

## Do contour tones induce syllable lengthening in Catalan and Spanish?\*

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### ABSTRACT

In both Spanish and Catalan, narrow contrastive focus and presentational broad focus in nuclear position have different pitch accent choices, namely a rising or a falling pitch accent, respectively. In oxytonic words, narrow contrastive focus displays a rise-fall complex pitch gesture in the last syllable of the utterance. This article investigates the effects of the complexity of such a pitch pattern on the durational properties of the syllables in both languages when compared to the simpler falling pitch movement. The results of a production experiment reveal that in general, the presence of a complex pitch pattern tends to have a lengthening effect on the target syllable. Yet we also find that some instances of this complex contour can be partially truncated, in which case it does *not* trigger lengthening. In sum, even though truncation and compression have been claimed to be language- and dialect-specific strategies (Ladd 1996, Grabe et al 2000), in our data, truncation can be considered a phonetic realization strategy that interacts with timing in such a way that there is a trade-off relationship between the two factors.

**Keywords:** contour tones, truncation and compression, lengthening effects, Catalan, Spanish.

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## 1. Introduction

In languages with a contrast between contour and non-contour tones, there are often restrictions on where those categories can occur. These restrictions vary from language to language, but there are some such patterns that recur independently and in unrelated languages. Contexts with a recurring appearance of contour tones are generally syllables that are significantly longer than elsewhere, while shorter contexts tend to produce neutralization. For example, it has long been noted that contour tones in Chinese languages such as Mandarin, Cantonese, and Fuzhou appear with fewer restrictions in language varieties that have coda contrasts, diphthongs, and longer rhyme durations, that is, in bimoraic syllables (Duanmu 1990, 1994a, b). Similarly, in Tokyo Japanese (unlike Kansai Japanese), a contour tone cannot be realized on a single mora (Maeda & Venditti 1998).<sup>1</sup> Nonetheless, the strictly moraic approach has been challenged by Zhang (2004), who points out that contour tones appear crosslinguistically in syllables which are long for independent reasons, e.g. syllables at the end of prosodic domains, syllables in shorter words, etc., and argues that the tone-bearing ability is rooted in phonetic behaviour. In the perception realm, experiments by Diehl & Kluender (1989) have revealed that high tones in Chinese can be misperceived as rising tones when syllables are longer.

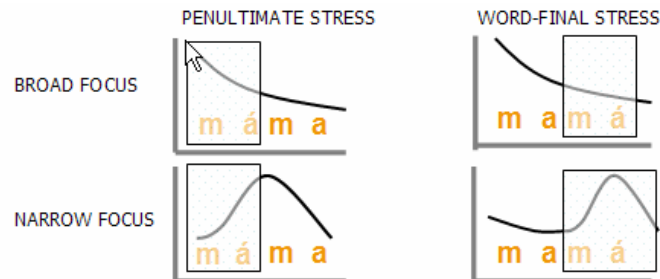
In pitch-accent languages it has also been observed that when potential contour tones appear as a result of two or three associated tones with a single syllable, either the contour is fully realized and ‘compressed’, or certain repair strategies appear, such as contour truncation (for examples of these different strategies, see Ladd 1996:132-136, Grabe et al 2000). Yet in compressing languages, a few studies have found that syllables bearing a complex pitch accent are longer than syllables bearing simpler pitch accents. For example, Gili Fivela (2005) reports that syllables in contrastive focus (e.g., rise-fall gestures) are 7% to 10% longer than syllables in broad focus (e.g., rise gestures), regardless of their position within the word. Similarly, Ortega-Llebaria & Prieto (2006) recently investigated the durational properties of words with broad vs. narrow contrastive focus in Catalan and Spanish. They found that duration was amplified in narrow-focused words, but only in final position. Since only in final position do we have a complex tonal gesture, the working hypothesis is that complex tonal gestures trigger lengthening. Crucially, durational differences only appeared between narrow vs. broad focus in oxytonic words, a context where we find the pressure of realizing a complex rising-falling tonal gesture only in narrow focus. By contrast, the lack of duration effect in paroxytonic words is attributed to the lack of realization of the complex gesture.

The goal of this paper is to systematically investigate the effects of the presence of complex pitch movement on the durational properties of syllables in Catalan and Spanish and to test whether the abovementioned restrictions are rooted in a systematic

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<sup>1</sup> On the other hand, in Cantonese, contour tones have a lengthening effect: specifically, there is a statistically significant difference between the duration of a level tone and that of either a morphologically-derived or a sandhi-derived rising tone (Yu 2003).

phonetic behaviour. Crucially, in both languages, narrow contrastive focus and presentational broad focus have different pitch accent choices. As Figure 1 shows, in Catalan narrow focus is realized as a rising accent and broad focus as a falling accent. Interestingly, when the accented syllable is in phrase-final position (*mamá*), the rising accent is realized as a complex rise-fall gesture, as follows.



**Figure 1.** Schematic representation of the realization of the nuclear pitch accent in broad focus and in narrow focus utterances, in words with penultimate stress and word-final stress.

This contrast will enable us to test the hypothesis that the presence of a complex contour in oxytonic words in narrow focus will trigger an extra amount of lengthening in this syllable. An analysis of 1280 utterances produced with the abovementioned contrasts revealed the following: a) in cases where the complex contour is fully realized, a clear difference is revealed between the duration properties of syllables carrying a narrow focus accent in oxytonic position vs. paroxytonic position; this is attributed to the pressure of realizing a complex tonal gesture only in oxytonic position (see Figure 1); b) in cases of truncated (or partially truncated) contours, there is no clear lengthening effect. The potential implications of these results for crosslinguistic work on the constraints and strategies of contour compression and truncation will be discussed.

The article is organized as follows. Section 2 presents the methodology of the production experiment. Section 3 presents the main pitch range and duration results of the production experiment. Finally, Section 4 discusses the main implications of this work for crosslinguistic studies on the interaction between pitch realization and duration.

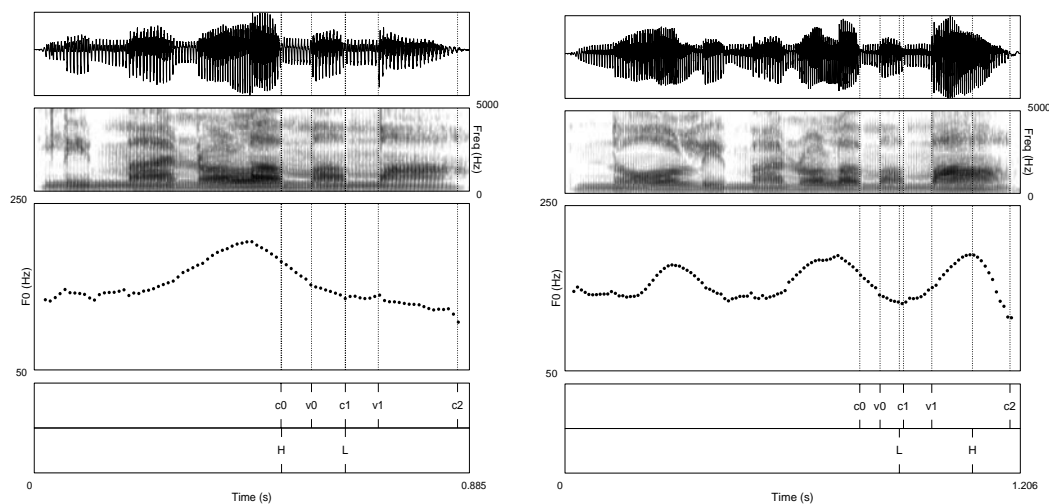
## 2. Experimental investigation

### 2.1. Method

#### 2.1.1. Materials

In both Catalan and Spanish, broad focus has been described as having a different prosodic realisation from narrow contrastive focus (e.g. *She broke her neck, right? — No, she broke her LEG*) (de la Mota 1995, Face 1995 for Spanish, Prieto 2002 for Catalan). In Spanish and Catalan, nuclear broad focus is realized with a falling nuclear

accent, while one of the possible realizations of the nuclear narrow contrastive focus is a non-downstepped rising accent, as Figure 2 shows. Interestingly, when the accented syllable is in phrase-final position (*mamá*), the rising accent is realized as a complex rise-falling gesture.



**Figure 2.** Waveforms, spectrograms, and F0 contours of the Catalan utterances *L'hi mano a la mamá* ‘I am asking this to Mum’ (broad focus, left panel) and *L'hi mano a la MAMÀ* ‘I am asking this to MUM’ (contrastive focus, right panel).

In order to test the hypothesis that the presence of a complex contour tone in oxytonic words with narrow-corrective focus will trigger an extra amount of lengthening, we planned a controlled production experiment comparing near-minimal-pair words bearing the two types of pitch accents. A previous study with similar speech materials for Catalan and Spanish (Ortega-Llebaria & Prieto 2006) found that durational differences between stressed syllables in narrow vs. broad focus were only found in oxytonic words, and not in paroxytonic words. This contrast was attributed to the pressure on the speaker of having to realize a complex tonal gesture only in narrow focus. Yet these materials did not control for segmental content, something that we do in the present experiment. The sentences under study were the following: (1) a broad-focus utterance (e.g. *Catalina me desanimó* ‘Catalina discouraged me’), and (2) a narrow-contrastive focus (e.g. *¿Catalina te animó?* ‘Did Catalina encourage you?’ – *No, Catalina me DESANIMÓ* ‘No, Catalina DISCOURAGED me’).

To better control for vowel and consonantal effects on duration (i.e. segmental effects), the target words selected are four two-syllable nouns that have the same segmental composition and that contrast only in stress position in both languages: Spanish/Catalan *mamá* ‘Mum’ vs. *mama* ‘Mum’, and *Mimí* ‘proper noun’ vs. *Mimi* ‘proper noun’. Each target word was placed in: (1) a broad-focus utterance (e.g. Span. *¿Qué pasa?* – *Se lo dice a mamá* ‘(S)he is telling Mum’); and (2) a narrow-contrastive focus, which is indicated in capital letters (e.g. Span. *¿Se lo dice a mamá?* – *No, se lo dice a MAMA* ‘No, (s)he is telling MUM’), as follows:

### Catalan

/a/

*L'hi dono a la mama*

'I am giving it to Mum'

*L'hi dono a la MAMA*

'(No), I am giving it to MUM'

*L'hi dono a la mamà*

'(No), I am giving it to Mum'

*L'hi dono a la MAMÀ*

'(No), I am giving it to MUM'

/i/

*L'hi dono a la Mimi*

'I am giving it to Mimi'

*L'hi dono a la MIMI*

'(No), I am giving it to MIMI'

*L'hi dono a la Mimí*

'I am giving it to Mimi'

*L'hi dono a la MIMÍ*

'(No), I am giving it to MIMÍ'

### Spanish

*Se lo doy a mama*

'I am giving it to Mum'

*Se lo doy a MAMA*

'(No), I am giving it to MUM'

*Se lo doy a mamá*

'(No), I am giving it to Mum'

*Se lo doy a MAMÁ*

'(No), I am giving it to MUM'

*Se lo doy a Mimi*

'I am giving it to Mimi'

*Se lo doy a MIMI*

'(No), I am giving it to MIMI'

*Se lo doy a Mimí*

'I am giving it to Mimi'

*Se lo doy a MIMÍ*

'(No), I am giving it to MIMÍ'

These nouns in two focus contexts were inserted in 20 frame sentences with different verb types (see Appendix) and placed in sentence-final position.

#### *2.1.2. Experimental procedure*

Subjects were presented with a Power Point presentation with 80 slides (20 utterances x 2 words x 2 focus types) which contained the right contexts to trigger an utterance with either broad or narrow focus, together with the answers, as follows:

#### Broad focus

Context: —¿*Què passa?*  
'What is going on?'  
—*L'hi dono a la mamà*  
'I am giving it to Mum'

#### Narrow-contrastive focus (with emphasis and assertiveness)

Context: —¿*L'hi dones a la mamà?*  
'Will you give it to “mamà”?'  
—*No, l'hi dono a la MAMA*  
'No, I will give it to “mama”'

First, the experimenter read the context question aloud to the subject. The subject was supposed to read out the answer with an appropriate intonation. If the experimenter thought that the utterance was mispronounced, the speaker was asked to repeat the sentence. The same process was repeated with each one of the slides.

Speakers were recorded individually in a quiet room, using a Sennheiser MKH20P48U3 omnidirectional condenser microphone and a Pioneer PDR609 digital CD-recorder. Speech samples were digitized at 32000 Hz in 16-bit mono, double-checking that the target utterances were produced with the intended prosody.

### 2.1.3. Subjects

Four young females of Central Catalan and four young speakers of Peninsular Spanish (between 23 and 40 years of age) participated in the experiment, uttering a total of 160 utterances per speaker (20 verb types x 2 focus conditions (broad vs. narrow) \* 4 target words stress conditions (*mama*, *mamá*, *mimi*, *mimí*) = 160 utterances per speaker. Thus we obtained a total of 1280 utterances (160 utterances x 8 speakers = 1280 utterances).

### 2.4. Data Analysis and Measurements

The following measurements were made with *Praat* (Boersma & Weekink 2005; Wood 2005) on each of the 1280 target words. Figure 2 shows the labels that we used to segment the target words. In tier 1, we marked the beginning and end of the target segments, for example, 'm', 'a', 'm' and 'a'. In tier 2, we marked the valley (L) and the peak (H) of the pitch accent. In the cases where the pitch line was flat or descending, marks were placed at the beginning and end of the syllable. A Praat script extracted the F0 value in Hz at the marked points and calculated the pitch excursion size by subtracting the F0 values at L from the F0 values at H for each of the 1280 tokens.

### 2.5. Statistical analysis

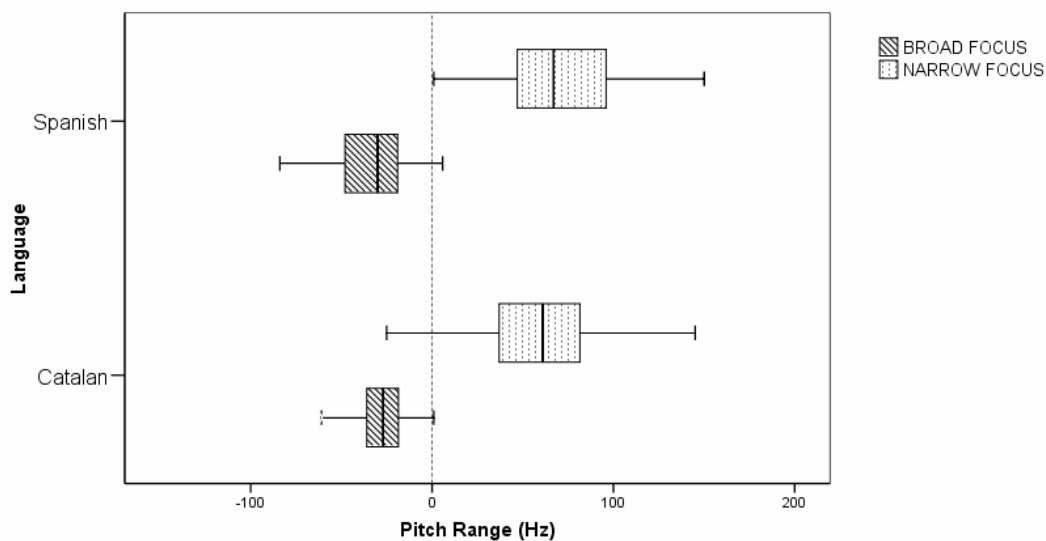
In order to ensure that our data did indeed include two types of accents with different intonation properties, a Repeated Measures ANOVA with the within-subject factor of intonation (broad focus vs. narrow focus) and the between-subject factor of language (Catalan and Spanish) was performed on the pitch-range measurements. After this, we performed a Repeated Measures ANOVA on the duration of stressed vowels with three within-subject factors: stress position (([+word-final]/[-word-final])) and accent-type (broad focus vs. narrow focus) and vowel (i, a), and the between-subject factor of language (Catalan and Spanish). Since vowel was not significant, we collapsed our data across vowels.

### 3. Results

The main research question posed by the study is whether syllable duration is amplified in contrastive narrow-focused words with respect to broad-focused words. That is, we investigate whether the presence of a complex f0 gesture accompanied by an increase in duration.

#### 3.1. Pitch excursion size differences

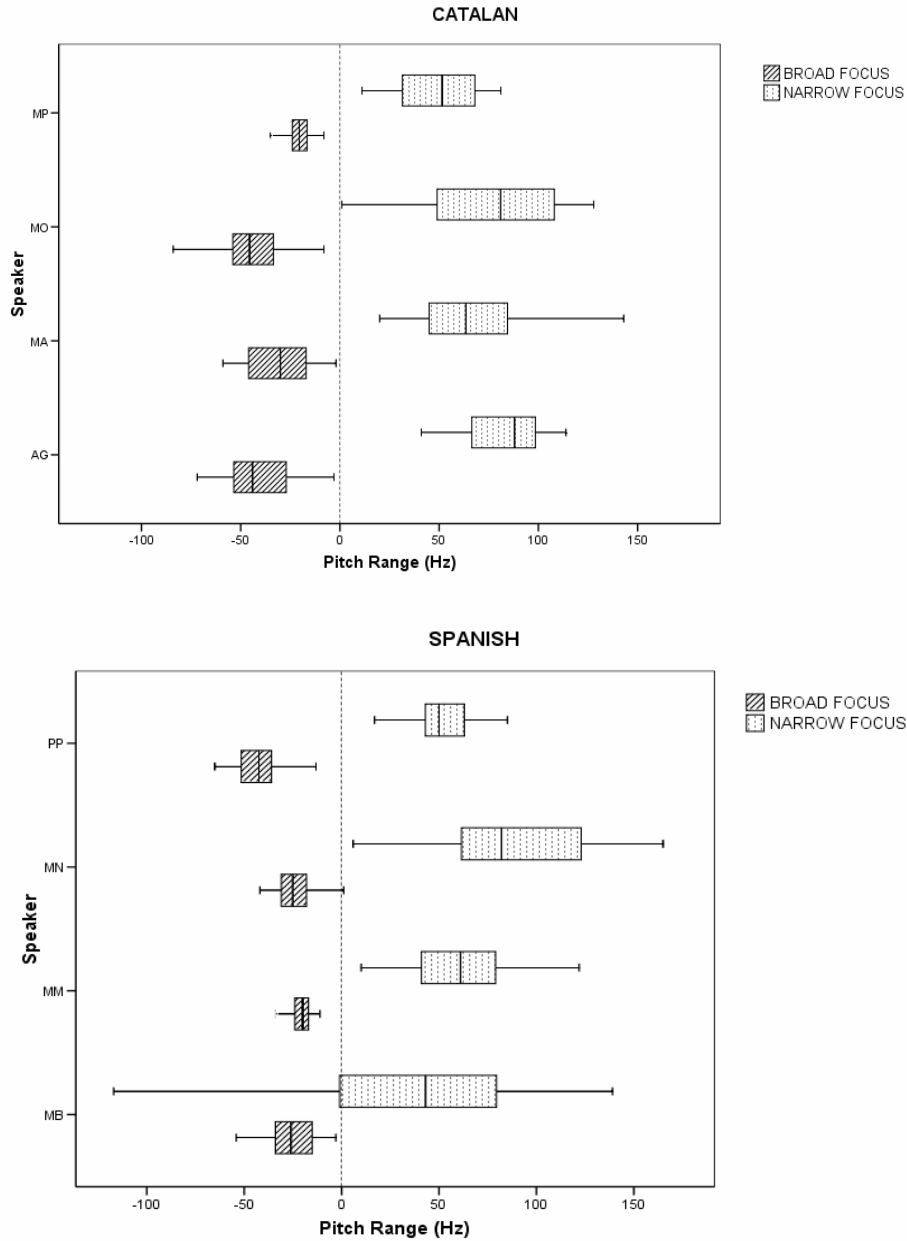
In this section, we check that the two types of focus (broad focus and narrow focus) in nuclear position were indeed realized using two different pitch accents, namely, a falling pitch accent and a rising pitch accent. The boxplots in Figure 3 show the mean pitch range values (in Hz) of stressed syllables in broad-focused and narrow-focused conditions (striped boxes vs. dotted boxes, respectively) for all four Catalan speakers and all four Spanish speakers. Remember that in cases in which the pitch was descending and no peak and valley could be visually identified, the pitch measures were taken at the beginning and at the end of the target accented syllable. As is clear from the graph, both Catalan and Spanish subjects consistently used a substantial pitch increase in narrow-focused sentences (a mean of 69.20 Hz, s.d. 28.47 in Spanish and 56.82 Hz, s.d. 45.04 in Catalan) and a negative increase in the broad-focus case (e.g. a mean of -33.65 Hz, s.d. 17.16 in Spanish and -28.36 Hz, s.d. 14.01 in Catalan).



**Figure 3.** Mean values (in Hz) of the pitch range of the stressed syllables in broad focus (striped boxes) and narrow focus (dotted boxes) in Spanish and Catalan.

If we plot the data separately by speaker (see Figure 4 below), the same pattern emerges for each one of the subjects, namely, speakers produce pitch accents with larger pitch ranges in narrow focus than in broad focus. While maintaining this difference, speakers also show some variation in the amount of pitch range values, especially in the narrow-

focus case. For example, Spanish speaker (MB) has a mean pitch range of 34.93 Hz, and Spanish speaker (MN) has a much larger mean pitch range of 81.60 Hz.



**Figure 4.** Mean values (in Hz) of the pitch range of the stressed syllables in broad focus (dashed boxes) and in narrow focus (dotted boxes) in Spanish and Catalan, plotted separately for all eight speakers.

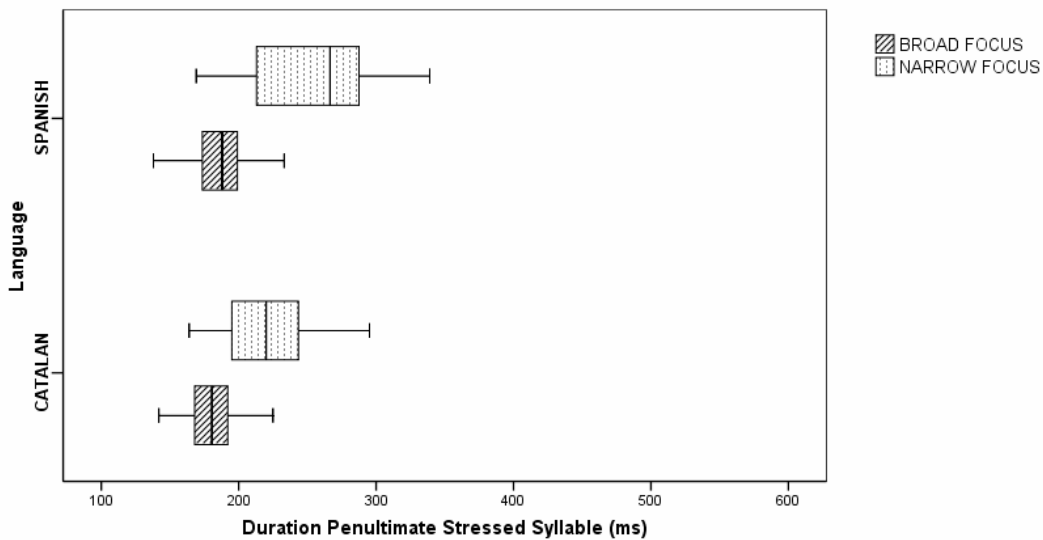
A Repeated Measures ANOVA on the pitch range of stressed syllables revealed highly significant effects of the accent factor on F0 variation (measured as pitch excursion size), at  $F(1,587)= 989.798$ ;  $p<.0001$  and no interaction between the accent\*language factor, at  $F(1,587)= 1.676$ ;  $p=.196$ . Hence, as expected, narrow focus was consistently

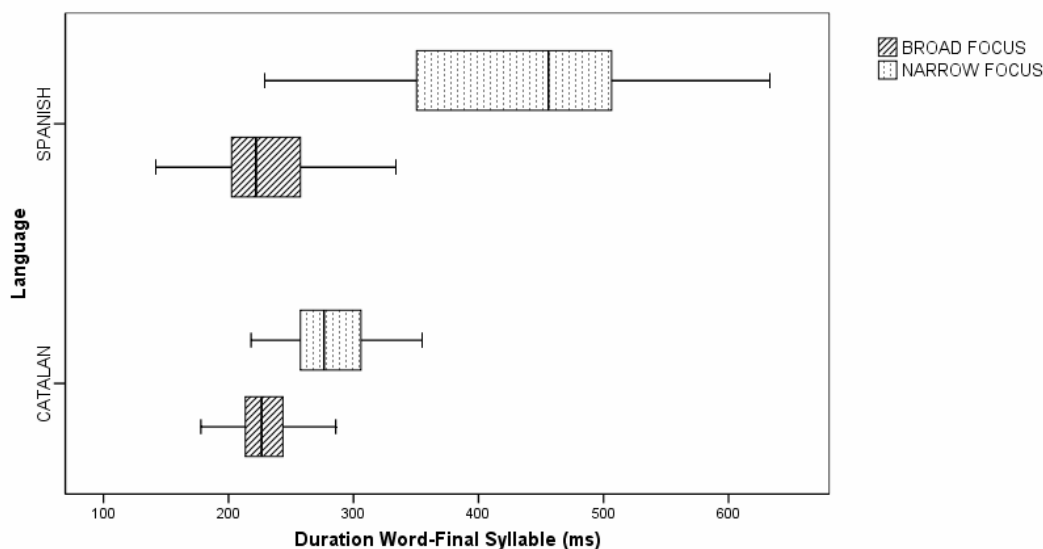


cued by a rising pitch accent in the two languages. By contrast, broad focus in both languages was cued by a falling nuclear pitch accent.

### 3.2. Durational differences

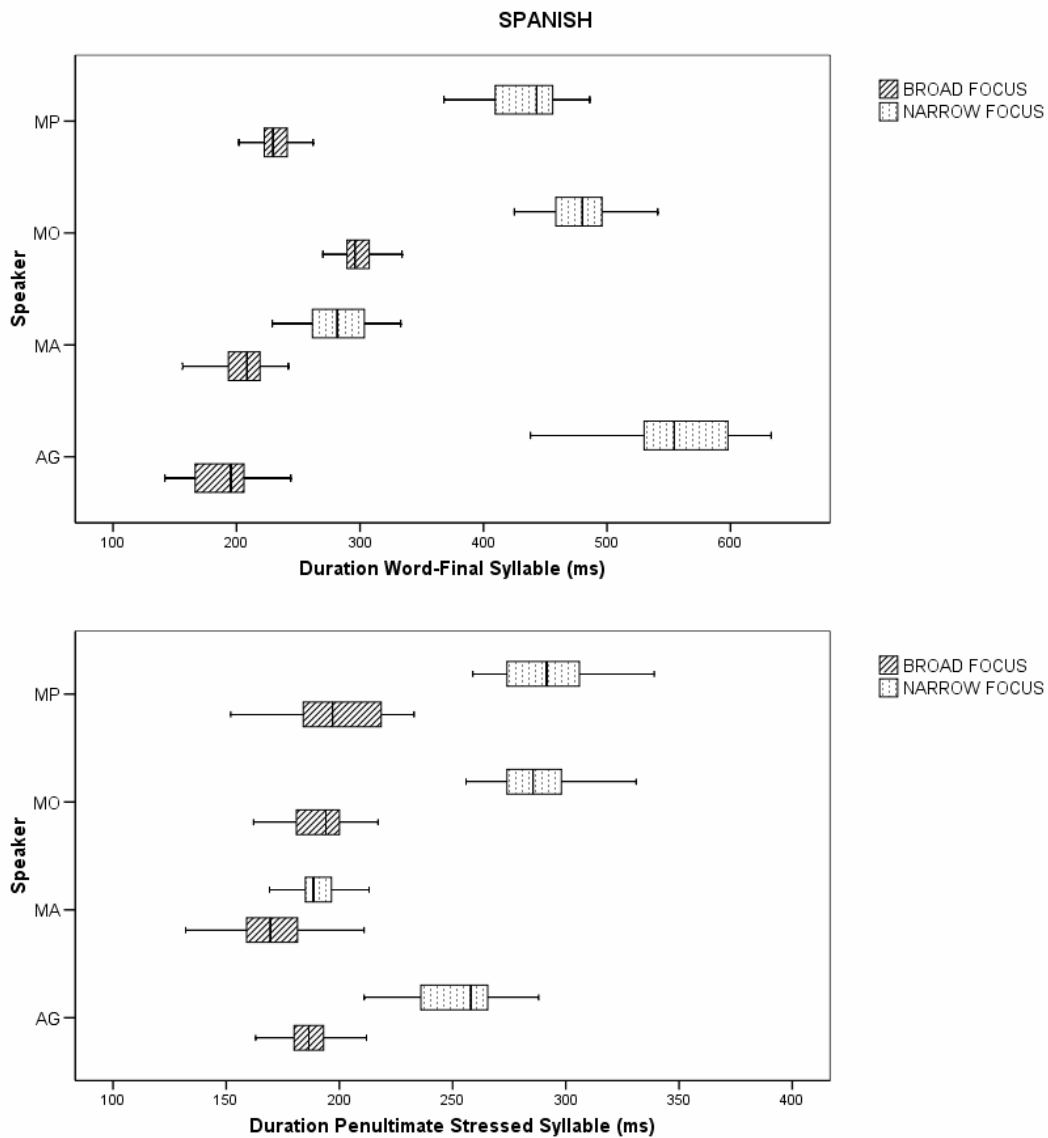
Figure 5 below displays the mean duration (in ms) of the target syllable in penultimate (upper graph) and word-final (lower graph) position in Catalan and Spanish across vowels. In all four plots, the duration of the stressed syllables is compared in the narrow-focused (dotted boxes) and broad-focused (striped boxes) words. The graphs reveal that in general stressed syllables in narrow-focused words are longer than in broad-focused words in both languages, in both penultimate and word-final position (mean differences in penultimate and final position for Catalan: 39 ms. and 55 ms; for Spanish: 69 ms and 207 ms.). In general, the data works as expected: we find greater duration values in narrow-focused than in broad-focused syllables, both in final and penultimate positions, and in both languages (that is, dotted boxes are always to the right of striped boxes). Yet the graphs also show that there is a contrast between Spanish and Catalan. While Spanish speakers produce an extra amount of lengthening in narrow-focused words in final position (see lower graph), this does not seem to be the case for Catalan speakers (mean and standard deviation for narrow focus in Spanish 437.5 ms (105.5) vs. 281.5 ms (33.7) in Catalan).





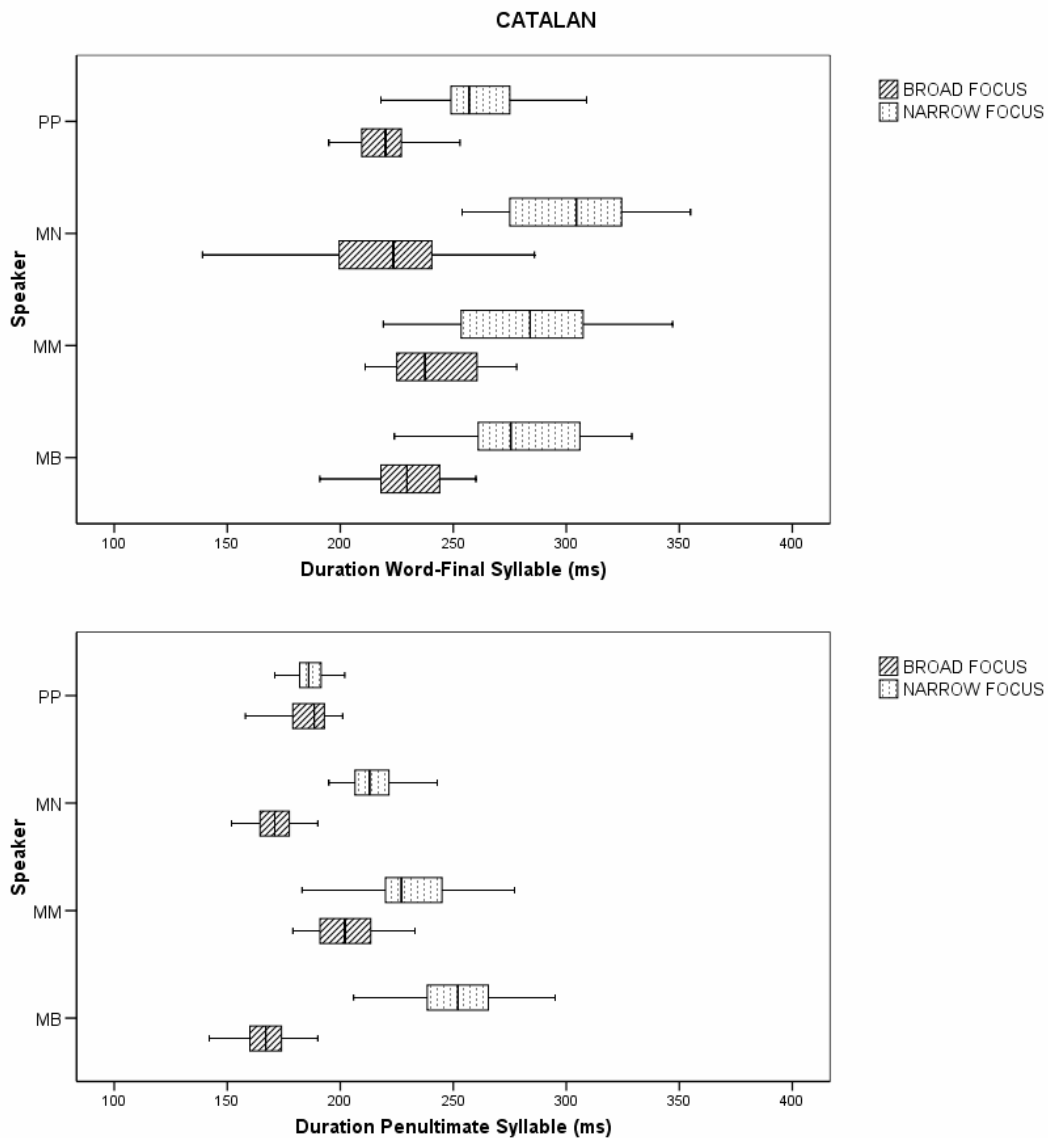
**Figure 5.** Mean values (in Hz) of the pitch range of the stressed syllables in broad focus (dashed boxes) and narrow focus (dotted boxes) in penultimate and word-final position, for both Spanish and Catalan.

The boxplots in Figure 6 depict the same data for each one of the four Spanish subjects. In general, it is very clear that all Spanish speakers display durational differences between narrow- and broad-focused syllables, both in penultimate and word-final position, and, importantly, there is a greater difference between the two when in word-final position, that is, when a complex tonal pattern is realized on the target syllable. For example, for speaker AG, the mean difference in duration between segments in broad focus and segments in narrow focus is 386 ms in oxytone words while this difference falls to 67 ms in paroxytone words, thus showing that the lengthening effect of narrow focus with respect broad focus is 316 ms longer in oxytone than in paroxytone words. For speaker MO these mean differences are 180 ms and 96 ms respectively, and for speaker MP they are 204 ms and 92 ms, showing that the lengthening effect of narrow focus in oxytone words is 84 ms longer than that of paroxytone words for speaker MO, and 112 ms for speaker MP. For speaker MA, the lengthening effect of narrow focus in oxytone words is only 56 ms longer than in paroxytone words since mean differences between narrow and broad focus in oxytone and paroxytone words are 76 ms and 20 ms respectively.



**Figure 6.** Mean values (in Hz) of the pitch range of the stressed syllables in broad focus (dashed boxes) and narrow focus (dotted boxes) in Spanish, plotted separately for all four speakers.

Yet for Catalan subjects, we find subject differences (see boxplots in Figure 7): while subjects MN and PP have an extra lengthening effect in narrow-focused syllables only of oxytonic words, speakers MB and MM do not display this difference. Thus, similarly to Spanish speakers, for Catalan speakers MN and PP, the lengthening effect of narrow focus in oxytone words is around 40 ms longer than that of narrow focus in paroxytone words (mean differences between narrow and broad focus for oxytonic and paroxytonic words for MN: 87 ms and 44 ms, for PP: 40 ms and 2 ms). However, this lengthening effect decreases to less than 10 ms for speaker MM (40 ms in oxytone words and 31 ms in paroxytone words) and even shows the opposite direction for speaker MB (52 ms in oxytone words and 83 ms in paroxytone words).



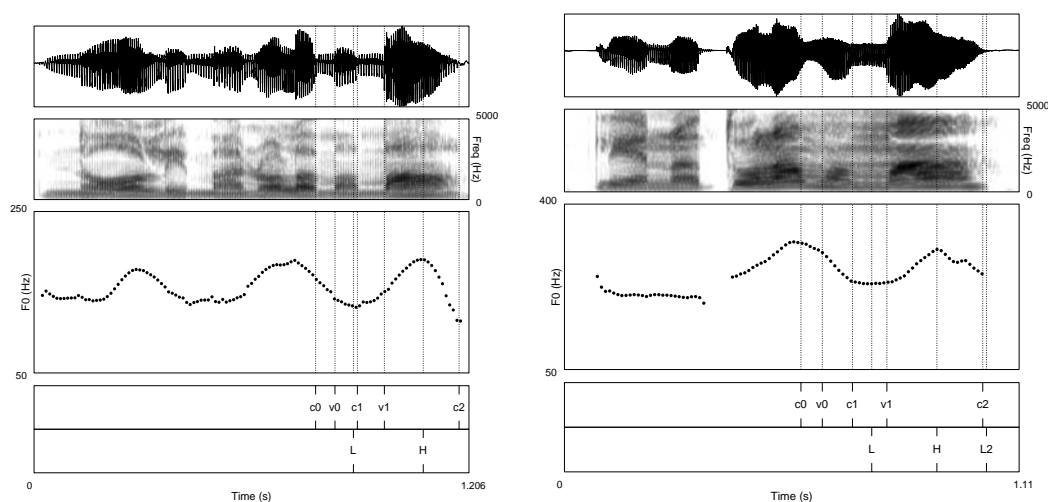
**Figure 7.** Mean values (in Hz) of the pitch range of the stressed syllables in broad focus (dashed boxes) and narrow focus (dotted boxes) in Catalan, plotted separately for all four speakers.

We performed a Repeated Measures ANOVA on the duration of stressed vowels with two main within-subject factors: Position (([+word-final]/[-word-final])) and Accent-type (narrow focus vs. broad focus) and vowel (i, a), and the between-subject factor of language (Catalan and Spanish). Both Accent type and Position have a significant effect on the duration of the target syllables (Accent type:  $F(1,318)= 910.65, p<.0001$ ; Position:  $F(1,318)= 793.22, p<.0001$ ) corroborating the hypothesis that narrow focus enlarges the duration of segments and that this lengthening effect is larger in oxytone words. There was no significant effect of vowel, thus indicating that lengthening effects are similar in vowels [a] and [i]. Importantly, there is a significant interaction between

Accent type\*Language ( $F(1,318)= 910.65, p<.0001$ ), meaning that the lengthening effect of narrow focus is larger in Spanish than in Catalan. In the next section, we investigate possible sources of variation that can explain the distinctive and surprising behavior of these two Catalan speakers.

#### 4. Discussion and Conclusion: sources of variation

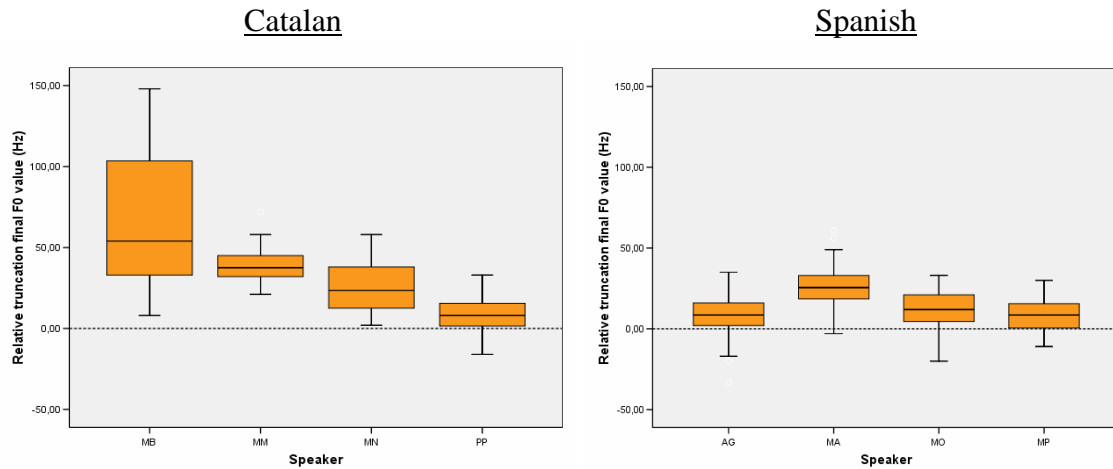
When searching for sources of variation in the data, we noticed that several of the complex pitch accents that appear in narrow-focused words in utterance-final position were truncated. Figure 8 shows the waveforms, spectrograms, and F0 contours of the Catalan utterance *L'hi mano a la MAMÀ* 'I am asking this to MUM' as uttered by two different speakers. In the left panel we see a fully compressed contour while the right panel shows a truncated contour.



**Figure 8.** Waveforms, spectrograms and F0 contours of two possible prosodic realizations of the Catalan utterance *L'hi mano a la MAMÀ* 'I am asking this to MUM'. Left panel shows a fully compressed contour and right panel a truncated contour.

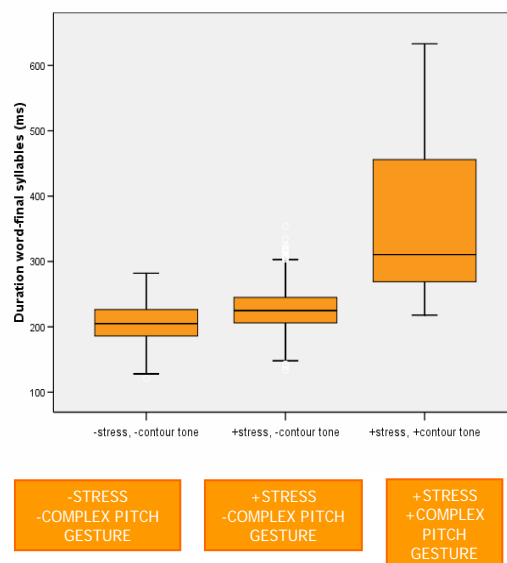
We hypothesize that, in our data, unexpected subject differences in durational patterns might be attributed to the presence of truncated contours. Figure 9 shows the mean relative truncation of the final F0 value (in Hz) for the four Catalan speakers (left panel) and the four Spanish speakers (right panel). This value was calculated as the distance in Hz from the final F0 value in each of the narrow-focused contours to the reference baseline of the speaker (that is, the bottom of the speaker's pitch range, a value obtained at the end of broad focus statements) so that higher values correlate with truncation and lower values with fully realized pitch contours. The graphs show that speakers use different degrees of truncation, and also partial truncation. In general, Spanish speakers produce less truncated contours than Catalan speakers. Within Spanish speakers, MA realizes full contours less often than the other speakers. And, among the Catalan speakers, MB and MM are the ones that truncate contours more often. Interestingly, if we compare this data with the graphs in Figure 7, we can see that the Catalan subjects with more truncation (MB, MM, and MN) are exactly the ones who display less

lengthening in narrow-focused words in final position. Similarly, the Spanish speaker that used full contours less often is the one with the shortest lengthening effect of narrow focus in word-final position.



**Figure 9.** Mean truncation of the final F0 value (in Hz) in narrow-focus utterances relative to the baseline for all speakers.

In sum, the results of our production experiment reveal that in both Catalan and Spanish, duration is amplified in narrow-focused words, whether in penultimate or final position. In general, duration is also amplified in syllables with a complex tonal gesture. Figure 10 shows the mean duration of word-final target syllables in different conditions in our data: [-stress, -complex pitch gesture], [+stress, -complex pitch gesture], and [+stress, + complex pitch gesture]. It is clear that once we control for final lengthening factors, we have to consider two factors that affect duration and that combine in an additive fashion: a) stress; and b) tonal gesture complexity. In our data, the presence of a complex pitch contour is the strongest lengthening factor:



**Figure 10.** Mean duration of word-final target syllables in different conditions: [-stress, -complex pitch gesture], [+stress, -complex pitch gesture], and [+stress, + complex pitch gesture].

Yet, in our data, truncation is used by some speakers as a phonetic realization strategy that interacts with timing. As we just saw, some Catalan speakers truncate (or partially truncate) the complex contour: precisely these speakers are the ones that do *not* display the expected amount of extra lengthening in these syllables. Thus, in our data, truncation of complex contours can be regarded as a phonetic realization strategy that interacts with timing in such a way that there is a trade-off relationship between the two factors. The observed phenomenon has consequences for crosslinguistic work on tonal realization strategies, namely, truncation and compression. Different studies have shown that there are crosslinguistic differences in the application of truncation and compression in standard varieties of English and German, and crossdialectal differences within Swedish and Danish (see Ladd 1996 and Grabe et al 2000). For example, while speakers of Cambridge English and Newcastle English compress rising and falling accents, speakers of Leeds English, in identical contexts, perform truncation. The data in this article challenge the view that truncation and compression are language and dialect-specific strategies (Ladd 1996, Grabe et al 2000), and favor the view that they can also be regarded as phonetic realization strategies that interact in a dynamic way with timing.

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## Appendix

### TARGET VERBS (CATALAN)

L'hi mano a la mama  
 L'hi cuso a la mama  
 L'hi dono a la mama  
 L'hi porto a la mama  
 L'hi torno a la mama  
 L'hi bullo a la mama  
 L'hi bato a la mama  
 L'hi poso a la mama  
 L'hi dicto a la mama  
 L'hi envio a la mama  
 L'hi pago a la mama  
 L'hi deixo a la mama  
 L'hi rento a la mama  
 L'hi cuino a la mama  
 L'hi busco a la mama  
 L'hi pinto a la mama  
 L'hi brodo a la mama  
 L'hi ballo a la mama  
 L'hi tallo a la mama  
 L'hi baixo a la mama

### TARGET VERBS (SPANISH)

Se lo mando a mama  
 Se lo coso a mama  
 Se lo vendo a mama  
 Se lo debo a mama  
 Se lo hago a mama  
 Se lo ruego a mama  
 Se lo nombro a mama  
 Se lo pongo a mama  
 Se lo dicto a mama  
 Se lo envío a mama  
 Se lo noto a mama  
 Se lo pago a mama  
 Se lo pido a mama  
 Se lo leo a mama  
 Se lo busco a mama  
 Se lo lavo a mama  
 Se lo llevo a mama  
 Se lo deajo a mama  
 Se lo presto a mama  
 Se lo guiso a mama