ACOUSTIC CORRELATES OF SPANISH STRESS IN FLUENT AND NON-FLUENT APHASIA: A PRELIMINARY STUDY

Lorraine BAQUÉ

Laboratori fLexSem, Universitat Autònoma de Barcelona (Spain)
Lorraine.Baque@uab.cat

ABSTRACT

The aim of this study is to determine whether fluent and non-fluent aphasics preserve the acoustic marks of lexical stress in a repetition task involving regular oxytone and paroxytone disyllabic Spanish words in isolation.

Acoustic analyses of each syllable (duration, F0, intensity) were performed. These data were then subjected to mixed-effects regression analyses, separately for oxytones and paroxytones, with subjects and items as random variables, and group, stress, syllable structure and all the possible interactions as predictors.

The results showed a different use of acoustic cues to lexical stress in both fluent and non-fluent aphasics as compared to controls. In non-fluent aphasics, abnormal acoustic characteristics were found that involved not only timing aspects but also F0 and intensity cues. In fluent aphasics, a "subtle phonetic deficit" was observed in lexical stress processing, especially in oxytones with complex first syllable structure.

Keywords: Lexical stress, Spanish, Acoustics, Fluent aphasia, Non-fluent aphasia.

1. INTRODUCTION

The representation of lexical stress in psycholinguistic models is still a controversial issue: while some authors argue that the stress pattern of all lexical items is stored in free stress languages [5, 17], others consider that regular stress patterns are computed and only irregular ones are stored and retrieved during word encoding [18].

In aphasia, it has often been assumed that phonetic and phonological impairments concern segmental content while stress patterns remain unimpaired in both fluent and non-fluent aphasia [8, 9, 22]. However, some studies have reported the existence of specific stress errors in fluent aphasics [21] and even postulate a double dissociation between segmental and metrical deficits in phonological encoding [6]. In these last studies, most observed stress assignment errors affected lexical items in which stress pattern was unpredictable on the basis of syllabic structure.

Concerning the acoustic characteristics of stress production by aphasic patients in several languages, there has generally been found to be a deficit in durational cue processing [10, 11, 23] in non-fluent aphasia, often interpreted as a secondary consequence of a basic timing deficit [7], whereas other acoustic stress correlates remain relatively unimpaired. There has also been reported to be a "subtle phonetic deficit" affecting stress realisations in fluent aphasia [13].

The aim of this preliminary research is to determine whether there is some kind of phonetic impairment in fluent and non-fluent aphasics' realisation of lexical stress contrasts in the most frequent (predictable) stress patterns in Spanish, namely paroxytone CV-CV and CVC-CV words, and oxytone CV-CVC and CVC-CVC words [14, 24].

Since in Spanish stress contrasts seem to involve characteristic modifications of both F0 and duration [20, 25], or F0 and intensity [19], the comparative analysis of these three parameters should allow us to discuss the relative impairment/preservation of each of them.

2. METHOD

2.1. Participants

Three groups of right-handed native speakers of Spanish took part in this experiment: 4 non-aphasic controls, 4 fluent aphasics and 4 non-fluent aphasics, respectively classified by their speech pathologist as Broca's and conduction aphasics. The three groups were matched by age (mean ages 56.5, 51.8 and 54.8 respectively), sex (3 males and 1 female in each group) and educational level (secondary school).

2.2. Material and procedure

In this study we used all the disyllabic words from the Spanish COGNIFON lexical corpus (Baqué, Estrada, Le Besnerais, Marczyk, & Nespoulous, 2006) in which the first syllable structure is either CV or CVC, and the last syllable structure is CV (paroxytones) or CVC (oxytones). The items selected were 41 oxytones (23 CV-CVC and 18

CVC-CVC) and 51 paroxytones (27 CV-CV and 24 CVC-CV).

All participants were asked to repeat these 92 words, presented in isolation with a falling conclusive intonation.

2.3. Data analysis

Three phoneticians were asked to listen to all the productions and indicate the stressed syllable(s). We excluded from the analyses those productions that presented an intra-lexical pause or different number of syllables (0-4 items per subject) or that were associated by at least one of the phoneticians with a different stress pattern (0-2 items per subject).

All the remaining 1032 productions were automatically segmented into phones and syllables (EasyAlign under Praat [4, 12]) and manually corrected. For each syllable we extracted the duration (in s.), the maximum intensity value (in dB) and the mean F0 value of the vowel (in Hz, using Hirst's algorithm [15]). In order to avoid an inter-speaker effect on F0 and intensity values, we calculated the ratio of the mean F0 value of each vowel divided by the mean F0 value of the entire word and the ratio of the maximum intensity value of the vowel divided by the maximum intensity value of the entire word.

We analysed the data by means of mixed-effects regression models [1] in which participants and items were entered as random factors. Oxytone and paroxytone words are hardly comparable. Therefore, we ran separate analyses for oxytones and paroxytones, and for each acoustic parameter (syllable duration, mean F0 ratio, maximum intensity ratio). The predictors were in all cases Group (Broca's aphasics, conduction aphasics and Controls, hereafter BA, CA and N0 respectively), First syllable structure (CV or CVC) and Stress (stressed vs unstressed syllable) and all the possible interactions.

3. RESULTS

3.1. Oxytones

3.1.1. Syllable duration

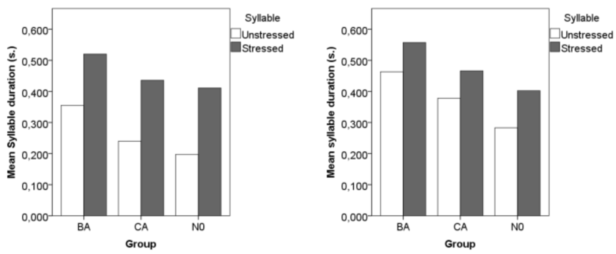
Our analyses show main effects of Group ($F(2, 9.03)=6.37$, $p<.05$), First syllable structure ($F(1, 81.99)=70.00$, $p<.001$) and Stress ($F(1, 81.83)=348.26$, $p<.001$), and three interactions: Group x First syllable structure ($F(2, 822.50)=6.30$, $p<.01$), Group x Stress ($F(2, 820.36)=4.64$, $p<.01$) and First syllable structure x Stress ($F(1, 81.82)=33.65$, $p<.001$).[1]

As can be seen in Figure 1, syllable duration is shorter in Controls' and conduction aphasics' productions (0.320 and 0.373 s.) than in Broca's aphasics' (0.469 s.), and in unstressed vs stressed syllables in the three groups. But the difference between stressed and unstressed syllables is significantly larger in control group (0.403 vs 0.232 s., $p<.05$) than in both aphasics groups (CA: 0.448 vs 0.297 s.; BA: 0.536 vs 0.401 s., $p<.05$).

In addition, all groups produce shorter mean duration values in words starting with a CV syllable than in those starting with a CVC syllable, but the difference is less important for the control group (0.304 vs. 0.343 s., $p<.05$) than for the two aphasic groups (CA: 0.338 vs 0.422 s.; BA: 0.438 vs 0.511 s.; $p<.05$).

Post-hoc analyses show that CA syllable durations are not significantly different from those of N0 syllables except for CVC unstressed syllables, which are longer. Moreover, contrary to what we see in control subjects, the final CVC syllable is longer in CVC-CVC than in CV-CVC words (0.466 vs 0.436 s., $p<.05$) in the CA group, and the same tendency is observed in the BA group (0.557 vs 0.520 s., $p<.10$). It seems that first syllable structure complexity has an impact on the two syllables of the word in aphasic speakers.

Figure 1: Mean syllable durations (in s.) as a function of Group and Stress in CV-CVC (left) and CVC-CVC (right) in oxytones.

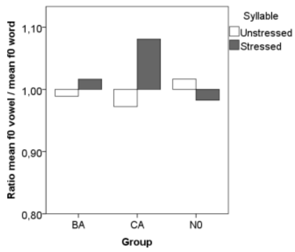


3.1.2. Fundamental frequency ratio

Our analyses show main effects of Group ($F(2, 8.55)=4.37$, $p<.05$) and Stress ($F(1, 83.96)=11.81$, $p<.001$) and an interaction effect for Group x Stress ($F(2, 809.33)=41.75$, $p<.001$). No main effect of First syllable structure and no other interactions are observed. Therefore, we analyse the results of CV-CVC and CVC-CVC words together.

As can be seen in Figure 2, even if final intonation is falling in the three groups' productions, the mean F0 ratio of vowels is higher in stressed final syllables in the productions of conduction aphasics (1.07 vs 0.97, $p<.05$) and lower in the control group (0.97 vs 1.02, $p<.05$). There is no difference between the two syllables in Broca's aphasics' productions (1.01 vs 0.99, p>.05). It seems that both aphasic groups, especially CA, tend to over-use F0 cues in stress-marking in oxytones, even in conclusive intonation.

Figure 2: Mean F0 ratio as a function of Group and Stress in oxytones.

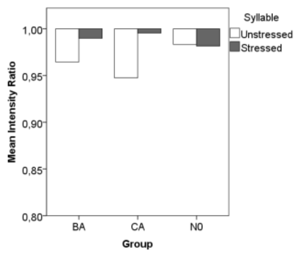


3.1.3. Intensity ratio

Our analyses show a main effect of Stress (F(1, 891.89)=185.87, p<.001) and an interaction effect of Group x Stress (F(2, 891.95)=59.71, p>.001), with no main effect of Group (F(2, 9.07)=3.39, p>.05) and no other interactions. Therefore, the results for CV-CVC and CVC-CVC words are presented together.

As shown in Figure 3, there is no difference between initial unstressed and final stressed syllable in the control group (0.98 in both cases), contrary to what is observed in both aphasic groups. These two populations increase intensity on the stressed syllable (BA: 0.99 vs 0.96; CA: 1.00 vs 0.94; p<.05). Similarly to what is observed with mean F0 ratio, both aphasic groups, and especially CA, over-use intensity as a stress cue in oxytones, even in conclusive intonation.

Figure 3: Mean intensity ratio as a function of Group and Stress in oxytones.



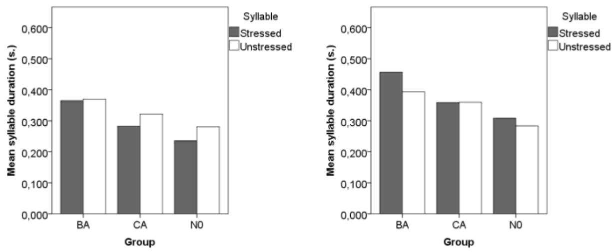
3.2. Paroxytones

3.2.1. Syllable duration

Our analyses show main effects for Group (F(2, 9.01)=6.11, p<.05) and First syllable structure (F(1, 100.87)=60.94, p<.001) and two interactions: Group x Stress (F(2, 1043.51)=10.52, p<.001) and First syllable structure x Stress (F(1, 100.70)=21.77, p<.001).

Similarly to what we see in oxytone words, mean syllable duration is shorter in control group and conduction aphasics (0.275 and 0.328 s.) than in Broca's (BA: 0.395 s.) and shorter in words starting with a CV syllable (0.308 s.) than in those starting with a CVC syllable (0.362 s.). But differences between initial stressed and final unstressed syllable durations differ depending on group and first syllable structure. In CV-CV words, control subjects and conduction aphasics lengthen the last (unstressed) syllable more than the initial (stressed) syllable (N0: 0.281 vs 0.236 s., CA: 0.322 vs 0.282 s., p<.05), while there is no difference in Broca's aphasics' productions (0.370 vs 0.365 s., p>.05). In CVC-CV words, there is no significant difference between stressed and unstressed syllable durations (N0: 0.308 vs 0.283 s.; CA: 0.359 s. in both syllables), while Broca's aphasic patients lengthen the first (stressed) syllable (0.457 vs 0.393 s.). This could be related to BA's inability to reduce initial stressed syllable duration.

Figure 4: Mean syllable durations (in s.) as a function of Group and Stress in CV-CV (left) and CVC-CV (right) paroxytones.

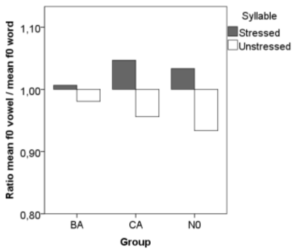


3.2.2. Fundamental frequency ratio

Analyses show a main effect of Stress (F(1, 98.55)=307.90, p<.001) and an interaction effect for Group x Stress (F(2, 974.20)=30.70, p<.001). No main effects of Group or First syllable structure and no other interactions are significant.

In the three groups' productions, the initial stressed syllable presents a higher mean F0 ratio, but the difference is much more important in the CA (1.10 vs 0.85, p<.05) and control groups (1.06 vs 0.90, p<.05) than in the BA group (1.03 vs 0.94; p<.05). It seems that conduction aphasics over-use F0 cues in stress marking, contrary to Broca's aphasics.

Figure 5: Mean F0 ratio as a function of Group and Stress in paroxytones.

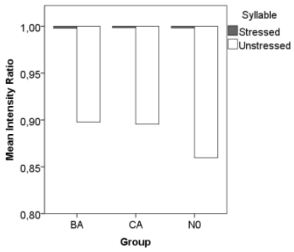


3.2.3. Intensity ratio

Our analyses show a single main effect of Stress (F(1, 104.15)=1003.47, p<.001) and Group x Stress interaction effect (F(2, 1041.47)=32.68, p<.001). No main effect of Group or First syllable structure and no other interaction are observed.

The three groups mark the stressed (initial) syllable by a higher intensity, but the difference between the two syllables is larger in the control group (1.00 vs 0.87) than in both aphasic groups (BA and CA: 1.00 vs 0.90).

Figure 6: Mean intensity ratio as a function of Group and Stress in paroxytones.



4. CONCLUSIONS

Taken together, our results show that the three groups tend to mark stressed syllables using at least three different cues: syllable duration, mean F0 ratio and intensity. Unsurprisingly, the differences between stressed and unstressed syllables vary depending on the position of the stressed syllable, as final syllables in falling intonation tend to be associated with longer durations and lower F0 ratio and intensity values [26].

However, even if the number of stress assignment errors is negligible in both Broca's and conduction aphasics' productions, the acoustic correlates of stress somehow differ from those seen in the control group.

The first difference concerns timing features in the Broca's aphasics. Unsurprisingly, speech rate is slower in the Broca's group, but it is noticeable that their initial syllable duration varies as a function of syllable structure but not of stress (contrary to N0 and CA). This result could be related to the inability of these patients to reduce first syllable duration [3] and to a "basic impairment in speech timing" [23]. Therefore duration differences between an oxytone and a paroxytone concern the second syllable, (insufficiently) longer if stressed. In addition, there seems to be a contradictory use of durational differences and F0 and intensity cues: when lengthening is insufficient (oxytones) there is an over-use of F0 and intensity ratio for stress marking, while the opposite is true in paroxytones.

The conduction aphasics' productions of paroxytones are quite similar to those of the control subjects, even if we observe less intensity differences between stressed and unstressed syllables. In oxytones they tend to over-use F0 and intensity cues in stressed syllables. Some difficulties in processing durational cues are associated with first syllable complexity (Laganaro, 2005).

Our results in this repetition task of disyllabic words in isolation are congruent with those of previous studies that conclude (e.g. [13]) that, in the absence of phonological impairment, there is a phonetic (motoric) deficit affecting not only segmental but also stress realisations in Broca's and –to a lesser extent– conduction aphasics' lexical stress processing. In the latter, a specific effect of syllable complexity and of (less frequent) stress pattern (oxytone) is observed.

However, in non-fluent (and fluent) aphasics abnormal characteristics of stress marking involve not only timing aspects but also F0 and intensity cues, contrary to what has been observed by other authors (e.g. [10, 23]) .

Further research with a full-scale group analysis is needed to validate these preliminary conclusions and a correlation analysis of different acoustical cues in Broca's aphasics' productions should be carried out in order to identify potential compensatory strategies in their contradictory use of the three principal acoustic parameters of stress.

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[1] We will only discuss here the main effects and the interactions that are relevant for the purpose of this contribution.