The search for phonological targets in the tonal space: H1 scaling and alignment in five sentence-types in Peninsular Spanish

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1. Introduction

The quest for phonological and linguistic units in the F0 continuum has been and still is one of the main research questions in intonation studies. In recent years there has been accumulating evidence that LH points in the tonal space behave as phonological targets. Indeed, H peaks of both nuclear and prenuclear pitch accents are produced with an amazing degree of stability in tonal scaling and tonal alignment across languages (see Arvaniti et al. 2000; Liberman and Pierrehumbert 1984; Prieto, van Santen, and Hirschberg 1995; Prieto, Shih, and Nibert 1996; Silverman and Pierrehumbert 1990; and recent work by Xu 1999, 2002). Nowadays, a central assumption of the standard autosegmental-metrical model (and of most work on intonation) is that pitch range variation is paralinguistic, that is, it expresses exclusively differences in emphasis or prominence. This assumption relies on a version of the so-called Free Gradient Hypothesis (Ladd 1996). It is indeed clear that one of the most common effects of gradually expanding the pitch range of a given pitch accent is the pragmatic reinforcement of the utterance, that is, an increase in the degree of speaker's involvement in the speech act. Recently, though, some work within the autosegmental model has revealed that pitch range variation does not always correspond to phonetically gradient changes indicating overall emphasis/prominence (due to the speaker's implication in the speech act) but rather it can trigger categorical distinctions in meaning (Hirschberg and Ward 1992; Ward and Hirschberg 1985; Ladd 1994, 1996). Thus, steps have been taken towards the phonologization of the pitch range category such as the inclusion of a [raised peak] feature (Ladd 1994, 1996) or an upstepped accent in the tonal inventory (Beckman et al. 2002).

This work sets out to contribute to this line of research by presenting new materials from Peninsular Spanish intonation with the goal of testing the predictions of the pitch target view and the free-gradient view of intonational production on the behavior of LH pitch accents in 5 different sentence-types (statements, yes-no questions, wh-questions, commands, and exclamatory sentences). The main goal of the study is to describe the effects of sentence-type information on the scaling and alignment behavior of sentence-initial peaks (H1). In this respect, Spanish represents a particularly interesting case, as past studies on Spanish intonation have noted that the presence of higher initial peaks both in interrogative (Canellada and Kuhlmann Madsen 1987; Navarro Tomás 1944; Sosa 1992, 1999) and imperative utterances (Kvavic 1988; Navarro Tomás 1944; Willis 2002). For example, Navarro Tomás points out that "in the first accented syllable [of interrogative utterances] pitch is increased by three or four semitones over the average level." (Navarro Tomás 1944:141), while "imperative expressions such as *¡Calla!* 'Shut up!', produced with no great emphasis, are produced with a first H peak which is 7 or 8 semitones higher than statements" (Navarro Tomás 1944:186; translation mine).[1]

The data analyzed in this article reveal that F0 levels attained by L and H values are strikingly regular across repetitions of the same utterances within subjects, thus confirming the prediction of the pitch-target hypothesis (i.e., in pronouncing an intonation contour, speakers clearly aim for precise F0 targets). Utterance-initial rising accents have different LH alignment and scaling properties depending on phrasal-type information. One the one hand, while late sentence-initial peaks are typical of statements and interrogatives, early peaks characterize imperatives and exclamatory sentences. On the other hand, sentence-type has also a clear effect on H1 scaling: Statements have the lowest F0 peaks, imperatives and interrogatives are higher, and exclamatives are the highest, clearly advocating for a 2-way (or possibly a 3-way) distinction in H1 height. In sum, the results of this article clearly demonstrate that F0 scaling variation is not only a continuum that varies gradiently to express emphasis, but it can also be used to convey grammatical differences, i.e., sentence-type marking.

2. Speech materials

It has often been reported that factors like phrasal length, phrasal position and within-word position of the target accent play a crucial role in determining the phonetic realization of pitch accents. For example, Silverman and Pierrehumbert (1990) for English and Prieto, van Santen, and Hirschberg (1995) for Spanish have reported that prosodic factors like sentence-position, within-word position and distance-to-stress trigger alignment changes on pitch accent gestures. With regard to pitch scaling, several production experiments have found that peak values of prenuclear accents are quite stable within speakers and can be predicted exclusively on the basis of the value of the previous peak (Liberman and Pierrehumbert 1984 for English; Prieto, Shih, and Nibert 1996 for Spanish). The database described in this section was designed to test the effects of utterance length and within-word position on the scaling and alignment patterns of pitch accents (and especially, utterance-initial pitch accents) found in the following sentence-types:

1. Statements
2. Yes-no questions
3. Wh-questions
4. Commands
5. Exclamative sentences

The two sets of utterances below show two-accent utterances containing words with penultimate stress (left-hand column) side by side with two-accent utterances containing words with final stress (right-hand column). Stressed syllables are marked in boldface. Whenever possible, words were composed of open syllables and sonorant consonants (to avoid segmentally-induced effects on the F0 curve). For a complete set of utterances (encoded using the same notational scheme), see the Appendix.

2p1: *La **ne**na **mi**ra*	2u1: *La ma**má** mi**ró***
2p2: *¿La **ne**na **mi**ra?*	2u2: *¿La ma**má** mi**ró**?*
2p3: *¿**Dón**de **mi**ra la **ne**na?*	2u3: *¿**Qué** mi**ró** la ma**má**?*
2p4: (imp.) *¡**Mi**ra a la **ne**na!*	2u4: (imp.)*¡Mi**rad** a la ma**má**!*
2p5: (excl.) *¡**Mi**ra a la **ne**na!*	2u5: (excl.) *¡Mi**ró** a la ma**má**!*

Two speakers of Peninsular Spanish (henceforth PS) read 2 repetitions of each utterance in the database in random order, for a total of 240 utterances (60 utterances x 2 repetitions x 2 speakers = 240 utterances). Speakers were asked to read the utterances with a normal speech rate and avoiding emphatic readings and pauses. The exclamative and imperative readings (which in some instances are just the same sentence; cf. 2p4 and 2p5 in the examples above) were elicited by prompting a written message to the reader that this particular meaning was intended.[2] All of the utterances were produced in a single intonational phrase, with no prosodic breaks. The two informants were a male speaker from Lleida, Guillem

Hernández (henceforth GH), and a female speaker from Huesca, Mercedes Nasarre (henceforth MN). Even though GH is a Catalan-Spanish native bilingual speaker, the intonation patterns produced by the two speakers were very consistent across sentence-types: The differences between both subjects potentially due to dialectal differences only emerged in some isolated examples (see wh-questions in section 3.2).

The database was prosodically annotated using ToBI, and the following measurements were manually indicated in each sound file: Utterance-initial F0 value (In), utterance-final value (Fin), highest F0 peak and lowest F0 value for every pitch accent and boundary tones. To calculate the timing values of peaks and valleys, the following measurements were also marked with the help of spectrograms: Onset (On1, On2) and offset (Of) of every target syllable.

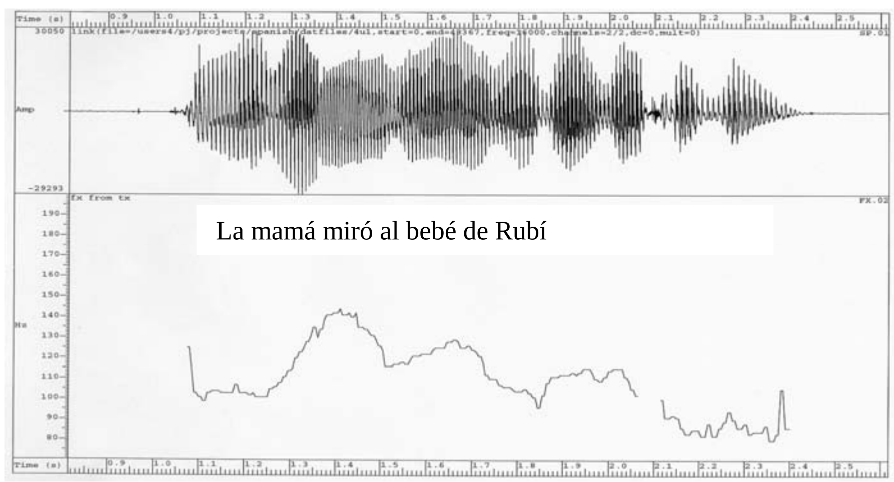

Figure 1. Waveform and F0 contour of the utterance *La mamá miró al bebé de Rubí,* produced by speaker GH.

3. Analysis of the data

3.1. Statements

Both speakers produced simple declarative sentences with a series of downstepped rising prenuclear accents and a rising nuclear accent (with very compressed pitch range). After the nuclear accent, the curve descends gradually to the bottom of the speakers' range. Figure 1 shows the waveform and the F0 contour of the 4-accent sentence *La mamá miró al bebé de Rubí* ‘Mummy looked at Rubí’s baby', as produced by speaker GH.

Utterance-initial and utterance-final F0 values were found to be rather constant for a given speaker, and no correlation was found between phrasal length and initial/final F0 values (with the exception of initial values in sentences with one accent, which are slightly lower than the rest for the two speakers). The two graphs in Figure 2 plot the average utterance-initial and final values (in Hz) for sentences of different lengths (1 to 4 pitch accents) for speakers GH and MN. Except for single-pitch accent sentences (e.g., *La mamá*), speakers produced the test utterances with an almost invariant utterance-initial (103 Hz for speaker GH and 225 Hz for speaker MN) and utterance-final F0 value (85 Hz for speaker GH and 184 for speaker MN). Pairwise *t*-tests comparing beginning and endpoint values in four utterance-length conditions (1 to 4 pitch accents) show that there is no statistical difference between them for the two subjects (except for utterance-initial F0 values in single-accent sentences, which are highly distinct; at $p < 0.01$). This result corroborates Liberman and Pierrehumbert's (1984) findings for English and Prieto, van Santen and Hirschberg’s (1995) for Spanish.

Figure 3 plots the average absolute F0 value of the first H peak (in Hz) in utterances of different lengths (1 to 4 pitch accents) for speakers GH and MN. The height of the first accent peak is rather constant across test sentences, with the exception of initial peaks in single-accented utterances (which are substantially lower). Pairwise *t*-tests comparing H1 in 4 different sentence-length conditions reveal that differences in height are only significant for 1-accent sentences (at $p < 0.01$) for the two subjects. These results confirm previous findings on Spanish H scaling (Prieto, van Santen and Hirschberg 1995) in the sense that utterance-length does not substantially affect the control of utterance-initial H pitch range values. That is, speakers do not seem to plan out the utterance in advance and do not progressively ‘adapt’ the height of the first peak to the length of the sentence (thus, no evidence is found of hard preplanning in Liberman and Pierrehumbert’s 1984 sense):

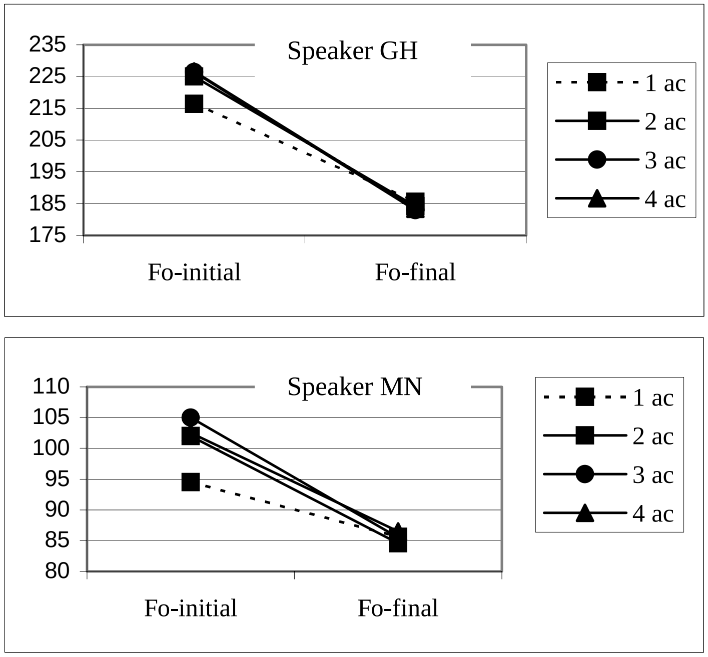

Figure 2. Mean utterance-initial and utterance-final F0 values (in Hz) in declarative sentences of different lengths (from 1 to 4 pitch accents) for speakers GH and MN.

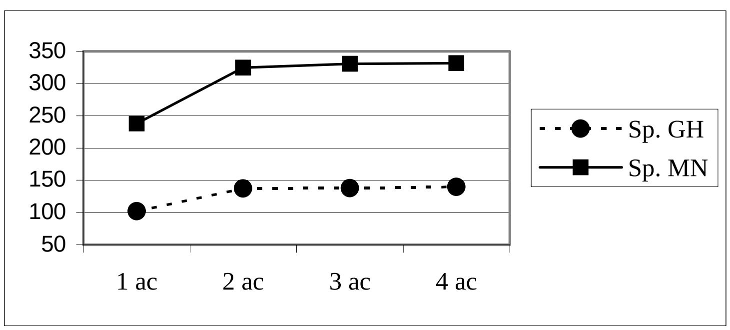

Figure 3. Mean absolute F0 value of the first peak (in Hz) in declarative utterances of different lengths (from 1 to 4 pitch accents) for speakers GH and MN.

Previous work on Spanish intonation of statements has acknowledged that rising gestures typically start at the onset of the accented syllable, while the peak is generally placed in the posttonic syllable in prenuclear positions and within the tonic syllable in nuclear positions (Face 2001a, 2001b; Navarro Tomás 1944; Hualde 2002; Prieto, van Santen and Hirschberg 1995; Sosa 1999, among many others). One possible interpretation of these facts is that the phonological composition of both rising accents is the same and that H in nuclear position is shifted backwards by prosodic pressure from the L boundary tone (cf. Nibert 2000; Prieto, van Santen and Hirschberg 1995). By contrast, recent work has attributed the contrast in H alignment in nuclear vs. prenuclear positions to a phonological contrast between two accent-types: L+H* for early peak nuclear accents and L*+H for a late peak prenuclear accents (cf. Beckman *et al* 2002; Face 2001a, 2001b; Hualde 2002; Sosa 1999, among others). The two graphs in Figure 4 plot the mean *peak delay* of the first H peak (or distance in ms from the peak to the onset of the accented syllable) as a function of two conditions: Phrasal position (nuclear vs. non-nuclear) and within-word position (antepenultimate, penultimate and final). As expected, H peak delay is significantly shorter in nuclear than in prenuclear position, in all within-word positions. Pairwise *t*-tests comparing the values of H1 peak delay in the two phrasal conditions (nuclear vs. prenuclear) were highly significant (at $p < 0.0001$) for the two speakers. Moreover, the data in Figure 4 shows a slight effect of within-word position, that is, peaks tend to be aligned with the right edge of the word and are progressively more retracted as the distance from the peak to the end of the word decreases in non-nuclear contexts.

Table 1 shows the mean relative peak delay in parentheses (calculated by dividing the absolute peak delay by the duration of the accented syllable) in the same conditions plotted in Figure 4. Relative peak delay measures reveal peaks in nuclear position are always realized within the boundaries of the accented syllable (i.e, the proportion is always less than 1), in contrast with peaks in prenuclear positions. The relative peak delay results in Table 1 clearly advocate for a distinct phonological representation between prenuclear (delayed rise) and nuclear accents (non-delayed rise) in declaratives (as advocated by Face 2001a, 2001b; Hualde 2002; Sosa 1999, among others) and exclude a phonetic explanation for early F0 peak alignment in nuclear contexts. Indeed, the phonetic explanation would not account for the presence of early H peaks in antepenultimate positions, where the prosodic pressure from the L boundary is not active anymore.

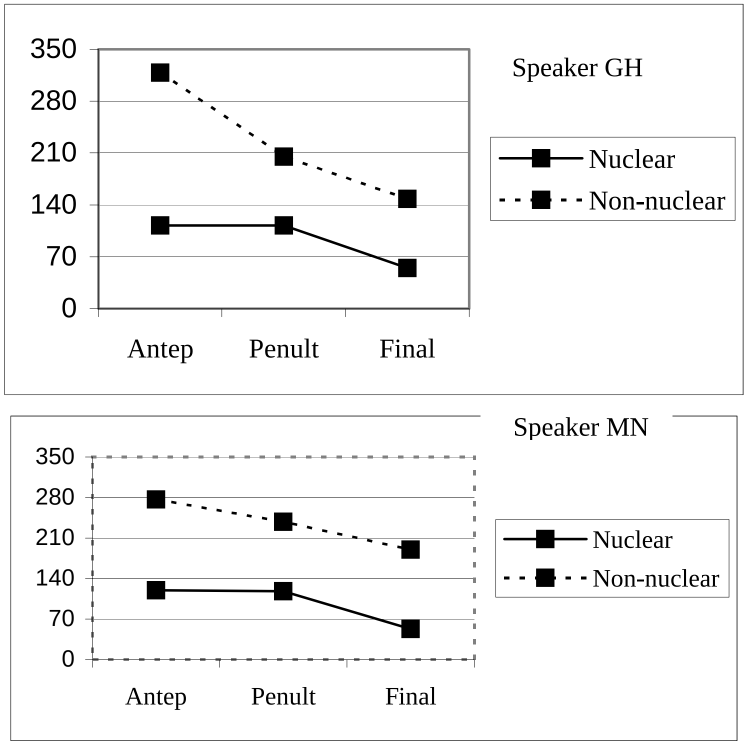

Figure 4. Mean peak delay (in ms) as a function of phrasal position (nuclear vs prenuclear) and within-word position (antepenultimate, penultimate, final) for speakers GH (top) and MN (bottom).

Table 1. Mean peak delay (in ms) in nuclear and non-nuclear positions for speakers GH (top) and MN (bottom).

Speaker GH	Prenuclear	Nuclear
antepenultimate	318.33 (2.64)	112 (0.74)
penultimate	205 (1.58)	112 (0.59)
final	148.33 (1.30)	55 (0.29)
Speaker MN	Prenuclear	Nuclear
antepenultimate	276.66 (2.15)	120 (0.70)
penultimate	238 (1.99)	118 (0.58)
final	190 (1.01)	53 (0.40)

3.2. Questions

Figures 5 and 6 illustrate the waveform and F0 contours of a yes-no question (*¿La nómada mira el número de lámina?*) and a wh-question (*¿Dónde mira la nómada el número de lámina?*) as produced by speaker GH. The two speakers used the same intonational contour for the two sentence-types (except for speaker MN, which very sporadically produced the contour in Figure 7).[3] Absolute interrogative sentences in Peninsular Spanish are characterized by an utterance-initial rising accent aligned with the first stressed syllable, followed by a continuously falling F0 gesture line over the phrase-medial accented syllables (in fact, all phrase-medial stresses were deaccented and showed a peak in our data, thus, the F0 value at the onset was always higher than at the offset). The last accent is always pronounced with a low tone followed with a final rise. Navarro Tomás (1968:226) describes the tune of a PS absolute interrogative sentence as follows: "Interrogative sentences are characterized by an utterance-initial high tone (which is higher than the normal tone), which descends gradually until it reaches the penultimate syllable in the utterance, starting to rise on the utterance-final syllable."

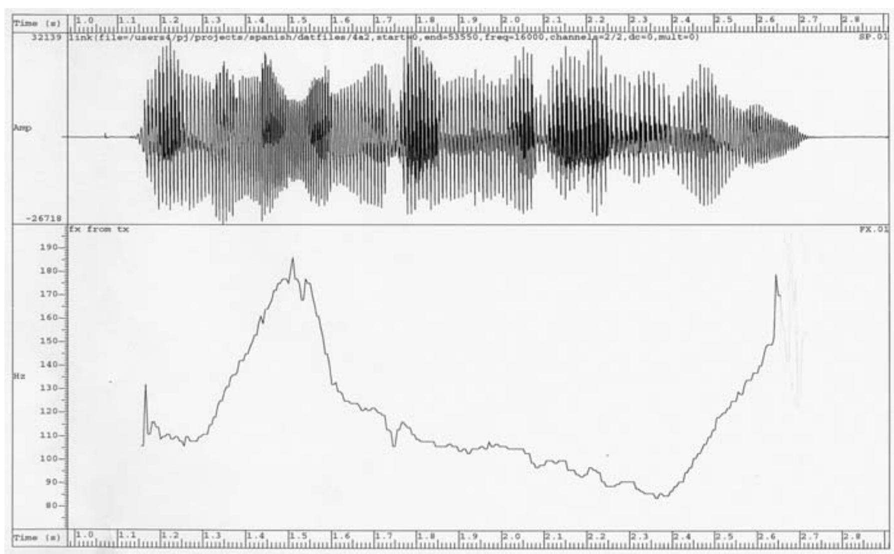

Figure 5. Waveform and F0 contour of the utterance *¿La nómada mira el número de lámina?* produced by speaker GH.

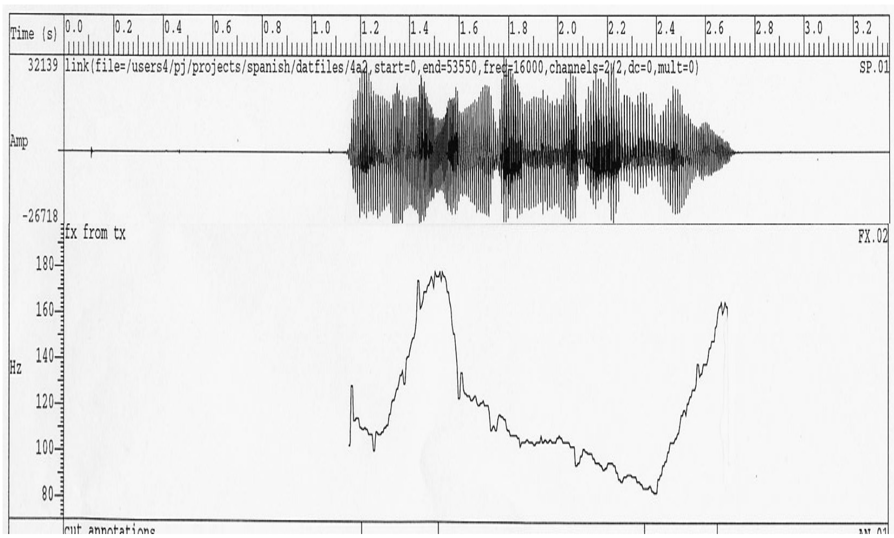

Figure 6. Waveform and F0 contour of the utterance *¿Dónde mira la nómada el número de lámina?*, produced by speaker GH.

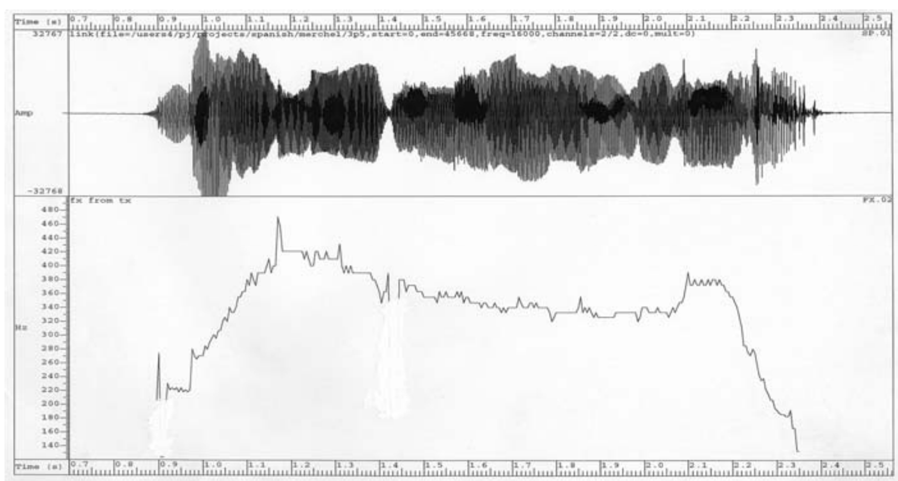

Figure 7. Waveform and F0 contour of the utterance *¿Dónde mira la nómada el número de lámina?*, produced by speaker GH.

Occasionally, speaker MN produced a different F0 contour for wh-questions, which is illustrated in Figure 7 (*¿Dónde mira la nena el loro?*). A prominent rising accent is placed on the wh-particle, and, afterwards, the pitch stays at a high level (forming a H plateau) which starts to descend drastically at the onset of the final accent. This contour is described by Navarro Tomás (1944) as one of the most common Peninsular Spanish intonational patterns for wh-questions.

Previous studies on the intonation of Peninsular Spanish (Navarro Tomás 1944, 1968; Sosa 1992, 1999; Quilis 1981) have noted that sentence-initial F0 peaks of interrogatives are significantly higher than those in statements. This phenomenon has also been noted in languages such as Danish and Swedish (Hadding and Studdert-Kennedy 1972) and in Bengali (Hayes and Lahiri 1991), but it does not occur in English or French (Mettas 1971). Navarro Tomás (1944, 1968) and Canellada and Kuhlmann Madsen (1987) claim that both utterance-initial F0 points and H1 peaks are higher in Spanish interrogatives than in statements: "Other things being equal, the melodic movement of a question is higher from the start than the same melodic movement in statements. This means that the declarative vs interrogative meaning can be perceived by the hearer from the start of the sentence." (Navarro Tomás 1944:136).[4] And "in the first accented syllable [of interrogative utterances] pitch is increased by three or four semitones over the average level characterizing the same syllable in statements." (Navarro Tomás 1944:141). By contrast, Sosa (1992, 1999) claims that it is only the first peak (and other prenuclear peaks) which is more prominent in all the Spanish dialects he analyses: "The increase in tonal height typical of interrogative contours systematically appears from the first accented syllable, not from the start of the utterance. This finding was confirmed by all of our acoustic analyses of the Spanish dialects under study, both for interrogatives ending in a final rise or a final fall." (Sosa 1999:150-154).

Let us first examine the behavior of utterance-initial and utterance-final F0 levels in interrogatives in our data. Mean utterance-initial and utterance-final values are plotted in the two graphs in Figure 8 in four length conditions (1 to 4 pitch accents) for speaker GH in both statements and questions.[5] For both sentence-types, utterance-initial and utterance-final values were almost constant across repetitions of the same contour and totally uncorrelated with sentence length for the two speakers. Moreover, utterance-initial values in questions are practically the same to those in statements: An average height of 103 Hz for statements and 104.4 Hz for interrogatives for speaker GH. *T*-tests comparing the values of utterance-initial points in statements vs. interrogatives reveal that their differences were not significant in any of the sentence-length conditions under consideration for the two speakers.

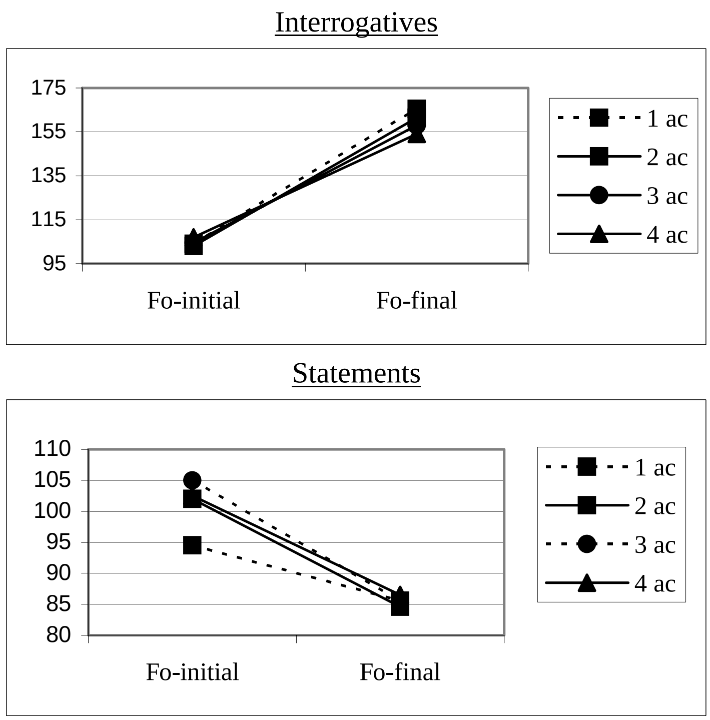

Figure 8. Mean utterance-initial and utterance-final F0 values of interrogative sentences and statements as a function of sentence-length (1 to 4 pitch accents) for speaker GH.

The two graphs in Figure 9 plot the average absolute F0 values (in Hz) of the first H peak in statements, yes-no questions, and wh-questions in utterances with different lengths (2, 3, and 4-accent utterances) for the two subjects. Most of the comparisons were performed on quasi minimal pairs of the type *La nena mira el loro, ¿La nena mira el loro?*, and *¿Dónde mira la nena el loro?* For both speakers, utterance-initial H peaks were scaled significantly higher in questions (both absolute and wh-questions) than in statements (an average difference of 20-25 Hz for the male speaker and 50-55 Hz for the female speaker). Pairwise *t*-tests comparing H1 in the three sentence-type conditions reveal that the two populations (questions vs. statements) are highly distinct (at $p < 0.01$) for the two subjects. As for the differences between the two types of interrogatives, only speaker MN displayed a statistically-significant tendency to pronounce higher peaks in wh-questions. MN's results confirm Navarro Tomás' claim that the first accent of a wh-question is typically more prominent than the first accent in yes-no questions. Also, the data shows a slight effect of utterance-length on the height of the first peak in questions for speaker GH: That is, 2-accent questions have a significantly lower peak than 3 and 4-accent utterances.

The plots in Figure 10 show mean peak delay values of the first H peak (or distance in ms. from the H peak to the onset of the accented syllable) in interrogatives and statements as a function of within-word position for both subjects. Clearly, there is a contrast in H1 alignment between statements and questions: While in statements H1 is generally aligned with the posttonic syllable (and, the closer the accent is to the upcoming word-boundary, the more retracted the peak is), in interrogatives the peak seems to be placed at a fixed position within the posttonic syllable (around 2/3 of the posttonic syllable; cf. Table 4) and reveal no effect of within-word position.

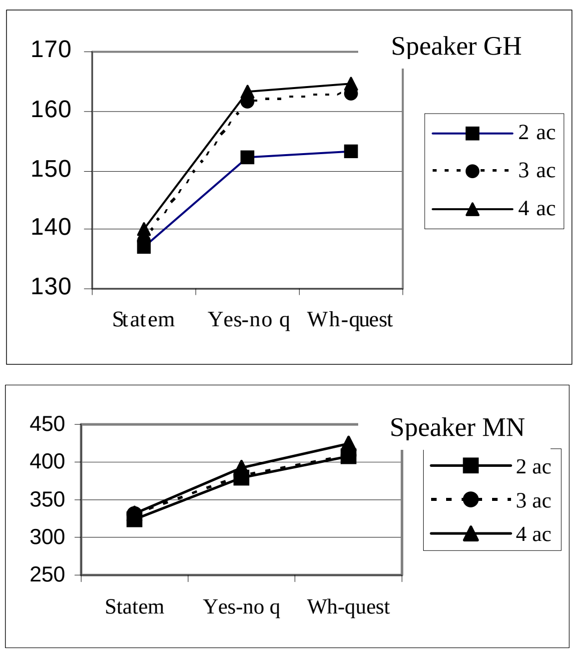

Figure 9. Mean absolute F0 value of the first peak (in Hz) as a function of sentence-type (statements, yes-no questions and wh-questions) and utterance-length (2 to 4 pitch accents) for the two speakers.

How is H1 aligned with respect to the stressed syllable in interrogative sentences? Table 2 shows the average *relative peak delay* values (calculated by dividing the absolute peak delay by the duration of the accented syllable) in different conditions (basically the same conditions plotted in Figure 10). Relative peak delay measures reveal that H1 peaks in interrogatives are realized in the posttonic syllable (within the 1.45 and the 2.14 range). Also, peaks in 2-accent sentences are placed consistently earlier than in 3 and 4-accent sentences, probably due to a clash effect with the upcoming nuclear L accent which forces H1 to shift earlier.

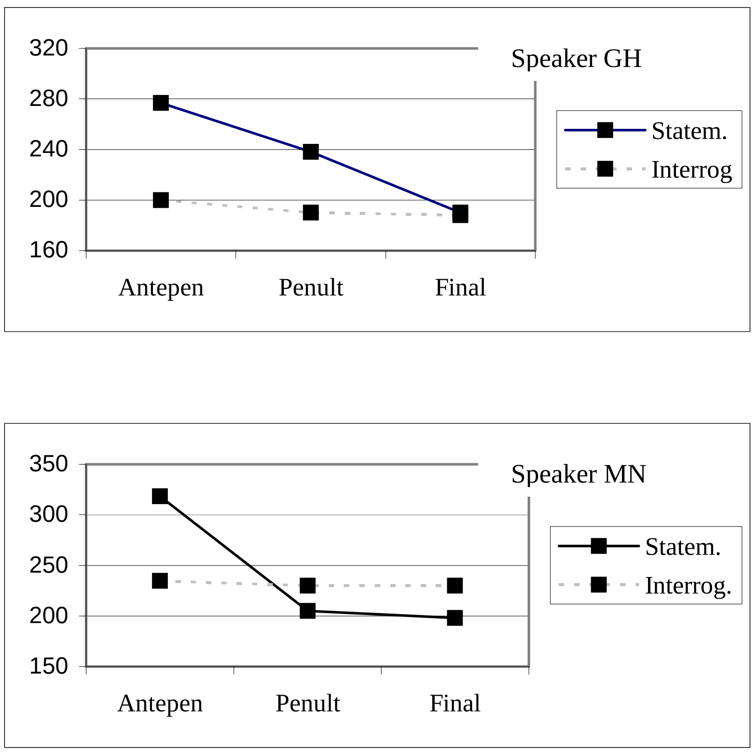

Figure 10. Mean peak delay of H1 (in ms) as a function of sentence-type (statements vs. interrogatives) and within-word position (antepenultimate, penultimate, final) for speakers GH (top) and MN (bottom).

Table 2. Mean relative peak delay of H1 interrogative sentences as a function of sentence length and within-word position.

Speaker GH	2 accents	3 accents	4 accents
antepenultimate	1.45	1.79	2.12
penultimate	1.46	1.73	1.93
final	1.38	1.62	1.64
Speaker MN	2 accents	3 accents	4 accents
antepenultimate	1.45	1.79	2.12
penultimate	1.46	1.73	1.93
final	1.38	1.62	1.64

In sum, the results presented in this section reveal that there is a clear contrast in H1 peak alignment and scaling in questions vs. statements. On the one hand, the difference between a question and a statement is conveyed by increasing the height of the first H peak (or local pitch range of the first pitch accent), even though sentence-initial F0 values are not higher in questions compared to statements (as it was claimed by Canellada and Kuhlmann-Madsen 1987 or Navarro Tomás 1944). On the other hand, H1 alignment behaves rather differently in interrogative sentences. Even though in both cases H1 is aligned with the posttonic syllable, the phonetic factors influencing its position are not the same: Specifically, H1 alignment in interrogatives is not affected by within-word position, but rather from the prosodic pressure from the upcoming L tone.

3.3. Commands and exclamatory sentences

This section investigates the tonal cues which characterize commands and exclamatory utterances. A number of studies on Spanish intonation have noted that the imperative tune is similar to the declarative one and it is mainly characterized by the use of an increased pitch range (Kvavik 1988; Navarro Tomás 1944). As Navarro Tomás (1944:186) states, "The intonation of commands, in their imperative expression, resorts to especially high and low tones. (..) Imperative expressions such as *¡Calla!* 'Shut up!', *¡Alto!* 'Stop!', *¡Fuera!* 'Get out!', produced with no great emphasis, are produced with a first H peak which is 7 or 8 semitones higher than statements and fall to the second syllable to 8 or 9 semitones lower that the reference start of the sentence (for a total fall of 16 semitones)."[6]

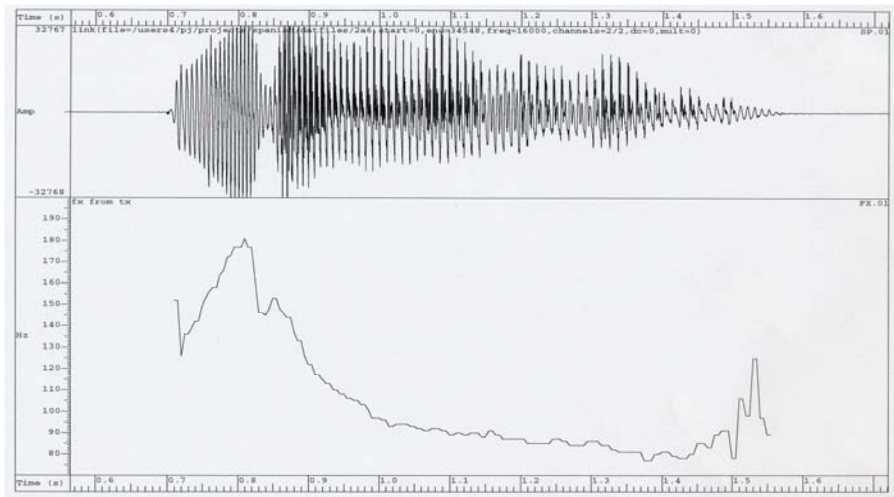

Figure 11 Waveform and F0 contour of the imperative reading of the utterance *¡Mira el loro de la nena!*, as produced by speaker GH.

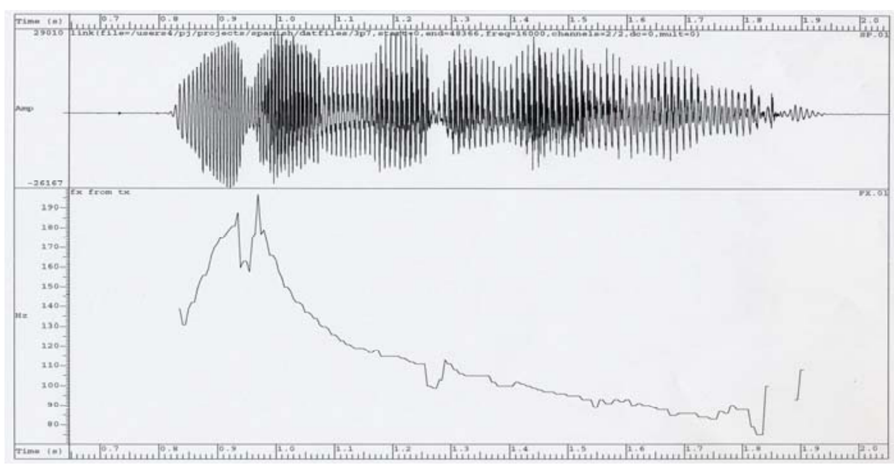

Figure 12. Waveform and F0 contour of the exclamative reading of the utterance *¡Mira a la nómada!*, as produced by speaker GH.

Figures 11 and 12 show the waveform and the F0 contours of the imperative utterance *¡Mira el loro de la nena!* and the exclamative utterance *¡Mira a la nómada!* as produced by speaker GH. Both contours, pronounced in a single intonational phrase, are characterized by a prominent sentence-initial pitch accent. The rest of the F0 contour is deaccented, looking as if the rest of the accents had been wiped out or very compressed. As can be observed below, the value of H1 height in these specific F0 contours produced by the male speaker is around 10 Hz higher in the exclamative than in the imperative utterance.

The data in Table 3 show the average utterance-initial and utterance-final F0 values for exclamative and imperative utterances. As in other sentence-types, both values are rather constant for a given speaker. *T*-tests comparing utterance-initial and utterance-final F0 values within speakers revealed that there is no statistical difference between these values in different phrasal length conditions neither in the exclamative nor in the imperative set (except for starting F0 levels of one-accent exclamatory sentences for both speakers, following the trend that starting F0 points and H peaks in utterances with one accent are lower than in longer utterances). Moreover, utterance-initial F0 values are significantly higher in both imperatives and exclamatory sentences than in statements and questions (around a 20 Hz average increase): For speaker GH, the average height of starting points for statements and interrogatives is 103 Hz and of imperative and exclamatory sentences 120 Hz; for speaker MN, 225 Hz for the former and 250 Hz for the latter).

Table 3. Mean utterance-initial and utterance-final F0 values (in Hz) of exclamative and imperative utterances for speakers GH and MN.

Speaker GH	Imperative		Exclamative	
	initial	final	initial	final
1 accent	123.24	83.25	100.6	89.4
2 accents	126.75	82.74	120.75	84.25
3 accents	121.8	84.6	115.5	88.33
4 accents	125.6	88	127.5	83.25
Speaker MN				
1 accent	268.5	190.5	231	166
2 accents	255.75	185	258.5	199.16
3 accents	258.2	184.5	262.16	197.5
4 accents	254.5	181.16	250.66	205.66

The following two graphs in Figure 13 plot the average height of the first H peak (in Hz) in exclamative and imperative utterances as a function of sentence-length (1-4 pitch accents). *T*-tests reveal that pitch scaling differences between H1 in both conditions (imperative vs. exclamative sentence-types) are statistically significant in all conditions except for the case of 3-accent sentences for speaker GH and 4-accent sentences for speaker MN.

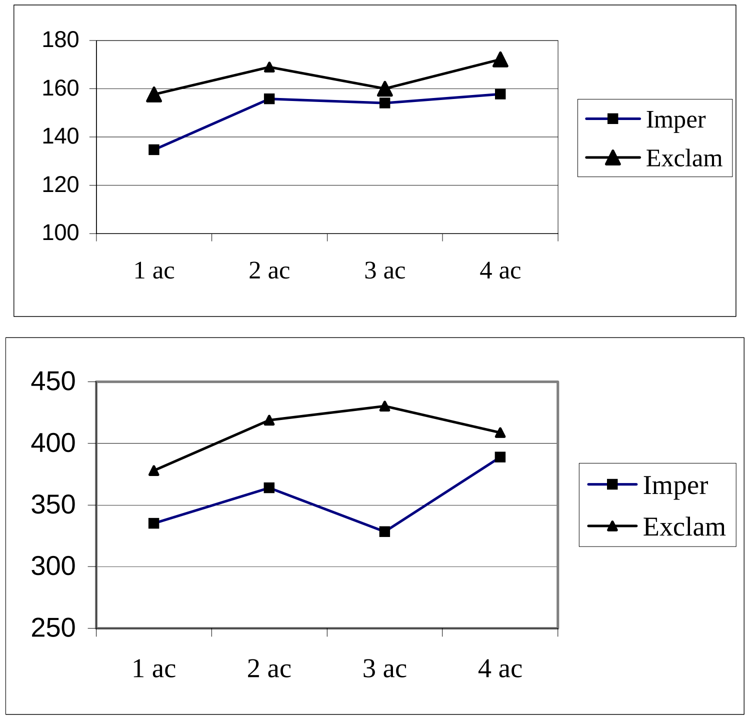

Figure 13. Mean absolute F0 value of the first peak (in Hz) as a function of sentence-type (imperative vs. exclamatory sentences) and utterance-length (1 to 4 pitch accents) for the two speakers.

How is H1 scaled in imperatives and exclamatory sentences in comparison with the rest of sentence-types? The two plots in Figure 14 show the mean absolute F0 value of the first peak (in Hz) as a function of sentence-type (statements and interrogative, imperative and exclamatory sentences) and utterance-length (1 to 4 pitch accents) for the two speakers. *T*-tests comparing H1 height differences demonstrate a significant statistical difference for H1 height between declaratives and the rest of sentence-types. In general, this lends support to Navarro Tomás' (1944) claim that pitch range of sentence-initial pitch accents were incremented by 7-8 semitones in the case of both imperatives and interrogatives. Finally, H1 is generally higher in exclamatory sentences, even though this tendency is not completely systematic across different length conditions.

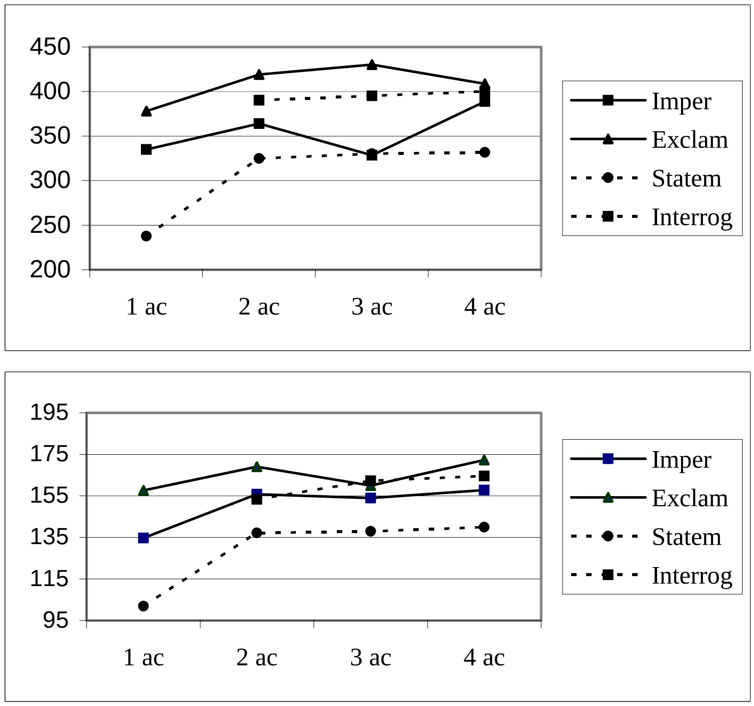

Figure 14. Mean absolute F0 value of the first peak (in Hz) as a function of sentence-type (statements and interrogative, imperative and exclamatory sentences) and utterance-length (1 to 4 pitch accents) for the two speakers.

Table 4 shows the average *relative peak delay* values (calculated by dividing the absolute peak delay by the duration of the accented syllable) in imperative and exclamatory utterances of different lengths. The data in the table reveal that the first rising pitch accent of imperative and exclamative contours is characterized by very early H alignment: The peak is always realized within the boundaries of the accented syllable. Furthermore, no consistent effect of sentence-length is found on H1 peak placement.

Table 4. Mean relative peak delay of H1 in interrogative sentences as a function of sentence length and within-word position for the two speakers.

Speaker GH	Imperative utterances	Exclamatory utterances
1 accent	0.66	0.75
2 accents	0.82	0.86
3 accents	0.85	0.88
4 accents	0.95	0.91
Speaker MN		
1 accent	0.80	0.77
2 accents	0.85	0.80
3 accents	0.88	0.85
4 accents	0.87	0.88

In sum, the data presented in this section clearly demonstrate that utterance-initial pitch accents of imperative and exclamative contours are characterized by a significant increase in H height, lending support to the claim that difference between declarative vs. imperative/exclamative readings is conveyed by tonal range differences (Navarro Tomás 1944; but see Willis 2002).[7] Moreover, H1 peaks of exclamatives tend to be higher compared to imperatives, even though the difference is only statistically significant for speaker MN. The data suggests that the increase in magnitude or pitch range of the local pitch accent is not only obtained by an increase in H1 height but also of the pitch register of the whole accent gesture, as utterance-initial values are also higher in these sentences. Finally, the results in this section show that utterance-initial pitch accents of imperative and exclamative contours are characterized by the presence of a very early peak, and that this alignment cue, together with an increase in pitch range, might be signaling different phrase-type readings. These phonetic cues are quite similar to the signaling of contrastive focus in Peninsular Spanish (cf. de la Mota 1995, Face 2001a, 2001b)

4. Phonological issues

4.1. Tonal alignment

In our data, sentence-initial rising accents present two basic tonal alignment patterns. A rise with a late H1 peak is found in statements and interrogatives and an early H1 peak is found in imperatives and exclamative utterances. As it is well-known, contrastive focus is also characterized by early

H alignment on the focused constituent (cf. de la Mota 1995, Face 2001a, 2001b). Nowadays, the standard autosegmental transcription of Spanish pitch accents with late F0 peak alignment is L*+H and for pitch accents with early F0 peak L+H* (see Sosa 1999; Face 2001a, 2001b; Beckman et al. 2002; Hualde 2002). Thus, starredness is used to express the phonetic alignment contrast properties of the H peak, following the idea that target alignment is a reflection of phonological association (Arvaniti, Ladd and Mennen 1998; Hayes and Lahiri 1991; Grice 1995, Arvaniti et al. 2000; Pierrehumbert and Beckman 1988; Pierrehumbert and Steele 1989). Indeed, such a phonological representation adequately captures the difference in H peak alignment of the pitch accents under study: Utterance-initial accents of commands, exclamatory utterances, and focused utterances are instances of L+H* and utterance-initial accents of statements and questions are instances of L*+H.

However, while this analysis easily captures the observed contrasts in H alignment, it would not account for L valley alignment contrasts like the ones reported by Willis (2003) for Dominican Spanish. This dialect displays a three-way contrast in the alignment patterns of rising accents: a) a rise with a late peak; b) a rise with an early peak; c) a posttonic rise.[8] In Dominican Spanish, the use of L*+H to express a late peak would preclude its use for a posttonic rise. In my view, if we want to provide a more comprehensive analysis of rising accents in Spanish (which can display contrasts on both H and L alignment) one must seriously reconsider using H alignment as a diagnostic for starring tones. What could be then an adequate phonological analysis able to account for contrasts in valley and peak placement? I suggest that the Spanish' representational puzzle can be resolved by resorting to Ladd's (1983, 1996:55) suggestion about separating phonetic alignment from phonological association and by using a phonological feature such as [delayed peak] as an attribute of accents, much in the same way the attribute [downstepped] and [upstepped] are used. As Ladd (1994) points out, "accents, in addition to being high or low, can be downstepped or non-downstepped, delayed or non-delayed, raised or non-raised." My proposal to account for the Dominican and Catalan facts is thus to label the three-way pitch accent contrast as follows: a) L+H*[delayed peak]: A rise with a late peak; b) L+H*: A rise with an early peak; c) L*+H post tonic rise

4.2. Tonal scaling

In their classic study about English tonal range, Liberman and Pierrehumbert (1984) found that gradual increasing in emphasis correlated with increasing tonal range of the pitch accent, without changing its phonological makeup. Nowadays, a central assumption of the standard autosegmental-metrical model (and of most work on intonation) is that pitch range variation is paralinguistic (that is, it conveys differences in emphasis or prominence). Recently, though, some work within the autosegmental model has revealed that pitch range can also display phonological categorical effects (Hirschberg and Ward 1992; Ward and Hirschberg 1985; Ladd 1994, 1996). As Ladd (1994:60) points out, "the central point of the descriptive proposals I have made here and elsewhere is that the Bruce-Pierrehumbert approach to intonational phonology must be enriched with a notion of categorical distinctions of pitch range."

The data reviewed in the preceding section has clearly shown that sentence-type information has a significant effect on H1 scaling: Exclamative contours have higher utterance-initial H peaks than imperative and interrogative contours, and, at its turn, the latter display higher H1 peaks than statements. In the recent literature, steps have been taken towards incorporating this pitch height difference in the phonological representation. In the case of Spanish, Sosa (1999) proposes the use of a sentence-initial %H boundary tone which has the effect of increasing the F0 level of the utterance-initial H peak. As he points out, "our solution is based on the claim that the utterance-initial %H boundary tone restricted to yes-no questions, has a local effect of upstep on the pitch height of the first accented syllable". We believe that Sosa's solution is not descriptively adequate, given that the height of utterance-initial positions is totally independent of the height of the first peak: 1) in imperative and exclamative contours, both the start point and H1 are produced with a higher pitch than in statements; 2) in interrogatives, the start point is produced at a normal pitch level and H1 is higher. That means that we independently need to resort to a separate phonological entity that can identify high %H boundary tones separately from high H1 peaks. Beckman et al.'s (2002) solution, on the other hand, relies on the use of a phonologically distinct upstepped accent ¡H, following Ladd's original (1983) suggestion to use an extrinsic [upstep] or [raised peak] feature assigned to pitch accents.

In my view, we need to further study the behavior or upstep phenomena and clarify what types of functions can have in a given language and what should be its phonetic interpretation. Do we have evidence for an [upstep] feature as a separate notion from [raised peak]? Do they have different properties? Recently, Truckenbrodt (2002) has shown that upstep can be found in nuclear accents of non-final intonational phrases in southern German and it is phonetically interpreted as a return to the sentence-initial F0 height and disregard of preceding downstep. In a recent Catalan experiment, Prieto (2002b) found an upstep effect on the second pitch accent of an utterance acting as a cue for a weak phrase boundary separating subjects from predicates. Figure 5 illustrates the waveform, F0 contour and labeling scheme of the utterance *El molí nét no li agrada* 'He does not like the clean mill'. Despite the fact that we are dealing with a non-descending contour, H2 height was rather constant within speakers and could be predicted quite successfully by a local upstep ratio of constant expansion from the previous' peak value.

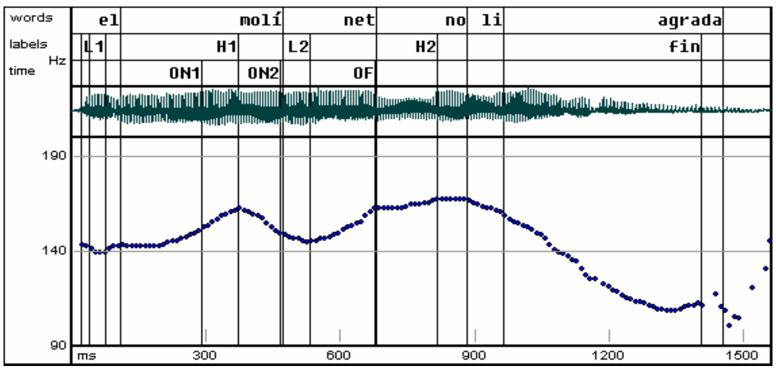

Figure 15. Waveform display, F0 contour and labels corresponding to the utterance *El molí nét no li agrada*.

I believe more work needs to be done on the characterization of upstep/raised peak features before proposing a reliable phonological interpretation of the Spanish facts. It can even be that upstep phenomena have different phonetic interpretations, like the German and Catalan cases seem to suggest.

5. Conclusions

The results of the present study clearly lend support to the target-based hypothesis of intonational production, that is, the claim that L and H points are carefully controlled by the speaker and are thus aligned and scaled in extremely consistent ways. The data shown in this article has revealed that both H1 alignment and scaling patterns are cueing sentence-type information. Most probably, Peninsular Spanish listeners rely on combinations of alignment and scaling cues of the first accent gesture to identify phrasal types from the beginning of the sentence. At its turn, speakers exploit the interplay between F0 peak alignment and F0 peak height to obtain a doubly robust cue for a phonological contrast, much in the same way contrastive focus is conveyed through early H1 peak alignment and high H1 scaling (de la Mota 1995; Face 2001a, 2001b, among others).

The analysis of the data has shown a clear contrast between late and early H1 peaks in different sentence-types: While declarative and interrogative F0 contours are characterized by a late H1 peak, imperative and exclamative contours are characterized by an early peak. The article has also addressed a recently debated issue within Spanish intonational studies about the appropriateness of a phonological analysis of these accents as L*+H vs L+H* accents. While this analysis easily captures the observed contrasts in H alignment, it is not able to capture contrasts in L valley alignment present in other Spanish dialects (contrasts such as those reported by Willis 2002 for Dominican Spanish) and in Romance languages such as Catalan. The phonological analysis proposed in this paper resorts to the extrinsic phonological notion of [delayed peak]: Accents can have the phonological property of having late or early peaks. This proposal does not directly link starredness to alignment properties and, in my view, provides a more complete analysis of rising accents in Spanish.

Finally, the article has shown that sentence-type information has a significant effect on H1 scaling: H1 peaks of interrogative, imperative and exclamatory sentences are significantly higher than peaks in corresponding statements, something which confirms previous observations on these Spanish contours (Canellada and Kuhlmann Madsen 1987; Kvavic 1988; Navarro Tomás 1944; Sosa 1992, 1999; Willis 2002). Pitch-range variability is not exclusively used in Peninsular Spanish to convey differences in emphasis or prominence (as the Free Gradient Hypothesis would contend), but rather it conveys sentence-type information. Following a suggestion by Ladd (1983), we propose to resort to an extrinsic feature [raised peak] applied to pitch accents. Even though the data seems to suggest an even further distinction in pitch height in exclamatory and wh-sentences (cf. speaker MN), we tentatively interpret this fact as a manifestation of a special degree of emphasis especially typical of these sentences.

Acknowledgments

The production experiment described in this article was recorded a few years ago with the original goal of developing a phonetically explicit F0 assignment model for the basic 5 sentence-types in Peninsular Spanish. A preliminary version of this work was presented at the conference Laboratory Approaches to Spanish Phonology and at the International Congress of Phonetic Sciences (Barcelona, 2003). I am grateful to J.M. Sosa, T. Face, J.I. Hualde, and E. Willis for helpful comments and suggestions. Thanks are due to the two speakers who read the database: Guillem Hernández, from Lleida and Mercedes Nasarre, from Huesca. This work has benefited from the participation of the author in the following research grants: "La interpretación y la combinación de los rasgos gramaticales: del léxico a la realización fonética" (BFF2000-0403-C02-02, Ministerio de Educación y Cultura), "Modelos de organización articulatoria y procesos de cambio fonético" (BFF2000-0075-C02-01, Ministerio de Educación y Cultura, Xarxa Temàtica en Gramàtica Teòrica (2000XT-00032, Generalitat de Catalunya) and Grup de Lingüística Teòrica (2001SGR 00150, Generalitat de Catalunya).

Notes

1. All translations from Spanish texts into English included in this article are the author's.
2. As the original goal of the recordings was to implement the results in a text-to-speech Spanish synthesizer, the description corresponds to intonational contours which are typical of a reading task.
3. The contours which were produced by MN with a different F0 curve were repeated during the recording session.
4. Canellada and Kuhlmann Madsen (1987) point out that "from the start of the utterance, interrogative contours are produced with a higher pitch level than statements. This is not only apparent in the strong utterance-final rise, but in each one of the utterance-initial syllables."
5. We opted not to reproduce MN's values here because the creakyness of her voice at especially high F0 levels made these F0 measurements quite unreliable.
6. Similarly, Willis (2002:347) concludes that there are also other prosodic cues which characterize imperative readings: "The local differences between imperative and declarative utterances include an increased tonal range at the local pitch-accent level, reduced intonational deaccenting, an increased use of an early H tone pitch accent associated with contrastive focus, and modifications of duration."

7. Willis (2002) argues that the increased pitch range found in Spanish imperatives presents variation and is thus not categorical. As Willis (2002:361) points out, “the data indicate there is an increased local tonal range in imperatives compared to declaratives, but it is not significant for all speakers.” We believe, though, that the context used to prompt the imperative reading could have been interpreted not as a real command by Spanish participants but as an exhortative-type sentence. In my opinion, the following situation example (Willis 2002:354) does accept an ambiguous response ranging between a command and a request: Situation: “You arrive home and it smells terrible, you say to John, ‘Open the door!’
8. In a closely related Romance language such as Catalan, rising pitch accents also display a three-way contrast on alignment: early accent peaks, late accent peaks and late accent peak with late accent valley (cf. Prieto 2002a).

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Appendix

1p1: La mira.
1p2: ¿La mira?
1p3: ¿Dónde la mira?
1p4: (imperative) ¡Mira!
1p5: (exclamative) ¡La mira!

2p1: La nena mira.
2p2: ¿La nena mira?
2p3: ¿Dónde mira la nena?
2p4: (imperative) ¡Mira a la nena!
2p5: (exclamative) ¡Mira a la nena!

3p1: La nena mira el loro.
3p2: La nena mira el loro?
3p3: ¿Dónde mira la nena el loro?
3p4: (imperative) ¡Mira el loro de la nena!
3p5: (exclamative) ¡Mira el loro de la nena!

4p1: La nena mira el loro de Sara.
4p2: ¿La nena mira el loro de Sara?
4p3: ¿Dónde mira la nena el loro de Sara?
4p4: (imperative) ¡Mira el loro de la nena de Sara!
4p5: (exclamative) ¡Mira el loro de la nena de Sara!

1u1: La miró.
1u2: ¿La miró?
1u3: ¿Qué le miró?
1u4: (imperative) ¡La miró!
1u5: (exclamative) ¡La miró!

2u1: La mamá miró.
2u2: ¿La mamá miró?
2u3: ¿Qué mira la mamá?
2u4: (imperative)¡Mirad a la mamá!
2u5: (exclamative) ¡Mirad a la mamá!

3u1: La mamá miró al bebé.
3u2: ¿La mamá miró al bebé?
3u3: ¿Qué miró la mamá del bebé?
3u4: (imperative) ¡Mira al bebé de la mamá!
3u5: (exclamative) ¡Miró al bebé de la mamá!

4u1: La mamá miró al bebé de Rubí.
4u2: ¿La mamá miró al bebé de Rubí?
4u3: ¿Qué miró la mamá del bebé de Rubí?
4u4: (imperative) ¡Mirad al bebé de la mamá de Rubí!
4u5: (exclamative) ¡Miró el bebé de la mamá de Rubí!

1a1: La lámina.
1a2: ¿La lámina?
1a3: ¿Qué es una lámina?
1a4: (imperative) ¡Mírala!
1a5: (exclamative) ¡La lámina!

2a1: La nómada mira.
2a2: ¿La nómada mira?
2a3: ¿Dónde mira la nómada?
2a4: (imperative) ¡Mira a la nómada!
2a5: (exclamative) ¡Mira a la nómada!

3a1: La nómada mira el número.
3a2: ¿La nómada mira el número?
3a3: ¿Cuándo mira la nómada el número?
3a4: (imperative) ¡Mira el número de la nómada!
3a5: (exclamative) ¡Mira el número de la nómada!

4a1: La nómada mira el número de lámina.
4a2: ¿La nómada mira el número de lámina?
4a3: ¿Dónde mira la nómada el número de lámina?
4a4: (imperative) ¡Mira el número de lámina de la nómada!
4a5: (exclamative) ¡Mira el número de lámina de la nómada!