Distinct Segmental Implementations in English and Spanish Prosody*

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ABSTRACT

This paper attempts to provide a substantial explanation of different prosodic implementations on segments in English and Spanish, arguing that the phonetic modification invoked by prosody may effectively reflect phonological structure. In English, a high front vowel in accented syllables is acoustically realized as higher F1 and F2 frequencies than in unaccented syllables, due to its more peripheral and sonorous articulation (Harrington et al. 1999). In this paper, an acoustic experiment was conducted to see if such a manner of segmental modification invoked by prosody in English extends to other languages such as Spanish. Results show that relatively more prominent syllables entail higher F1 values as a result of their more sonorous articulation in Spanish, but either front or back vowel does not show a higher F2 or a lower F2 frequency. This is interpreted as an indication that a prosodically prominent syllable entails its vocalic enhancement in both horizontal and vertical dimensions of articulation in English. In Spanish, however, only the vertical dimensional articulation is maximized, resulting in a higher F1. I suggest that this difference may be attributed to the different phonological structures of vowels in English and Spanish, and that sonority expansion alone would be sufficient in the articulation of prosodic prominence as long as the phonological distinction of vowels is well retained.

Keywords : prosody, vowels, hyperarticulation, sonority expansion

1. Introduction

This paper attempts to provide an explanatory account of the differences in segmental implementations of prosody between English and Spanish, showing that a vowel's horizontal and vertical articulation is enhanced in prosodically salient (that is, accented or stressed) position in English, but the vertical dimensional articulation is merely maximized in Spanish. I argue that this difference might be due to the distinct vowel systems between English and Spanish. According to Harrington et al. (1999)'s instrumental study, a vowel enhances its sonority to maximize the vocalic contrast with a flanking consonant in prosodically salient

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position and is concomitantly hyperarticulated to make a clearer differentiation from any other vowel that might have occurred in the same position. On the other hand, the acoustic experiment that I conducted to examine Spanish shows that a vowel increases its sonority with no hyperarticulation in accented or stressed position. That is, a vowel's F1 significantly increases in accented or stressed syllables but F2 does not exhibit any significant difference between prosodically different syllables. This may be interpreted as the clarity of the manner contrast between the vowel and a neighboring consonant, thus merely providing a clearer sonority rise from the edge of the syllable to its nuclear vowel in Spanish. A vowel, however, does not make a more peripheral articulation, which suggests that a vowel does not necessarily enhance its systemic contrast with any other vowel in the same position.

The difference in the articulation of prosody between English and Spanish might be induced by their different vowel systems. A vowel's sonority expansion in an accented syllable might forfeit structural contrast between the accented vowel and a lower unaccented vowel due to perceptual crowd in the English vowel system. Therefore, hyperarticulation may be necessarily executed in the horizontal dimension of the oral cavity. On the other hand, Spanish, involving a considerably simpler vowel system compared to English, guarantees greater auditory space among vowels. There might be little risk of perceptual confusion between a more sonorous accented vowel and a lower unaccented vowel. That is, sonority expansion does not interfere with perceptual distinction among vowels, and a more peripheral articulation with an extreme effort may not be required in prosodically salient position.

2. Background

There have been two claims about the vocalic articulation of prosody; a prosodically prominent position is articulated by the maximum vertical expansion of its vowel (Summers, 1987; Beckman et al., 1992) and by both horizontal and vertical enhancement, that is, hyperarticulation (Engstrand, 1988; Lindblom, 1990; Lindblom & Engstrand, 1989; de Jong, 1995).

According to de Jong (1995), accentual prominence is enhanced in both horizontal and vertical dimensions of the oral cavity; a lower tongue body for low vowels, a higher tongue body for non-low front vowels, a backer tongue body with greater upper lip protrusion for non-low back vowels, etc., localized hyperarticulation. This claim is somewhat different from Beckman et al. (1992), who find that accented vowels are articulated simply with a lower and longer jaw movement. That is, speakers have a "sonority expansion" strategy for the articulation of accented syllables; speakers intend to produce a louder vowel to enhance the perceptual salience of accented syllables, providing more open vowels. According to this model, the vertical dimensional contrast of vowels alone, rather than both the horizontal and vertical dimensional contrasts, seems to be enhanced in prominent position.

According to the Hyperarticulation model, relative prominence among accented words is signalized by variable lingual kinematics in such a way that low vowels in prosodically more prominent syllables show a lower tongue body, with non-low front vowels having higher tongue body and non-low back vowels having a backer tongue body (e.g. Engstrand, 1988; de Jong, 1995). A low vowel, then, does not have any conflicting manner of supralaryngeal articulation to enhance its contrastive specifications for the accented syllable, simply because the two modifications of a lower jaw and a more peripheral articulation induced by a lower tongue body are not mutually incompatible, implementing a higher F1 frequency. That is, its sonority expansion is assumed equally as a hyperarticulation of the manner feature specification that makes a low vowel the ideal nucleus for an accented syllable.

Along this path, Harrington et al. (2000) brings up a question of what would happen to the supralaryngeal articulation of a high front vowel in accented position, in which case enhancing the clarity of the sonority rise into the vowel seems incompatible with enhancing the paradigmatic specification of the accented vowel's place target. In other words, a more open oral tract increases the sonority contrast between the vowel's manner specification and that of the neighboring consonant, but such sonority expansion cannot be executed simultaneously with a more peripheral articulation, i.e., a higher tongue body constriction as it is a high vowel.

Harrington et al. examine the manner of how sonority expansion and hyperarticulation are performed simultaneously in nuclear accented position of the high front vowel [iː] in Australian English, and they report that the vowel [iː] is implemented as a higher F2 due to either a fronter palatal constriction or a narrower cross-sectional area of the palatal constriction. This shows hyperarticulation such that the peripherality of [iː], either frontness or highness, can be maximized in the auditory space of the English vowel system. Moreover, the sonority contrast is also increased in the accented syllable; the vowel [iː] shows either lower tongue height, acoustically implementing a significantly higher F1 or an off-glide later in its articulation. It is their contention that two prominence-enhancing strategies, hyperarticulation and sonority expansion, are reconciled in English.

3. Experiment

In this section, I examine the vocalic articulation of prosodic prominence in Spanish, comparing the acoustic correlates of tongue body configurations between prominent and less prominent syllables as well as between horizontal and vertical articulatory dimensions. In other words, I investigate the manner of how two prominence-enhancing strategies, hyperarticulation and sonority expansion, are conciliated in prosodically prominent positions, relating with that of English.

3.1 Methods

Spanish nonsense words /CVpo/ with /b, d, g/ and /i, e, a, o, u/ were recorded in carrier sentences by two male native Spanish speakers and repeated 6 times in a randomized order. The target /CV/ syllables were placed in three relative degrees of prosodic prominence in carrier sentences: that is, accented and stressed position, unaccented but stressed position, and unaccented and unstressed position.[1] As shown in (1a), the syllable BÍ in the target word BÍPO, for example, is accented and stressed (hereafter, accented) because the stress-bearing syllable is nuclear-accented. The syllable bí in (1b) is lexically stressed but follows the nuclear-accented word DICEN; therefore, it is not accented. The postnuclear-accented but stressed syllable as in (1b) is, henceforth, called stressed. The syllable bi in the target word bipó is not lexically stressed or sententially accented; thus, it is unaccented and unstressed (hereafter, unstressed).[2] Consequently, there are three different syllables with relative prosodic strength; the accented syllable is the most prominent, and the stressed syllable is more prominent than the unstressed syllables.

(1)

(a) Nuclear accented and stressed /í/

A: ¿Qúe dicen para mi?	'What do they say for me?'
B: Dicen BÍPO para ti.	'They say BÍPO for you.'

(b) Postnuclear accented but stressed /í/

A: ¿Escriben bípo para mi?	'Do they write bípo for me?'
B: ¿No, DICEN bípo para ti.	'No, they SAY bípo for you.'

(c) Postnuclear accented and unstressed /i/

A: ¿Escriben bipó para mi?	'Do they write bipó for me?'
B: ¿No, DICEN bipó para ti.	'No, they SAY bipó for you.'

The sentences containing the target CV syllables were recorded in 16 bit and 8 KHz onto a Sun Sparc station using a Sony F-VX30 microphone. Among formant trajectories, F1 and F2 were calculated using Entropic's Waves program at the steady state portion. The F1 and F2 frequency values that were obtained from the formant trajectory measurements were confirmed by the LPC spectra display. The frequencies corresponding to the vowel's first and second peaks were taken as data from the spectra. The 25ms spectrum windows were created for the

1) Accent denotes a relative prominence assigned at the level of sentence, and stress, lexically at the level of word.

2) Stress is marked by the acute mark [´] in Spanish.

F1 and F2 measurements from a mid point of steady vowels. I intended to compare F1 and F2 frequencies between prosodically prominent and less prominent syllables: between accented and stressed syllable and between stressed and unstressed syllables.

3.2 Results

I present F1 and F2 frequency values over 5 different vowels, comparing between accented and stressed syllables in Tables 1 and 2 and examine the manner of how two prominence-enhancing supralaryngeal articulations, i.e., hyperarticulation and sonority expansion, are reconciled in Spanish. For both speakers 1 and 2, F1 values are significantly higher in the accented syllables than in the stressed syllables ($p < 0.0005$), but F2 frequencies are not statistically different between the accented and stressed syllables except the vowel /u/ in the case of speaker 2.[3] For the front vowels of /i/ and /e/, F2 frequencies tend to be higher, and for the back vowels of /o/ and /u/, F2 frequencies tend to be lower in accented positions, but the differences are not statistically significant.

Table 1. F1 and F2 mean frequencies between accented and stressed syllables (sp. 1)

	accented	stressed	t-value	accented	stressed	t-value
	F1 (SD): Hz	**F1** (SD): Hz		**F2** (SD): Hz	**F2** (SD): Hz	
/i/	426.55 (17.70)	388.72 (11.54)	7.593*	2138.33 (81.16)	2114.33 (54.51)	1.041
/e/	483.00 (31.51)	445.66 (15.14)	4.530*	1901.77 (76.35)	1855.55 (77.65)	1.801
/a/	807.22 (28.69)	734.44 (25.21)	8.084*	1281.77 (92.45)	1265.33 (76.33)	0.582
/o/	618.83 (42.33)	508.05 (15.34)	10.437*	924.22 (218.52)	1015.05 (93.82)	-1.620
/u/	467.72 (20.32)	397.70 (15.18)	11.490*	840.61 (115.48)	858.64 (115.38)	-0.462

Table 2. F1 and F2 mean frequencies between accented and stressed syllables (sp. 2)

	accented	stressed	t-value	accented	stressed	t-value
	F1 (SD): Hz	**F1** (SD): Hz		**F2** (SD): Hz	**F2** (SD): Hz	
/i/	355.77 (21.71)	306.27 (13.84)	8.156*	2328.27 (48.10)	2317.88 (55.88)	0.601
/e/	549.11 (23.83)	465.88 (15.15)	12.502*	1733.55 (48.60)	1712.50 (58.28)	1.177
/a/	780.88 (33.57)	697.88 (22.50)	8.712*	1291.77 (54.68)	1302.11 (78.87)	-0.457
/o/	546.05 (24.23)	483.05 (12.46)	9.584*	914.66 (56.19)	974.47 (73.37)	-2.717
/u/	416.16 (30.55)	371.33 (14.13)	5.650*	808.38 (62.65)	935.50 (54.95)	-6.471*

Tables 3 and 4 show F1 and F2 mean frequencies between stressed and unstressed syllables. Both speakers show that F1 values are significantly higher in stressed syllables than

3) Speaker 2 shows that the F2 mean frequency of /u/ is statistically lower in the accented syllable, which might be induced by extreme lip protrusion along with a backer articulation.

in unstressed syllables ($p < 0.0005$), but that F2 frequencies are not significantly different.

Table 3. F1 and F2 mean frequencies between stressed and unstressed syllables (sp 1)

	stressed	unstressed	t-value	stressed	unstressed	t-value
	F1 (SD): Hz	**F1** (SD): Hz		**F2** (SD): Hz	**F2** (SD): Hz	
/i/	388.72 (11.54)	336.55 (35.04)	5.998*	2114.33 (54.51)	2086.94 (67.15)	1.343
/e/	445.66 (15.14)	418.64 (16.39)	5.068*	1855.55 (77.65)	1780.70 (118.51)	2.222
/a/	734.44 (25.21)	642.55 (54.98)	6.445*	1265.33 (76.33)	1252.22 (77.83)	0.510
/o/	508.05 (15.34)	464.16 (22.83)	6.768*	1015.05 (93.82)	999.44 (94.50)	0.497
/u/	397.70 (15.18)	358.38 (17.26)	7.136*	858.64 (115.38)	908.61 (133.89)	-1.179

Table 4. F1 and F2 mean frequencies between stressed and unstressed syllables (sp 2)

	stressed	unstressed	t-value	stressed	unstressed	t-value
	F1 (SD): Hz	**F1** (SD): Hz		**F2** (SD): Hz	**F2** (SD): Hz	
/i/	306.27 (13.84)	259.00 (20.61)	8.076*	2317.88 (55.88)	2288.50 (41.01)	1.795
/e/	465.88 (15.15)	426.00 (13.24)	8.408*	1712.50 (58.28)	1729.00 (58.79)	-0.846
/a/	697.88 (22.50)	612.33 (33.81)	8.937*	1302.11 (78.87)	1321.11 (51.52)	-0.856
/o/	483.05 (12.46)	437.44 (29.91)	5.824*	974.47 (73.37)	953.33 (60.07)	0.935
/u/	371.33 (14.13)	323.55 (22.31)	7.674*	935.50 (54.95)	925.27 (87.92)	0.418

2.5 Discussion

I have shown that F1 frequencies are significantly higher in prosodically more prominent positions but that F2 frequencies are not such a case in Spanish. This can be interpreted as saying that prosodic prominence can be maximized by the sonority expansion of vowels alone in Spanish, and that a more peripheral articulation does not seem to play a significant role in enhancing the prosodic prominence. This is not consistent with Harrington et al.'s finding of English; both hyperarticulation and sonority expansion are concomitantly executed in English.

Now, it should be considered why Spanish and English adopt different strategies to enhance prosodic prominence in the supralaryngeal articulation of vowels. Among potential phonological or phonetic attributes, the phonological structures of vowels may be ascribed to the distinct vocalic implementations of prosody between English and Spanish. The vowels are articulatorily and perceptually more crowded in English than in Spanish; there are 12 vowel phonemes in English, that is, /i, ɪ, e, ɛ, æ, ə, ʌ, ʊ, u, o, ɔ, and ɑ/, but there are merely 5 vowel phonemes in Spanish, /i, e, a, o, u/.[4] The sonority expansion of an accented vowel might forfeit the structural distinction from a lower unaccented vowel due to perceptual crowd in the English vowel system. For example, when the tense vowel [i] is articulated with a more oral opening

4) I consider only American English here.

in an accented position, acoustically, a higher F1 frequency will be manifested. This will result in decreasing the perceptual distance with the lax vowel [ɪ] in unaccented position because the vowel [ɪ] intrinsically has a higher F1 frequency than the vowel [i]. Consequently, a more sonorous articulation of [i] in the accented position might jeopardize the phonological distinction between [i] and [ɪ]. This requires an additional strategy of supralaryngeal articulation to maintain the contrast; therefore, hyperarticulation may have to play a decisive role in retaining the phonological contrast of the vowels; horizontally a more accurate constriction of [i] could make a sufficient distinction from the unaccented lax vowel [ɪ]. In other words, a higher F2 causes the tense vowel [i] to be more peripheral in the auditory space of English vowels.

On the other hand, Spanish, involving a considerably simpler vowel system compared to English, guarantees greater auditory space among vowels. There might be little risk of perceptual confusion between a more sonorous accented vowel and an unaccented lower vowel. That is, sonority expansion does not interfere with perceptual distinction among vowels, and a more peripheral articulation with extreme effort may not be required in prosodically salient position.

3. Conclusion

I have shown that syllables with relative prominence have different segmental implementations between English and Spanish; vocalic contrasts are enhanced in prosodically prominent position along both horizontal and vertical dimensions in English or merely along the vertical dimension in Spanish. I argue that this difference might be due to the distinct vowel systems between English and Spanish, and that the differences in the articulation of prosody may emerge from functional nature; that is, sonority expansion alone would be sufficient as long as the phonological distinction among vowel qualities are well retained.

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