RESLA 23 (2010), 153-173

THE ROLE OF DURATION IN INTONATIONAL MODELLING. A COMPARATIVE STUDY OF PENINSULAR AND ARGENTINEAN SPANISH

EVA ESTEBAS VILAPLANA*
UNED

ABSTRACT. *The aim of this study is to compare the intonation of neutral declaratives in Peninsular Spanish (PS) and in Argentinean Spanish (AS) by means of the Autosegmental-Metrical framework. Previous works showed that both varieties differ in the production of both nuclear and pre-nuclear accents. In this study we demonstrate that there is a more robust parameter that contributes to differentiate neutral declaratives in PS and AS, namely, the duration of the nuclear syllable. 600 utterances with one and two accents were analyzed. The pitch traces of PS and AS obtained in this study show similar characteristics in the two languages. Furthermore, the results demonstrate that the duration of the nuclear syllable is significantly longer in AS than in PS indicating that duration seems to be more important than intonation to distinguish between AS and PS declaratives. These results are important to implement Spanish intonation to speech synthesis and speech recognition systems.*

KEY WORDS. *Declarative intonation, duration, Autosegmental-Metrical framework, nuclear and pre-nuclear accents.*

RESUMEN. *El principal objetivo de este trabajo es comparar la entonación de frases declarativas neutras en español peninsular y en español argentino mediante el modelo Métrico-Autosegmental. Descripciones anteriores demuestran que ambas variedades difieren en la producción tanto de acentos nucleares como de acentos prenucleares. En este estudio presentamos evidencia de que hay otro parámetro que aporta diferencias entonativas entre los enunciados declarativos de ambas variedades, la duración de la sílaba nuclear. Se analizaron 600 frases declarativas neutras de un y dos acentos. Los resultados demuestran que la duración de la última sílaba acentuada es mayor en español argentino que en peninsular y que este índice aporta mayor diferenciación entre la entonación de ambas variedades que las mismas diferencias melódicas. Estos resultados son importantes para la implementación de la entonación española a sistemas de síntesis y reconocimiento del habla.*

PALABRAS CLAVE. *Entonación declarativa, duración, modelo Métrico-Autosegmental, acentos nucleares y prenucleares.*

1. INTRODUCTION

Early works on the intonation of neutral declarative sentences in Peninsular Spanish (PS) point out the different status of nuclear and pre-nuclear accents (Navarro Tomás 1944; Quilis and Fernández 1985; Canellada and Kuhlmann Madsen 1987; Alcoba and Murillo 1999). Whereas pre-nuclear accents are characterized by a rising movement in the vicinity of the accented syllables, the nuclear configuration tends to exhibit a progressively falling contour which starts after the last pre-nuclear accent and finishes at the end of the sentence. A schematized pitch contour is illustrated in Figure 1 for the sentence *Viene de Málaga* with two accented syllables (underlined). The shaded boxes indicate the limits of the accented syllables. The pre-nuclear syllable shows a rising pitch trajectory with an F0 peak on the post-accented syllable. The nuclear syllable exhibits no F0 peak but is part of the final falling slope.

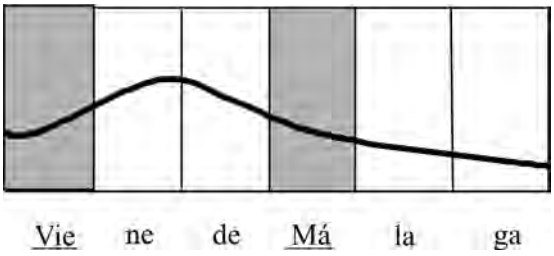

Figure 1. *Schematization of a neutral declarative F0 trace for the sentence* Viene de Málaga *in PS showing a pre-nuclear rise with the F0 peak at the post-tonic syllable and a progressively falling nuclear accent. The shaded boxes stand for accented syllables.*

With the development of the Autosegmental-Metrical (AM) model of intonational analysis (Pierrehumbert 1980; Ladd 1996; Gussenhoven 2004), a large number of instrumental studies have emerged with the aim of modelling the pre-nuclear and nuclear configurations of broad focus Spanish declaratives (Prieto, Van Santen and Hirschberg 1995; Prieto 1998; Sosa 1995, 1999; Face 2001; Beckman, Díaz-Campos, McGory and Morgan 2002; Estebas-Vilaplana 2006; Face and Prieto 2007; Estebas-Vilaplana and Prieto 2008; among others). Whereas all these studies coincide in the phonetic description of both pre-nuclear and nuclear accents, the phonological interpretation has been a rather controversial issue.

The first detailed experiments to describe pre-nuclear and nuclear accents in neutral declaratives within the AM approach were conducted by Prieto, Van Santen and Hirschberg (1995), Prieto, Shih and Nibert (1996) and Prieto (1998) for Mexican Spanish. According to these studies, both pre-nuclear and nuclear accents were described as H* (a high tone associated to the stressed syllables) but with different phonetic realizations. Pre-nuclear accents were modelled as H* with a delayed F0 peak,

that is, with a peak aligned after the accented syllable. Nuclear accents were characterized as H* with an F0 peak located within the limits of the accented syllable. The use of H* by Prieto et al. (1995) in the nuclear configuration was due to the fact that they found two possible realizations of the nuclear accent in their data, namely, a progressively falling contour and a strongly lowered peak. This analysis was maintained in Nibert (2000) for Peninsular Spanish.

Further studies on Spanish intonation have proposed a different phonological interpretation for pre-nuclear rises. Sosa (1999), Face (1999, 2001), Beckman, et al. (2002) and Calleja (2004) describe the rising movement of pre-nuclear accents in Spanish by means of a bitonal accent (L*+H). This accent involves a low F0 within the accented syllable and a sharp rise after the accented syllable. The motivation for the bitonal L*+H interpretation is that there is an F0 valley which occurs at the beginning of the stressed syllable. Beckman et al. (2002) postulate a clear difference between L*+H (*late* rising accent with the F0 peak after the accented syllable) and L+H* (*early* rising accent with the F0 peak within the accented syllable). Hualde (2002), in his turn, finds that neither H* nor L*+H describe pre-nuclear rises in Spanish satisfactorily. He claims that H* fails to account for the fact that the tone is low at the onset of the stressed syllable. However, he discards L*+H since he assumes that it is not contrastive with L+H*. He proposes a pitch accent where both tones are associated with the stressed syllable (L+H)* and the different location of the peak is the result of contextual differences. More recent research on Spanish pre-nuclear rising accents (Estebas-Vilaplana 2006 and Pamies 2007) suggests the possibility of analysing those accents as an L* pitch accent followed by an H word edge tone which signals the end of the accented word. This possibility, however, is discarded in Prieto, Estebas-Vilaplana and Vanrell (2010) since it was observed that even though the location of the peak varies depending on the stress condition of words (oxytones, paroxytones and proparoxytones) the H is always anchored after the accented syllable and thus there is no clear alignment with the end of the word.

Finally, Face and Prieto (2007) point out the necessity of having three different rising accents in Spanish: L*+H, L+H* and L+>H*. L*+H is used for those cases where the rise starts after the accented syllable (e.g. the pre-nuclear accents of Spanish yes-no questions). As in Beckman et al. (2002), L+H* indicates that the F0 peak is aligned within the accented syllable (e.g. the nuclear accent used to convey contrastive focus). Finally, L+>H* indicates that the rising movement starts within the accented syllable but the peak is located at the post-tonic syllable (e.g. the pre-nuclear accents in neutral declaratives). The distinction between L*+H and L+>H* was not attested in Beckman et al. (2002) who described the two rising patterns as L*+H. The two proposals are schematized in Figure 2 (adapted from Face and Prieto 2007). The three-way contrast of rising accents in Spanish has been maintained in the late versions of the Sp-ToBI framework (a follow-up of the AM model) for PS (Estebas-Vilaplana and Prieto 2008, 2010) and for other varieties, such as Canarian Spanish (Cabrera and Vizcaíno 2010).

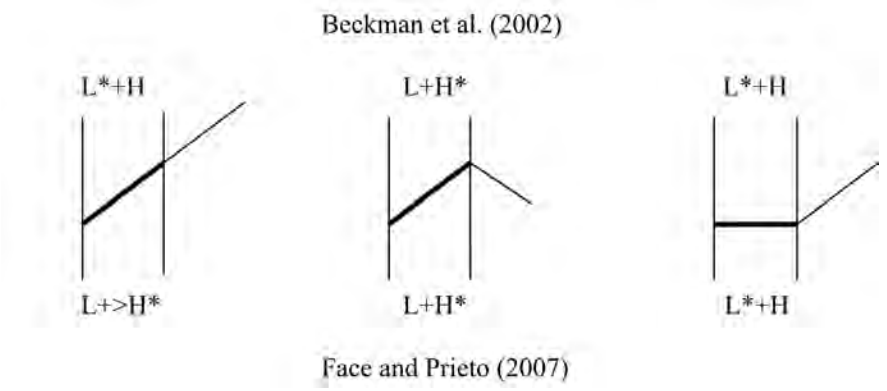

Figure 2. *Comparison between the realization and interpretation of the rising pitch accents in the original Sp_ToBI proposal (Beckman et al. 2002) and in the revised proposal (Face and Prieto 2007). The vertical lines indicate the limits of the accented syllable and the other lines the F0 movements.*

Studies on Buenos Aires Spanish (Sosa 1999; Toledo 2000; Kaisse 2001; Gurlekian, Torres and Colantoni 2004; Colantoni and Gurlekian 2004) have demonstrated that pre-nuclear accents in broad focus declaratives show a different alignment pattern than that of PS and most of the varieties of Spanish (Sosa 1999). In Buenos Aires Spanish the F0 peak of pre-nuclear accents is aligned within the accented syllable. The tonal category used to describe such pattern is H* or H*+L for those cases that there is a fall on the post-tonic syllable. This is illustrated in Figure 3 which compares the F0 trajectories of L+>H* and H*+L. However, Colantoni (2005) reports the existence of both L*+H and L+H* occasionally in pre-nuclear position and shows that there is a great variability in the usage of these two pitch accents in other varieties of Argentinean Spanish (AS).

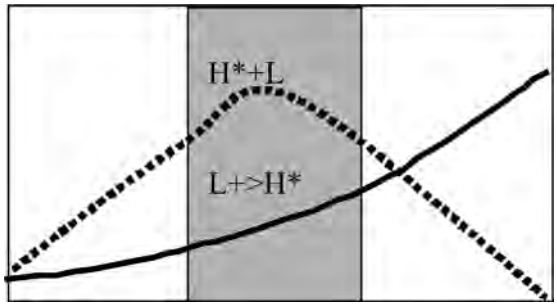

Figure 3. *Comparison between a pre-nuclear rising accent in PS (L+>H*) and in AS (H*+L) in neutral declaratives. The shaded box indicates the limits of the accented syllable. The white boxes stand for the pre-tonic and post-tonic syllables.*

The nuclear accent has also undergone a variety of phonological descriptions. Basically, the debate lies between H* (an F0 peak) and L* (an F0 valley). As mentioned before, Prieto, et al. (1995), Prieto, Shih and Nibert (1996), Prieto (1998) and Nibert (2000) propose H* to account for the last accent of a neutral declarative in Spanish since a strongly lowered F0 peak is observed in some of their data. This tonal category is also used in declaratives with only one accent where a clear high target is produced within the limits of the accented syllable. However, since the majority of declaratives with pre-nuclear accents shows no peak on the final accent but a progressively falling movement (the *"tobogán"* or "slide pattern" in Sosa's terms), several authors such as Sosa (1999), Beckman et al. (2002), Estebas-Vilaplana and Prieto (2008, 2010) suggest to interpret the nuclear accent in multi-stressed declaratives as a low tone (L*). As mentioned in Estebas-Vilaplana (2008), this triggers a phonological problem since the final accent of neutral declaratives is interpreted as H* or L* depending on the presence or not of pre-nuclear accents, even though the meaning of both types of sentences (multi- and single stressed) is the same. Despite this observation, L* seems to be the strongest candidate to account for the nuclear accent in multi-stressed declaratives due to the absence of an F0 peak. The lack of a clear intonation unit for the description of the nuclear accent in declaratives has brought Hualde (2009) to suggest that maybe there is no pitch accent associated to this final stressed syllable and that the only suprasegmental feature that is actually attested is duration. Thus, he proposes to mark the final pitch accent of a neutral declarative in Spanish as "dur*".

In AS the nuclear accent of broad focus declaratives has been also described as a falling contour (Kaisse 2001; Toledo 1989, 2000; Arana, Blázquez, Dabrowski and Labastía 2007). The suggested pitch accent to account for such a falling movement varies in the literature: L* in Arana at al. (2007) and H+L* in Gabriel et al. (2010).

The aim of this study is to carry out a comparative analysis between the neutral declarative intonation of PS and AS, so as to see whether the pitch differences reported in previous studies are actually the most important cues to distinguish the two types of intonation or rather there is another parameter, namely, the duration of the nuclear syllable, that plays a stronger role in differentiating the two intonational patterns. Thus, in this paper we will test the hypothesis that the main cue to set apart the declarative intonation of the two varieties is not pitch variation but variation in the duration of the nuclear syllable. We expect to find that in AS the duration of the nuclear syllable is much longer than in Central PS. In order to do so, the data of two female speakers, one from Madrid and another one from Buenos Aires were examined.

2. METHODOLOGY

2.1. *Materials*

The data examined in this paper consisted of neutral declarative utterances containing one or two accents. In all cases, the target (nuclear) syllable belonged to a proparoxitonic word so that the nuclear accent was not at the end of the phrase and thus

we could better examine the final tonal movement. In sentences with one accent, one unstressed syllable preceded the accented one in order to see the pitch pattern in the pretonic syllable. Single stressed utterances had the following rhythmic distribution *w-s-w-w*, where *w* stands for a weak, unstressed syllable and *s* for a strong, stressed syllable. Most syllables had a CV structure (e.g. Má-la-ga), except for a few cases with a CVC structure (e.g. the last syllable of the word si-nó-ni-*mos*). The syllables with a CVC structure were always located at the end of the sentence and the final consonant was always voiceless. Examples of single-stressed sentences are provided in (1).

(1) De Málaga.
Mi nómina.
Sinónimos.

Sentences with two accents contained six syllables with the following rhythmic pattern: "s-w-w-s-w-w". An example is provided in (2).

(2) Llega de Málaga.
Mira mi nómina.
Sabe sinónimos.

Sentences were designed with the maximum number of voiced segments possible to avoid interrupted F0 contours. The target syllables included combinations of a nasal consonant ([m] or [n]) and a non-high vowel ([a], [e] or [o]). The reason to choose nasals and non-high vowels in the target syllables was to control the intrinsic duration of the nuclear syllable so that differences in the final duration measurements could not be attributed to segmental differences.

Overall 20 sentences with one stress and 20 sentences with two stresses were designed. See the Appendix at the end of the paper for the list of sentences used in the experiment.

2.2. *Data recording*

The data were recorded by one Central PS female speaker from Madrid (ES) and an AS female speaker from Buenos Aires (MS). They had a similar age (between 30 and 35 years old). The speakers received instructions to read the sentences as natural as possible as is they were answers to the question "what happens?". The speakers read the data five times, so that we could gather five repetitions of each sentence. Overall, we obtained and analyzed 600 utterances: 300 for Central PS and 300 for AS.

2.3. *Data analysis*

The sentences were analyzed by means of the *Praat* software (Boersma and Weenik 1992-2001) which allows for a time-aligned inspection of the speech waveform and the F0 trace. For each sentence we analyzed two parameters: 1) pitch and 2) duration.

For the analysis of pitch the following pitch labels were placed in the two types of sentences.

1. Sentences with one accent:
    1. Phrase initial F0 value (F1)
    2. F0 value at the beginning of the nuclear syllable (F2)
    3. Highest F0 value of the nuclear syllable (F3)
    4. F0 value at the end of the nuclear syllable (F4)
    5. Phrase final F0 value (F5)

2. Sentences with two accents:
    1. Phrase initial F0 value or F0 value at the beginning of the pre-nuclear accented syllable (F1)
    2. F0 value at the end of the pre-nuclear accented syllable (F2)
    3. Highest F0 value of the pre-nuclear accented syllable (F3)
    4. F0 value at the beginning of the nuclear syllable (F4)
    5. Highest F0 value of the nuclear syllable (F5)
    6. F0 value at the end of the nuclear syllable (F6)
    7. Phrase final F0 value (F7)

Similarly, the following duration measurements were taken for the two types of sentences.

1. Sentences with one accent:
    1. The duration of the whole utterance (D1)
    2. The duration of the nuclear syllable (D2)
    3. The duration between the onset of the nuclear syllable and the F0 peak (D3)

2. Sentences with two accents:
    1. The duration of the whole utterance (D1)
    2. The duration of the pre-nuclear accented syllable (D2)
    3. The duration between the offset of the pre-nuclear accented syllable and the F0 peak or peak delay (D3)
    4. The duration of the nuclear syllable (D4)
    5. The duration between the onset of the nuclear syllable and the F0 peak (D5)

The pitch and duration measurements were recorded in a script. The results were subsequently transferred to a statistics program for further analysis.

An example of the data analysis is provided in Figure 4 for the sentence *Llega de Málaga*. The five panels displayed in each graph show 1) the speech waveform, 2) a spectrogram with an overlapped F0 trace, 3) the syllable boundaries marked at the end of each syllable, 4) the labels corresponding to the F0 values and 5) the duration measurements. The syllable boundaries were included so as to see the location of the F0 peaks with respect to the accented syllables. Since the nuclear syllable *Má-* does not show any clear F0 peak, points F4 (F0 value at the beginning of the nuclear syllable) and F5 (highest F0 value of the nuclear syllable) coincide. As far as duration measurements are concerned, the D1 value (duration of the whole utterance) corresponds to the duration between the first and the last boundaries in the last panel. Finally, point D5 (duration between the onset of the nuclear syllable and the F0 peak) is not labelled in this graph because there is no F0 peak within the nuclear syllable and hence the highest F0 corresponds to the beginning of the nuclear syllable.

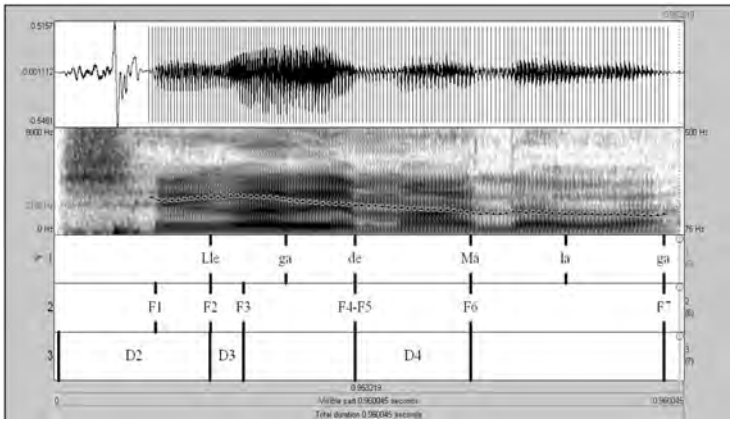

Figure 4. *Display of speech waveform, spectrogram and F0 trace, syllable boundaries, F0 landmarks and duration measurements for the sentence* Llega de Málaga *produced by a speaker of AS.*

3. Results

3.1. *Pitch*

The analysis of the intonational movements of single and double-stressed declaratives in PS and AS covers the following configurations: 1) the nuclear accent of single-stressed sentences, 2) the nuclear accent of double-stressed sentences and 3) the pre-nuclear accent of double-stressed sentences.

3.1.1. The nuclear accent of single-stressed sentences

Figure 5 displays an example of a single-stressed declarative (*De Málaga)* produced by the AS speaker (left graph) and the PS speaker (right graph). Each graph shows 1) the speech waveform, 2) a spectrogram with an overlapped F0 trace, and 3) the syllable boundaries marked at the end of each syllable.

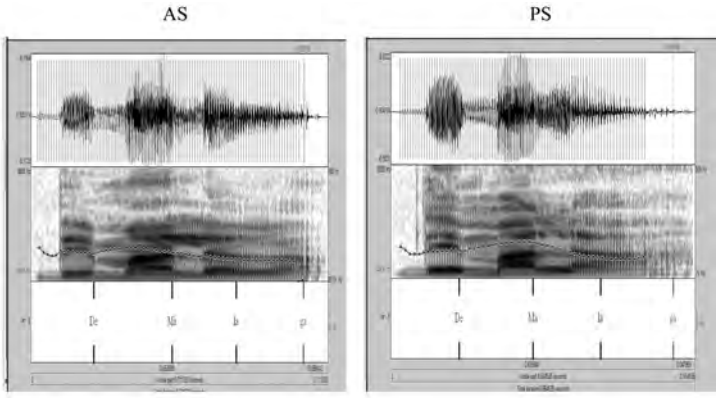

Figure 5. *Speech waveform and spectrogram with an overlapped F0 trace for the single-stressed declarative* (De Málaga) *produced by the AS speaker (left graph) and the PS speaker (right graph).*

In order to analyze the trajectories of the nuclear accent in single-stressed neutral declaratives in detail the mean F0 values were obtained for the two varieties at the following targets: 1) beginning of the utterance, 2) beginning of the accented syllable, 3) highest F0 point, 4) end of the accented syllable and 5) end of the utterance. These values are presented in Figure 6.

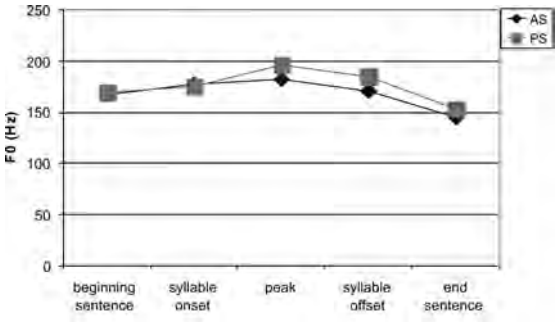

Figure 6. *Mean F0 values in Hz at the beginning of the sentence, at the onset of the accented syllable, at the highest F0 point (peak), at the offset of the accented syllable and at the end of the sentence for single-stressed declaratives in PS and AS.*

The results displayed in Figure 6 show that both speakers produce a similar F0 trajectory in the nuclear accent of single-stressed declaratives. The maximum F0 point is slightly lower in AS than in PS but this may be due to pitch range differences between the two speakers. The AS speaker has a much narrower pitch range (148-209 Hz) than the PS speaker (135-250 Hz). Thus, according to our data, the two Spanish varieties seem to produce single-stressed neutral declaratives in the same way. The only difference observed between the AS and PS is the location of the F0 peak within the accented syllable. As presented in Figure 7, the F0 peak is realized much earlier within the accented syllable in AS than in PS. Two-paired t-tests show that the differences in the alignment of the F0 peak within the accented syllable in the two varieties are significant at $p<0.0001$. Despite these alignment differences, we still think that the same tonal unit is used in the two varieties to produce the nuclear accent of single-stressed declaratives since in both cases the F0 peak is clearly anchored within the limits of the accented syllable. Thus, the accent we propose to describe such configuration is H* or L+H* which stands for a rise with the peak aligned within the accented syllable. In section IV we will discuss these findings and their implications further.

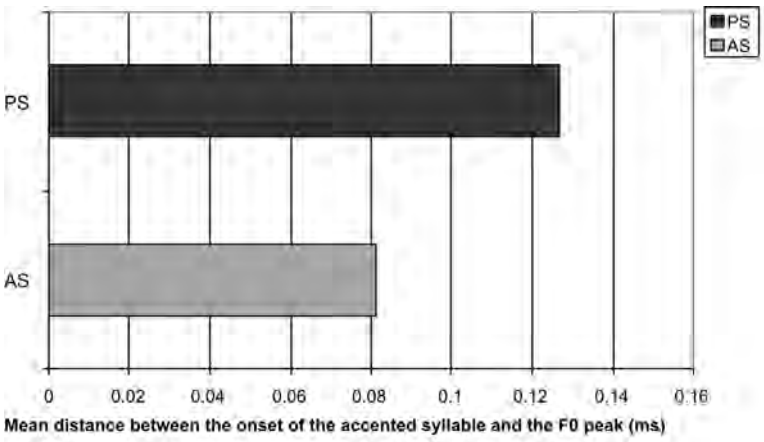

Figure 7. *Mean peak displacement in ms with respect to the onset of the accented syllable (0 value) for PS and AS.*

3.1.2. The nuclear accent of double-stressed sentences

As expected, the nuclear accent of double-stressed declaratives shows a similar F0 movement in the two varieties which involves a progressively falling contour beginning at the offset of the pre-nuclear syllable till the end of the utterance. This is illustrated in Figure 8 below for the sentence *Llega de Málaga* produced by both speakers.

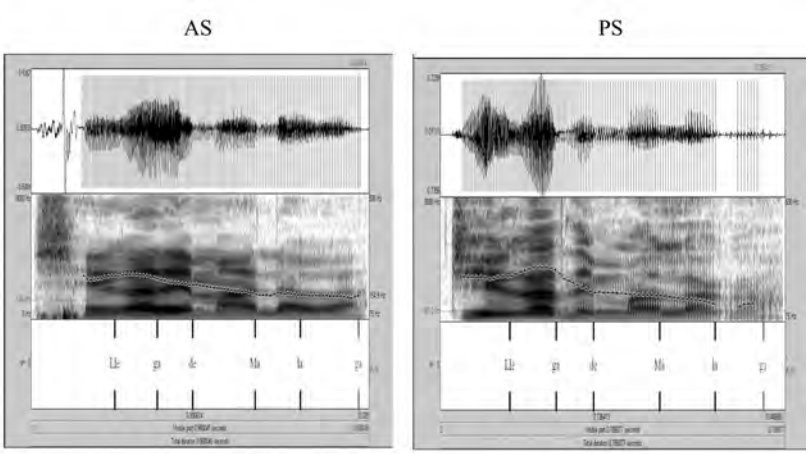

Figure 8. *Speech waveform and spectrogram with an overlapped F0 trace for the double-stressed declarative* (Llega de Málaga) *produced by the AS speaker (left graph) and the PS speaker (right graph).*

In order to confirm the slide pattern observed in the data, the mean F0 values at the beginning and at the end of the nuclear accent as well as at the end of the whole utterance were obtained for both varieties. These measurements are presented in Figure 9.

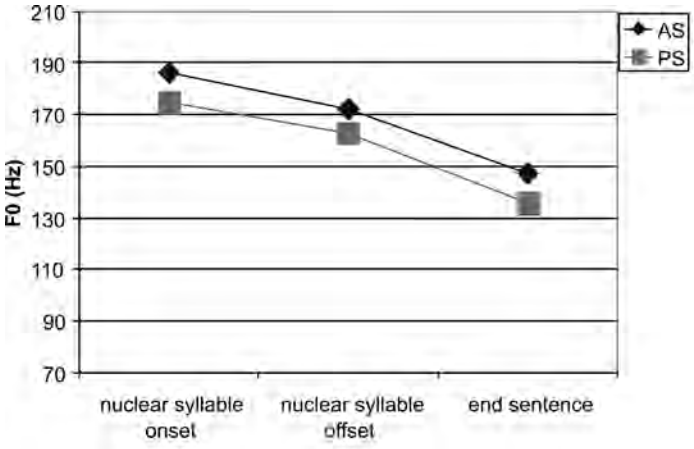

Figure 9. *Mean F0 values in Hz at the beginning and at the end of the final accented syllable as well as at the end of the whole sentence for double-stressed declaratives in PS and in AS.*

Thus, the pitch configuration of the nuclear accent in double-stressed neutral declaratives observed in this study coincides with former analyses of both PS and AS.

3.1.3. The pre-nuclear accent of double-stressed sentences

As mentioned in the introduction, previous studies on pre-nuclear accents in declarative sentences in PS have described the rising pitch trajectory as L*+H (Sosa 1999; Face 1999, 2001; Beckman et al. 2002; Calleja 2004) or L+>H* (Face and Prieto 2007; Estebas-Vilaplana and Prieto 2008, 2010). The first analysis assumes a low F0 during the accented syllable and a subsequent rise in the post-tonic syllable. L+>H*, on the other hand, indicates that the rising movement begins during the accented syllable with the highest F0 on the post-tonic. The results obtained in our experiment corroborate this second interpretation, since the rising trajectory starts in the accented syllable and the peak is anchored on the post-accented syllable. This is illustrated in Figure 10 which displays the mean F0 values at the beginning and at the end of the accented syllable as well as at the peak of the rise for the PS speaker.

Studies on AS (Sosa 1999; Toledo 2000; Kaisse 2001; Gurlekian, Torres and Colantoni 2004; Colantoni and Gurlekian 2004) show that in the Buenos Aires variety the F0 peak of rising pre-nuclear accents in neutral declaratives is located within the accented syllable and thus the phonological characterization for this pitch movement is H*+L which involves a high target on the accented syllable and a subsequent F0 fall. The results obtained in this study, however, do not support the findings reported in the aforementioned studies. Alternatively, our AS data show a pitch movement closer to the PS results. As observed in Figure 10, the AS speaker also shows a rising trajectory in the pre-nuclear configuration with the peak located after the accented syllable.

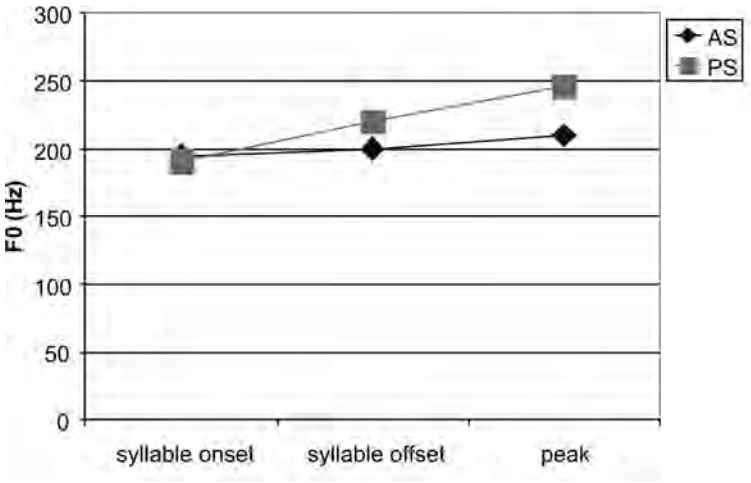

Figure 10. *Mean F0 values in Hz at the beginning of the accented syllable, at the end of the accented syllable and at the peak of the rise in pre-nuclear position for the PS and the AS speakers.*

If we compare the AS and the PS rising trajectories we could see that the slope of the rise is greater in PS than in AS. As previously mentioned, this may be due to the narrower pitch range of the AS speaker (148-209 Hz) as compared to that of the PS speaker (135-250 Hz). Given the subtle rising movement observed within the accented syllable in AS (from 195 Hz to 200 Hz), it can be an issue of future research to decide whether this movement should be interpreted as L*+H rather than L+>H*. However, what is clear from our findings is that we cannot account for the pre-nuclear rise in our data as an instance of H*+L since the F0 peak is clearly located after the accented syllable offset.

If we compare the actual displacement of the F0 peak in the two varieties (Figure 11) we can see that even though the peak is more displaced in PS (0,051 ms) than in AS (0,056 ms), this difference is not significant ($p>0.05$). These findings corroborate the results reported in Colantoni (2005) that there is some variability in Buenos Aires Spanish with respect to the realization of pre-nuclear accents. She argues that sometimes pre-nuclear accents may show a displaced peak, as is the case in our data.

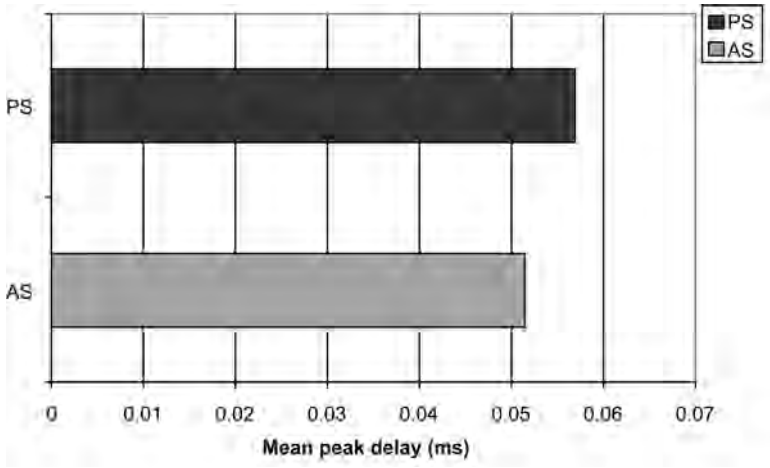

Figure 11. *Mean peak displacement in ms with respect to the end of the pre-nuclear accented syllable (0 value) for PS and AS.*

Overall, the results of this study show that both languages use a rising accent with a displaced F0 peak in the pre-nuclear configuration of neutral declaratives. Even though this pattern is expected in PS, it differs from the pitch movement described in previous studies on AS. Our data is in line with Colantoni (2005) who suggests that there is variability in the use of L*+H and L+H* in AS.

3.2. *Duration*

Given the few differences observed in the data of the two informants with respect to the melodic production of neutral declaratives, the parameter of syllable duration was

examined. Our hypothesis was that in AS the nuclear syllable is much longer than in PS. We hypothesized that durational differences are more relevant than pitch differences to distinguish the intonation of the two varieties.

In order to compare the two varieties we normalized the duration of the nuclear syllable in all sentences by dividing the original duration of the nuclear syllable by the duration of the whole sentence both in single-stressed and in double-stressed productions. The results are presented in Figures 12 and 13 which exhibit the mean duration of the accented syllable in PS and AS for sentences with one accent and with two accents respectively.

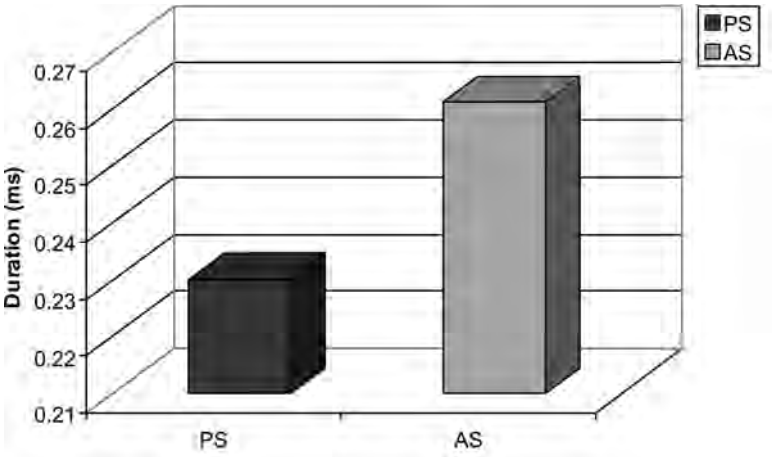

Figure 12. *Mean nuclear syllable duration in ms for sentences with one accent in PS and AS.*

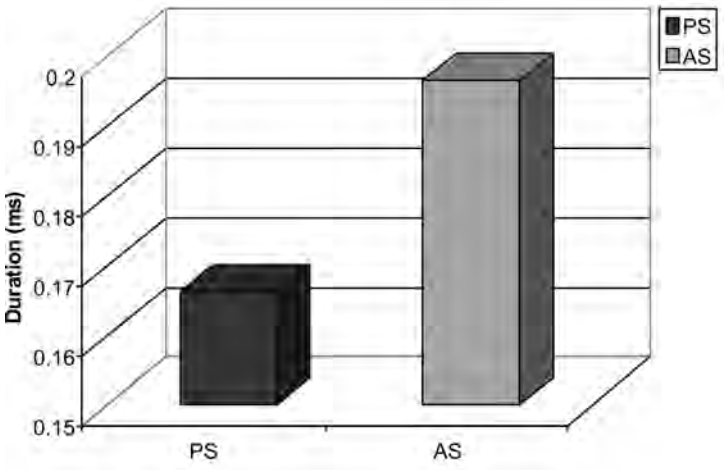

Figure 13. *Mean nuclear syllable duration in ms for sentences with two accents in PS and AS.*

The results presented in Figures 12 and 13 show that both for single and double-stressed sentences the mean duration of the nuclear syllable is longer in AS than in PS. In sentences with one accent, the mean duration of the nuclear syllable is 0,229 ms for PS and 0, 261 ms for AS. In sentences with two accents, the mean duration of the nuclear syllable is 0,166 ms for PS and 0,196 ms for AS. These differences were statistically confirmed by two-paired t-tests, which showed that differences in the duration of the nuclear syllable in PS and AS are significant ($p<0,0001$) for the two types of sentences. As we will discuss in the next section, durational differences in the production of the nuclear accent of neutral declaratives in PS and AS seem to be more relevant than intonational differences.

4. Discussion

The results found in this study have shown that the main difference between the production of a neutral declarative sentence in PS and in AS is not on the pitch contours but on the duration of the nuclear syllable which has proved to be significantly longer in AS than in PS.

The nuclear tonal movements of single-stressed declaratives obtained in our data are the same in PS and in AS. The pitch trajectory shows a gentle rise with the peak aligned within the accented syllable. Even though in AS the peak alignment was a bit earlier than in PS, we still think that the tonal entity to describe such rises must be the same and that the small differences observed in the location of the peak are realizational differences. Within the Sp_ToBI framework (Beckman et al 2002; Estebas-Vilaplana and Prieto 2008, 2010), this pitch accent is described as L+H* which involves a rising movement from a low (L) target. In earlier versions of the AM model (Prieto et al. 1995), the tone used for such configuration was H*. However, after the first version of the Sp_ToBI system (Beckman et al 2002), H* is only used when it is preceded by another high tone and there is no F0 minimum before it. For AS, Colantoni and Gurlekian (2004) use H*+L to describe the last accent of a declarative sentence. Given the similarities in the pitch traces of PS and AS observed in our data, we think that the same pitch accent has to be used to describe the nuclear accent of the two varieties. Our proposal is to stick to the L+H* category since the final low tone after H* observed in the pitch contours can be accounted for by a low boundary tone (L%).

As expected, the pitch trajectory of the nuclear accent in double-stressed sentences is the same in the two varieties, namely, a progressively falling pitch movement. The convention used in this study to describe this nuclear tone is a low pitch accent (L*) as argued in many other works both for PS (Sosa 1999; Beckman et al 2002; Estebas-Vilaplana and Prieto 2008, 2010; among others) and for AS (Arana at al. 2007). Finally, Gabriel et al. (2010) propose the H+L* pitch accent to account for the nuclear accent of single and multi-stressed sentences in AS since they observed a high target before the low tone. This tonal category is not confirmed in our data. Single-stressed utterances clearly show a rising movement rather than a fall in the nuclear syllable (see Figure 5 for

more details). The progressively falling pattern in double-stressed structures may make us reconsider the possibility of using H+L* in this position to account for the fall. However, as pointed out in Grice (1995), leading and trailing tones, that is, the tones that precede or follow a starred tone, are usually fixed in time with respect to the starred one. In other words, the H in H+L* is used to describe a pitch movement that takes place in the pre-tonic syllable and not in an indefinite number of unstressed syllables, as it is the case with multi-stressed declaratives where the number of syllables between the last pre-nuclear accent and the final accent may vary across utterances. Thus, we think that the phonological category that better accounts for the final accent of double-stressed declaratives is a monotonal low entity (L*).

As far as the pre-nuclear accents are concerned, former studies on PS and AS intonation have argued that these two varieties use different intonation patterns in the pre-nuclear stretch. In PS, pre-nuclear accents show a rising F0 with the peak anchored after the accented syllable. Earlier accounts of the AM framework (Sosa, 1999; Face 1999, 2001; Beckman et al 2002; Calleja 2004) have described such rises as L*+H. Later descriptons (Face and Prieto 2007; Estebas-Vilaplana and Prieto 2008) have adopted the L+>H* category which indicates that the accented syllable is perceived as high since the rising trajectory actually starts within the accented syllable even though the peak is realized on the post-tonic. Face (2007) shows that the pre-nuclear rises in declarative sentences (L+>H*) are different from the pre-nuclear accents in yes-no questions (L*+H) and that speakers can perceive this difference as linguistically relevant. Previous studies on AS, on the other hand, have shown that pre-nuclear accents in broad focus declaratives exhibit an F0 peak aligned within the limits of the pre-nuclear accented syllable, described as H*+L (Colantoni and Gurlekian 2004). The results found in our study confirm the findings obtained in previous studies of PS in that the F0 of pre-nuclear rises is located after the accented syllable but disagree with the previous descriptions of AS. In our AS data the F0 peak in pre-nuclear accents is not located within the limits of the accented syllable but follows a similar pattern to the PS intonation, with the peak aligned after the offset of the accented syllable. Our results of AS are in line with Colantoni (2005) which reports the existence of both L*+H and L+H* in pre-nuclear position in this variety. Given the similar pitch trajectories obtained in the pre-nuclear accents of our data, in the present study we propose to model the pre-nuclear accents of both PS and AS in the same way, namely, L+>H*. However, in order to clarify the phonological status of pre-nuclear accents in declarative sentences in AS we would need 1) to examine more speakers and 2) to carry out perception tests so as to see whether peak alignment differences are phonological relevant or not. In other words, we would need to investigate whether H*+L and L+>H* are contrastive or maybe they respond to the same tonal category which may be produced with different alignment patterns in AS.

Given the similarities observed in this study with respect to the pitch traces of single and double-stressed neutral declaratives in PS and AS, we explored another factor, the duration of the nuclear accent. We assumed that differences in the duration of the nuclear syllable could be more relevant in distinguishing the PS and the AS declarative intonation

than the actual pitch trajectories. The results showed significant differences between the two varieties exhibiting a longer duration in AS than in PS. Thus, the findings obtained in this study show that durational differences in the nuclear syllable have to be taken into consideration in the description of neutral declarative intonation in PS and AS.

In order to confirm whether these differences are categorical, that is, in order to see whether in AS the duration parameter has to be incorporated in the phonological description of the nuclear accent in declaratives, further research is needed. In particular, it is necessary to carry out perceptual studies so as to investigate whether durational differences are perceived as categorically different or not. Recent studies on intonational modelling and the relation between intonation and pragmatics have highlighted the importance of duration in the description of intonation. For example, Hualde (2009) suggests that the final pitch accents in neutral declaratives in Spanish has to be described in terms of duration ("dur*") and not in terms of intonation since no relevant pitch movement is observed. Similarly, Escandell Vidal (in press) shows that there are some cases in Spanish that the distinction between narrow focus and broad focus is only triggered by durational differences. In other words, the nuclear accent is longer in narrow focus than in broad focus with no additional pitch movement. Even though more research on durational differences has to be carried out, the results of this study suggest that the incorporation of duration in intonational modelling seems to be rather necessary.

These findings are also relevant for the implementation of Spanish intonation to speech synthesis and speech recognition systems since including differences in the duration of the nuclear accent in the two varieties may help to achieve a more natural speech and higher levels of recognition.

5. Conclusion

In this study we have compared the intonation of neutral declaratives in PS and in AS by means of the Autosegmental-Metrical framework. 600 single and double-stressed neutral declaratives have been analysed in terms of pitch and duration. The results obtained in this study have shown that the intonational patterns of neutral declaratives in PS and AS are very similar and that the parameter that triggers the main difference between the two varieties is the duration of the nuclear syllable which is significantly longer in AS than in PS. These findings seem to suggest that it may be necessary to incorporate duration in the phonological systems of intonation. Similarly, the implementation of duration differences in speech synthesis and speech recognition systems may contribute to a more natural speech and a clearer recognition.

Acknowledgements

I would like to thank Jorge Rico for helping me with the writing of the *Praat* script. I am also grateful to Eva Samaniego and Micaela Silva for recording the materials. This research has been funded by the grant HUM2006-01758/FILO.

NOTES

* Correspondence to: Eva Estebas Vilaplana. UNED. Departamento de Filologías Extranjeras y sus Lingüísticas. Facultad de Filología. Paseo Senda del Rey, 7. 28040 Madrid. E-mail: eestebas@flog.uned.es

REFERENCES

Alcoba, S. and J. Murillo. 1999. "Intonation in Spanish". *Intonation systems: a survey of twenty languages*. Eds. D. Hirst and A. Di Cristo. Cambridge: Cambridge University Press. 152-166.

Arana, V., B. Blázquez, A. Dabrowski, L. Labastía. 2007. "Argentinean Spanish (Buenos Aires)". Paper presented at the "Workshop on Sp_ToBI". 3rd Phonetics and Phonology in Ibera Conference. University of Braga.

Beckman, M., M. Díaz Campos, J. T. McGory and T. A. Morgan. 2002. "Intonation across Spanish, in the Tones and Break Indices framework". *Probus* 14: 9-36.

Boersma, Paul and David Weenink 1992-2001. "Praat: a system for doing phonetics by computer". [Available at http://www.praat.org].

Cabrera, M. and F. Vizcaíno. 2010. "Canarian Spanish". *Transcription of Intonation of the Spanish language*. Eds. P. Prieto and P. Roseano. München: Lincom Europa.

Calleja, N. 2004. "Alineamiento fonético de acentos tonales en el castellano de Vitoria". *Estudios de Fonética Experimental* 13: 39-63.

Canellada, M. J. and J. Kuhlmann Madsen. 1987. *Pronunciación del español*. Madrid: Castalia.

Colantoni, L. and J. Gurlekian. 2004. "Convergence and intonation.Historical evidence from Buenos Aires Spanish". *Bilingualism: Language and Cognition* 7(2): 107-119.

Colantoni, L. 2005. "Peak alignment of pre-nuclear and nuclear accents in Argentine Spanish". Paper presented at the "II Spanish ToBI Workshop". 2nd Phonetics and Phonology in Iberia Conference. Barcelona.

Escandell Vidal, V. In press. "Con la entonación en foco". *Oralia*. Ed. A. Hidalgo.

Estebas-Vilaplana, E. 2006. "Word edge tones in Spanish pre-nuclear accents". *Estudios de Fonética Experimental* 15: 11-42.

Estebas-Vilaplana, E. 2008. "Modelling final declarative intonation in English and Spanish". *Estudios de Filología Inglesa. Homenaje a la Dra. Asunción Alba Pelayo*. Eds. L. Alba and T. Gibert. Madrid: Editorial UNED. 109-129.

Estebas-Vilaplana, E. and P. Prieto. 2008. "La notación prosódica del español: una revisión del Sp_ToBI". *Estudios de Fonética Experimental* 17: 265-283.

Estebas-Vilaplana, E. and P. Prieto. 2010. "Castilian Spanish". *Transcription of Intonation of the Spanish language*. Eds. P. Prieto and P. Roseano. München: Lincom Europa. 17-48.

Face, T. 1999. "A Phonological analysis of rising pitch in Castilian Spanish". *Hispanic Linguistics* 11: 15-37.

Face, T. 2001. *Intonational marking of contrastive focus in Madrid Spanish*. PhD dissertation. Ohio State University.

Face, T. 2007. "The role of intonational cues in the perception of declaratives and absolute interrogatives in Castilian Spanish". *Estudios de Fonética Experimental* 16: 185-225.

Face, T. and P. Prieto. 2007. "Rising accents in Castilian Spanish: a revision of Sp-ToBI". *Journal of Portuguese Linguistics* (special issue on Prosody of Iberian Languages). Eds. G. Elordieta and M. Vigário. 117-146.

Gabriel, C., I. Feldhausen, A. Pesková, L. Colantoni, S. Lee, L. Labastía, V. Arana, B. Blázquez, A. Dabrowski and M. Vázquez. 2010. "Argentinean Spanish (porteño)". *Transcription of Intonation of the Spanish language*. Eds. P. Prieto and P. Roseano. München: Lincom Europa.

Grice, M. 1995. "Leading tones and downstep in English". *Phonology* 12: 183-234.

Gurlekian, J., H. Torres and L. Colantoni. 2004. "Modelos de entonación analítico y fonético-fonológico aplicados a una base de datos del español de Buenos Aires". *Estudios de Fonética Experimental* 13: 275-302.

Gussenhoven, C. 2004. *The Phonology of Tone and Intonation*. Cambridge: Cambridge University Press.

Hualde, I. 2002. "Intonation in Spanish and the other Ibero-Romance languages: overview and status quaestinois". *Romance phonology and variation*. Eds C. Wiltshire and J. Camps. Amsterdam: John Benjamins. 101-115.

Hualde, I. 2009. "The metrical tier in Spanish intonation". Paper presented at the "IV Workshop on Sp_ToBI: Transcription of Intonation of the Spanish language". 4th Phonetics and Phonology in Iberia Conference. Las Palmas de Gran Canaria.

Kaisse, E. 2001. "The long fall: An intonational melody of Argentinean Spanish". *Features and Interfaces in Romance*. Eds. J. Herschensohn, E. Mallén and K. Zagona. Amsterdam: John Benjamins. 148-160.

Quilis, A. and J. A. Fernández. 1985. *Curso de fonética y fonología española*. Madrid: CSIC.

Ladd, D. R. 1996. *Intonational Phonology.* Cambridge: Cambridge University Press.

Navarro Tomás, T. 1944. *Manual de entonación española*. New York: Spanish Institute in the United Status.

Nibert, H. J. 2000. *Phonetic and phonological evidence for intermediate phrasing in Spanish intonation*. PhD dissertation. University of Illinois at Urbana-Champaign.

Pamies, A. 2007. "Observaciones sobre la estructura melódica en enunciados declarativos". *Proceedings of the III Congreso de Fonética Experimental*. Universidad de Santiago de Compostela. 475-488.

Pierrehumbert, J. 1980. *The Phonology and Phonetics of English Intonation*. PhD dissertation. Bloomington: Indiana University Press.

Prieto, P. 1998. "The scaling of the L tone line in Spanish downstepping contours". *Journal of Phonetics* 26: 261-282.

Prieto, P., E. Estebas-Vilaplana and M. M. Vanrell. 2010. "The relevance of prosodic structure in tonal articulation. Edge effects at the prosodic word level in Catalan and Spanish". *Journal of Phonetics*. 38(4): 687-705.

Prieto, P., C. Shih and H. J. Nibert. 1996. "Pitch downtrend in Spanish". *Journal of Phonetics* 23: 445-473.

Prieto, P., J. van Santen and J. and Hirschberg. 1995. "Tonal alignment patterns in Spanish". *Journal of Phonetics* 23: 429-451.

Sosa, J. M. 1995. "Nuclear and pre-nuclear tonal inventories and the phonology of Spanish declarative intonation". *Proceedings of the Thirteenth Congress of Phonetic Sciences*. Eds. K. Elenius and R. Branderand. 646-649.

Sosa, J. M. 1999. *La entonación del español*. Madrid: Cátedra.

Toledo, G. 1989. "Señales prosódicas del foco". *Revista argentina de lingüística* 5: 205-230.

Toledo, G. 2000. "H en el español de Buenos Aires". *Langues et Linguistique* 26: 107-127.

APPENDIX

Sentences with two stresses

1. *Llega de Málaga.*
   "(S)he comes from Málaga".
2. *Llega de Módena.*
   "(S)he comes from Módena".
3. *Llega de Mónaco.*
   "(S)he comes from Mónaco".
4. *Llega de Mérida.*
   "(S)he comes from Mérida".
5. *Mira mi nómina.*
   "(S)he looks at my payroll".
6. *Mira mi médula.*
   "(S)he looks at my marrow".
7. *Mira mi nódulo.*
   "(S)he looks at my nodule".
8. *Mira mi médico.*
   "(S)he looks at my doctor".
9. *Sabe de móviles.*
   "(S)he knows about mobile phones".
10. *Sabe de módulos*
    "(S)he knows about modules".
11. *Sabe sinónimos.*
    "(S)he knows synonyms".
12. *Sabe monólogos.*
    "(S)he knows monologues".
13. *Sale de Mónica.*
    "It is from Mónica".
14. *Sale de Melanie.*
    "It is from Melanie".
15. *Sale de nómada.*
    "(S)he is dressed as a nomad".
16. *Sale de mágico.*
    "(S)he is dressed as a magician".
17. *Va de fenómeno.*
    "(S)he a phenomenon".
18. *Va de monógamo.*
    "(S)he is monogamous".
19. *Va de monótono.*
    "(S)he is monotonous".
20. *Va de lunático.*
    "(S)he is lunatic".

Sentences with one stress

1. *De Málaga.*
2. *De Módena.*
3. *De Mónaco.*
4. *De Mérida.*

5. *Mi nómina.*
6. *Mi médula.*
7. *Mi nódulo.*
8. *Mi médico.*
9. *De móviles.*
10. *De módulos.*
11. *Sinónimos.*
12. *Monólogos.*
13. *De Mónica.*
14. *De Melanie.*
15. *De nómada.*
16. *De mágico.*
17. *Fenómeno.*
18. *Monógamo.*
19. *Monótono.*
20. *Lunático.*