakers A.R. and M.E.

If these results are compared with the ones obtained for lower-level boundaries (section 6.5.1.1.2. and appendix 7, section 6.2), it can be observed that sentences show a higher level of reset than any other type of boundary. Again, the 'End of Parenthetical Element' boundary is the one showing similar, although slightly lower, levels of reset (31.56 Hz for the topline, and 35.54 Hz for the bottomline, in the case of speaker A.R.; 62.71 Hz for the topline, and 36.6 Hz for the bottomline, in the case of speaker M.E.).

These results favour the idea that amount of reset can be an additional cue to indicate sentence boundary, specially when no total reset is produced.

7.4.3. Summary

The results presented here and in the previous chapters about the status of the sentence as an intonational unit lead to the following conclusions:

- a) the sentence does not seem to be an obligatory domain for the placement of a single 'supra-line' pattern; it can coincide with an 'intonational clause', or a 'macro-unit' containing several 'intonational clauses', but not necessarily.
- b) there are in general recognizable phonetic cues related to the global structure of intonation which indicate a sentence boundary, such as a total reset (only in the topline, only in the bottomline, or in both lines at the same time), a large amount of reset, or even a large initial range.

c) accordingly, the sentence seems to play an important role in the intonational structuring of paragraphs, at least for the placement of intonational breaks.

7.5. 'Supra-declination' patterns at the paragraph level

The existence of intonation units involving whole paragraphs has been hypothesized already in previous studies. Since Lehiste's (1975) paper, some studies have reported the presence of some kind of 'supra-declination' pattern through the different resets of a paragraph for languages as Swedish (Bruce, 1982b), Danish, (Thorsen, 1985), English (Ladd, 1988), Dutch (Sluijter & Terken, 1992, 1993), or French (Nicolas, 1995), among others. For Spanish, this tendency has also been shown in Garrido *et al.* (1993).

However, the data presented in Garrido (1993) indicated that this global pattern is not so recognizable when the analysis of less controlled material is attempted. The results presented in section 7.3 also seem to confirm this idea.

In the following sections, these hypotheses are tested in the selected paragraphs sub-corpus.

7.5.1. A global pattern for paragraphs

An analysis of the initial and final values of the sentences contained in the paragraphs of the sub-corpus has been carried out, in order to check the presence of global 'supra-declination' patterns covering paragraphs. Following the methodology presented in Sluijter & Terken (1992, 1993), the F0 values corresponding to the initial and final top and bottom lines of the different sentences of each paragraph have been considered, as illustrated in figure 7.11.

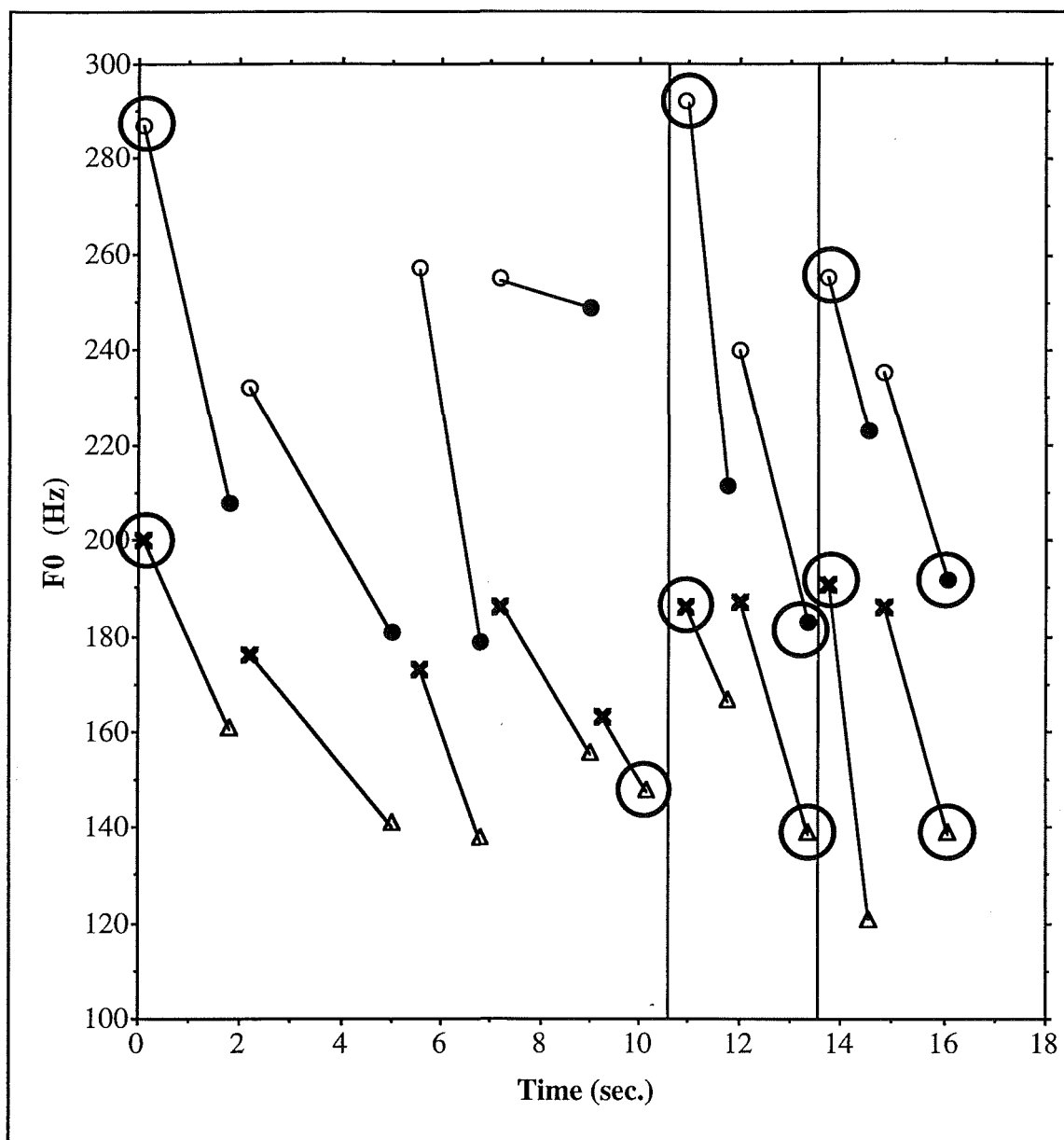


Figure 7.11. Top, mid and bottom lines corresponding to paragraph 24 ('Commentaries' set), uttered by speaker M.E. The circles indicate the points selected for analysis.

The collected values have been analysed separately taking into consideration the number of sentences of the paragraph. A detailed presentation of the results is included in appendix 9: section 4.1 includes the data about the 'sentence initial' values ('Beginning topline' and 'Beginning bottomline'), and section 4.2 the data about the sentence final values ('End topline' and 'End bottomline'). The tables contained in each section show the mean values for top and bottom lines in each sentence position, presented separately according to the number of sentences in the paragraph: 'cat 1' for paragraphs containing one sentence, 'cat 2' for paragraphs containing two sentences, and 'cat. 3' for paragraphs containing three sentences (see section 7.1.2 for more details about the definition of these categories).

Figures 7.12 and 7.13 plot graphically this data, for speakers A.R. and M.E. respectively.

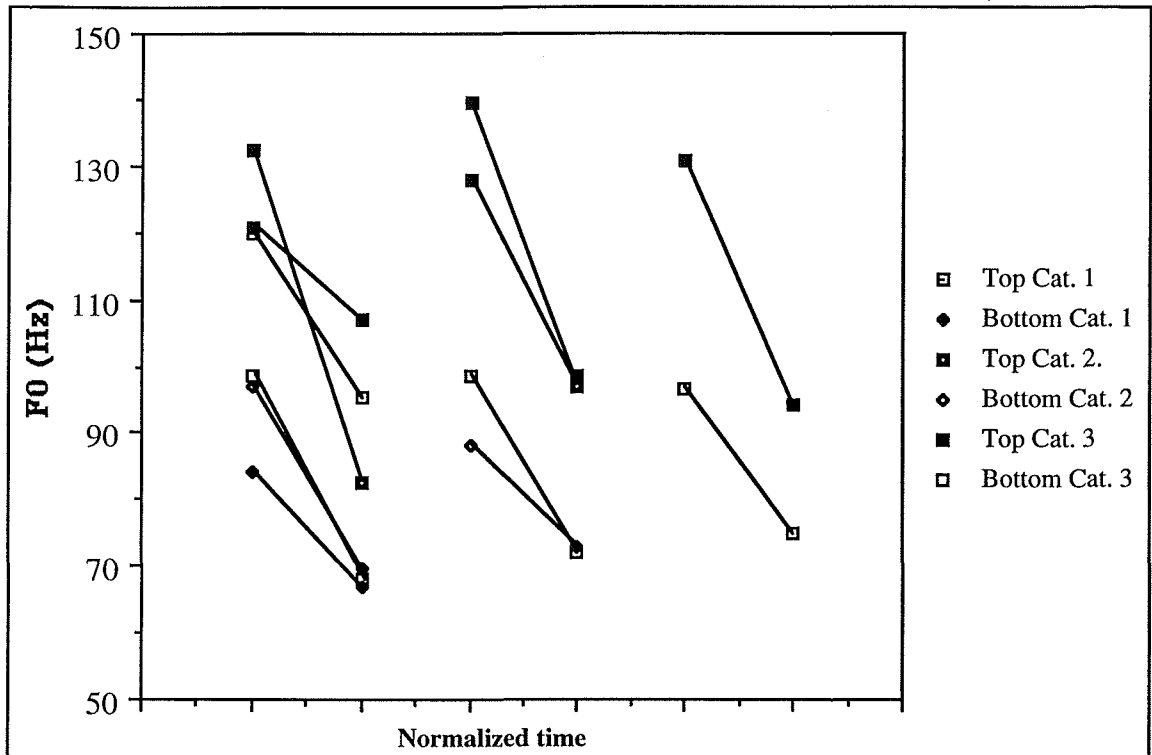


Figure 7.12. Calculated top and bottom lines for the sentences of paragraphs corresponding to speaker A.R. The results are presented separately for one-sentence, two-sentence and three-sentence paragraphs.

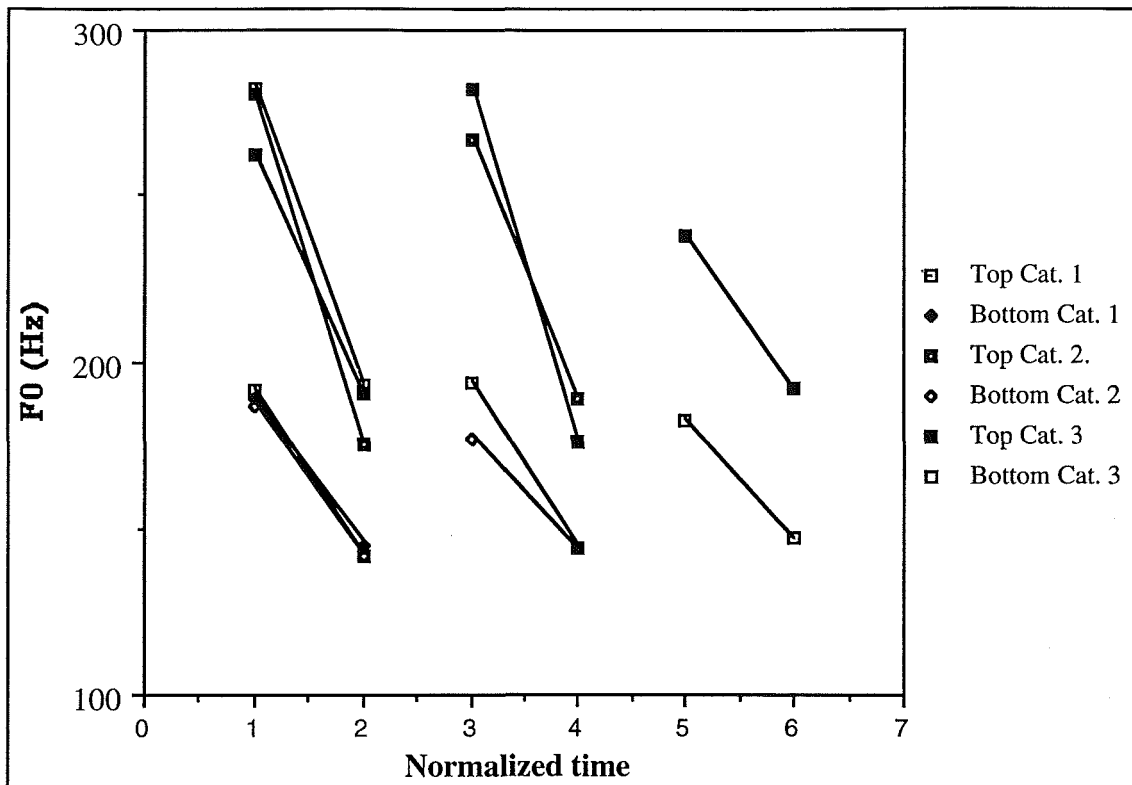


Figure 7.13. Calculated top and bottom lines for the sentences of paragraphs corresponding to speaker M.E. The results are presented separately for one-sentence, two-sentence and three-sentence paragraphs.

The results seem to indicate the presence of some global paragraph declination in the case of the two-sentence paragraphs (cat. 2), both in top and bottom lines. In this category, the mean value for the initial points of the first sentence is higher than the corresponding mean value for the points at the beginning of the second sentence, both in speaker A.R. and in speaker M.E. However, in the case of the three-sentence paragraphs (cat. 3), some kind of reset seems to appear: initial values of the second sentence are higher (or equal), in top and bottom lines, than the values at the beginning of the first sentence of the paragraph.

These results can be interpreted as an evidence that intermediate intonation units between sentence and paragraph can appear if the paragraph is long enough to make it necessary. Accordingly, sentences could be grouped in larger units, that would be then the 'immediate constituents' of the intonational structure of paragraphs. In some of these cases, as has been observed for sentences, it would not be possible to establish a single pattern covering all the paragraph, but lower-level units including one or several sentences.

The question of sentence grouping is reviewed in more detail in the following section.

7.5.2. Sentence grouping in paragraphs

The idea of intonational grouping of sentences has already been considered in the proposal of Nespor & Vogel (1986). This hypothesis seems to be confirmed with the data collected in this study.

There are cases among the paragraphs selected for analysis in which a global 'supra-declination' pattern covering all the sentences of the paragraph can be defined. The example presented in figure 7.14 illustrates this possibility. It corresponds to the paragraph 22 of 'Commentaries' set, and includes two sentences.

En cualquier caso, la Declaración de Birmingham ha apostado por una Europa unida a la vez que más plural - es significativa la referencia al respeto a la historia, cultura y tradiciones de las naciones -, descargada de burocratismo y con un papel relevante de los ciudadanos. Se alerta, al respecto, sobre el déficit informativo existente hasta ahora, que ha dejado a los ciudadanos al margen de un acontecimiento histórico como fue el tratado de Maastricht en cuanto que conformador de un nuevo modelo político para la Europa de finales de siglo.

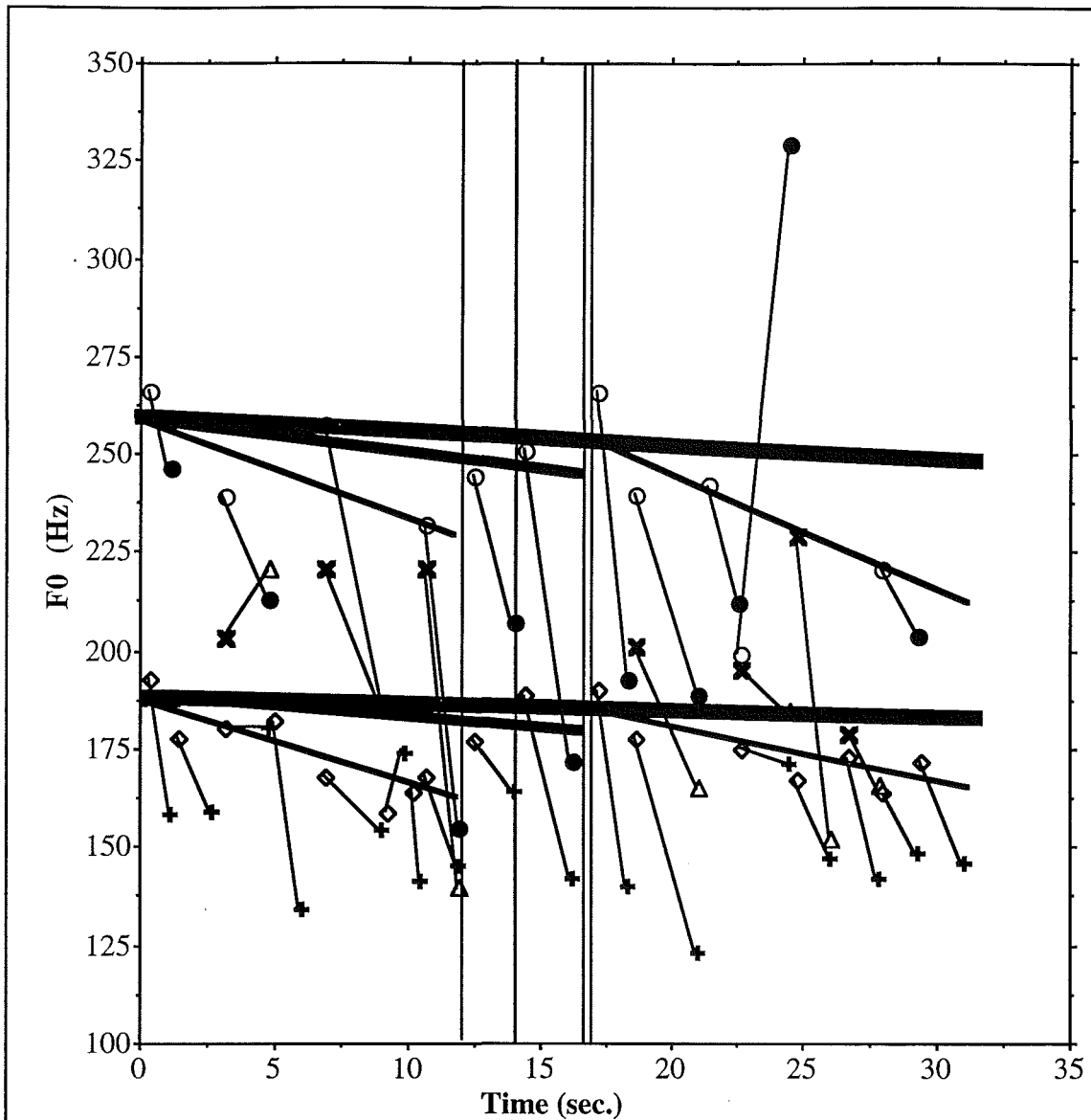


Figure 7.14. Top, mid and bottom lines corresponding to paragraph 22 ('Commentaries' set), uttered by speaker M.E. The thickest 'supra-lines' correspond to the hypothetical paragraph pattern.

There are also cases, however, in which it is more difficult to defend the existence of a single pattern. This can be observed, for example, in the intonation contour represented in figure 7.15. It corresponds to the paragraph 12 of the 'Commentaries' set, which contains three sentences.

Durante mucho tiempo tuve, desde entonces, la sensación de que había una época para la amistad y que esa época había pasado para mí. Un ejemplar soberbio de amigo sobrevivió a la glaciación. En una hilera de noches más bien lúgubre, heroicamente cariñoso compartió conmigo una dieta, implacable e inexplicable, de huevos "poché" con caviar de salmón y chuletitas "villeroy".

In this case, it seems that the first and second sentences are grouped in a single intonational clause, while the third sentence of the paragraph belongs to a different unit. No global pattern seems to exist in this paragraph.

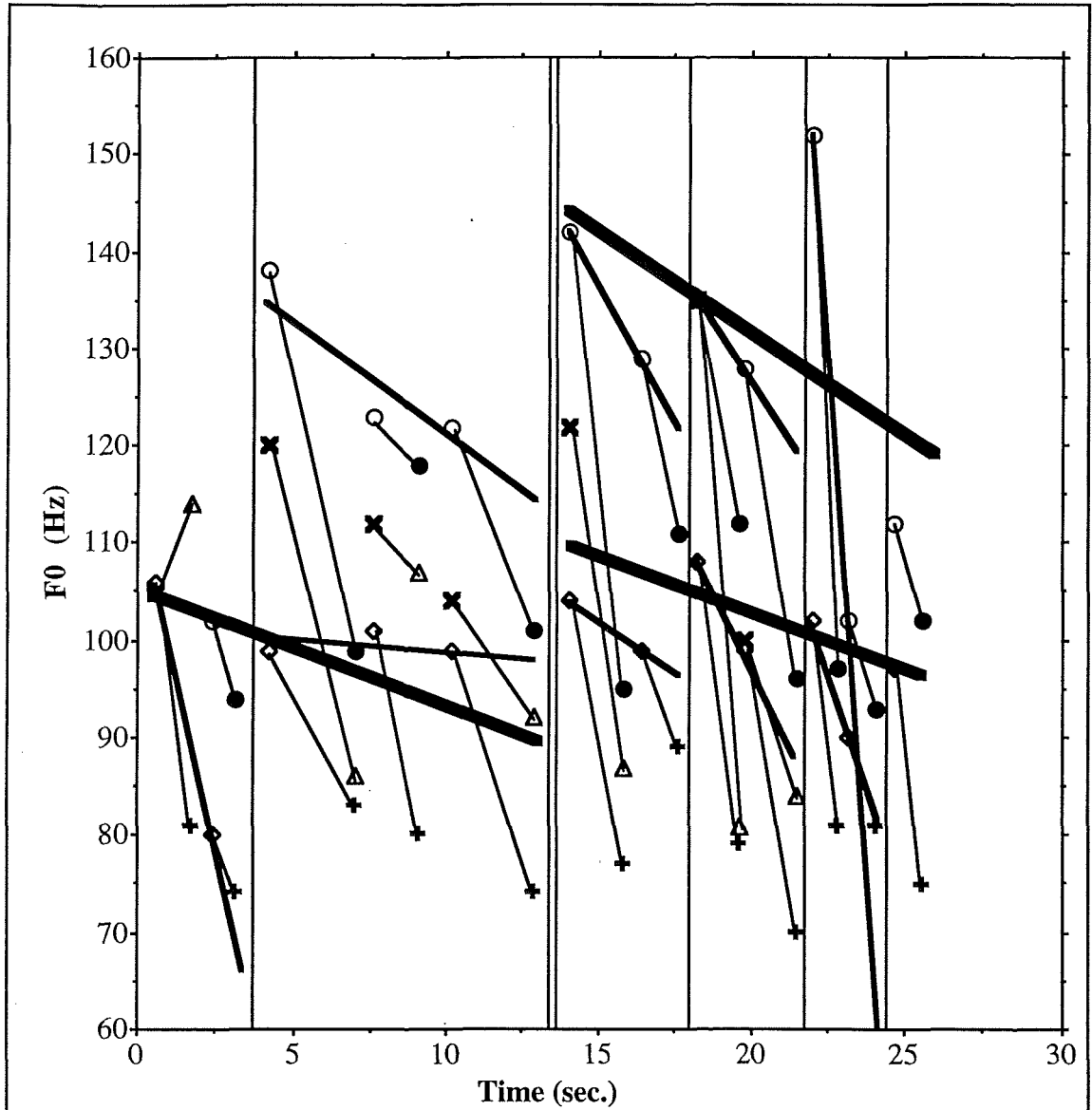


Figure 7.15. Top, mid and bottom lines corresponding to paragraph 12 ('Commentaries' set), uttered by speaker A.R. The thickest drawn 'supra-lines' correspond to the patterns of the two hypothetical units defined here.

The prosodic tree included in figure 7.16 would represent the theoretical intonational structure of this paragraph, containing, as in the case of sentences, two main intonational units.

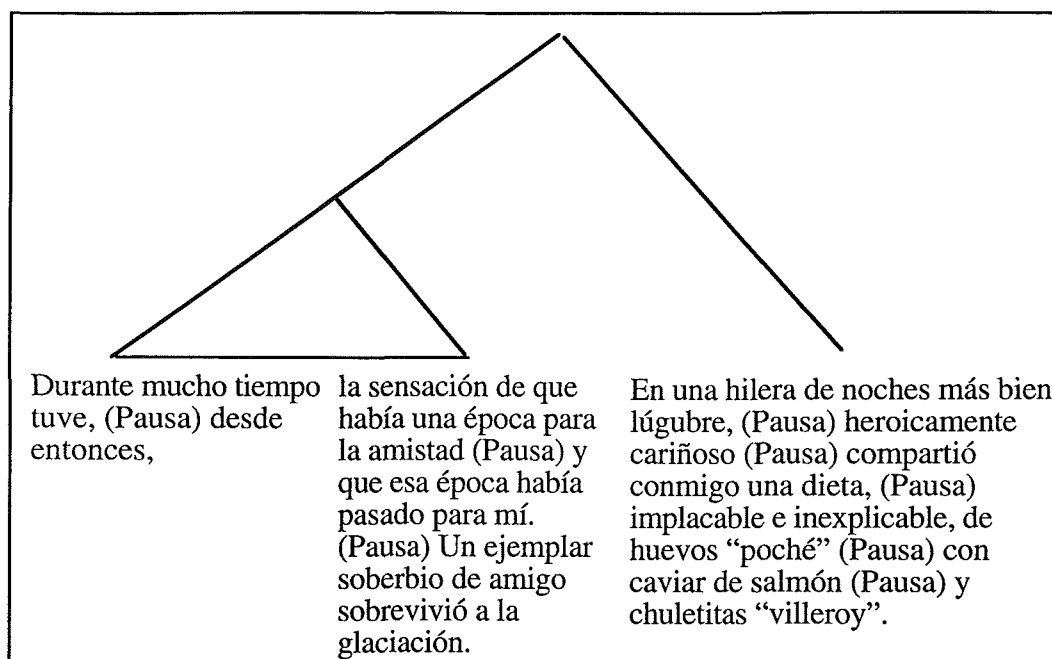


Figure 7.16. Simplified prosodic tree for paragraph 12 ('Commentaries' set), uttered by speaker A.R.

7.5.3. Summary

It seems that the intonational structure of paragraphs can be compared with the one described for sentences in the previous chapter. A single pattern covering the whole pattern is not always recognizable, and in some cases, more than one intonational clause (or intonational clauses groupings) can be identified. These 'macro-units' can cover different domains, sometimes larger than a single sentence. The notion of sentence grouping can be used then to explain the inclusion of two sentences into a larger-level unit, between the sentence and the paragraph domain.

As in the case of sentences, it can be hypothesized that the paragraph is an optional rather than an obligatory domain for intonational structuring.

7.6. Variation of paragraph patterns according to phonetic factors: the influence of paragraph length

It can be hypothesized that, as in the case of phonic groups, the initial and final values of the intonation contours of paragraphs can change according to some factors, as for example, their length. Thorsen (1985, 1986) analysed this hypothesis, showing that initial and final values are quite constant independently of the length of the paragraph, while the starting values of contours within the paragraph depend on the number of sentences and the length of each one.

A similar analysis of the initial and final values of the paragraphs has been carried out here. The F0 values corresponding to the initial point of first top and bottom lines of the paragraphs (T.I. and B.I., respectively), and the final points of the last top and bottom lines of the paragraph (T.F. and B.F., respectively), have been taken into account for this analysis. The location of the selected points is exemplified in figure 7.17.

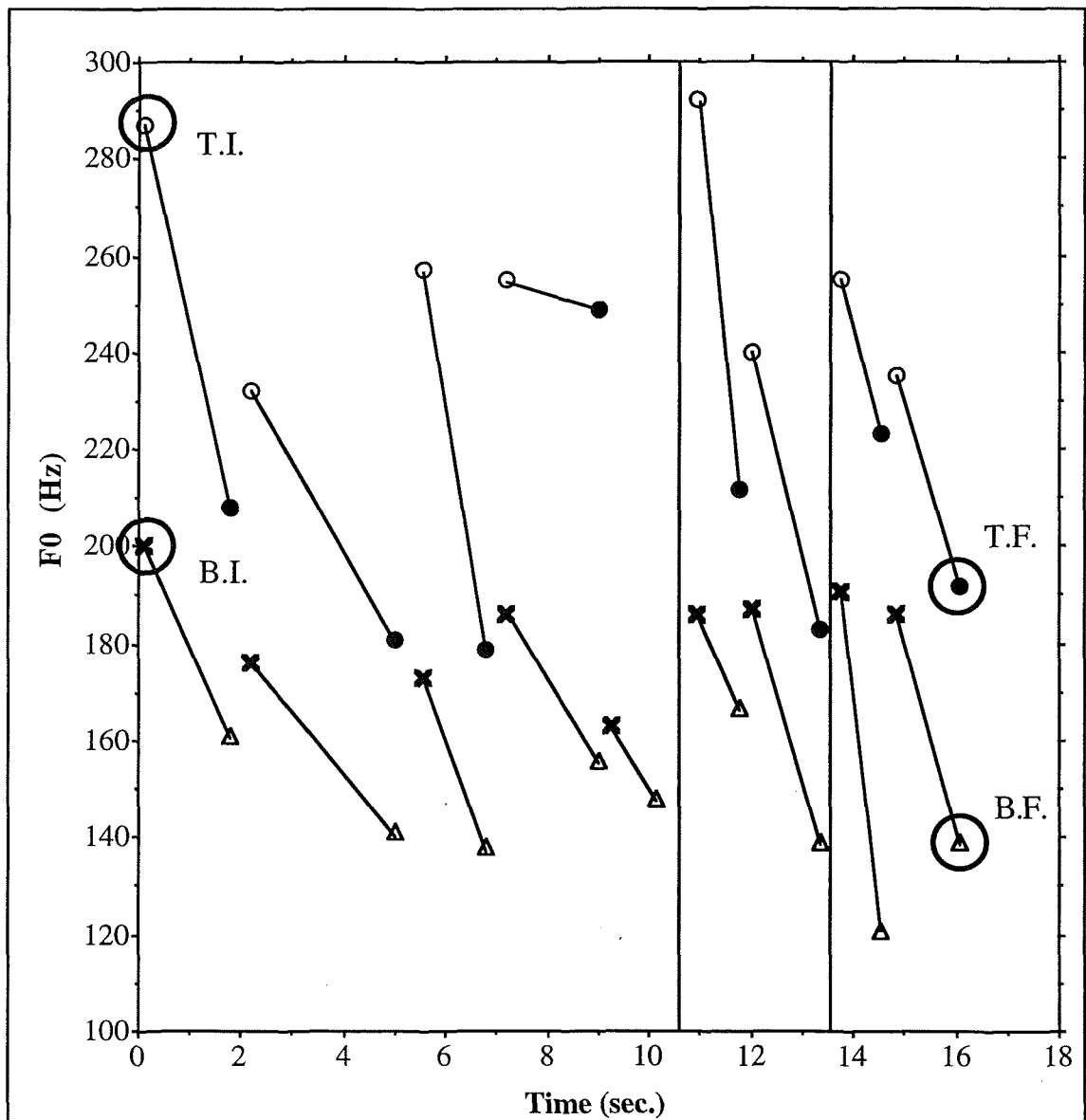


Figure 7.17. Top, mid and bottom lines corresponding to paragraph 24 ('Commentaries' set), uttered by speaker M.E. The circles indicate the points selected for analysis.

The obtained results are presented in appendix 9: a table containing the global results is included in section 5.1, and the same results are presented in section 5.2 separately for each length category ('sil. 1' for paragraphs between 8 and 61 syllables, 'sil. 2' for paragraphs between 62 and 114 syllables, 'sil. 3' for paragraphs between 115 and 167 syllables, and 'sil. 4' for paragraphs between 168 and 220 syllables; see section 7.1.2 for more

details about the definition of these categories). The analysis of the results by speaker seems to indicate that initial and final values are quite constant for each speaker, as shown by the relatively small standard deviations obtained. This data agrees with the ones given by Thorsen (1985, 1986). The final value of the bottom line (B.F.) seems to be specially constant, showing the lowest standard deviations of the four points (6.65 Hz in the case of speaker A.R.; 5.6 Hz in the case of speaker M.E.).

When the results separated by paragraph length are analysed, it can be observed first that the final values of the bottom lines (B.F.) seem to be the point that appears to be less affected by paragraph length. For speaker A.R., the values obtained are 69.5 Hz (sil. 1), 72.8 Hz (sil. 2), 73 Hz (sil. 3), and 65.67 Hz (sil. 4); the obtained means for the different categories are in a range of only 8 Hz. For speaker M.E., the means obtained are 147 Hz (sil. 1), 145 Hz (sil. 2), 142.5 Hz (sil. 3) and 150 Hz (sil. 4), which also represents a range of 8 Hz. It seems then that this point is the most invariant in the paragraph, and could be considered as a reference value for any speaker.

The same tendency can be observed for the rest of the points (T.I., B.I. and T.F.): the values tend to be higher for 'sil. 2' than for 'sil. 1' paragraphs. Values for 'sil. 3' and 'sil. 4', however, are also lower than the ones obtained for 'sil. 2' paragraphs. In the case of the T.I. point, for example, the obtained results for speaker A.R. are 117.5 Hz (sil. 1), 130.33 Hz (sil. 2), 124.5 Hz (sil. 3) and 121 Hz (sil. 4). For speaker M.E., the obtained values are 271.5 Hz (sil. 1), 291.33 Hz (sil. 2), 265.5 Hz (sil. 3) and 270 Hz (sil. 4). Similar tendencies are observed in B.I. and T.F. points. This data can not be interpreted as an evidence that there exist a consistent correlation between these values and paragraph length, but rather as an indication of a 'partial preplanning' of the intonational structure of paragraphs. According to this hypothesis, it seems that the speaker is able to predict the intonational organization of utterances only to a certain extent. If the paragraph is longer than this limit, only a part of the paragraph is preplanned from the beginning. The rest of the paragraph is then included in a different intonational (or 'preplanning') unit. However, the material analysed here is not sufficient to establish definitive conclusions from these results. In any case, the data obtained here does not seem to coincide with the ones presented in Thorsen (1985, 1986).

7.7. General summary

In this chapter, the modelling of intonation contours in a sub-corpus of selected paragraphs has been attempted. The goals established at the beginning of the chapter are summarized again here:

- a) the application of the 'topline-bottomline' framework to the modelling of paragraph intonation, and the use of the 'intonational clause' approach to describe the structuring of paragraph contours;
- b) the analysis of the sentence and paragraph as intonation units;
- c) the study of the variation of the paragraph intonation depending on phonetic factors, such as paragraph length.

The same 'topline-bottomline' approach defined for sentences has been applied here for modelling paragraph intonation. The global shape of the paragraphs taken as whole and the 'intonational clause' approach have been used to describe the organization of their intonation structure.

This 'intonational clause' analysis has shown how sentences do not always present an 'intonational clause' pattern, that is, a single 'supra-line' having the complete sentence as domain. However, sentence boundaries seem to be marked phonetically in a consistent way, using the presence of total resets, a large initial range, or a large amount of reset between the end of the previous sentence and the beginning of the next one. These results can be considered as an indication that the sentence is a unit which plays a role in the intonational organization of utterances in readings.

As in the case of sentences, paragraphs have not appeared to be an obligatory domain for global intonational patterns. Their length seems to be a factor determining their organization into one or several intonation units. The domain of these units is variable, and they can cover one sentence, more than one sentence, or less than one sentence. This organization of paragraph intonation can be partially related to the reading preplanning strategies of the speaker.

Finally, the analysis of the variations of paragraph contours depending on the length has shown a certain tendency of some points in the contour, specially the initial ones, to vary with length. These results do not coincide with the ones presented in previous studies, but the material analysed here is not sufficient to obtain more than preliminary indications. However, the final point of the last bottom line seems to be quite invariant, and can be considered as a good reference value for each speaker.

Chapter 8

BUILDING THE MODEL

This chapter deals with the definition of a model for the generation of Spanish intonation in reading text, using the data collected in previous chapters. The model is oriented to the automatic generation of intonation contours in TTS systems. However, it has to be pointed out in advance that the proposal presented here can not be considered a complete model. A first attempt to define a general framework and a generation procedure is presented, and further analyses should be necessary to complete it.

The main characteristics of the proposed model can be summarized in the following way:

- a) Using the terminology defined in chapter 1, the model can be considered as 'phonetic' because it only predicts the shape of the intonational contours, but not the parsing of the text input in prosodic units. The text analysis and parsing is assumed to be done before the application of this model. This linguistic information necessary as input of the model is detailed in section 8.1.
- b) The model can also be defined as 'hierarchical', because it assumes different levels or cycles for the generation of the contours. Two main levels are considered here, a local and a global one. They are described in more detail in section 8.2.
- c) The model generates a stylized contour similar to the ones obtained in the analysis task of this work, with a series of inflection points linked with straight lines. This output is described in more detail in section 8.3.

Figure 8.1 presents schematically the generation process proposed in the model.

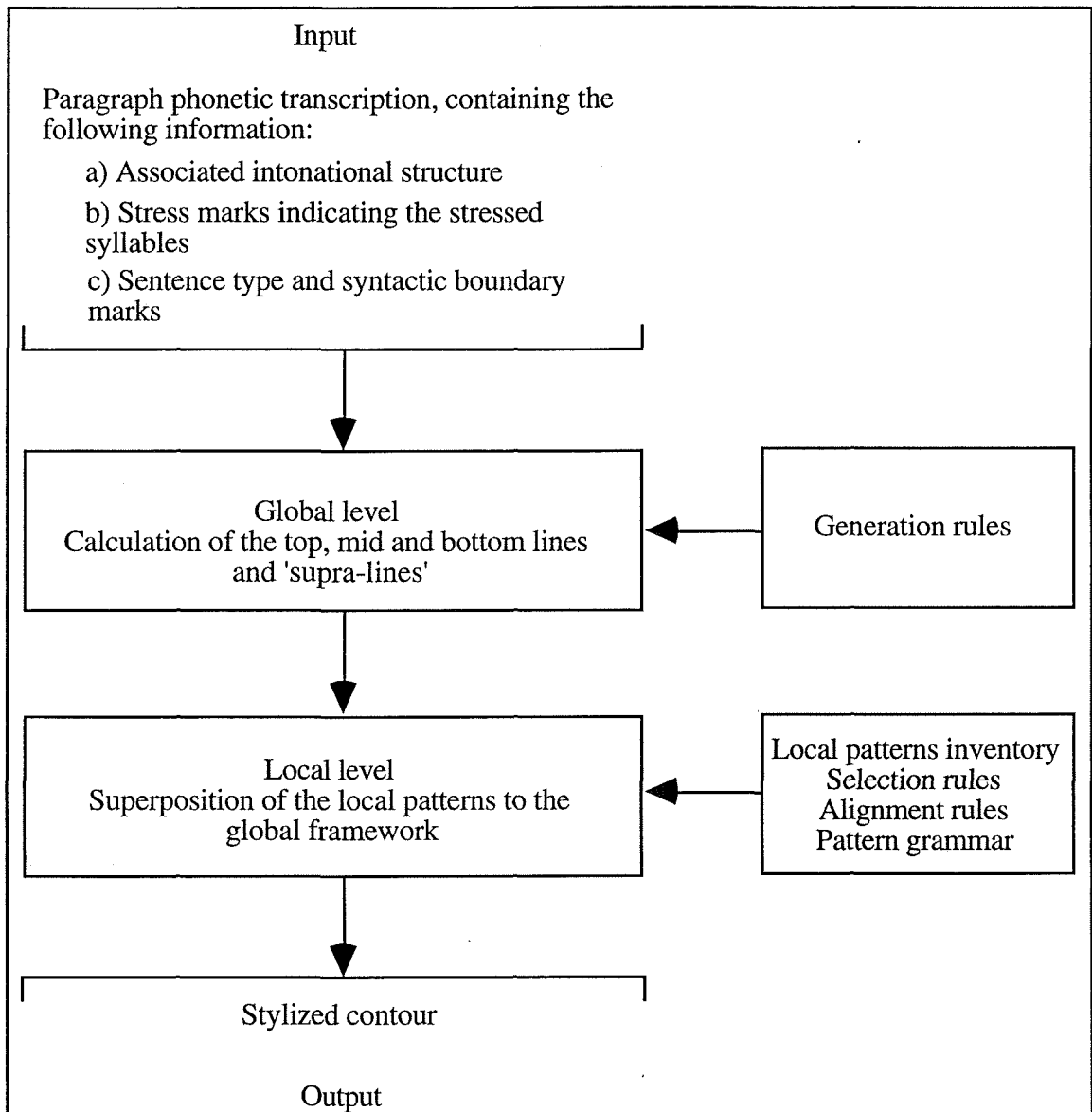


Figure 8.1. Schematic representation of the components of the proposed intonation model.

These different steps are discussed in more detail in the following sections. Also, the application of the model to generate the intonation contour of the following sample paragraph is considered:

La dotación policial, después de forzar una de las ventanas de la planta baja de la casa, sofocó el fuego con el extintor del vehículo. Una vez en el interior, los agentes encontraron a tres de los niños. Los vecinos informaron entonces de que en la vivienda se encontraban más personas dentro y, en una segunda intervención, la policía encontró al cuarto niño y a la mujer.

(Par. 38, 'News' set)

A more detailed description of the generation of the intonation contour for this paragraph can be found in appendix 10.

8.1. Input of the model

The paragraph has appeared to be the highest-level unit where intonation patterns have been found in this study. For this reason, the paragraph has been chosen as the basic generation unit in this model. A chain containing the phonetic transcription of the paragraph and a series of prosodic markers is considered to be the input of the model.

According to the results presented in previous chapters, it seems necessary to add some information to the phonetic transcription of the paragraph for the generation of the contour. Three main types of information seem necessary to be present:

- 1) A representation of **intonational structure** of the paragraph, including the parsing of the text into phonic groups, that is, the location of pauses, and an associated structure indicating how these phonic groups are grouped into intonational clauses and higher-level units.
- 2) Information about the syllables bearing lexical stress along the paragraph. Although the validity of the tonic group as an intonational unit in Spanish does not seem to be clear, the results presented in chapter 4 indicate that the information related to stress position is necessary to locate specific inflection points along the contours.
- 3) Information related to sentence type, and about the syntactic boundary linked to each defined pause. This information is necessary for the selection of the local patterns appearing at the end of each phonic group, and for the definition of the level of reset associated to each phonic group boundary.

In the following subsections, these three types of information are considered in more detail. At the same time, an example of input representation for the sample paragraph is proposed.

8.1.1. Intonational representation

The results obtained in this work (chapter 6 and 7) seem to favour the idea that the global shape of the intonation contours in large units, such as sentences or paragraphs, is determined through some form of phonological representation, that groups and structures the different prosodic units of a utterance. Although these results are not complete enough to define clear

rules for building these structures, and in fact their definition is outside the scope of this work, the use of such a type of representation seems to be very adequate for the prediction of the global shape of intonation contours in paragraphs.

The first information that should be contained in this intonational representation is the one referred to the parsing of the text into phonic groups. Pause marks should be included at specific syntactic boundaries, defining a set of phonic groups for each paragraph, as shown in figure 8.2.

[La dotación policial,] (P) [después de forzar una de las ventanas de la planta baja de la casa,] (P) [sofocó el fuego con el extintor del vehículo.] (P) [Una vez en el interior,] (P) [los agentes encontraron a tres de los niños.] (P) [Los vecinos] (P) [informaron entonces de que en la vivienda se encontraban más personas dentro] (P) [y, en una segunda intervención,] (P) [la policía encontró al cuarto niño y a la mujer.]

Figure 8.2. A proposal of pause (P) placement for the text of paragraph 38 ('News' set).

This intonational representation should also include some information about the hierarchy established among the different phonic groups, grouping them in different-level intonational clauses. The criteria determining this grouping have not been fully established here, but some tendencies can be outlined. The results presented in chapters 6 and 7 suggest that the paragraph and the sentence seem to be the highest-level units playing a role in the intonational organization of the analysed material. These results also indicate that intermediate units, containing several sentences, can be identified in some cases between the paragraph and the sentence level. However, these units have not appeared to be as obligatory domains in intonational parsing. According to these considerations, a possible first level of bracketing of phonic groups in the sample paragraph can correspond to the three sentences (S) contained in it, as illustrated in figure 8.3.

[[La dotación policial,] [después de forzar una de las ventanas de la planta baja de la casa,] [sofocó el fuego con el extintor del vehículo.]]S1

[[Una vez en el interior,] [los agentes encontraron a tres de los niños.]]S2

[[Los vecinos] [informaron entonces de que en la vivienda se encontraban más personas dentro] [y, en una segunda intervención,] [la policía encontró al cuarto niño y a la mujer.]]S3

Figure 8.3. Sentence bracketing for the text of paragraph 38 ('News' set).

Below the sentence level, smaller units can also be considered. As suggested in chapter 6, sentences tend to be organized in two main parts. The 'tension part' - 'distension part' approach predicts that the limits between these two intonational clauses correspond to specific syntactic boundaries. In the considered example, each sentence can be then split in two intonational clauses (IC), following these syntactic criteria, as shown in figure 8.4. In this figure, the 'IC1' label indicates the first intonational clause of each sentence, or 'tension part', and 'IC2' indicates the second intonational clause, or 'distension part'.

```

[[[La dotación policial,] [después de forzar una de las ventanas de la planta baja de la
casa,]]IC1
[sofocó el fuego con el extintor del vehículo.]]IC2]S1

[[[Una vez en el interior,]]IC1
[[los agentes encontraron a tres de los niños.]]IC2]S2

[[[Los vecinos]]IC1
[[informaron entonces de que en la vivienda se encontraban más personas dentro] [y,
en una segunda intervención,] [la policía encontró al cuarto niño y a la mujer.]]IC2]S3

```

Figure 8.4. Proposed 'tension part' - 'distension part' bracketing for the text of paragraph 38 ('News' set).

Below this level, and depending on the syntactic complexity of the sentences, more intonational clauses could be established. As suggested in chapter 6, some boundaries, such as the end of parenthetical elements, strongly favour the start of a new intonation unit. A new level can be then introduced in the proposed structure for the chosen paragraph, and new units established, as can be seen in figure 8.5. The boundaries of these new units are indicated with the label 'IC'.

```

[[[Los vecinos]]IC1
[[[informaron entonces de que en la vivienda se encontraban más personas dentro] [y,
en una segunda intervención,]]IC[[la policía encontró al cuarto niño y a la
mujer.]]IC]IC2]S3

```

Figure 8.5. Proposed intonational clause bracketing for the third sentence of paragraph 38 ('News' set).

A possible structure for the selected sample paragraph can be the one presented in figure 8.6.

[[[La dotación policial,] [después de forzar una de las ventanas de la planta baja de la casa,]]IC1
 [sofocó el fuego con el extintor del vehículo.]]IC2]S1

[[[Una vez en el interior,]]IC1
 [[los agentes encontraron a tres de los niños.]]IC2]S2

[[[Los vecinos]]IC1
 [[[informaron entonces de que en la vivienda se encontraban más personas dentro] [y, en una segunda intervención,]]IC [[la policía encontró al cuarto niño y a la mujer.]]IC]IC2]S3

Figure 8.6. Proposed intonational bracketing for the text of paragraph 38 ('News' set).

8.1.2. Stress marks

The input representation should be provided with marks indicating the location of the different stressed syllables in the text. As has been discussed in chapter 4, the knowledge of the location of the stressed syllables is necessary for the placement of specific inflection points of the local patterns. The intonational structure of figure 8.6 can be enriched with stress marks, as shown in figure 8.7.

[[[La **dotación** policial,] [después de forzar **una** de las ventanas de la **planta baja** de la **casa**,]]IC1
 [sofocó el **fuego** con el extintor del **vehículo**.]]IC2]S1

[[[**Una vez** en el interior,]]IC1
 [[los agentes encontraron a **tres** de los **niños**.]]IC2]S2

[[[Los vecinos]]IC1
 [[[informaron entonces de que en la vivienda se encontraban **más personas dentro**] [y, en **una segunda** intervención,]]IC [[la policía encontró al **cuarto niño** y a la **mujer**.]]IC]IC2]S3

Figure 8.7. Proposed stress marking (in bold characters) for the text of paragraph 38 ('News' set).

8.1.3. Sentence type and syntactic boundaries information

Finally, information related to the type of syntactic boundary and the sentence type should be added to this representation. According to the results obtained in this work, syntactic information seems necessary for the selection of the local pattern at the end of the group, and for the selection of the level of reset associated to each group boundary.

Each phonic group should be labelled with information about the type of boundary appearing at its end. The definition of a complete inventory of syntactic labels is out of the scope of this work, and it does not have necessarily to coincide with the one defined here.

In the case of the sample paragraph, the different phonic groups can be labelled in a way similar to the one presented in figure 8.8.

<p>[[[La dotación policial,] (<i>Beginning parenthetical element</i>) [después de forzar una de las ventanas de la planta baja de la casa,]]IC1 (<i>Subject/Predicate</i>) [sofocó el fuego con el extintor del vehículo.]]IC2]S1 (<i>Sentence</i>)</p> <p>[[[Una vez en el interior,]]IC1 (<i>End fronted element</i>) [[los agentes encontraron a tres de los niños.]]IC2]S2 (<i>Sentence</i>)</p> <p>[[[Los vecinos]]IC1 (<i>Subject/Predicate</i>) [[[informaron entonces de que en la vivienda se encontraban más personas dentro] (<i>Coordinate clauses</i>) [y, en una segunda intervención,]]IC (<i>End fronted element</i>) [[la policía encontró al cuarto niño y a la mujer.]]IC]IC2]S3 (<i>Sentence</i>)</p>
--

Figure 8.8. Proposed syntactic labelling for the intonation units of the text of paragraph 38 ('News' set).

Sentences should also be marked with a label indicating its sentence type, such as 'Declarative', 'Yes-No question', 'Wh- question' or 'Exclamative'. These labels are necessary to select the adequate local pattern at the end of the contour. In the case of the paragraph considered here, the three sentences are labelled as 'Declarative', as is shown in figure 8.9.

[[[La dotación policial,] (*Beginning parenthetical element*) [después de forzar una de las ventanas de la planta baja de la casa,]]IC1 (*Subject/Predicate*)
 [sofocó el fuego con el extintor del vehículo.]]IC2]S1 (*Sentence-Declarative*)

[[[Una vez en el interior,]]IC1 (*End fronted element*)
 [[los agentes encontraron a tres de los niños.]]IC2]S2 (*Sentence-Declarative*)

[[[Los vecinos]]IC1 (*Subject/Predicate*)
 [[informaron entonces de que en la vivienda se encontraban más personas dentro] (*Coordinate clauses*) [y, en una segunda intervención,]]IC (*End fronted element*)
 [[la policía encontró al cuarto niño y a la mujer.]]IC]IC2]S3 (*Sentence/Declarative*)

Figure 8.9. Proposed syntactic labelling for the intonation units of the text of paragraph 38 ('News' set).

8.2. Levels of the model

As discussed in chapter 1, the proposed model is intended to take into account a hierarchical structure of intonation. The results of this work seem to suggest the existence of two main levels in Spanish intonation contours:

- a) A global level, covering the paragraph, sentence, and phonic group domains analysed in this work. The main function of this level is to define the global shape of F0 contours. It will assign top, mid and bottom lines to the different intonational units marked in the input text.
- b) A local level, which selects the local patterns from the inventory, according to the information contained in the input, and places them in the global grid.

These two levels are described in more detail in the following subsections.

8.2.1. Global level

The function of this level is to establish the global patterns corresponding to paragraphs, sentences, intonational clauses and phonic groups of the input text. In this work, a common descriptive framework using top, mid and bottom lines and 'supra-lines', has been proposed for the patterns corresponding to these units. Using the information present at the input, the global level calculates the top, mid and bottom lines for each unit.

The assignment procedure consists of several steps, as many as levels in the hierarchy are present in the input representation. The first step implies the calculation of the 'supra-lines' pattern (or patterns) corresponding to the

highest-level layer of intonation units defined in the input intonation structure. The values for initial and final points of these 'supra-lines' should be previously set as 'speaker-dependent' variables, according to the reference values given at the input. Taking these reference values as starting points, top, mid and bottom lines (or 'supra-lines', depending on the complexity of the input) are calculated. The height of the initial points can also be modified depending on the length of the paragraph.

Figure 8.10 offers the possible shape of the global high and low 'supra-lines' for the chosen paragraph, uttered by speaker M.E. A single pattern for the whole paragraph is considered. Only top and bottom 'supra-lines' have been drawn here, in order to simplify the graphic representation. The labels HT1, HT2, LT1, LT2, HB1, HB2, LB1 and LB2 indicate the points whose values should be set at input. In this case, HT1, LT1, HB1 and LB1 correspond to the values of the initial points of the 'supra-lines' calculated for the paragraphs of speaker M.E. (see section 7.3.1, and appendix 9, section 2, for more details). HT2, LT2, HB2 and LB2 have been calculated using the data about the slope of these 'supra-lines' (also included in appendix 9, section 2).

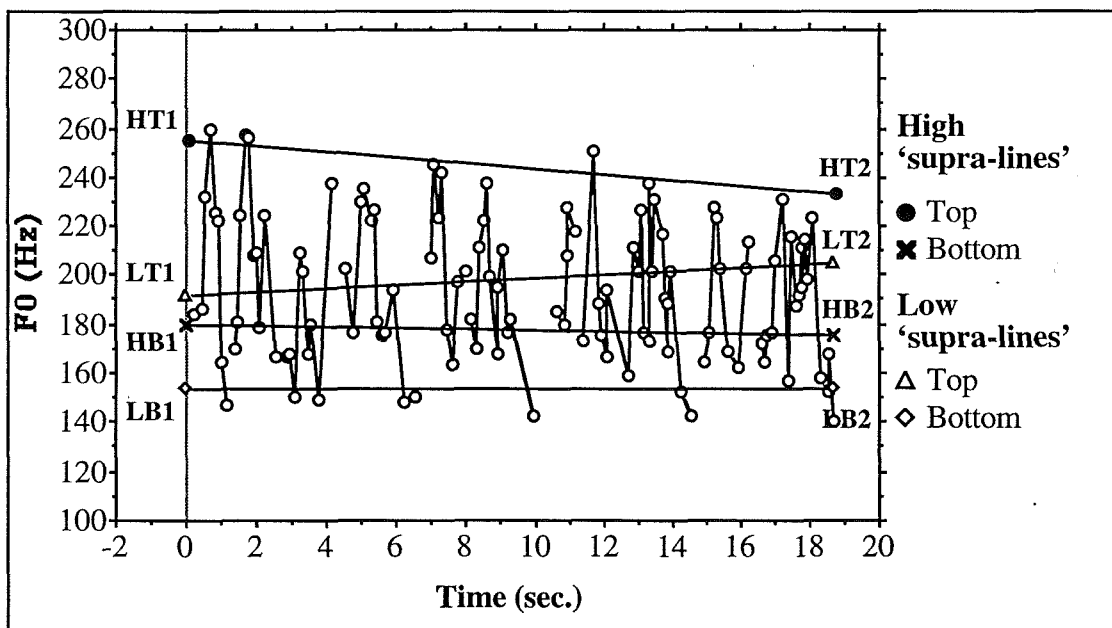


Figure 8.10. Stylized contour and predicted paragraph high and low 'supra-lines' for paragraph 38 ('News' set), uttered by speaker M.E.

These high and low 'supra-lines' are used as the basic **reference grid** for the generation of the lower-level top and bottom lines. The high 'supra-lines' represent the highest F0 level at which the top and bottom lines of the paragraph can start as a function of time. The low 'supra-lines' indicate the minimum F0 level that top and bottom lines can reach at their end, also as a function of paragraph length.

The lines corresponding to the immediate lower-level of units in the intonation structure are set according to this global reference grid. In the example considered here, this level includes the different sentences of the paragraph, but it can also include groups of sentences, or parts of sentences, depending on the input. Figure 8.11 presents an hypothetical representation of the top and bottom 'supra-lines' of the three sentences included in the sample paragraph. A single 'supra-lines' pattern for each sentence is considered here.

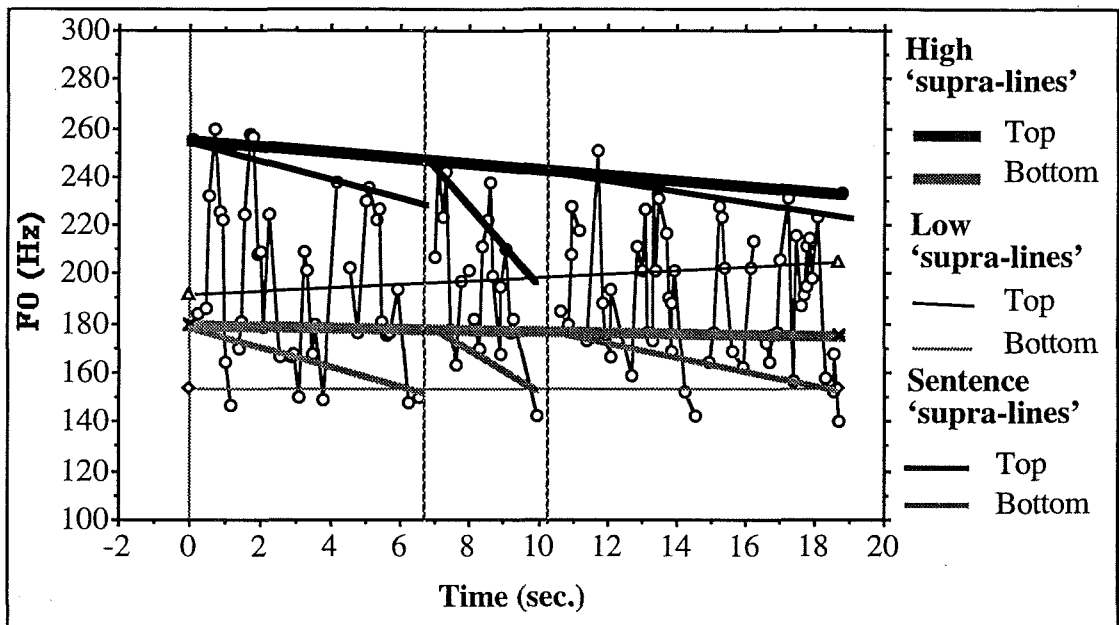


Figure 8.11. Sentence 'supra-lines' superimposed to the paragraph 'supra-lines' presented in figure 8.10.

This superimposing procedure is repeated for each of the different levels of intonational clauses present in the input intonational structure. The complexity of this 'supra-lines' structure will be dependent then on the complexity of the input text.

Finally, the obtained 'supra-lines' are used to calculate the top, mid and bottom lines of the different phonic groups of the paragraph. The calculation of these lines is based on the same principles as in the case of the 'supra-lines', that is, they are set according to the position of the immediate higher-level 'supra-lines'. Figure 8.12 presents an example of possible top and bottom lines for one of the sentences of the selected paragraph. Mid lines have not been included.

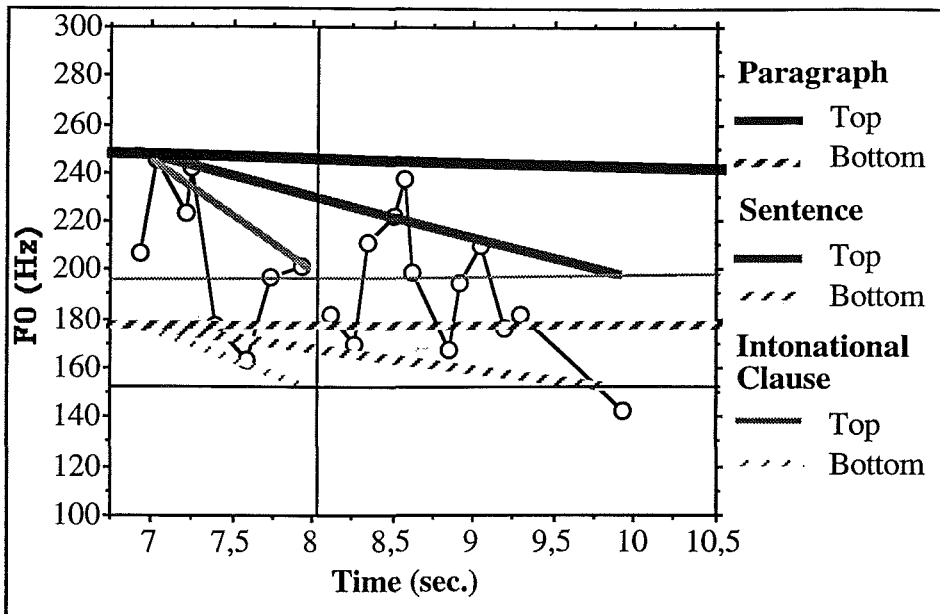


Figure 8.12. Top and bottom lines corresponding to the two phonic groups of the sentence '*Una vez en el interior, los agentes encontraron a tres de los niños*', uttered by speaker A.R.

The top and bottom lines predicted for the rest of sentences of the paragraph are represented in the figures included in appendix 10 (section 2).

These lines constitute the necessary input for the local level to assign the corresponding F0 value to the inflection points, as described in the next section.

8.2.2. Local level

The goal of the local level is to build the intonation contour using the top, mid and bottom lines calculated by the global level. The local level selects the local patterns adequate for each position and links them to form the complete contour, placing them at the right F0 height according to the top, mid and bottom lines. This level performs also the alignment of the inflection points of each pattern to specific points in the utterance.

The local level should include four main components:

- 1) an inventory of local movements;
- 2) a set of pattern-selection rules;
- 3) a set of alignment rules;
- 4) a grammar that defines the possible concatenations of patterns.

In the following paragraphs these four components are described in more detail.

The application of this local level to the chosen paragraph is illustrated in appendix 10 (section 3).

8.2.2.1. Local patterns inventory

The local patterns inventory should contain a description of the different possible patterns that can be used to generate the contours. Every pattern should be defined as a series of movements and inflection points, as discussed in chapter 4. Each inflection point should have associated to it some information related to its location within the utterance, to be used in the alignment process. Figure 8.13 offers an example of these patterns, extracted from the inventory presented in appendix 3 (section 1).

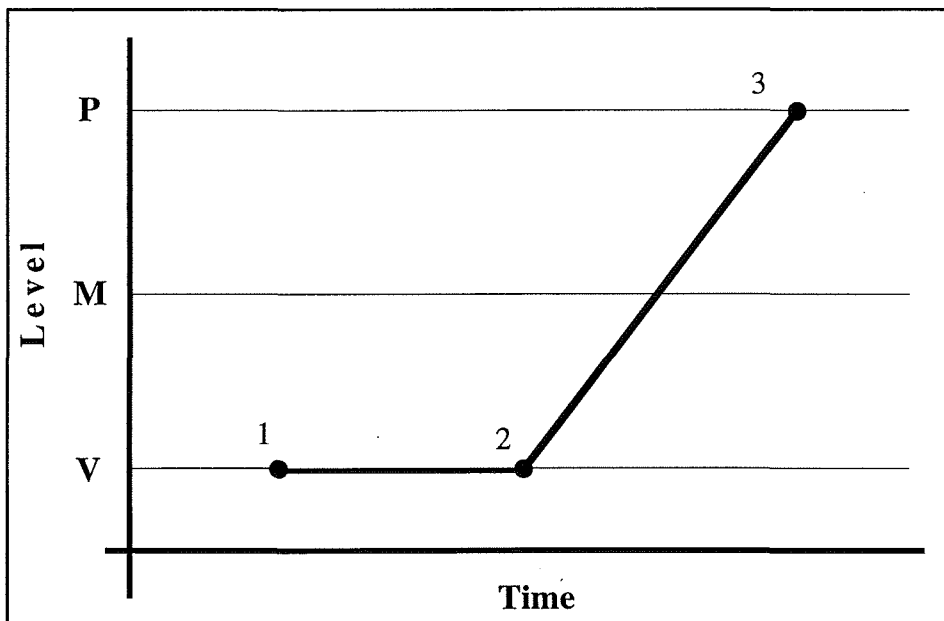


Figure 8.13. Schematic representation of the initial pattern 7 (V - Level - V - Rising - P), as defined in appendix 3, section 1.1.

As has been established in chapter 4, the defined patterns could be grouped into four different sets:

- 1) initial;
- 2) post-initial;
- 3) internal;
- 4) final.

The set of final patterns would be divided as well in three different subsets:

- 1) falling;
- 2) rising;
- 3) rise-fall.

The different patterns included in each group could be represented in the form of grammars of points and movements, as the ones included in appendix 3 (section 2).

The height of each inflection point is determined by the top, mid and bottom lines obtained as output of the global level, as illustrated in figure 8.14. The squared area indicates the shape of the pattern presented in figure 8.13, after insertion in the generated contour.

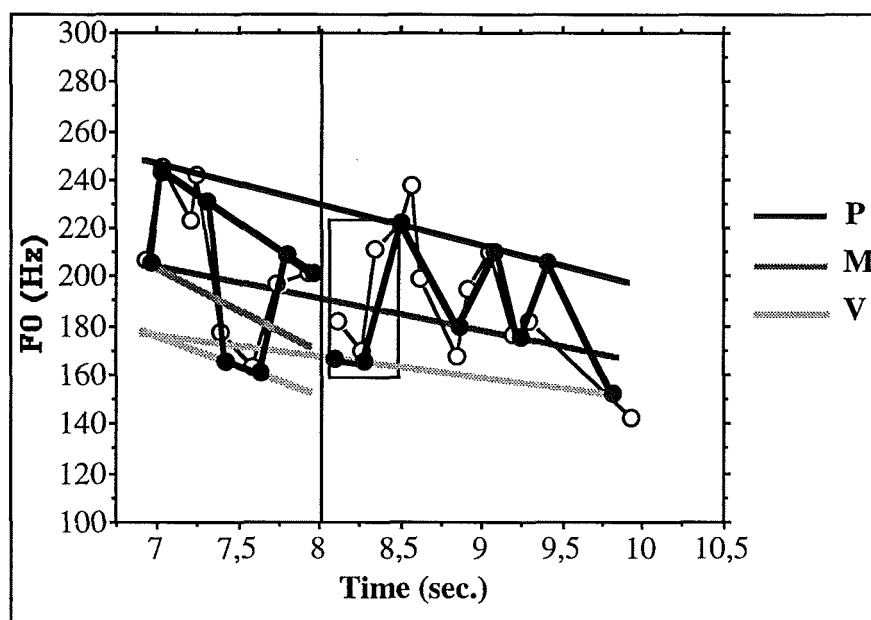


Figure 8.14. Stylized (white dots) and predicted (black dots) intonation contours for the sentence '*Una vez en el interior, los agentes encontraron a tres de los niños.*', uttered by speaker M.E.

8.2.2.2. Selection rules

Each pattern should have an associated rule (or rules) defining the conditions at which it can be used. The complete specification of the rules is out of the scope of this work, but some observations can be made about the factors determining this selection. The results obtained in chapter 4 seem to indicate that the distance between stressed syllables is one of these factors, specially in the case of initial and internal patterns. In the case of final patterns, the selection criteria seem to be dependent on the sentence type of the sentence in which they are included, if the phonic group is sentence-final, or dependent on the syntactic boundary, in the case of non-sentence-final groups.

8.2.2.3. Alignment rules

The different inflection points of each pattern have to be aligned to specific points in the utterance, according to the information contained for the selected pattern in the patterns inventory. These rules have not been specified here, although a first inventory could be built using the information included in chapter 4 and appendix 3 (section 1). These rules should indicate, for example, that the beginning of the rising movement of an initial pattern has to be located at the beginning of the stressed syllable, or that the inflection point corresponding to the peak can be delayed until the end of the stressed syllable or the following unstressed syllable, as figure 8.15 shows.

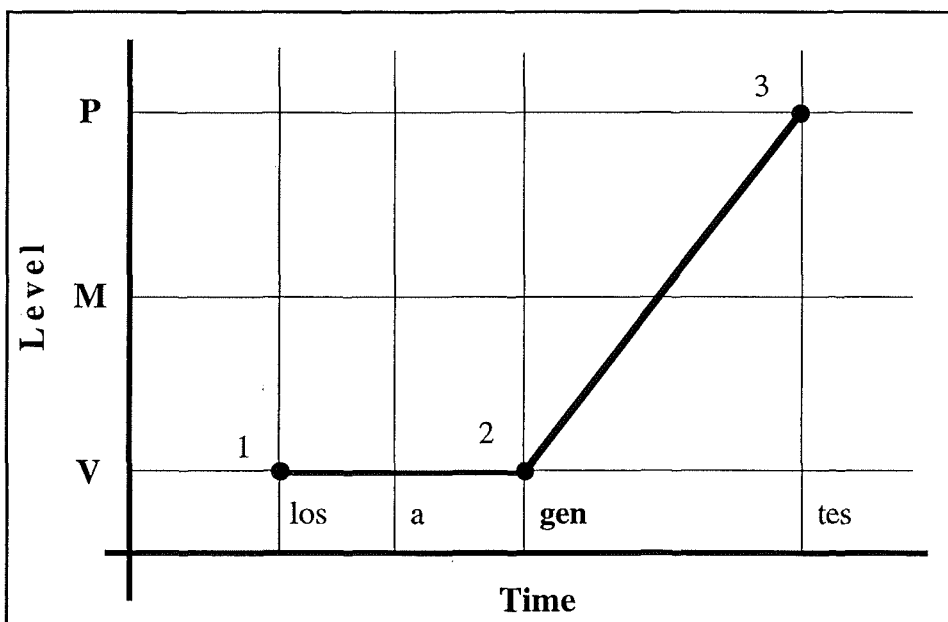


Figure 8.15. Temporal alignment of the initial pattern included in figure 8.13 to the tonic group [los agentes] in the phonic group '*los agentes encontraron a tres de los niños*'.

8.2.2.4. A grammar for the concatenation of patterns

The local level also needs a set of rules, or grammar, which defines the possible combinations of local patterns to form acceptable intonation contours. The results of this work do not allow to establish a complete proposal of grammar, but a first attempt has been made. The possible combinations of local patterns for a phonic group can be represented using the general rule included in figure 8.16. Parenthesis indicate that the corresponding pattern type is optional.

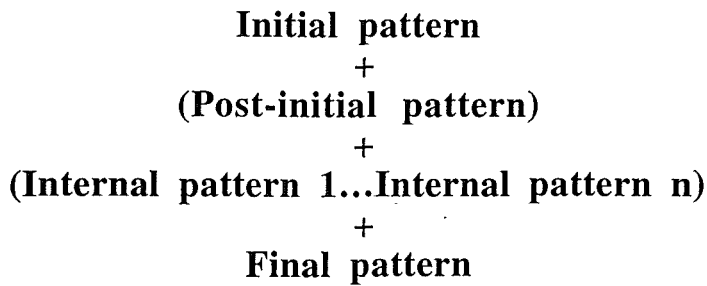


Figure 8.16. A grammar representing the possible combinations of local patterns in a phonic group.

According to this general rule, only initial and final movements appear to be obligatory in building up the intonation contour of a phonic group.

Figure 8.17 illustrates the application of this rule to the combination of patterns in the contour of the sample sentence included in figure 8.14.

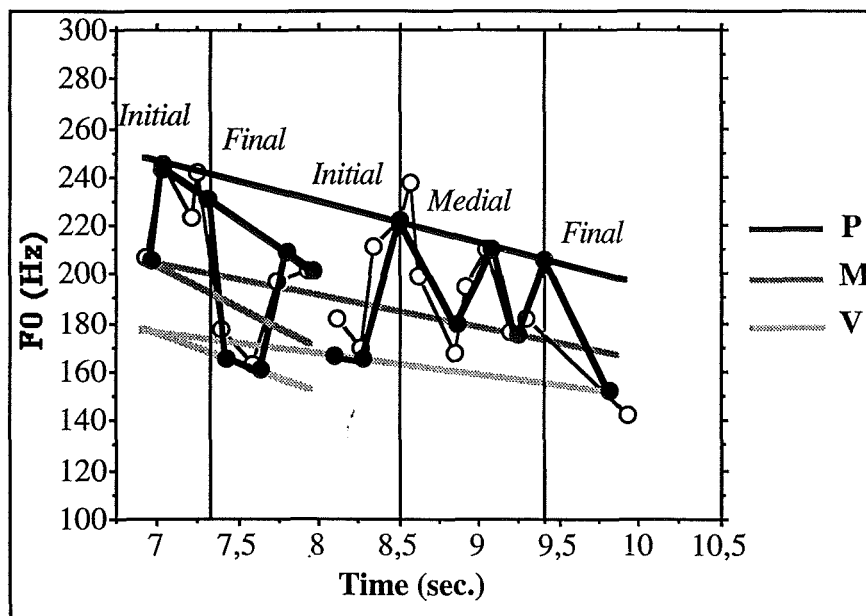


Figure 8.17. Stylized (white dots) and predicted (black dots) intonation contours for the sentence 'Una vez en el interior, los agentes encontraron a tres de los niños.', uttered by speaker M.E. Vertical lines represent boundaries between each type of pattern.

8.3. Output of the model

The output of this model is a chain of inflection points for each phonic group defined at the input. Every inflection point has two values associated to it, the first one corresponding to its F0 value, and the second one indicating its alignment to the phonetic transcription.

Figure 8.18 shows a possible output contour for the same sample sentence of previous figures.

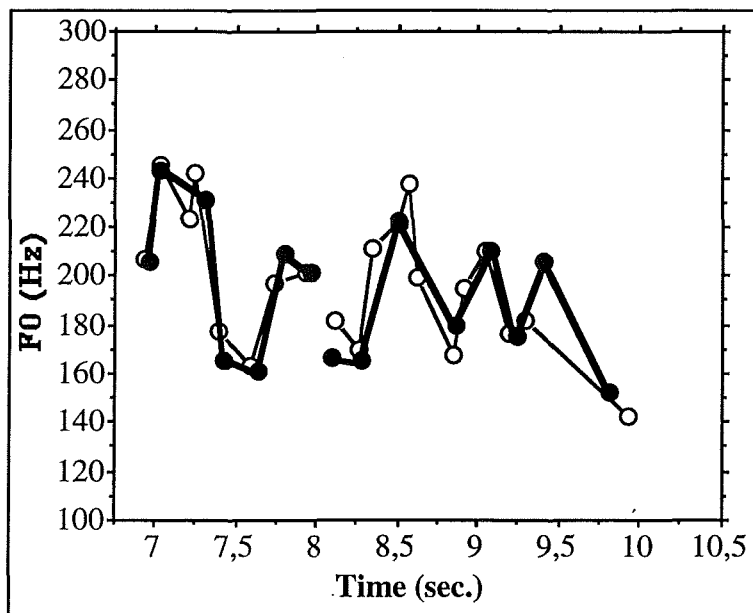


Figure 8.18. Stylized (white dots) and predicted (black dots) output contour for the sentence '*Una vez en el interior, los agentes encontraron a tres de los niños*', uttered by speaker M.E.

The predicted intonation contours for the rest of the sample paragraph can be found in appendix 10 (section 4).

The interpolation of the inflection points to obtain the complete intonation contour is assumed to be done beyond the output of the model. The insertion of interruptions in the contour due to the presence of unvoiced segments is also outside the scope of the model.

Chapter 9

CONCLUDING REMARKS

In this last chapter, the main implications of the results and the model presented in this work are discussed. First, the obtained results are analysed from the point of view of the description of intonation, not only in Spanish, but also in other languages. The results are also considered from the point of view of speech technology. Finally, a review of the main questions that this work leaves unsolved is presented.

9.1. Implications for the description of Spanish intonation

The work presented here has attempted a global phonetic description of Spanish intonation, from tonic groups to paragraphs. Several questions that could have been treated in much more detail have been left without a more precise answer. However, it has been preferred to offer a general view of Spanish intonation, in order to define a global model, rather than to focus on specific problems. For this reason, this work probably does not solve any of the questions still pending in the theoretical description of Spanish intonation, but it rather it suggests new ones for further research.

It is also important to note that this work describes the intonation of a type of material not considered in previous studies of Spanish prosody. The analysis of the intonation contours in readings of news texts has not been attempted for Spanish. In addition, the syntactic complexity of the speech material considered here is much greater than in the material used in previous descriptions of Spanish intonation. However, these characteristics of the analysed material resulted in a less 'controlled' phonetic description, which has not allowed to analyse some phenomena in much detail.

9.1.1. The description of Spanish local movements

As far as the description of Spanish local movements is concerned, the main contribution of this work is to provide a formal inventory of patterns in readings not found in previous studies.

In the case of non final patterns (initial and internal), the data presented here agree in general with the results of previous descriptions (Navarro, 1944; Fant, 1984), mainly in those aspects referring to the location of inflection points. As those studies suggested already, this work has showed, for example, that the beginning of the rising movement of an accent coincides in general with the beginning of the stressed syllable, and that the peak of these accents can appear both on the stressed syllable or on a syllable following this one.

A different approach to the description of final movements has been suggested here. The classification presented here differs in several ways from the classical description of Navarro (1944), as has been already discussed in chapter 4. However, it also shows some similarities, as for example, the definition of a rise-fall pattern, already described by Navarro.

9.1.2. The description of Spanish global movements

The description of global movements in Spanish has been attempted using the 'topline-bottomline' framework, different from the one used in more classical descriptions (Navarro, 1944, for example). The main advantage of the framework used here seems to lie in the fact that it allows a description of the different-level global phenomena using the same formalism.

As far as the question of intonational domains is concerned, classical descriptions of Spanish intonation have considered the sentence as the only intonation unit above the phonic group. The results presented in this work support the idea that new intonation units and patterns have to be defined between the phonic group and the sentence, and even between sentence and paragraph. The concept of 'intonational clause' has been introduced, although its definition and analysis has not been completed.

At the sentence level, it seems that the traditional 'tension part'-'distension part' approach can be also a useful descriptive model for complex sentences. However, despite the predictions of Navarro's model, the main phonetic cue to indicate the boundary between these two units does not seem to be a final local movement, but rather the amount of reset existing between the end of the first part and the beginning of the second one. The existence of a unique

pattern for the whole sentence has not been demonstrated clearly here; at least two patterns appear to be possible, as was discussed in chapter 6.

9.1.3. Spanish intonation compared with other languages

The framework used here for the description of Spanish intonation is similar to other ones used for modelling the intonation of several languages (the IPO framework, for example). The results obtained here indicate that Spanish intonation can be described in similar terms as the intonation of other languages. Specific similarities or differences among languages, such as the use of local movements or the shape of global lines, have not been analysed here, but the definition of a descriptive framework as this one can facilitate this type of comparative studies.

9.2. Implications for the general description of intonation

9.2.1. Intonation as a hierarchical phenomenon

The results of this work seem to support the hypothesis of a hierarchical structure for intonational phenomena. Although the question of preplanning has not been analysed in detail here, it seems that a hierarchical organization is present in the intonation contours, and some 'partial preplanning' can be recognized.

From the point of view of the phonetic description, the results seem to confirm the 'supra-declination' hypothesis, or at least the idea that intonational mechanisms can be found above the intonational unit or phonic group level.

The intonational structure proposed here support with phonetic data some descriptions of phonological structure suggested, for example, by Nespor & Vogel (1986) or Ladd (1986). The results obtained here seem to indicate that the same type of units that Nespor & Vogel consider for the description of segmental phonological processes can also be considered as the domain of suprasegmental phenomena, in this case the presence of specific intonational patterns.

9.2.2. Intonational units

The question of the definition of intonational units has been partially approached in previous chapters. Four analysis levels have been considered - tonic group, phonic group, sentence and paragraph -, and finally four

intonational levels have been accepted: phonic group (or intonation group), intonational clause, sentence and paragraph.

The relevance of the tonic group for the description of local intonational patterns has not been demonstrated here. Nevertheless, the use of stressed syllables as 'reference points' in the evolution of intonational contours has been checked. This data suggest that the use of the stress group, in the way defined in chapter 1 (a group of syllables formed by a stressed syllable and the following unstressed ones), instead of the tonic group, is more adequate for the description of the domain of local intonational patterns in Spanish. However, this question has not been analysed in detail here.

The main contribution to the description of intonation units at intonation group level is perhaps the proposal of the F0 reset as a possible cue for intonation group boundary. Reset has appeared to be a consistent phonetic cue for boundary marking of these basic units, in addition to more classical cues, such as final movements, energy lowering or pauses.

The concept of intonational clause has been introduced here but only as a descriptive tool. Much more research and discussion is needed to accept the phonological existence of a separate type of units. Nespor & Vogel (1986) accept already that intonation units can be grouped in a single unit, but they do not consider the existence of a separate type of unit at the phonological level. However, the analysis of a complex material as the one studied here indicates that these units seem necessary to describe the intonational phenomena which take place between phonic group and paragraph levels.

The status of sentences and paragraphs as intonational units has not been fully demonstrated here. They appear to play a role in the intonational organization of utterances, but they do not seem to be an obligatory domain for the intonational patterns described here.

9.3. Implications for speech technology

The description of Spanish intonation by means of a formal framework has been attempted, in order to allow the application of the results to the development of automatic systems of intonation generation. A set of patterns are offered, and some indications for the use of these patterns to express several linguistics meanings have been outlined. However, it has to be pointed out that the application of this model to TTS systems exactly as is presented here assumes the existence a powerful syntactic analyser, and a 'phonological' parser which determines the intonational structure of the input text.

9.4. Further research

The work presented here is an acoustic description of Spanish intonation, taking as starting point a stylization procedure that makes use of perceptual criteria. The relationship between the described patterns and the different linguistic factors has also been described in acoustical terms. However, a perceptual validation of the model, both at the global and the local level, is necessary:

- a) **framework evaluation:** the existence of three different levels (P, M and V) in the intonation contours has to be validated by means of perceptual tests; also, the perceptual effect of modelling global contours by means of reference lines should be analysed.
- b) **local pattern evaluation:** the perceptual interpretation of the use of the defined local patterns arises also as a necessary task.
- c) **global pattern evaluation:** a perceptual validation of the hierarchical structuring of intonation contours could be attempted.

From the point of view of the acoustical description, some questions remain unsolved. The development of a grammar that predicts the concatenation of local patterns seems necessary for a model oriented to speech technology applications. The analysis of the relationship between the location of the peaks in internal local patterns and stress or syntactic structure should also be continued. Finally, factors affecting the hierarchical organization of sentence intonation should be analysed in more detail.

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