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## PROSODIC MARKERS AT SYNTACTIC BOUNDARIES IN SPANISH

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### ABSTRACT

This paper presents a preliminary examination of the use of vowel duration and  $F_0$  movements as markers of different types of syntactic boundaries in Spanish. The study is based on a corpus of sentences extracted from read newspaper articles. Results reveal that certain prosodic cues might convey information about internal syntactic boundaries and that other cues may be related to a syntactic cohesion.

### INTRODUCTION

Studies devoted to the use of prosodic markers to signal syntactic boundaries have been carried out for different languages. For example, Klatt [1] reports on the use of vowel duration to signal syntactic boundaries in English, and the use of  $F_0$  cues is discussed, among others, by Cooper and Sorensen [2]. As far as Spanish is concerned, Signorini *et al.* [3] consider the relationship between local  $F_0$  movements and juncture, but the question of syntactic boundaries is not directly addressed.

In the present paper the relationship between prosody and syntactic boundaries in Spanish is explored in two ways. First of all, it is intended to establish the type of phonetic phenomena which may signal the presence of a syntactic boundary. Secondly, the prosodic characteristics of different types of boundaries are compared.

Vowel duration and  $F_0$  movements have been taken into account here, but other cues such as pauses should be explored in future studies.

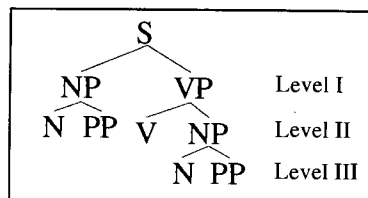
### EXPERIMENTAL PROCEDURE

#### Corpus

A large corpus of paragraphs extracted from Spanish newspapers has been collected and labelled according to syntactic and prosodic criteria. One hundred nineteen sentences read by three

non professional speakers have been chosen for the present experiment. Recordings were made in semi-anechoic conditions using a Tascam 112 cassette recorder and a Sennheiser MKH2 microphone.

Four types of syntactic boundaries are considered in order to study its effects on prosodic parameters: NP(Subject)-VP, VP-NP(Object), N-PP where N is the head of the NP (Subject) and N-PP where N is the head of the NP(Object). The hierarchical structure in three different levels can be seen in the syntactic tree:



The following variables have been taken into account in choosing the sentences from the corpus: (1) presence or absence of a pause at the NP-VP boundary; (2) length of the phrase preceding the boundary; two types of phrases have been included: long ones - more than 8 syllables - and short ones - between 2 and 8 syllables -; (3) stress placement, in order to have an equal number of stressed and unstressed syllables before the boundary; (4) syllabic structure and number of allophones in the syllables analyzed: CV syllables and CVC syllables have been included in equal numbers.

#### Measurements

The signal has been low-pass filtered and digitized at 10 kHz sampling rate using a MacAdios II™ card. Waveform displays, broad-band spectrograms and  $F_0$  contours were plotted for each sentence using the Mac Speech Lab II™

software running on an Apple Macintosh IIvx™. F<sub>0</sub> contours were obtained with a pitch tracking algorithm using an auto-correlation technique.

The duration of the vowel preceding the boundary and also in certain word-internal positions has been measured. In order to characterize F<sub>0</sub> movements, maximum and minimum values in the F<sub>0</sub> contour observed before and after boundaries have been measured at vowel centers. Maxima were located in vowels showing an F<sub>0</sub> value higher than the value at the preceding and following syllables. Accordingly, minima were located in vowels showing an F<sub>0</sub> value lower than the value at the preceding and following syllables.

**RESULTS**

**Vowel duration**

In order to compare the effect of different types of boundaries in vowel duration, only syllables containing vowels [e] and [o] have been taken into account, since it is known that these vowels have very similar intrinsic durations [4]. All vowels considered in the comparisons are non-prepausal and unstressed.

It can be seen from data in figure 1 that no significant differences have been found between the duration of vowels preceding the four types of syntactic boundaries.

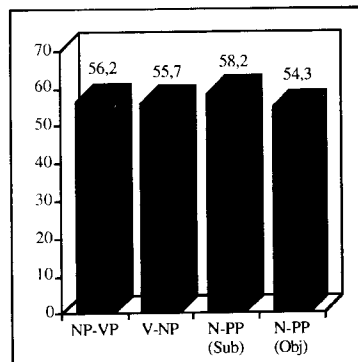


Figure 1: Vowel duration (in ms.) at different types of syntactic boundaries.

In order to assess the differences in duration between vowels located before a syntactic boundary and vowels which are

not in this position, a comparison was made with a different group of vowels. They were selected from the penultimate syllable of nouns heading an NP or selected by a PP; both phrases were adjacent to the verb and subcategorized by it.

In this case, only non-prepausal vowels were analyzed and an equal number of stressed and unstressed vowels were compared; the comparison includes the vowels [e], [o] and [a]. Results are shown in figure 2:

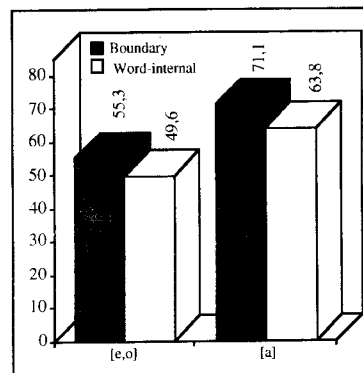


Figure 2: Vowel duration (in ms.) at syntactic boundaries and in word-internal position

Although no statistically significant differences appear, a tendency can be observed towards longer vowel durations when they occur in a syntactic boundary. It should be noted that vowels were non-prepausal in both cases, thus, the effects of pre-pausal lengthening have been avoided.

**F<sub>0</sub> movements**

Two parameters have been studied for each type of boundary: contour shape and reset.

F<sub>0</sub> movements have been characterized in terms of the local shape of the F<sub>0</sub> contour. Peaks and valleys adjacent to the boundary are used to define this contour.

An initial distinction will be made between boundaries signaled by a pause and boundaries which are realized without pause. Results for boundaries which are not coincident with a pause are summarized in table 1:

Table 1: Relationship between  $F_0$  shape and type of syntactic boundary in boundaries without pause (B: type of boundary; S: stressed / unstressed syllable; % P: percentage of occurrence of a peak before the boundary; % PFS: percentage of cases in which, when there is a peak, it appears in the syllable just before the boundary)

B	S	% P	% PFS
NP-VP	stressed	73	75
	unstressed	95	72
V-NP	unstressed	68	100
N-PP(S)	unstressed	79	73
N-PP(O)	unstressed	92	64

Table 1 shows that in most cases boundaries are preceded by  $F_0$  peaks; it also shows that when peaks appear, they are mostly located in the syllable that immediately precedes the boundary, irrespective of the stressed or non-stressed character of the syllable. It seems that no influence of the type of syntactic boundary can be found in the occurrence and location of peaks.

The results for boundaries occurring simultaneously with a pause are shown in table 2:

Table 2: Relationship between  $F_0$  shape and type of syntactic boundary in boundaries with pause (see table 1 for legend)

B	S	% P
NP-VP	stressed	59
	unstressed	74

Resets have been examined in all types of boundaries. A reset has been considered to occur if the  $F_0$  peak following the syntactic boundary is higher than the preceding peak, or if the following valley is higher than the preceding one. Three categories of reset can then be defined: (a) only peak-to-peak reset, (b) only valley-to-valley reset, and (c) simultaneous peak-to-peak and valley-to-valley reset.

Results are presented in tables 3 and 4 below.

Table 3: Percentage of resets (%R) and most frequent reset type (RT) at the NP-VP boundary (P: peak-to-peak reset; V: valley-to-valley reset)

	S	% R	RT
With pause	stressed	82	P+V 64%
	unstressed	74	P+V 50%
Without pause	stressed	58	V 57%
	unstressed	42	V 75%

Resets appear more frequently when the NP-VP boundary is coincident with a pause. It is also worth noting that in those cases, simultaneous peak and valley resets are found.

Table 4: Percentage of resets (%R) and most frequent reset type (RT) at syntactic boundaries without pause preceded by an unstressed syllable (P: peak-to-peak reset; V: valley-to-valley reset)

B	% R	RT
NP-VP	42	V 75%
V-NP	42	V 38%
N-PP (S)	26	V 80%
N-PP (O)	34	P 75%

It appears from these results that the frequency of occurrence of resets can be related to the degree of syntactic cohesion.

## DISCUSSION

As far as temporal markers of syntactic boundaries are concerned, only vowels in non-prepausal position have been examined, since the effects of prepausal lengthening in Spanish are already well established [4]. A tendency towards a lengthening of vowels in syntactic boundaries seems to appear, but the results are not conclusive from a statistical point of view (see figure 2).

An examination of the shape of the  $F_0$  contour shows that an  $F_0$  peak is consistently present in the syllable preceding the boundary when a pause is not produced. The presence of this peak could be also explained as a function of the lexical accent. It is interesting to note that in the case of unstressed syllables, the peak could be the result of a shift from the lexically stressed syllable, as

discussed in [5]. Nevertheless, the presence of a peak simultaneously to the stressed syllable preceding the boundary suggest that NP-VP boundaries may, at least in some cases, inhibit peak displacement, so that  $F_0$  peaks could mark the boundary. It seems also that pauses tend to reduce the occurrence of  $F_0$  peaks at NP-VP boundaries (see table 3).

Resets also tend to appear at syntactic boundaries. It is worth noting that they seem to be related to the occurrence of a pause in the case of NP-VP boundaries.

The discrimination of the type of syntactic boundary by means of prosodic cues has also been studied. It seems clear that vowel duration does not distinguish between the types of syntactic boundaries observed. The  $F_0$  shape at boundaries without pause does not seem to contribute either to this differentiation.

$F_0$  resets seem to be the only prosodic cue that behaves in a different way according to the type of boundary, since NP-VP and V-NP boundaries show a higher percentage of resets than N-PP boundaries (see table 4). Resets could be then related to major boundaries.

Further research is needed to establish whether the degree of reset can cue differences in the syntactic hierarchy.

The relationship between concomitant cues can also be explored. On the one hand, the presence of a pause seems to trigger a reset (see table 3). On the other hand, it could be also possible that  $F_0$  peaks were related to pauses, since peaks at boundaries seem to be more frequent when pauses are not present (see tables 1 and 2).

### CONCLUSIONS

A first attempt to describe the behaviour of prosodic cues at syntactic boundaries in Spanish has been presented. The results of the study are not conclusive about the use of prosodic cues in marking different types of boundary. Moreover, vowel lengthening and  $F_0$  movements adjacent to boundaries which do not coincide with a pause can not be clearly related to syntactic phenomena. However, some results tend to favor the hypothesis that resets could be indicators of the degree of syntactic cohesion.

### Acknowledgment

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