

Comparing the ‘Magnifying Lens’ Effect of Stress to that of Contrastive Focus in Spanish

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1. Introduction

Stress, which is the linguistic property that makes a syllable in a word more prominent than others, has been defined as ‘localized hyperarticulation’ (de Jong 2004). Hyperarticulation is a term coined by Lindblom (1990) that explains phonetic variation as a function of communicative and situational demands. Since speech production is adaptive, speakers make certain parts of the speech more intelligible to the listener regardless of the articulatory effort it may cost them because these hyperarticulated speech parts carry the most relevant information in the message. Defining stress as localized hyperarticulation implies that its function consists of conveying relevant linguistic information to the listener in a clearer manner. Thus, the effect of stress on the speech signal is that of a magnifying lens - it amplifies contrasts.

Focus, in particular contrastive focus, has a similar function to stress as it makes a word more prominent within the sentence. In stress-accent languages, the device used to convey focus on a word is the placement of a pitch accent on the stressed syllable of that word (Pierrehumbert & Beckman 1986). For example in the sentence ‘No, MARY’s coming’, spoken as an answer to ‘Is Peter coming?’, ‘Ma’, the stressed syllable of ‘Mary’, bears a pitch accent. By means of this intonational pattern the speaker attracts the listener’s attention to the focused word, and, consequently, the stressed syllable of the focused word is expected to be hyperarticulated (de Jong 2004).

De Jong (2004) and de Jong and Zawaydeh (2002) provide evidence for stress and focus as a case of localized hyperarticulation. They show that stress enlarges the vowel durational differences that cue vowel contrasts, such as long and short vowels in Arabic or American /ε/ and /æ/. However, the vowel durational differences that cue the voicing contrast of a following stop are enlarged only in English, because Arabic uses other phonetic parameters to cue voicing. In addition, when the stressed syllable is placed under focus, those contrasts that have been magnified under stress become further amplified. Based on these results, de Jong (2004) concludes that the magnifying lens effect of stress and focus consists of amplifying only those differences relevant to the phonology of a particular language.

Hay, Momoto, Coren, Moran & Diehl (2006) tested the above hypothesis in English, French and German by comparing spectral and durational differences in stressed vowels that were placed in focus and non-focus contexts. Their results indicate that, in spite of their different phonological systems, the three languages resort to the same strategy when amplifying spectral differences under focus: all vowels expand their acoustic/auditory space. However, languages differ in the way duration is used. Only German speakers enlarge durational differences since in German there is a contrast between long and short vowels. They conclude that it is difficult to confine the amplifying effect of focus to the relevant phonological contrasts of a language. Since a contrast can be cued by several acoustic parameters that enhance each other auditorily, and a single parameter can contribute to the enhancement of different contrasts (Kingston & Diehl 1994), it is difficult to decide which parameters are the most relevant in a language. Instead, the authors propose that “the amount of contrast enhancement of a vowel property in [+focus] context is possibly related to the between-category variation of that property in [-focus] context.” (Hay et al. 2006: 3031).

In summary, it is clear that stress and focus have a magnifying lens effect on some phonetic material; however, which phonetic material is being modified and why, and whether this material is identical in stress and focus across languages are questions to be investigated here. Specifically, this

article contributes to the above discussion by providing data from Spanish as well as an alternative hypothesis concerning which phonetic material is modified that complements the previous ones. In the above experiments, the effect of focus on stressed syllables was examined, which introduced covariation between the effects of stress and focus. An experimental design that separates the effect of stress from that of focus is needed in order to compare the stress-related phonetic variation in deaccented contexts with the phonetic variation stemming from focus on stressed and unstressed syllables. There are two logical outcomes. Either the phonetic variation that cues stress in deaccented contexts will become enlarged under focus due to the exaggerated differences between stressed and unstressed syllables, or these differences will be lost as all syllables are realized as stressed under focus. In stress accent languages, where stressed syllables constitute the landing site of pitch-accents, it is likely that the stress contrast is lost under focus, as it makes all syllables sound stressed.

The hypothesis that I would like to propose is that the magnifying lens effect under focus in stress accent languages will be conditioned by the phonetic material that is devoted to make syllables sound stressed by amplifying only those cues that either enhance or do not interfere with the perception of the vowel as stressed. Thus, it is possible that languages that use abundant phonetic material to cue stress, that is those in which stress information in the speech signal is redundant, will allow more variation of the phonetic material under focus than languages that have to maintain the percept of stress by resorting to less phonetic material. For example, in languages where vowel reduction is a strong cue to stress, variations in duration that cue other contrasts, such as the voicing of a following stop consonant, will not be banned. In fact, data from de Jong (2004) show that when a speaker places a pitch accent on the unstressed syllable of ‘**rabid**’ in order to differentiate it from ‘**rabbit**’, as in the sentence ‘He said rabid, not rabbit’, he produces the unstressed /i/ with durations close to those of stressed vowels while preserving a longer /i/ before the voiced consonant of ‘**rabid**’, than before its voiceless counterpart in ‘**rabbit**’. Thus, variations in duration that do not interfere with the perception of /i/ as a stressed vowel are possible because /i/ is probably¹ produced as a full vowel, and therefore, there is sufficient phonetic material other than duration to make this vowel sound stressed. However, in languages like Spanish, where there is no phonological vowel reduction and stress is cued mainly by duration (Ortega-Llebaria & Prieto 2007) variations in duration of all material under focus will enhance the perception of the syllable as stressed. Consequently, variation of duration cues will be more restricted.

In order to test the above hypothesis, homophonous words that differ only in stress (tonic *dé* ‘to give’ and atonic *de* ‘of’) were placed in three intonation contexts, namely post-focal, declarative and focal sentences. In the first context, both words were deaccented. In declarative sentences, only the stressed word received a pitch accent, while in the last context, both words received a pitch-accent. The key questions to be investigated are: (1) whether the stress contrast between [e] and [é] is preserved in deaccented contexts, and if it is, (2) whether the phonetic material that differentiates [e] from [é] in deaccented contexts is lost in focus. If the variation in the phonetic material which is under focus is constrained by the loss of the stress contrast, the variations in duration in /d/, the onset of the target word, should also work towards creating the perception of the syllable as being stressed. In Mexican Spanish, voiced stops that do not follow a nasal consonant are produced with lenition. This degree of lenition decreases if the following vowel is stressed (Cole, Hualde & Iskarous 1999, Ortega-Llebaria 2003). Enhancement of the stress percept will prevent /d/ in the atonic word *de* from becoming lenited, and since lenition correlates with duration, all /d/s in focus will be as long as any stressed /d/.

2. Methodology

2.1. Subjects

Ten native speakers of Mexican Spanish (5 males and 5 females) participated in the study. They were from Central Mexico, spoke Spanish with their families, completed primary and secondary

¹ No data on the vowel quality of /i/ was provided in de Jong (2004). However, informal testing of 6 native English speakers carried by the author revealed unanimous agreement that /i/ is not reduced in this context.

school entirely in Spanish, and did not learn a second language until age 14. Their ages ranged from 21 to 30 at the moment of the recordings and they were graduate students at the University of Texas. No subject reported having speaking or hearing problems.

2.2. Materials

Two segmentally identical words that differed only in their stress patterns, i.e., tonic *dé* and atonic *de*, were embedded in declarative, focal, and post-focal sentences. In the declarative sentences, tonic *dé* received a pitch accent while atonic *de* did not. In focal sentences, both tonic *dé* and atonic *de* were produced with a pitch accent. In the post-focal sentences, both *dé* and *de* were de-accented. Occasionally, tonic *dé* received a pitch-accent of a extremely reduced range. Therefore, as shown in Table 1, there was co-variation between stress and accent in declarative sentences: all stressed syllables were also accented and all unstressed syllables were de-accented. In post-focal sentences, this co-variation tended to disappear since both stressed and unstressed syllables became [-accented]. In focal contexts, there was no co-variation either because both stressed and unstressed syllables did bear a pitch-accent.

	dé [+stress]	de [-stress]
Declaratives	+accent	-accent
Post-focal	-accent	-accent
Focus	+accent	+accent

Table 1. Stress contrasts across sentences with different intonation.

In order to elicit the declarative, focal, and post-focal intonation contours, the words *dé* and *de* were placed in a context. For *dé*, subjects were told that Luisa and Eva lent *Damián* an object, for example a coffee pot, to use while they were on a trip. After their arrival, Luisa and Eva wanted *Damián* to return that object to them. After explaining this context, the experimenter asked each subject three questions. The first question, *¿Qué quieren Luisa y Eva?* ‘What do Luisa and Eva want?’, elicits a declarative in which *dé* bears a pitch accent. The second question, *¿Quieren que *Damián* se quede con la cafetera?* ‘Do they want *Damián* to keep the coffee-pot?’, elicits the answer *No, quieren que *Damián* les DE la cafetera* ‘No, they want *Damián* to GIVE them the coffee-pot’, where *dé* receives a focal accent. The third question, *¿Quieren que *Pepe* les dé la cafetera?* ‘Do they want *Pepe* to give them the coffee-pot?’, elicits the answer *No, quieren que *DAMIAN* les dé la cafetera* ‘No, they want *DAMIAN* to give them the coffee-pot’, where *Damián* receives a focal accent and *dé* becomes de-accented or occasionally receives a pitch-accent of a very reduced range. The word *cafetera* was but one of 30 objects figuring in the questions posed to the subjects. Accordingly, the total data set consists of 1800 sentences (2 stress conditions * 3 sentence types * 30 objects * 10 subjects). Contexts and sentences for unstressed *de* are given in Appendix 1 and the names of the 30 objects are listed in Appendix 2. Recall that atonic *de* receives a pitch accent only when placed under focus.

2.3. Measurements

By measuring duration, vowel quality and spectral tilt in tonic /é/ and atonic /e/ in the target words *dé* and *de*, it is possible to determine which phonetic material cues the stress contrast in deaccented syllables, and whether this contrast is lost under focus. Stressed syllables are longer than their unstressed counterparts in Spanish (see for example Navarro Tomás 1914, 1964, Quilis 1971, Solé 1984, Ortega-Llebaria & Prieto 2007). Spectral tilt measures the difference in amplitude of the frequencies in the higher region of the spectrum in relation to those in the lower region. Sluijter & van Heuven (1996a, b) and Sluijter, van Heuven & Pacilly (1997) found that spectral tilt was a correlate of stress in Dutch and English (but see Campbell & Beckman 1997); however, Ortega-Llebaria & Prieto (2007) found that this phonetic parameter was not a strong correlate of stress in Castilian Spanish. Although phonological vowel reduction, a cue to stress in languages like English or Catalan, does not

exist in Spanish, some dialects, amongst them Mexican Spanish, exhibit some reduction of mid vowels in certain contexts (Canellada & Kuhlman-Madsen 1987).

Since the duration of /d/ correlates with lenition, as lenited /d/ is shorter, and degree of consonant lenition relates to stress (Cole, Hulade & Iskarous 1999, Ortega-Llebaria 2003), measuring the duration of /d/ will test whether the magnifying lens effect in focus is constrained by the loss of the stress contrast in this context. Hence, no /d/s will be lenited if the stress contrast is lost in focus.

Measurements of duration, vowel quality and spectral tilt were performed on vowel [e] from tonic word *dé* and atonic word *de*. Using Praat (Boersma & Weenik 1992), the beginning and the end of [e] were marked manually based on F2 and then different scripts extracted the duration of the vowel in seconds, and the mean value of F1 and F2 in Hertz. Vowel quality was measured as the difference between F2 and F1.

Before measuring spectral tilt, all files were normalized for loudness. First, the average loudness of all files (-30.5dBs) was calculated over 50-millisecond windows. Then, the loudest part of each waveform was set at -30.5dBs, thereby lowering or raising all other parts of the same waveform by the same amount. No clipping happened in any file.

Following normalization, the 10th percentile of the F1 distribution was calculated separately for each subject. A script filtered two bands for each instance of vowel [e]. Band 1 ranged from 0 Hertz to the value in Hertz of the 10th percentile, and band 2 ranged from the value in Hertz of the 10th percentile to 4,000 Hertz. Consequently, band 1 contained F0 and only 10% of the values of F1 regardless of voice differences amongst speakers, and band 2 contained the remaining F1 and all the other formants up to 4,000 Hertz. Since spectral tilt measures the intensity of F0 with respect to the intensities in higher regions of the spectrum, it is important to separate F0 from F1. Including F1 into band 1 would mix the intensity of F0 at the source – the property that we want to measure – with frequency amplifications that took place in the oral cavity (i.e., vowel formants). By using each speaker's 10th percentile as the cut off score, we minimized this possible error by the same amount in each subject. Afterwards, a script measured the intensity of each band using the command 'Get intensity' from Praat. Spectral tilt was calculated as the ratio of band 1 to band 2 (i.e., band 1/band 2). Therefore, ratio values closer to 1 indicate that the intensity in the lower parts of the spectrum (band 1) is similar to that of higher frequencies (band 2). Ratio values above 1 show that the intensity of band 1 is higher than the intensity of band 2, while ratio values below 1 show the inverse relation between the intensity in the bands. Thus, increasing intensity in the higher parts of the spectrum with respect to the lower parts correlates with smaller ratios.

All segments were embedded in a sentence containing the fragment '*les dé la*' or '*les de la*'. The duration of the consonants /sd/ preceding target /e/ was also measured. The segment /s/ was included in the measurements because in those cases where /d/ was lenited, it was very difficult to separate both sounds. Thus, it was more reliable to measure the interval between the two /e/ vowels, the span '*les de*', than trying to measure the duration of /d/ alone. Since the effects of focus on duration affect mainly the syllable under focus and not syllables to its left (Cambier-Langeveld & Turk 1999), including /s/ in the measurements will not distort the possible effects of focus on the onset /d/.

2.4. Statistics

2.4.1. On vowel /e/

In order to examine whether speakers maintain a stress contrast across vowels bearing different F0 intonation contours, a repeated measures ANOVA with the within-subject factors of stress ([+stress], [-stress]) and intonation (declarative sentences, post-focal and focal sentences) was performed separately for each set of measurements (duration, spectral tilt, and vowel quality) on the vowel [e]. Afterwards, the use that speakers made of the cues of duration, vowel quality and spectral tilt in classifying vowels according to stress was evaluated. A Stepwise Linear Discriminant Analysis (LDA) was undertaken with all of the acoustic cues entered together as independent variables and with stress as the grouping variable. This determined how well the stress contrast was predicted in each of the intonation contexts. Moreover, the LDA performed on each measurement indicated the contribution of each cue in classifying vowels as stressed or unstressed.

2.4.2. On the consonant /d/

A Repeated Measures ANOVA with the within-subject factors of stress ([+stress], [-stress]) and intonation (declarative sentences, post-focal and focal sentences) was performed on the duration of the segments [sd]. In Spanish, stress constrains the degree of lenition by making onsets of unstressed syllables more lenited than those in stressed syllables (Cole, Hualde & Iskarous 1999, Ortega-Llebaria 2003). Since lenited consonants are shorter than their fully articulated counterparts, the results of the ANOVA indicate whether stress has an effect on the duration of these consonants and whether this effect appears in the same contexts where /e/ is realized as stressed.

3. Results

3.1 Duration of /e/

The graph in Figure 1 shows the durational distributions of stressed and unstressed [e] in post-focal, focal, and declarative sentences. Declarative and post-focal sentences show similar patterns: stressed vowels are longer than their unstressed counterparts ([e] in declarative sentences: stressed mean=62.5ms, sd=16.4; unstressed mean=48.3ms, sd=9; post-focal sentences: stressed mean=57.1ms, sd=12.4; unstressed: mean=48.8ms, sd=10.2). Notice, however, that while unstressed vowels display similar means and standard deviations (mean difference=5ms), stressed [e] in declarative sentences is longer than in post-focal contexts (mean difference=54 ms). Therefore, although stressed [e] is longer than unstressed [e] in both sentence types, this difference is enlarged in declarative sentences.

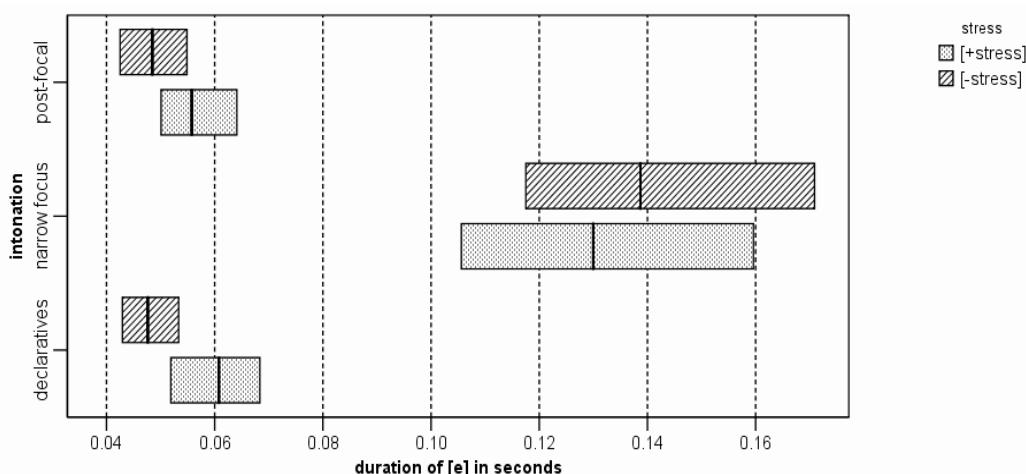


Figure 1. Durational differences between [e] and [é] in declarative, focal and post-focal contexts. Box-plots display the 25th, 50th and 75th percentile of each distribution.

Focal sentences differ from declarative and post-focal sentences in several ways. First, the vowel [e] in this context is remarkably long. In fact, the mean duration of [e] in focus more than doubles the mean duration of [e] in the other two contexts ([e] in focus: mean=139.9 ms, sd=39, declaratives: mean=55.4ms, sd=15, post-focal: mean=52.9ms, sd=12). Second, the unstressed as opposed to the stressed vowel is the longest, reversing the pattern we found in the other two contexts (stressed [e]: mean=135.5ms, sd=42.7; unstressed [e]: mean=144.3ms, sd=36.2). Finally, distributions in focus clearly show a wider range of values than in the other two contexts indicating more subject variation in focus sentences.

Results from the repeated measures ANOVA show a significant effect of stress and intonation, as well as of the interaction of these two factors (stress: $F_{(1,299)} = 4.570$; $p = 0.033$; intonation: $F_{(2,298)} = 196.736$; $p < 0.0001$; stress*intonation: $F_{(2,299)} = 5.832$; $p = 0.005$). Multiple comparisons with the Bonferroni adjustment confirm, on the one hand, that stressed vowels have significantly longer durations than their unstressed counterparts only in declarative and post-focal sentences ($p < 0.0001$ for

both sentence types). The observed tendency for unstressed vowels to be longer in focal contexts is statistically non-significant ($p=0.111$). On the other hand, the longest duration of [e] in focus is significantly different from the duration of [e] in the other two sentence types.

In summary, duration marks the stress contrast only in declarative and post-focal sentences by making the stressed vowel longer than their unstressed counterpart. This difference becomes enlarged in declarative sentences. In focus, however, [e] lengthens regardless whether it bears stress or not and it becomes at least twice as long as in the other two contexts. Consequently, durational differences as a cue to the stress contrast disappear when the vowel is under focus.

3.2. Spectral Tilt

Figure 2 displays the spectral tilt distributions of [e] in stressed and unstressed contexts embedded in post-focal, focal, and declarative sentences. Stressed [e] tends to display smaller spectral tilt ratios than its unstressed counterpart across sentence types showing that stressed vowels tend to increase the energy in the higher regions of the spectrum relative to the energy in the lower regions. As with duration, distributions in focus differ greatly from those in declarative and post-focal sentences: ratios in focus are the smallest. This pattern may indicate that regardless of whether they bear stress or not, vowels in focus may sound ‘more stressed’ than vowels in declarative and post-focal sentences.

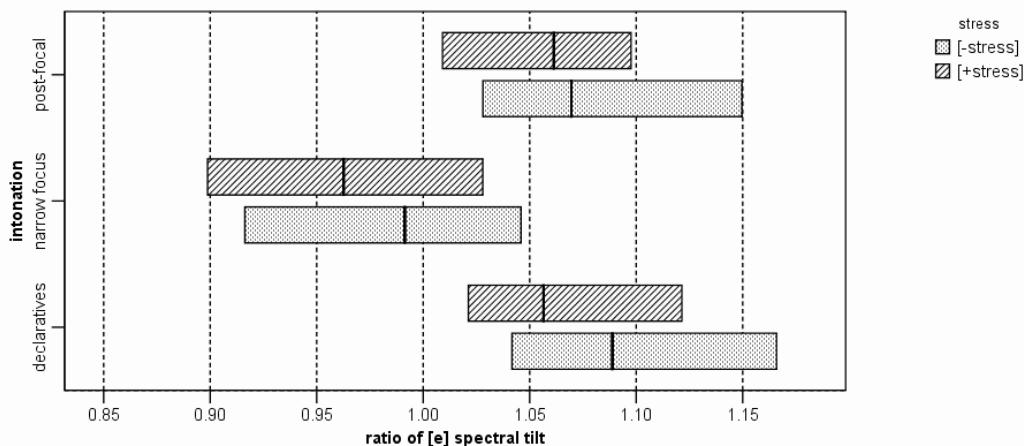


Figure 2. Differences in spectral tilt between [e] and [é] in declarative, focal and post-focal contexts. Box-plots display the 25th, 50th and 75th percentile of each distribution.

Results from the repeated measure ANOVAS show a significant effect of stress, intonation, and the interaction ‘stress*intonation’ (stress: $F_{(1,288)} = 77.302$; $p < 0.0001$; intonation: $F_{(2,288)} = 253.201$; $p < 0.0001$; stress*intonation: $F_{(2,288)} = 3.451$; $p = 0.034$). Multiple comparisons with the Bonferroni adjustment reveal that the stress contrast is strongly significant in declarative sentences, marginally significant in post-focal sentences and non-significant in focal sentences (declaratives: $p < 0.0001$, post-focal: $p = 0.01$; focus: $p = 0.181$). Moreover, the spectral tilt in focus significantly differs from the tilt in the other two sentence types.

Thus, only in declarative sentences do stressed vowels have consistently flatter spectral tilts than their unstressed counterparts. This difference between stressed and unstressed vowels decreases in post-focal contexts and disappears in focus. In the latest context, both stressed and unstressed vowels display the flattest spectral tilts. Consequently, spectral tilt is a more reliable cue to the stress contrast in declarative than in post-focal sentences, while in focus, a stress contrast based on spectral tilt differences disappears making both stressed and unstressed vowels sound stressed.

3.3. Vowel quality

Figure 3 displays the box-plots for the vowel quality of [e] in stressed and unstressed *de* embedded in the three sentence types. As with the preceding cues, speakers tend to maintain a stress contrast in declarative and post-focal contexts which disappears in focus position. Only in declarative and post-focal sentences do speakers tend to reduce the F1-F2 distance in unstressed [e] by changing unstressed [e] into a more centralized vowel. This pattern is most obvious in declarative sentences, (stressed [e]: mean=1.404Hz, sd= 195); unstressed [e]: mean=1.266Hz, sd=185), it reduces in post-focal sentences (stressed [e]: mean=1.361Hz, sd=183; unstressed [e]: mean=1.302Hz, sd=205), and disappears in focal contexts (stressed [e]: mean=1.588Hz, sd=194; unstressed [e]: mean=1.585Hz, sd=206). Moreover, focal contexts differ from the other two in that the distance between F1 and F2 notably increases in focus, and consequently, focus contains the most unreduced [e] exemplars. Since unreduced vowels tend to be perceived as stressed while reduced vowels are heard as unstressed, both stressed and unstressed [e] in focus may be perceived as stressed.

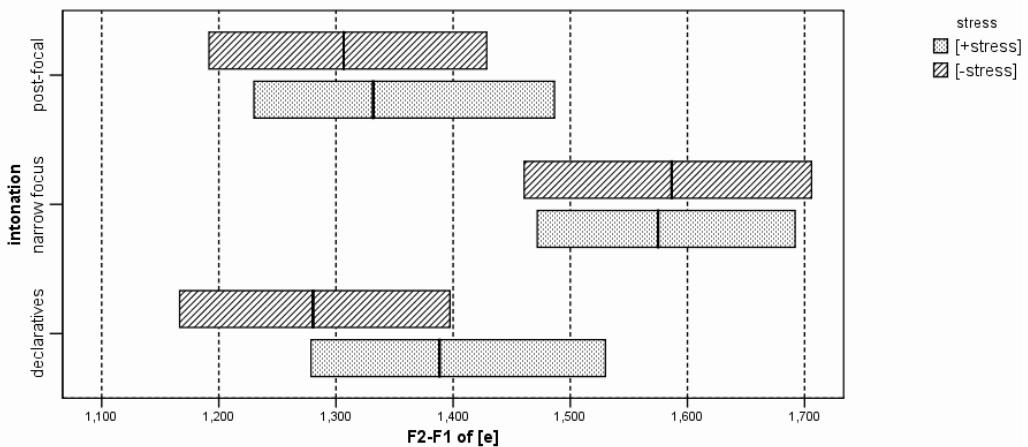


Figure 3. Differences in vowel quality between [e] and [é] in declarative, focal and post-focal contexts. Box-plots display the 25th, 50th and 75th percentile of each distribution.

Repeated measures ANOVAS show that stress, intonation, and stress*intonation have a significant effect on vowel quality (stress: $F_{(1,288)} = 125.293$; $p < 0.0001$; intonation: $F_{(2,288)} = 998.141$; $p < 0.0001$; stress*intonation: $F_{(2,288)} = 63.157$; $p < 0.0001$). Multiple comparisons with the Bonferroni adjustment confirm that the stress contrast is strongly significant in declarative sentences, marginally significant in post-focal sentences and non-significant in focus (declaratives: $p < 0.0001$; post-focal: $p = 0.03$; focus: $p = 1$). Moreover, both vowels in focus have significantly larger F1-F2 distances than vowels in the other two contexts. Thus, speakers express a stress contrast by reducing unstressed [e] to a more centralized vowel only in declarative sentences. In post-focal sentences, vowel reduction may not be a very reliable cue to stress, while vowels under focus are always unreduced regardless whether they bear stress or not.

In summary, results from the ANOVAS indicate that the stress contrast is maintained in declarative sentences since stressed vowels have longer durations, flatter spectral tilts and fuller vowel qualities than their unstressed counterparts. In post-focal sentences, duration seems to be the most reliable cue to stress. However, when vowels are under focus, the stress contrast disappears because both stressed and unstressed vowels have the longest durations, the flattest spectral tilts and the most unreduced vowel qualities indicating that they may be produced as stressed regardless of bearing or not linguistic stress.

3.4. Linear discriminant analysis on vowel /e/

A Linear Discriminant Analysis (LDA) was performed on [e] separately for each sentence type with duration, spectral tilt and vowel quality entered together as independent variables and stress as the grouping variable. Classification results indicate that 78% of occurrences of [e] were correctly predicted as stressed or unstressed in declarative sentences, 67% in post-focal sentences and only 56% in focal positions. Thus, speakers do maintain a stress contrast in both declarative sentences, yet somewhat less effectively in post-focal sentences. However, in focal position speakers tend to lose the distinction between stressed and unstressed vowels since the classification scores were barely above chance.

In order to assess the contribution of each cue in the prediction of the stress contrast, LDAs were applied separately on each measurement within each sentence type. Figure 4 shows that as expected, the classification scores of duration, spectral tilt and vowel quality were around chance in focal sentences. In post-focal sentences, duration reached the highest score by correctly classifying 66% of vowels as stressed or unstressed, while spectral tilt and vowel quality scored at chance level. In declarative sentences, duration also obtained the highest percentage (75%), and spectral tilt and vowel quality increased their classification scores to 57% and 64% respectively.

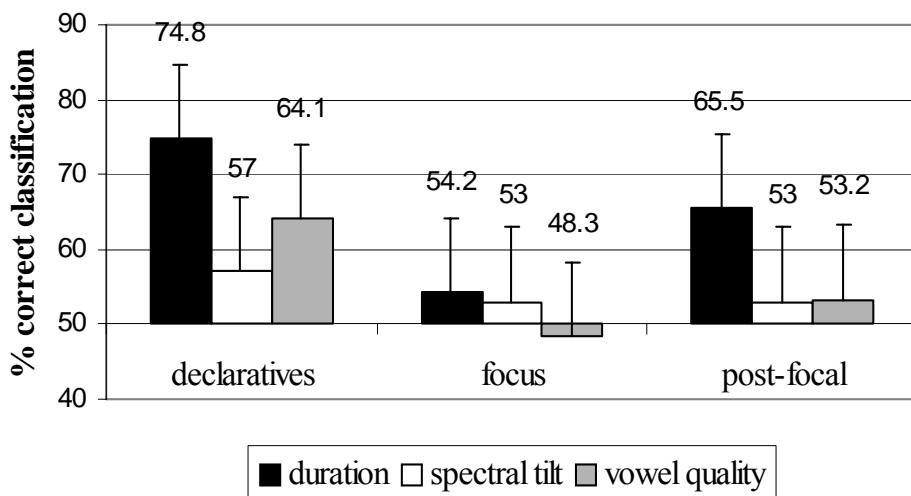


Figure 4. Percentage of accurate classification scores of [e] as stressed or unstressed.

Results from the LDAs agree with those of the ANOVAS in that speakers of Mexican Spanish consistently preserve the stress contrast in declarative sentences. They also preserve this contrast, although less effectively, in post-focal contexts while they neutralize it when vowels are under focus. Moreover, in contexts where the stress contrast is preserved, speakers use duration as the main cue: stressed vowels are longer than their unstressed counterparts. Cues of vowel quality and spectral tilt are used only in declarative sentences, where the durational differences between stressed and unstressed vowels are the largest. These results rule out a possible compensatory relationship between duration and other cues.

Thus, the first question asked earlier, namely whether the stress contrast between [e] and [é] is preserved in deaccented contexts, is answered affirmatively. Speakers of Mexican Spanish make stressed vowels longer than their unstressed counterparts. The second question, however, has a negative answer. These durational differences were not amplified in focus. On the contrary, they were erased by making unstressed [e] as long as — or longer in some instances — than stressed [é]. Variation in other phonetic material in the vowel also patterned towards making [e] sound equally stressed as [é]. Unstressed [e]s had similar vowel qualities and spectral tilts as stressed [é]s. Therefore, the hypothesis that losing the stress contrast in focus implies that phonetic variation will aim at making segments under focus sound stressed is confirmed for vowel [e]. In the next section, we will examine

whether the phonetic variation of /d/ also indicates that the stress contrast is lost in focus while it is preserved in post-focal contexts.

3.5. Duration of /sd/

The graph in Figure 5 shows that duration of [sd] patterns differently in focus than in the other two contexts. While in declarative and post-focal contexts the consonants in stressed syllables are longer than those in unstressed syllables (declaratives: [+stress] mean=87.5ms, sd=.02; [-stress] mean=71.8ms, sd=.01; post-focal: [+stress] mean=81.3ms, sd=.01; [-stress] mean=73ms, sd=.01), in focus, [sd] before unstressed [e] is longer than [sd] before stressed [é] ([+stress] mean=171.5ms, sd=.20, [-stress] mean=188.5ms, sd=.45). Moreover, [sd] duration in focus almost doubles that of the other two contexts.

Repeated measures ANOVAS yielded a significant effect for intonation and stress*intonation ($F_{(2,288)}=3402,8$, $p<.0001$; $F_{(2,576)}=69.161$, $p<.0001$). Post-hoc tests confirmed that [sd] in focus is significantly longer than [sd] in the other two contexts. Moreover, [sd] in unstressed syllables is significantly longer than [sd] in stressed syllables. This pattern is reversed in declarative and post-focal sentences, where [sd] in stressed syllables is significantly longer than [sd] in unstressed syllables. Thus, duration patterns in the onset consonants under analysis were similar to those found in vowels. The stress contrast was preserved in declarative and post-focal sentences by lengthening consonants and vowels of the stressed syllables. In focus, however, this contrast was lost by lengthening both stressed and unstressed syllables. Unstressed syllables were even longer than their stressed counterparts ensuring that both syllables were produced as stressed regardless of having linguistic stress or not.

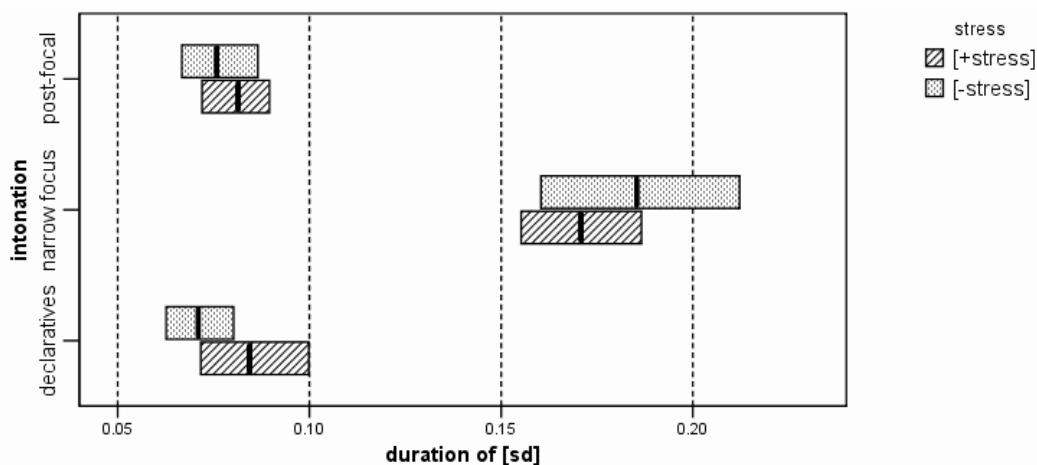


Figure 5. Duration of [sd] in stressed and unstressed syllables across intonation contexts.

4. Discussion

In Spanish, duration cues the stress contrast in the absence of pitch accents: stressed vowels are longer than their unstressed counterparts in the deaccented syllables of post-focal context. Moreover, results from LDAs show that duration is the only cue that predicts stress variation in these sentences. In declarative sentences, where there is co-variation between stress and accent, this duration difference becomes enlarged. Vowel quality and spectral tilt also cue the stress contrast in this context by producing stressed [é]s with fuller vowel qualities and flatter spectral tilts than their unstressed counterparts. Yet, the LDAs indicate that duration is by far the best predictor of stress, while scores for vowel quality and spectral tilt are barely over chance.

These results concerning the importance of the cues contrast with those obtained for Catalan and Dutch (Ortega-Llebaria, Prieto & Vanrell submitted, Sluijter et al. 1996a, 1997). Catalan has phonological vowel reduction: stressed vowels have full qualities while unstressed vowels become

reduced. In contrast to Mexican Spanish, these reduction patterns are preserved in deaccented syllables where stressed vowels are produced with full qualities and unstressed vowels are reduced. Similarly, in Dutch, spectral tilt cues stress in deaccented syllables. Thus, in the absence of a pitch-accent, Catalan and Dutch speakers maintain a stress contrast via differences in vowel quality and spectral tilt respectively, whereas in Spanish the stress contrast is maintained only by lengthening stressed vowels. Consequently, duration is the main cue to stress in Spanish because it cues stress regardless of the presence or absence of a pitch accent and it obtains the highest prediction scores in LDAs. In contrast, vowel quality and spectral tilt appear only with the presence of a pitch-accent and their prediction scores are barely over chance. Hence, the answer to the first research question, namely which phonetic material cues stress in deaccented syllables in Spanish, is differences in duration.

As for the second question, namely whether the phonetic material that cues stress in deaccented syllables is lost in focal contexts, the answer is affirmative. Although Spanish speakers produced [e] with durations that doubled those in declarative and post-focal contexts, the lengthening effect related to stress becomes lost. Unstressed [e] was as long as stressed [é]. Moreover, probably due to the fact that both vowels had a pitch accent, they also displayed full vowel qualities and flat spectral tilts. Therefore, the stress contrast was lost by making unstressed [e] acquire the characteristics of stressed vowels. Both vowels had long durations, full qualities and flat spectral tilts. As a result, the variations in the duration of /d/, the onset of the target word, should also serve to create perception of the syllable being stressed. Results confirm this prediction. Enhancement of the stress percept in focus prevented /d/ in the atonic word *de* from having the short durations of lenited consonants, even though the context favored this outcome.

Thus, our results show that although duration is the main cue to stress in Mexican Spanish, durational differences do not become amplified under focus providing support to the hypothesis that in stress-accent languages such as Spanish, the amplifying-lens effect of focus depends on the phonetic material that cues stress. In these languages, all syllables that receive a pitch accent are perceived as more prominent or stressed. Consequently, the phonetic material that gets amplified under focus either enhances the perception of stress or does not interfere with it. Since in Mexican Spanish stress is cued only by duration, syllables that receive a pitch accent must be long enough to be perceived as stressed. This is why intervocalic [d] in unstressed *de* has the length of a full stop in spite of being in a context that favours lenition.

In contrast, languages that use more phonetic material than Spanish to cue stress show more flexibility in using the phonetic material under focus to cue contrasts other than stress. English, for example, uses vowel reduction and duration to cue stress in deaccented syllables (Sluijter & van Heuven 1997 but see also Campbell & Beckman 1997). When inherently unstressed words such as the determiners *a* and *the* are placed under focus, they tend to be produced with long full vowel, suggesting that, as is the case in Spanish, the stress contrast disappears in this context. However, it is still possible to change durations as long as the perception of the vowel under focus as being stressed is not distorted. As mentioned in the introduction, in de Jong (2004), one of the tasks consisted of producing sentences with contrastive focus on unstressed syllables such as ‘He said raBID, not rabbit’. The strong tendency of associating pitch accents with stressed syllables was made evident by the fact that only one subject out of five produced a pitch accent on the unstressed syllable. However, this subject resolved the conflicting demands of the task by making the unstressed syllable as long as the stressed syllables. Yet, he enlarged the vowel durational differences that related to the voicing of the coda consonant illustrating that languages in which stress is related to several cues may have more flexibility in using these cues to enhance contrasts other than stress.

As in English, the stress contrast in Catalan is cued by differences in duration and vowel quality in deaccented contexts (Ortega-Llebaria & Prieto submitted). Unlike English, vowels in unstressed words such as *de* or *a* remain reduced when placed under focus. Moreover, full vowels that become reduced when unstressed remain reduced when placed under focus. For example, *pont* ‘bridge’ and *punt* ‘full stop’ are pronounced with the full vowels [o] and [u] respectively. When adding the stressed suffix /et/, [o] and [u] become unstressed and they reduce to [u]. Both words are produced as [pun'tet]. In a sentence like *Vols dir [pun'tet] de pont o [pun'tet] de punt?* ‘Do you mean [pun'tet] as in bridge or [pun'tet] as in full stop?’, speakers do not change the reduced vowel quality of [u] into [o] in the target word ‘pontet’ even though they place a pitch accent on the unstressed syllable. It seems, then, that

Catalan might have more flexibility than English in allowing variation of the phonetic material related to stress when the syllables are placed under focus. Thus, examining how phonetic material is changed in unstressed syllables under focus across languages provides an interesting test for the proposed hypothesis.

Appendix 1: Sentences for unstressed ‘de’

- 1) Context for unstressed ‘de’
Damián tiene una _____ nueva. Está muy contento y quiere contárselo a sus amigas Lola y Eva.
 ‘Damian has a new _____. He is very happy about it and wants to tell the news to his friends Lola and Eva’.
- 2) Answer spoken with declarative intonation:
¿Qué quiere Damián? — Quiere platicarles de la _____.
 ‘What does Damian want?’ — ‘He wants to tell them about his new _____.’
- 3) Answer with the target word in focus:
No lo entiendo. ¿Dices que quiere platicarles EN la _____? — No, quiere platicarles DE la _____.
 ‘I do not understand. Are you saying that he wants to talk to them IN his new _____?’ — ‘No, he wants to tell them ABOUT his new _____.’
- 4) Answer with the target word in post-focal position:
¿Damián quiere PRESTARLES la _____? — No, quiere PLATICARLES de la _____.
 ‘Is Damián going to LEND them his new _____?’ — ‘No, Damian is going to TELL them about his new _____.’

Appendix 2: Names of the 30 words used to fill in the blanks in the sentences above.

<i>cafetera</i>	‘coffee pot’	<i>tostadora</i>	‘toaster’	<i>matelería</i>	‘table cloth’
<i>cubitera</i>	‘ice maker’	<i>cadena</i>	‘chain’	<i>cubertería</i>	‘set of cutlery’
<i>computadora</i>	‘computer’	<i>bufanda</i>	‘scarf’	<i>trituradora</i>	‘grinder’
<i>impresora</i>	‘printer’	<i>cobija</i>	‘blanket’	<i>vajilla</i>	‘china’
<i>grabadora</i>	‘recording device’	<i>chamarra</i>	‘shirt’	<i>revista</i>	‘magazine’
<i>heladera</i>	‘ice-cream maker’	<i>perrita</i>	‘little dog’	<i>orquídea</i>	‘orchid’
<i>lavadora</i>	‘washing machine’	<i>gatita</i>	‘little cat’	<i>butaca</i>	‘armchair’
<i>coctelera</i>	‘cocktail maker’	<i>bicicleta</i>	‘bicycle’	<i>chaqueta</i>	‘jacket’
<i>secadora</i>	‘dryer’	<i>motocicleta</i>	‘motorcycle’	<i>camiseta</i>	‘T-shirt’
<i>refrigeradora</i>	‘refrigerator’	<i>tetera</i>	‘tea pot’	<i>pecera</i>	‘fish tank’

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