Pre-Nuclear Tonal Inventories of Spanish Intonation

Eugenio Martínez-Celdrán[†], Ana Ma. Fernández-Planas[†] and Natalia Fullana-Rivera[†]
† Laboratori de Fonètica. Universitat de Barcelona, Spain
E-mail: emartine@fil.ub.es, planas@fil.ub.es, fullnat@yahoo.es

ABSTRACT

The present study examined the main pitch accents in Spanish declarative and interrogative sentences. We looked at speech produced under laboratory conditions, as it allowed us to control for the word type according to its stress. Contrary to Sosa's [8] conclusions that the peaks in declarative utterances are always on post-tonic syllables and the pitch accent is L*+H, our results show that a certain degree of variability of pre-nuclear contours exists, mainly H* and L+H*, in both sentence types. Our results also show that the predominant structure in sentences with paroxytone words is L*+H in the first pitch accent of the sentence, but this structure is less frequent in sentences containing oxytone words. Furthermore, if the sentence consists of several pitch accents, the pitch accent immediately preceding the nuclear tone is normally H*, due to the downstep effect of the sentence.

1. INTRODUCTION

J.M. Sosa [8] pointed out about the intonation of Spanish declaratives that «the peaks are always on unstressed syllables. At least for pre-nuclear contours, the common assertion that the highest point corresponds to stressed syllables is not in keeping with my findings. The stressed syllable is always low, followed by the high on the subsequent unstressed syllable, even across words and syntactic phrases. If there is at least one accented syllable in the pre-nuclear contour, the pitch accent will be L*+H». Other authors [2, 4, 5] have endorsed Sosa's [8] findings.

The aim of this study was to examine whether Sosa's assertion applies to both the declarative sentence type and the interrogative sentence type.

As Sosa's work focused on declarative sentences only, which were mostly made up of paroxytone words (or words accented on the penultimate syllable), in this paper we extended the study of both sentence types to oxytone words (or words accented on the last syllable).

2. METHOD

2.1. POINTS OF ANALYSIS

The study of pitch accents in Spanish declaratives and interrogatives was based on two types of stressed words: oxytone and paroxytone words[1].

Our objective was to determine automatically which tone – high (H) or low (L) – is for the most part associated with the stressed position, pre-stressed or post-tonic position in each of those two word types. In all cases, a post-tonic syllable was the unstressed syllable that came after a stressed syllable, even if the stressed syllable belonged to another word (as was the case of oxytone words). And in the case of paroxytone words, a pre-stressed syllable of the preceding word (if present) was analyzed when the word did not contain a pre-stressed syllable.

2.2. DECISION AS TO THE RESULTING TYPE OF PITCH ACCENT

In order to determine whether the resulting pitch accents were monotonal or bitonal, we followed the psycho-acoustic principle that takes into account the differential threshold of perception of the existing difference between two tones. Thus, we adopted the threshold that [7] proposed. That is, when two consecutive tones had a difference smaller than 1.5 semitones (ST), they were considered as one tone only[2]. When the difference was larger than 1.5 ST, bitonal accents were considered to have been produced.

2.3. STIMULI AND SUBJECTS

A total of 32 sentences comprised the corpus of study. They were distributed into four blocks of eight sentences each. Each sentence was composed of either oxytone words or paroxytone words. More precisely, block 1 contained sentences made up of oxytone words such as *La mansión se dibujó sobre el azul* and *El peral se destacó sobre el jardín.* Block 3 comprised sentences with paroxytone words. Examples of sentences in block 3 were *Las casonas estaban en la colina* and *Las manzanas estaban en la mesita*. Blocks 2 and 4 were designed by means of adding an adjective to the grammatical subject of the sentence (e.g., *Las casonas <u>marinas</u> estaban en la colina* and *La mansión <u>añil</u> se destacó sobre el jardín*).

Another varying characteristic of the stimuli was the number of pitch accents in the sentences. Out of the 32 sentences, 16 sentences had three pitch accents (blocks without enlargement) and the remaining 16 had four pitch accents (enlarged blocks). For this study, one less pitch accent in each type of block was analyzed, resulting in 80 pitch accents in total ((16 sentences x 2 pre-nuclei) + (16 sentences x 3 pre-nuclei)).

Eight subjects (4 male, 4 female) participated in the experiment. They were speakers of Standard Peninsular Spanish without a noticeable regional accent. Four

[1] Proparoxytone words were not included in this study, due to their infrequent use in Spanish [6] presents the usage percentages of the different types of stressed words: oxytone words 17.75%, paroxytone words 79.50%, and proparoxytone words 2.75%.

[2] H* indicates that there are no perceptual differences (no larger than 1.5 ST) between the stressed syllable and its adjacent syllables.

ISBN 1-876346-48-5 © 2003 UAB

subjects produced the declarative sentences, while the other four speakers produced the interrogative sentences. In both cases, all subjects read the sentences twice.
A total of 640 pre-nuclear accents was obtained for declarative sentences (80 pre-nuclear accents x 4 subjects x 2 repetitions), and another 640 accents for interrogative sentences (80 pre-nuclear accents x 4 subjects x 2 repetitions).

2.4. ANALYSIS OF DATA

SIL's program, *Speech Analyser* v. 1.06a, was used to analyze F0. Frequency values were always measured at the centre of the vowel. For that purpose, four windows were present on the computer screen: waveform, spectrogram, F0 curve, and intensity curve. The maximum value of intensity was chosen, provided that it was located approximately at the vowel midpoint. At that point, the F0[3] value was noted down. Finally, the resulting pitch accents were obtained by means of specific rules created with the statistical package SPSS10.0.

3. RESULTS

The results obtained are classified according to the five pitch accents that appear in Tables I and II. The classification was also based on the word type (oxytone or paroxytone word) and its order of appearance in the pre-nuclear contour (1st, 2nd, and 3rd position).
Values with higher frequencies are highlighted in bold type in the tables below:

Pitch accent	Oxytone word (%) 1st	2nd	3rd	Paroxytone word (%) 1st	2nd	3rd
1. H*	6.3	32.8	20.3	3.9	21.9	**48.4**
2. L+H*	**71.1**	**35.9**	**45.3**	17.2	6.3	3.1
3. L*+H	21.1	16.4	34.4	**77.3**	**41.3**	15.6
4. H+L*		3.1			30.5	32.8
5. H*+L	1.6	11.7		1.6		

Table I. Frequencies of declarative intonation accents.

Pitch accent	Oxytone word (%) 1st	2nd	3rd	Paroxytone word (%) 1st	2nd	3rd
1. H*	0.8	**40.6**	**76.6**	0.8	14.1	**50**
2. L+H*	14.1	3.1	12.5	0.8		
3. L*+H	**83.6**	14 .1	3.1	**98.4**	24.2	
4. H+L*	0.8	30.5	1.6		28.9	25
5. H*+L	0.8	11.7	6.3		**32.8**	25

Table II: Frequencies of interrogative intonation accents.

A quick look at the results points to the fact that Sosa's [8] assertion should be refined both for declarative utterances (in particular, when they are composed of oxytone words) and interrogative sentences.
Next, the most frequent pitch accents obtained in the study are displayed in Table III. In addition to the sentence type, the word type, according to its stress, and the position of the word in the sentence in relation to the nucleus were taken into account.

Sent.	Word type	1st position pre-nuc.	2nd position pre-nuc.	3rd position pre-nuc
Decl.	oxytone	L+H*	L+H*	L+H*
	paroxytone	L*+H	L*+H	H*
Inter.	oxytone	L*+H	H*	H*
	paroxytone	L*+H	H*+L	H*

Table III: Most frequent pitch accents.

As seen in Table III, the typological variety existent in the production of speech is clearly demonstrated. Moreover, the most frequent pitch accents found point to the importance of considering the type of accent and its position in the sentence in the analysis of pre-nuclear contours.
By arranging the results of Table III in bar graphs, it is possible to find out which positions of the pre-nucleus are better defined as to their most frequent typology:

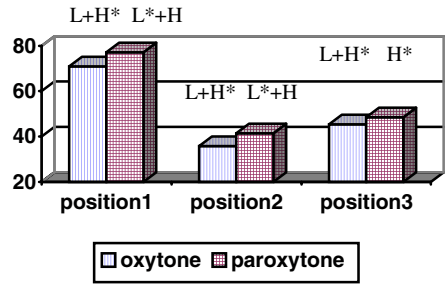

Figure 1. Declarative sentence type.

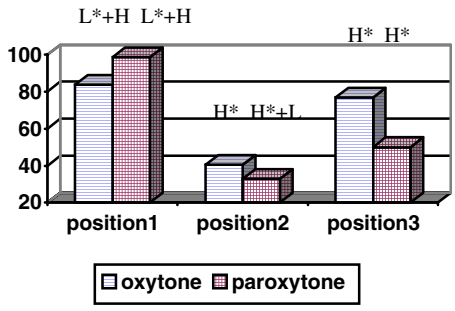

Figure 2. Interrogative sentence type.

In Figure 1, it can be seen that position 1 has a clear presence in the type of the most frequent pitch accents obtained, since the percentage values of position 1 are closer to 100% than those of positions 2 and 3 in both sentence types. On the other hand, in all sentence positions the paroxytone word presents a better-defined taxonomy by position in the declarative sentence type; while the paroxytone word is better defined only in the first position

[3] It is important to mention this procedure, for several people contributed to the analysis of data. The following members on the research group of the Phonetics Lab at the Faculty of Philology at the U.B. analyzed the declarative sentences: V.Salcioli, L.Romera, J. Castellví, A.Ortega, and Mª C.Amorós, as well as G.Toledo and, of course, the authors of this study. And three advanced students on the Experimental Phonetics course, N.Ariet, J.Frago, and M.Gil, helped in the analysis of interrogative sentences. Consequently, an objective criterion of analysis was necessary, so that collaborators could carry out the analysis on the same basis.

in the case of interrogative sentences.
It should also be noted that the third position is better defined in interrogative utterances than in declarative sentences (especially in oxytone words), as they approximate more the nucleus, which invariably has a rising tone in these sentences.
The two graphs in Figure 3 further illustrate the taxonomic variety of Table III by means of the waveform and the F0 curve. The first graph corresponds to the declarative sentence *La mansión añil se dibujó sobre el azul* (made up of oxytone words). The second graph contains the declarative sentence *Los tomates pelados estaban en la cocina* (with paroxytone words).
The first graph in Figure 4 corresponds to the interrogative sentence *¿El peral se destacó sobre el jardín?* (oxytone words), and the second one to the interrogative sentence *¿Las manzanas cocidas estaban en la mesita?* (paroxytone words).

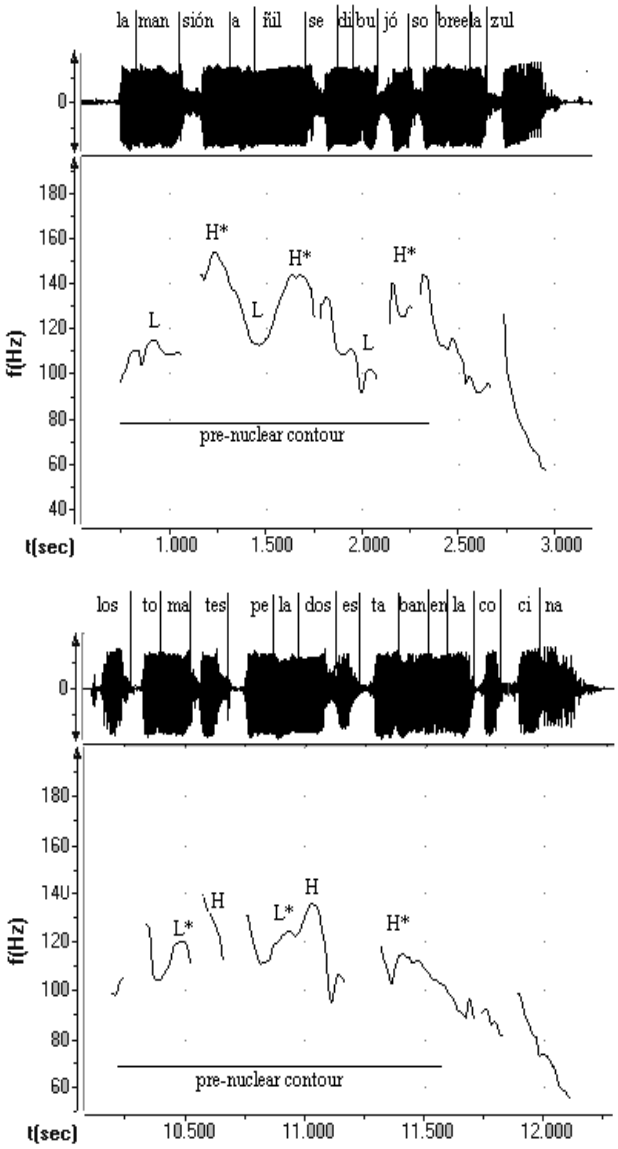

Figure 3. Declarative sentence type.

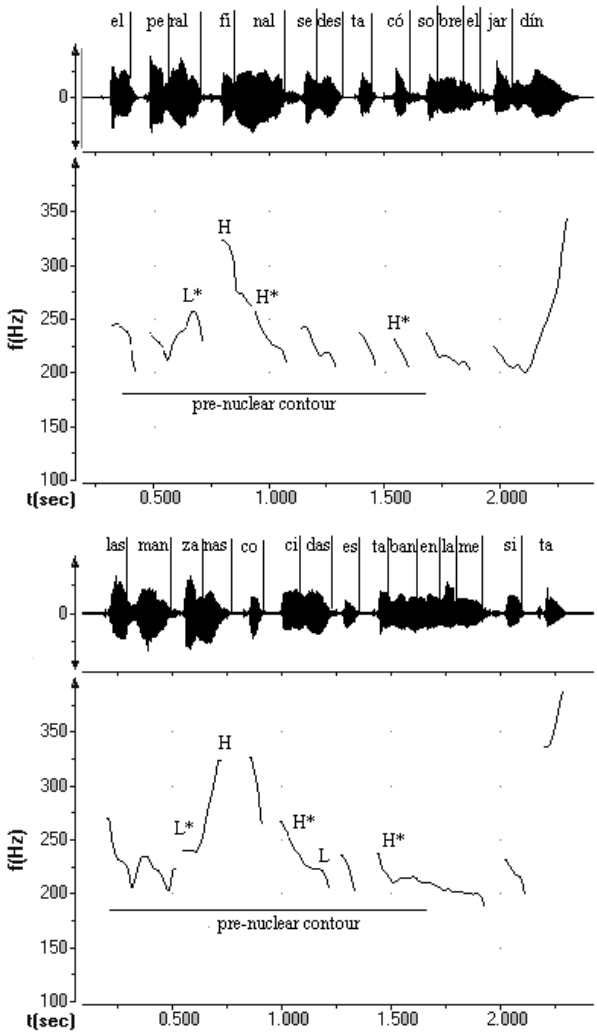

Figure 4. Interrogative sentence type.

Figure 5 displays the correspondence between the various pitch accents and their position in the sentence (labeled with the numbers 1-3, that is, from first accent to third accent). This figure is a broad generalization of the results obtained, as neither the word type nor the sentence type was taken into account. The predominance of the type L*+H in the first pre-nuclear sentence position can be observed, as well as that of the type H* in the last position before the nucleus.

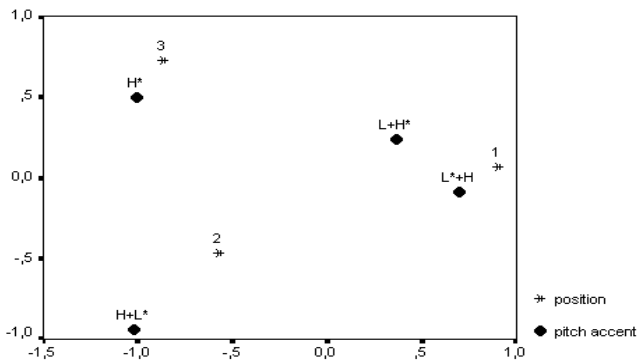

Figure 5. Analysis of the correspondences between pitch accents and their position in the sentence.

ISBN 1-876346-48-5 © 2003 UAB

4. DISCUSSION

Based on the results reported here, it then seems necessary to refine Sosa's [8] statement that: «the peaks are always on unstressed syllables […] If there is at least one accented syllable in the pre-nuclear contour, the pitch accent will be L*+H». Another reason for refinement lies in the fact that [8]'s work looked at sentences with paroxytone words almost exclusively, and did not consider any filter, such as the filter used in this study – the threshold of 1.5 ST – to examine whether there were perceptual differences between a valley and a peak.

According to our results, there seems to exist a great variety of pitch accents in all sentence positions. Although the results are consistent with Sosa's findings in that the predominant pitch accent in the first position of the pre-nuclear contour is L*+H, this is not the case of positions 2 and 3. Nor is it (L*+H) predominant in declarative sentences with oxytone words. Instead, in the third position the most common pitch accent is H*, probably due to the downstep effect that takes place in any sentence [3]. Furthermore, if we take, for instance, a male voice and a declarative sentence type, the following mean values are obtained: the minimum value is 77 Hz, and the value of the post-tonic syllable, according to its sentence position, steps down progressively towards the minimum value: 143-133-126-80 Hz. The last value is that of the declarative nucleus. If the mean values for interrogative sentences are calculated, the minimum value is 97 Hz, and the values of post-tonic syllables are as follows: 150-130-113-165 Hz. In this case, the third position is the closest one to the minimum value, as the interrogative nucleus is not only rising, but also one of the highest values. In Table III, it can be observed that the most frequent pitch accent for the third position is H*, whereas L*+H is always the most frequent pitch accent for the initial position, especially in interrogative sentences. Starting with a high value allows the differences between the valley and peak to go beyond the filter of 1.5 ST. But when the value is low, the differences hardly ever excel the filter, and so the resulting pitch accent is basically monotonal. In declarative sentences, the means of the differences in ST of stressed and post-tonic syllables adopt the following sequence, according to the order of appearance in the sentence: 1.70-1.40-1.00-1.90 ST; and in the interrogative sentence type: 4.40-2.60-0.90-4.00 ST. All this gives us an idea of the differences between valleys and peaks, and how these differences diminish from the initial position to the third position, while the nucleus presents noticeable differences again. In both sentence types, the differences of the third position are below the threshold considered.

Last, it should be noted that in the first position of declarative sentences the predominant pitch accents have the peak at the end of the word, despite the fact that the stress is on the last syllable of oxytone words and on the penultimate syllable of paroxytone words. That is to say, the peak signals the end of the word, which agrees with the results found for Catalan [1].

5. CONCLUSIONS

To sum up, although there exists a great deal of variety of declarative pitch accents, the predominant accent in the first position of the nucleus is L*+H. But this is not the case of the second and third positions. Rather, the most frequent accent is H* in the position immediately preceding the nucleus, as long as there is more than one pitch accent in the pre-nuclear contour of the sentence, both in declarative and interrogative sentences. Furthermore, there seems to be a tendency to the alignment of the peak with the end of the word, at least in declarative sentences.

ACKNOWLEDGMENTS

We would like to thank Pilar Prieto for discussion of this material.

This research was supported by SEUID– Department of the State of Education, Universities, Research and Development–from the Ministry of Science and Technology in Spain, Reference # PB98-1230.

REFERENCES

[1] E. Estebas-Vilaplana, "The modelling of prenuclear accents in central Catalan declaratives", *Catalan Journal of Linguistics 2, Special Issue on Romance Intonation*, in press

[2] T. L. Face, "Intonation in Spanish declaratives. Differences between lab speech and spontaneous speech", *Catalan Journal of Linguistics 2, Special Issue on Romance Intonation*, in press

[3] D. R. Ladd, *Intonational phonology,* Cambridge: Cambridge University Press, 1996.

[4] T. Navarro Tomás, *Manual de entonación española*. Madrid: Guadarrama, 1974, 4th ed.

[5] P. Prieto, J. van Santen and J. Hirschberg, "Tonal alignment patterns in Spanish" *Journal of Phonetics*, vol.23, 4, pp.429-451, 1995.

[6] A. Quilis, *Fonética acústica de la lengua española,* Madrid: Gredos, 1981.

[7] A. C. M. Rietveld, and C. Gussenhoven, "On the relation between pitch excursion size and prominence", *Journal of Phonetics*, 13, pp. 299-308, 1985.

[8] J. M. Sosa, "Nuclear and pre-nuclear tonal inventories and the phonology of Spanish declarative intonation", in K. Elenius and P. Branderud (eds.) *Proceedings of the ICPhS 95*. Arne Stombergs: Stockholm, vol. 4, pp. 646-649, 1995.