

## THE PHONETICS OF DISCOURSE: STRONG SYLLABLE POSITIONS IN MEXICAN SPANISH AND BRAZILIAN PORTUGUESE

*Antônio R. M. Simões*

The University of Kansas  
Department of Spanish and Portuguese  
Lawrence KS 66045

### ABSTRACT<sup>†</sup>

The main objective of this investigation is the analysis of segment duration in discourse in order to provide a basis for the study of lexical and intonational stress in Spanish and Portuguese. The present study is limited to the study of lexical stress in discourse. Duration of syllable nuclei is studied acoustically and perceptually from spontaneous speech recordings.

In the acoustical study, measurements using Sona-Graph™ were taken from speech samples recorded from Mexican and Brazilian television broadcasts, and from dialogues between four subjects in interviews led by the researcher. The results indicate certain "areas of prominence" at the discourse level that can be contrasted in both Mexican Spanish (MSpn) and Brazilian Portuguese (BP). These can be found at any linguistic level: segment, syllable, word, sentence or discourse. Due to "areas of strength" there are syllables that will preserve most of their quality at those "strong points" and lose quality in "weak points". The acoustical results in this study indicate that syllables are strong in MSpn at the stressed and poststressed positions, whereas in BP the strong position is at the stressed syllable position only.

In addition to these results, measurements of duration in non-prepausal position, show that vowels can be longer in pretonic and posttonic word position. It was not attempted, however, to determine which lengthening factors operate in the languages studied.

In the perceptual study, subjects were able to point out which vowels were deleted and replaced by noise. In a group of twelve speakers of American English, Spanish and Brazilian Portuguese, American subjects performed better, indicating that

probably it was due to their awareness of forms in a second language.

An additional finding is the presence of recurring intonational phrase in Spanish and BP. In Spanish, these "phonetic continuums" are often characterized by a relatively flat prefinal melodic curve, with an overall varying durations of 1.2 to 2.0 seconds. In BP, such continuums have durations of .9 to 1.2 seconds, and varying melodic curves. Such results may profitably be linked to metrics in poetry, and consequently to the study of metrics and any other area of research in phonetics at the sentence and discourse domains.

### 1. INTRODUCTION

This is a study of stress which forms part of a long-term project to find the principles of production and perception in Spanish and Portuguese, within the realm of experimental phonetics. Any scholar who has studied linguistic stress, whether lexical or intonational, knows how problematic it can be to find an explanation or definition of "stress" (see Bolinger: 1961; Lehiste: 1970; Ladefoged: 1982). Therefore, it is not clear in the general theory of phonetics what "stress" means. I find it helpful though, to use Ladefoged's (1975) remarks on this topic which states that the major components of stress are fundamental frequency, intensity and duration. It is extremely difficult to prove or disprove this claim empirically. Even to prove the existence of truly minimal pairs in discourse, in terms of lexical stress, is problematic. First, words like the noun "record" and the verb "recgrd" cannot be considered minimal pairs since in English the vowels in these words do not have the same quality. Truly minimal pairs in terms of contrastive lexical stress can only be found in very few words like the noun "rgbel" and the verb "rebgl" in certain varieties of English. Although in BP and Spanish discourse, it is not easy to find minimal pairs contrasting stress, it is not as

---

<sup>†</sup> This study was supported by the General Research Fund of the University of Kansas.

difficult as it is in English. There are also serious obstacles to extract these minimal pairs properly from spontaneous speech for experimental work with them. Brazilian Portuguese, for example, is somewhat similar to English in terms of the constantly changing quality of vowels. As an illustration, suppose one attempts to extract minimal pairs in BP, using word pairs such as "evitar" (to avoid) and "evita" (s/he, it avoids), hoping that the speakers will produce expected minimal pairs [e.vi.tá] (to avoid) and [e.ví.ta], (s/he, it avoids). In other words, Brazilian linguists know that these are common forms of pronunciation in discourse, but they also know that the written "r" may surface in spontaneous speech, the vowel [e] in the first syllable may raise to an [i], and that the postonic [a] may show some degree of centralization. Therefore, such variations make extraction of minimal pairs difficult because a great amount of speech recordings is necessary and most of the data will not be used for this particular goal.

At this stage of the process, one may either hypothesize that there is a functional or contrastive entity "stress" or that there is not. If there is such an entity, its fundamental components also have to be defined and then we need to verify whether or not these fundamental components exist and to what extent. In the case of BP and MSpn, the hypothesis here is that there is contrastive stress. Again, only after one has gathered valid data from spontaneous speech in contrast to any artificial elicitation of minimal pairs, can the existence of contrastive stress be empirically shown. On the basis of linguistic intuition, we make the assumption that contrastive stress exists in MSpn and BP and attempt in this paper to find to what extent duration can be considered a major component of stress in BP and MSpn.

Although the present investigation deals only with recordings of Latin American Spanish and Brazilian Portuguese, the long-term goal is to include all varieties of these languages. The term "strong position" refers to any highlighted or prominent syllable nucleus in the discourse. "Strong positions" may be found in any linguistic domain: for example, in the segment domain at syllable nuclei filled by inherently strong vowels such as, in Spanish and BP, the [a] vowel relative to vowels such as [e] or [o], at stressed position within a word, in different areas of a sentence, in the intonational phrase, etc. Thus, these "strong positions" include "stress" in the word domain and "accent" in the intonational domain. In sum, "strong positions" are recurrent patterns of better defined acoustical images at any point in the discourse. My goal is to find out what factors influence the occurrence of

recurrent patterns of clear acoustical images, and then how to interpret them at the perceptual level.

To close these introductory remarks, it is important to mention that results from this study coincide in part with studies of metrics the Spanish and Portuguese poetic traditions. It is hoped, that by using the experience accumulated in a different area of language analysis, we can find different ways to look into discourse analysis, and by doing so, explain various linguistic phenomena from this perspective.

## 2. Relevance of Studies in Duration

Although there is no phonemic contrast between long and short segments in MSpn and BP, there are many reasons for analyzing duration. Fant (1970, 224) had already observed that "the simple and fundamental cue of duration deserves greater attention than is conventionally paid to it." In addition, I would like to note that acoustics and perception of speech, namely functional integration of all linguistic components, cannot be dissociated from the time axis.

Investigators have dealt with temporal organization of speech sounds in a variety of ways. A brief look into applied and theoretical areas of speech analysis such as building of speech models, or in descriptive works dealing with rhythmic patterns, intrinsic duration, semantics, and syntax, will show continuing efforts to understand the temporal patterns of speech sounds. One of the major obstacles in studies of duration is to decide precisely where a sound segment begins and ends. In the case of a vowel, its duration may be the portion that goes from the onset of the formant structure to its offset. The terms onset and offset are used in the same sense they are used in Lehiste and Peterson (1961). Or, vowel duration may extend beyond these boundaries, as seen in some studies (e.g. Parker and Diehl, 1984). In order to eliminate inconsistencies, one has to decide where segmental boundaries are located, and develop procedures for finding them.

One of the first works that dealt with phonological and phonetic factors in terms of temporal organization of sound segments is the work of A. Martinet (1949) which points to a universal tendency in languages to shorten vowels following tense consonants, lengthen vowels that follow lax consonants. Jakobson and al. (1952) observed that tense consonants, i.e. [f,s,ʃ,p,t,k], are longer than lax consonants, i.e. [v,z,ʒ, b,d,g]. A number of other studies have dealt with duration in the phonological and phonetic domain, such as Fry's (1955) where duration is shown to

be a more effective cue for judgments of stress, the study by Miller and Nicely (1955) that proposes the acoustico-physiological feature "duration" to distinguish [s,ʃ,z,č] from twelve other consonants, and Peterson and Lehiste's (1960) study which noted that duration is affected by the nature of the consonant after a syllable nucleus, namely, a syllable becomes longer when followed by a voiced consonant and shorter when followed by a voiceless consonant with the longest syllable nucleus occurring before a voiced fricative. Other languages show some difference in how segment duration is patterned. Chafcouloff and al (1976) observed that in French all constrictives, viz. fricatives, especially in bisyllabic words, become longer if followed by [i,y,u], but [ʃ] becomes shorter in contact with the rounded, mid, front [œ]. In Italian, Ferrero et al. (1979) showed that shortening of frication duration in Italian unvoiced fricatives [s,ʃ] does not bias perception toward the corresponding [z,č] as English does (Cole and Cooper, 1975), but instead toward the unvoiced affricates [ts,tʃ]. Major (1981) and Nobre and Ingemann (1987) concluded that duration is a major component of stress in BP. In Spanish, Delattre (1966) finds that closed *syllables* are longer than open ones, whereas in Navarro Tomás (1967) we find a study of vowel duration where *vowels* in closed syllables are shorter than vowels in open syllables. Navarro Tomás also observes the kinds of consonants that affect differently the vowel duration.

Rhythmic factors may also affect word duration as Pike (1945) has argued. On the other hand, studies by Kozhevnikov and Chistovich (1965) and Noteboom (1972) propose that rhythm is independent of word duration, viz. subjects are much more aware of duration if a monotonous pitch is used than if normal pitches are used. Simões (1987a) notes the inadequacy of relating word duration to rhythm in BP, and Kelm (1989) also sees no results that makes such a correlation in both MSPn and BP.

Studies at the word level by Lehiste (1970), Raphael (1972), Umeda and al. (1973), Simões (1980) indicate that duration is linked to position within word, length of word, word boundary and the interaction of these factors. Major (1981, 1985) observed that in BP any phonological process has to take place first at postonic position, then pretonic and then in stress position.

In term of syntactic factors, it is important to mention the work of Gaitenby (1965, mentioned in Klatt (1976)) that shows duration as a parameter that delimits syntactic units. Other investigations followed confirming duration as a cue that signals syntactic boundaries: Harris and

Umeda (1974), Lindblom (1978), and Schreiber and Read (1982), to mention some.

These results have helped researchers in the design of speech models, especially models that attempt to include characteristics related to semantics (Umeda:1975; Klatt:1976): emphasis, contrastive stress, topicalization (focus), and word novelty. Schreiber and Read (1984) gave extra duration to words at syntactic boundaries to improve listening comprehension in children. However, they did not observe improvements in the listening comprehension of adults under the same conditions.

Therefore, as we study lexical stress in discourse, other factors have to be considered whenever a given duration becomes relatively shortened or lengthened. These factors include as mood or physical condition of the speaker (extralinguistic), emphasis or word novelty (semantic consideration), prepausal lengthening (sentence domain), intrinsic features of speech sounds, and so forth as set forth in Klatt (1976). It is not in the scope of the present study to observe which and how these factor operate in Spanish and Portuguese.

Some works that used duration in the design of models are those of Klatt (1976), for English, which suggests that recurrent rules to shorten or lengthen inherent durations from smaller units (phonemes), i.e. locally, up to higher units (sentences), operating cyclically; Lindblom and Rapp (1973), for Swedish, suggest the inverse operation, viz. from higher units into smaller units, down to the word domain, only. Later, Lindblom and al. (1981) extended Klatt's (1976) formula and developed several hypotheses about the psychology of speech timing. In their extension of Klatt's formula, Lindblom and al. (1981) applied duration rules cyclically from smaller to higher units. Although Klatt's (1976) model does not necessarily reflect speech production processes, Simões (1987) suggested a redefinition of inherent duration of a sound in BP in terms of median duration in case one attempts to extend the model in terms of speech production processes. By the same token, since there is no minimal duration at discourse domain, namely a syllable nucleus can be completely deleted, Klatt's (1976) linear equation can be simplified from  $D_o = K * (D_i - D_{min}) + D_{min}$  to  $D_o = K * D_i$ .

As a general synthesis of these results we may say that duration at the phonological and phonetic level is affected by language specifics and articulatory effort. When a minimal effort is required, there is a reduction of the targeted sound segment, whereas under maximum articulatory effort there is a lengthening of the targeted

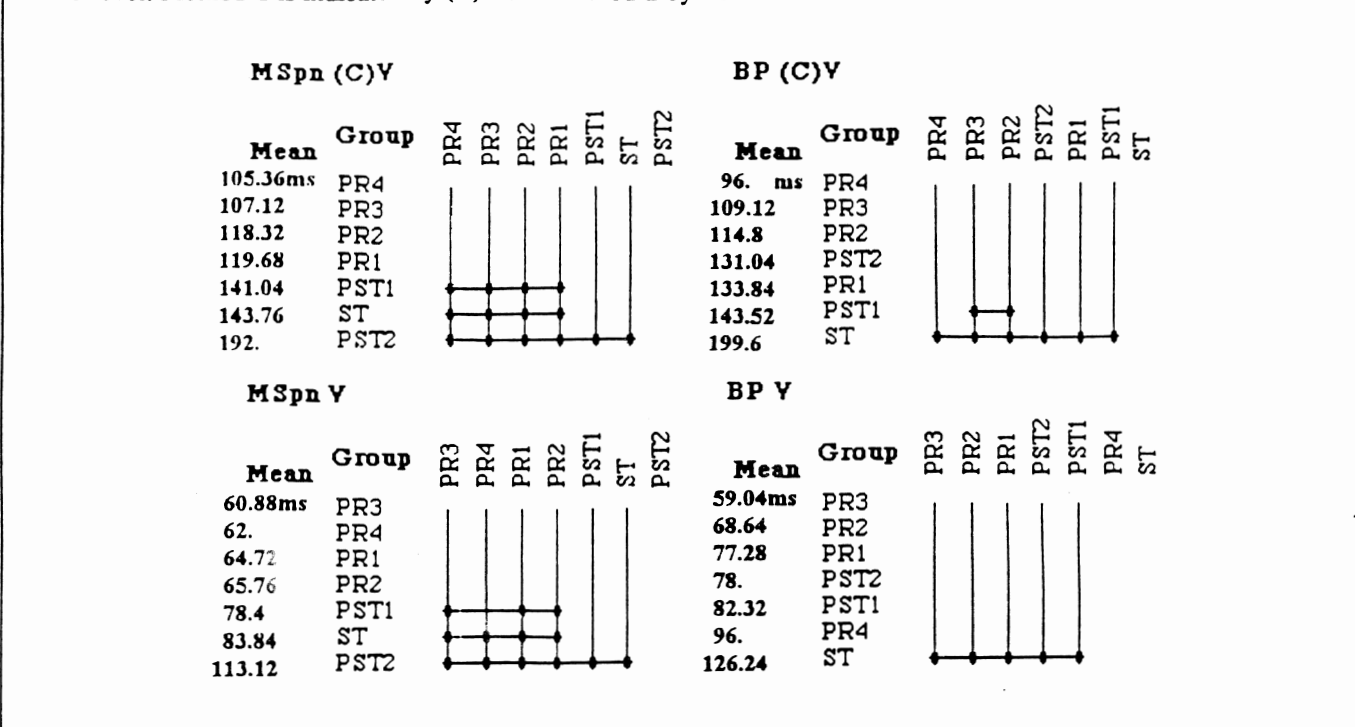
segment. The sounds adjacent to the targeted sound are affected differently in each language. Articulatory effort will be greater during vocal cords vibration, stressing of a sound-segment, or in articulatory displacement (distance) during changes in articulatory gestures. As Lehiste (1970) remarks, the greater the displacement the longer the sound-segment.

### 3. Results and Discussion

The experimental procedures for first stage of this study was as follows. Initially, television broadcasts via satellite, from Mexico and Brazil, were recorded, first into a regular video cassette and then from the video cassette into audio cassettes. From these audio cassette recordings, both the syllable nuclei, and sequences of consonant plus a syllable nuclei were measured. Segmentation procedures followed those described in Simões (1987) with modifications made as needed.

More than four hundred measurements of these durations were taken, several statistical tests were made. Results of an ANOVA multiple range test of the relationship between all syllables measured are shown in Figure 1. Since there is no significant difference between measurements taken of the syllable nuclei and measurements of a consonant followed by a syllable nucleus, only the measurements of the syllable nuclei will be discussed. The abbreviations in Figure 1 mean the following: ST, stressed; PR1, prestressed, viz. one syllable before the stressed one; and similarly PR2, PR3, PR4; PST1, poststressed, viz. one syllable after the stressed syllable; and similarly PST2, PST3. The results indicate that all relationships are linked to lexically stressed and poststressed syllables in MSpn and to stressed syllable in BP. Such results are probably showing that these prominent syllables are significant points of reference in discourse in terms of production.

Figure 1: ANOVA results of multiple range test. The intersection of lines denotes pairs that are significantly different at the .05 level. Method-1 is indicated by (C)V and method-2 by V.



Following the results from the acoustical analysis as seen in Figure 1, a perceptual test was designed. In this perceptual study, sentences from the same recordings, as the acoustical analysis described above, were modified in the DSP5500 Sona-Graph™. These modifications were made in terms of sentence and word domains (see

Appendix). At the sentence domain modifications took place near the beginning or the end of the sentences; then, at those points in the sentence, vowels in prestressed, stressed, and poststressed syllables were edited out and replaced by background noise of equal duration from portions of the recordings in which there was no

speech. The whole formant structures of vowels were replaced from the onset from the consonant release to the offglide of each vowel, using, in general, the second formant as reference (Lehiste and Peterson:1961; Simões:1987). The vowels replaced are shown in the Appendix.

Native speakers of Spanish listened to the Spanish tapes, native speakers of Brazilian Portuguese listened to Brazilian Portuguese tapes and native speakers of American English with near-native speaker proficiency of Spanish and/or Brazilian Portuguese were also asked to listen to the tapes. They totalled twelve subjects, four for each group. These subjects were asked to perform two tasks in listening to these modified tapes. First, they were told that these tapes were recorded via satellite and that possibly the tapes lost some information during the transmission or maybe no information was lost. They were asked to comment after each sentence. After having listened to one sentence, their impressions on any aspect of the task (comprehension, speakers accent, their judgement about the test itself, and so forth) were discussed. The intention was to conduct a less structured, less controlled experiment, so that unpredicted results could appear. Thus, instead of the usual procedure in this type of study, namely to give subjects a set of possible answers to choose from, subjects were interviewed and asked to comment on each sentence they listened to, and as they talked I took notes.

After all sentences were played and discussed, I explained to them that, in fact, some words in the sentences had been modified. In the second task, I asked them to listen again to each sentence, and decide: if they thought a word was modified and to point out the word. If they identified a word, I asked them to tell me what the change was and where in the word the change took place.

The general results I have gathered, so far, from their reactions, can be summarized as follows. Some of the subjects in this experiment had more difficulty in pointing out the modification at the beginning of a sentence than at the end of a sentence. This is surprising, considering that perceptual tests have shown that subjects tend to perform poorly in specifying where information was deleted or added. Furthermore, the Spanish speakers in this experiment had more difficulty in pointing out where the modification took place and very often did not hear any change. The American subjects performed very well in

pointing out in Spanish and Portuguese, where the modifications took place which vowel was missing. The Brazilians were good at that task, too, but they did not identify the correct place as often as the Americans. There was no control of the environments where these syllable nuclei were deleted, since the sentences were selected randomly.

After having examined the speech samples and interpreted the acoustical and perceptual results in the preceding television broadcasts, two interviews in Spanish and Portuguese were made. The speakers were two native speakers of Spanish, one female university student from Colombia and one male university student from Mexico; then, two native speakers of BP, one female university student from the city of São Paulo and one male student from the city of Rio de Janeiro. The four speakers are between 20 and 30 years old.

The duration of syllable nuclei and larger speech units, that is "phonetic continuums" or intonational phrases, was acoustically analyzed in these interviews. The goal here is to observe duration patterns in dialogues, and thus to what extent it played a role as a correlate of lexical stress. In terms of the relevance of duration to stress at the word level, duration can be considered as one of its major components. In discourse, however, factors such as word or phrase final lengthening may cause unstressed vowels to be longer than stressed vowels. This applies to both Spanish and BP. One example from Spanish is shown in Figure 2. Although it is not difficult to find in non-prepausal position stressed syllable nuclei shorter than unstressed ones in Spanish and BP, it is more common to find these occurrences in Spanish.

In larger units, phonetic continuums, the equivalent of intonational phrases, were observed in this study to fall within the intervals of .9 to 1.2 seconds in BP and 1.2 to 2.0 in Spanish in the recordings made for the dialogues. These continuums are often characterized by an overall flat prefinal intonation as depicted in Figure 3. This of course does not mean that all Spanish intonation is like this example. Such continuums, in terms of duration, seem to be equivalent to the eight-syllable verse in Spanish and the seven-syllable verse in Portuguese, which coincide somewhat with the English iambic tetrameter, under the English tradition of the syllabic foot.

Figure 2: Speech sample "... sistema bipartidista ..." (ing. "bipartisan system") from Spanish, spoken by a Colombian woman. The word "bipartidista" is in prepausal position. Lexically stressed syllables are "-te-" in "sistema," and "-dis-" in "bipartidista." In [sis.té.ma] the postressed [a] is longer than the stressed [é], and in [bi.par.ti.ðis.ta], all prestressed vowels are about the same or longer than the stressed [í].

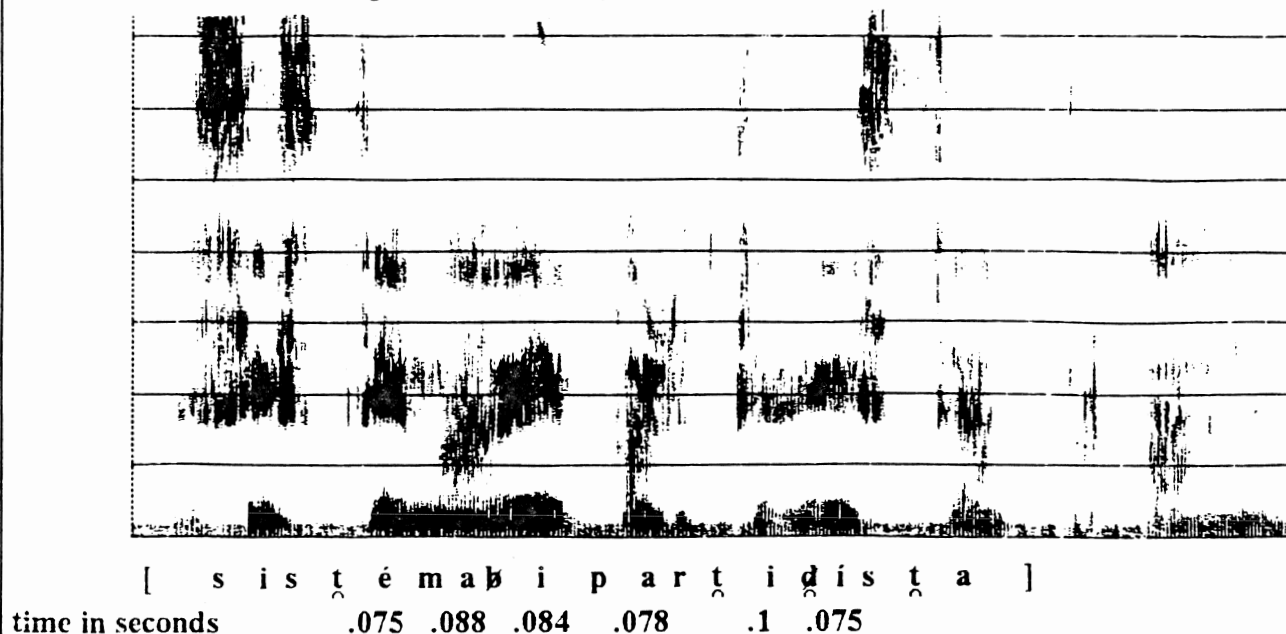
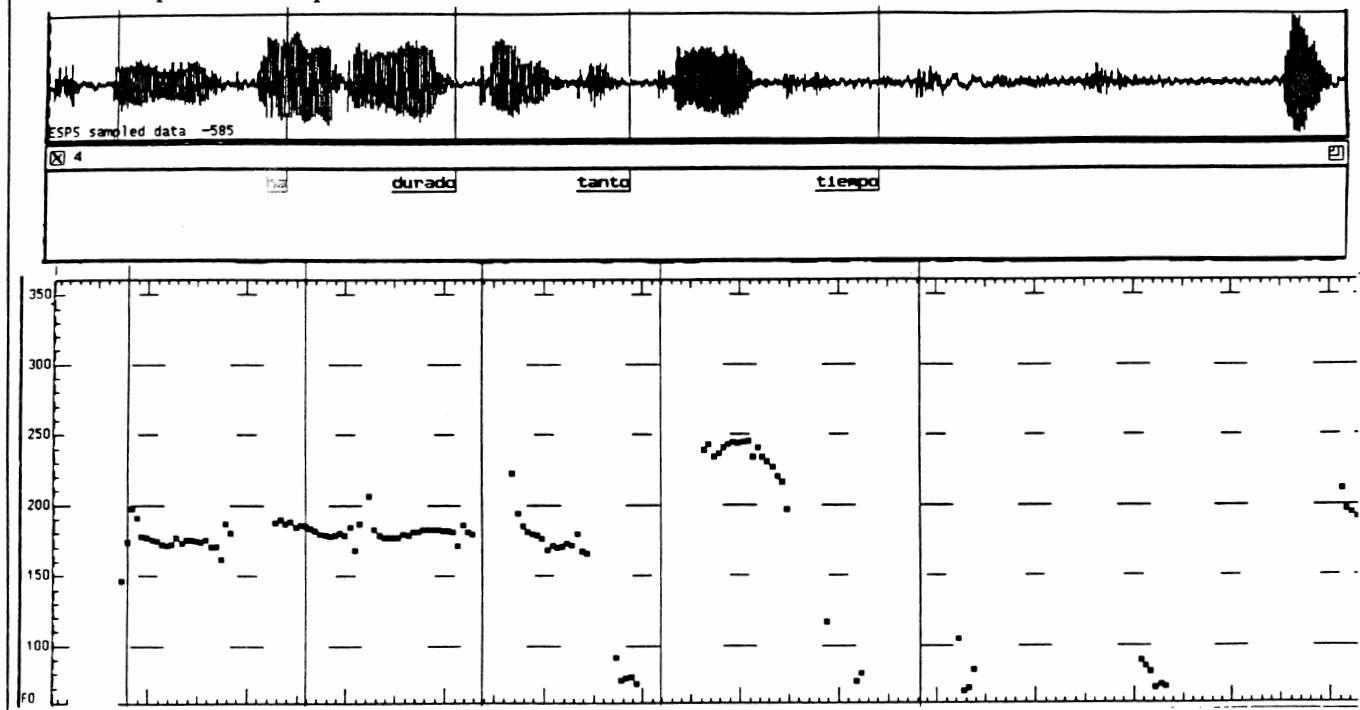


Figure 3: An example of recurring phonetic continuum in Spanish extracted from spontaneous dialogues: a flat prefinal intonational pattern. The speaker is a woman from Colombia.





Analysis of the data has brought to my attention a possible link between the present results and techniques for metrics in poetry. If one looks into versification in Spanish and Portuguese, it will be observed that syllable counting in these languages reflects what has been observed here. In other words, Spanish metrics, similar to Italian, counts the number of syllables in a verse by adding one count after the last stressed syllable, regardless of the presence or absence of a poststressed syllable. Portuguese had the same syllable counting until the last century. Since then, starting with Castilho (1908) in 1850, and confirmed in Spina (1971), metrics in Portuguese is done by counting up to the last stressed syllable in a verse, and no longer adds another count. French and Provençal are known to count syllables similarly to Portuguese.

The length of what I have been calling a "phonetic continuum" in the dialogues analyzed varies as expected, but there are some generalization that can be drawn. As mentioned in the results, these phonetic continuums fall into different patterns in Portuguese and Spanish. If we refer again to poetic metrics, it will be observed that, similarly to what one finds in spoken language, although a verse in poetry can vary from one to usually twelve syllables, poets, and we may infer native speakers who listen to poetry, have their preferences to convey their messages. In BP, a verse with seven syllables is the most used by poets, and the most popular type of verse for both reading and singing; in Spanish, the preference is for eight-syllable verses in singing and eleven-syllable verses in reading. This preference can, in my opinion, indicate what patterns to look for in discourse.

Examination of spectrograms in the present study shows that signal amplitude of Spanish words is clearly maintained not only on stressed syllables but also on poststressed syllables in physical and structural (i.e. expected) prepausal positions, creating a prolonged intonation at these points in the discourse. In BP, in such positions, poststressed syllables tend to disappear at the discourse level, creating a damping, namely a rapid decrease in signal amplitude after the stressed syllable.

#### 4. Conclusion

According to Ladefoged (1982:104) "The most reliable thing for a listener to detect is that a stressed syllable frequently has a longer vowel." This seems to be in fact the case for lexical stress, and especially in English. In Spanish and Brazilian Portuguese *discourse*, especially in Spanish, although duration is one of the major components of stress, as we go into spontaneous speech,

in non prepausal position, duration is not the most reliable correlate of lexical stress. Perhaps, in the case of Spanish and Portuguese, amplitude may play a more reliable role for in the identification of stress in discourse.

To summarize the major points of the present study, *acoustically* (1) in discourse, in prepausal and non-prepausal, lexically stressed syllable nuclei are often shorter than unstressed syllable nuclei; (2) in Mexican Spanish, lexically stressed and poststressed syllables are the most significant syllables in spontaneous speech, whereas in Brazilian Portuguese only the stressed ones have been observed as most significant syllables. This paper calls such syllables as strong syllables; (3) again, still in acoustical terms, recurring phonetic continuums were observed to measure between 1.2 to 2.0 seconds in MSpn and .9 to 1.2 seconds in BP. These phonetic continuums coincide with studies in metrics in the poetic tradition in Spanish and Portuguese. Finally, in a *perceptual* study (4) subjects were able to identify place and quality of vowels that were replaced by noise in sentences extracted from television broadcasts, and that subjects performed better in these tasks in a second language.

It seems to me that a theory of stress has to be elaborated in terms of spontaneous speech, and in terms of physiological, acoustical, and perceptual correlates.

#### WORKS CONSULTED

- Abaurre-Gnerre, M.B. (1979). *Phonostylistic aspects of a Brazilian Portuguese dialect: implications for syllable structure constraints*, unpub. diss. Buffalo: State University of New York.
- Abaurre-Gnerre, M.B. (1981). *Processos fonológicos segmentais como índice de padrões prosódicos diversos nos estilos formal e casual do português do Brasil. Cadernos de Estudos Lingüísticos*, 2, 23-44.
- Abercrombie, D. (1967). *Elements of general phonetics*. Edinburgh: Edinburgh University Press.
- Beckman, M.E. (1986). *Stress and non-stress accent*. Dordrecht: Foris Publications.
- Bolinger, D. (1961). Contrastive accent and contrastive stress. *Language*, 37, 83-96.
- Câmara, J.M. (1970). *Estrutura da língua portuguesa*. Petrópolis, Brazil: Editora Vozes.
- Câmara, J.M. (1977). *Para o estudo da fonêmica portuguesa*. Rio de Janeiro: Padrão.
- Castilho, A.F. de (1908). *Tratado de Metrificação Portuguesa*, In *Obras completas de A.F. de Castilho*, LVI, 5.<sup>a</sup>

- edição, vol 1. Lisboa, Portugal: Empreza da História de Portugal, Livraria Moderna.
- Chafcouloff, M. et al. (1976). Effets de la coarticulation sur les caractéristiques acoustiques des contours fricatives du français. In *Travaux de l'Institut de phonétique d'Aix*, 3, 61-113.
- Cole, R.A. and W.E. Cooper (1975). Perception of voicing in English affricates and fricatives. In *Journal of the Acoustical Society of America*, 58, 1280-87.
- Delattre, P. (1966). A comparison of syllable length conditioning among languages. *International Review of Applied Linguistics*, 4, 183-98.
- Fant, C.G.M. (1970). Acoustic theory of speech production, 2nd ed. The Hague: Mouton.
- Ferrero, F.E. and al (1979). Fricative duration of Italian unvoiced fricatives. In *Frontiers of speech communication research*, B. Lindblom and S. Ohman, eds. New York: Academic Press, 159-65.
- Fry, F.B. (1955). Duration and intensity as physical correlates of linguistic stress. In *Journal of the Acoustical Society of America*, 27, 4.
- Flege J.E. & O.-S. Bohn (1989) An Instrumental Study of Vowel Reduction and Stress Placement in Spanish-Accented English. *SSLA*, 11, 35-62.
- Godínez, M. (1978). A survey of Spanish and Portuguese phonetics. *UCLA Working Papers in Phonetics*.
- Green, J.N. (1988). *Spanish. The romance languages*, M. Harris & N. Vincent, eds. New York: Oxford University Press.
- Harris, J.W. (1983). *Syllable structure and stress in Spanish*. A nonlinear analysis. Cambridge, MA.: MIT Press.
- Harris, M.S. and N. Umeda (1974). Effects of speaking mode on temporal factors in speech. In *Journal of the Acoustical Society of America*, 56, 1016-18.
- Jakobson, R., G. Fant, and M. Halle (1969). *Preliminaries to speech analysis*, 8th edition. Cambridge, Ma.: MIT.
- Kelm, O.R. (1989). *Temporal aspects of speech rhythm which distinguish Mexican Spanish and Brazilian Portuguese*, unpub. diss. Berkeley, Ca.: University of California.
- Klatt, D.H. (1976). Segmental duration in English. *Journal of the Acoustical Society of America*, 59, 1208-21.
- Klatt, D.H. & L.C. Klatt (1990). Analysis, synthesis, and perception of voice quality variations among female and male talkers. *Journal of the Acoustical Society of America*, 87 (2), February, 820-57.
- Kozhevnikov, V.A. and L.A. Chistovich (1965). Speech articulation and perception, *JPRS* 30. Washington, DC.
- Ladefoged, P. (1982). *A course in Phonetics*, 2nd. edition. San Diego: Harcourt Brace Jovanovich.
- Lehiste, I. (1970). *Suprasegmentals*. Cambridge, MA: MIT Press.
- Lehiste, I. & G.E. Peterson (1961). Transitions, glides, and diphthongs. *Journal of the Acoustical Society of America*, 33, 268-77.
- Lindblom, B. (1978). Final lengthening in speech and music. In *Travaux de l'Institut de phonétique de Lund*, 13.
- Lindblom, B. and K. Rapp (1973). Some temporal regularities of spoken Swedish. Publication no. 21. Stockholm: Institute of Linguistics of the University of Stockholm (unpub.).
- Lindblom, R. et al (1981). *Durational patterns of Swedish phonology: do they affect short-term motor memory processes?* Bloomington, Indiana: Indiana University Linguistic Club.
- Major, R. (1981). Stress-timing in Brazilian Portuguese. *Journal of Phonetics*, 9, 343-51.
- Major, R. (1985). Stress and rhythm in Brazilian Portuguese. *Language*, 61, 2, 259-89.
- Martinet, A. (1949). Phonology as functional phonetics. *Publications of the Philological Society*, no. 15. London: Oxford University Press, 1-27.
- Miller, G.A. and P.E. Nicely (1955). An analysis of perceptual confusion among some English consonants. In *Readings in acoustics phonetics*, 301-15
- Navarro Tomás, T. (1967). *Manual de pronunciación española*, 6ª edición. Madrid: Consejo Superior de Investigaciones Científicas.
- Navarro Tomás, T. (1983). *Métrica española*, 6ª edición. Barcelona: Editorial Labor.
- Nobre, M.A. and F. Ingemann (1987). Oral vowel reduction in Brazilian Portuguese. In R. Channon and L. Shockey, eds., *In Honor of Ilse Lehiste*. Providence, USA: Foris Publication.
- Noteboom, S.G. (1972). Temporal patterns in Dutch. In *Proceedings of the 7th international congress of phonetic sciences*, 984-89.
- Parker, E.M. and R.L. Diehl (1984). Identifying vowels in CVC syllables: effects of inserting silence and noise. In *Perception & Psychophysics*, 36 (4), 369-80.
- Parkinson, S. (1988). Portuguese. *The romance languages*, M. Harris & N. Vincent, eds. New York: Oxford University Press.
- Peterson, G.E. and I. Lehiste (1960). Duration of syllable nuclei in English. In *Journal of the Acoustical Society of America*, 32, 693-703.
- Pike, K.L. (1945). *The intonation of American English*. Ann Arbor: University of Michigan Press.
- Quilis, A. & J.A. Fernández (1982). *Curso de fonética y fonología españolas para estudiantes anglo-americanos*, 10ª edición. Madrid: Consejo Superior de



Investigaciones Científicas, Instituto Miguel de Cervantes.

- Raphael, L. (1972). Preceding vowel duration is a cue to the perception of the voicing characteristics of word final consonant in American English. In *Journal of the Acoustical Society of America*, 51, 1296-1303.
- Schreiber, P.A. and W.Ch. Read (1982). Why short subjects are harder to find than long ones. In *Language acquisition: the state of the art*, Wanner and Gleitman, ed. Cambridge, Ma.: Cambridge University Press.
- Simões, A.R.M. (1980). *Étude acoustique des consonnes [s] et [z] du Brésilien*. Mémoire de D.E.A., ms. Aix-en-Provence, France: Institut de phonétique.
- Simões, A.R.M. (1987) *Temporal organization of Brazilian Portuguese vowels in continuous speech: an acoustical study*, unpub. diss. Austin, TX: University of Texas.
- Simões, A.R.M. (1987a). Brazilian Portuguese rhythm: stress-timed, syllable-timed, or samba? Paper presented at the *University of Texas Colloquium on Hispanic and Luso-Brazilian Literatures, and Romance Linguistics*, October.
- Spina, S. (1971). *Manual de versificação românica medieval*. Rio de Janeiro: Ed. Gernasa.
- Umeda, N. et al (1973). Fricative--the physical properties and allophones. In *Journal of the Acoustical Society of America*, 53, 373(A).

## APPENDIX

Sentences for the perceptual test in the first stage of the experiment. These sentences are from television broadcasts from Brazil and Mexico. Sentences were chosen randomly and modifications were made in the first and last content words of each sentence. Vowels of any type were deleted and replaced by background noise from the DSP 5500 Sona-Graph of same duration, in prestressed, stressed, and poststressed positions. Replaced vowels are in bold types, in parentheses, with its phonetic symbol and syllable position indicated at the end of the sentence.

### Brazilian Portuguese:

- Sentence 1: O g(e)neral Agenor Homem de Carvalho esteve hoje no Rio acompanhando a visita do Presidente Collor de Mello. PR2 [e] replaced by noise.
- Sentence 2: Janine sempre conviveu comigo no Brasil, isso não resta dúvidas, os documentos são suficientes pra provar isso... Mesmo em português... Não resta dúvida de

que... eu vou levar Janine, vou provar a verd(a)de. ST [a] replaced by noise.

Sentence 3: O Min(i)stro da Justiça e o Chefe do Gabinete Militar da Presidência são convidados pela Polícia Federal a depor sobre as denúncias contra o ex-ministro Antônio Rogério Magri. ST [i] replaced by noise.

Sentence 4: O código de defesa do consumidor completa um ano e cria novos hábit(o)s. PST2 [u] replaced by noise.

Sentence 5: As mulher(e)s foram exigir a regulamentação da aposentadoria aos cincüenta e cinco anos para a mulher do campo. PST1 [i] replaced by noise.

Sentence 6: A temperatura chega a trinta graus em São Paulo, trinta e oito no Rio de Janeiro, vinte e nove em Belo Horizonte, vinte e seis em Brasília e trinta e dois em F(o)rtaleza. PR2 [o] replaced by noise.

### Mexican Spanish:

Sentence 1: El d(e)stituido mandatario recordó que la Organización de Estados Americanos, la OEA, efectuó gestiones para resolver la crisis haitiana mediante la firma de un protocolo firmado el pasado veinticinco de febrero, en Washington. PR2 [e] replaced by noise.

Sentence 2: La falta de medicamentos sigue golpeando a los pacientes de la Caja Costarricense de Seguro S(o)cial. PR1 [o] replaced by noise.

Sentence 3: En Guatem(a)la, el coronel Mario Rolando Terraza Pinto, comandante de la zona militar número veinte, con sede en Santa Cruz del Quiché, dijo que la guerrilla fue derrotada en el departamento occidental de esa región. ST [a] replaced by noise.

Sentence 4: El sistema educativo de Costa Rica podría experimentar una huelga debido al malestar que existe entre los docentes por los nuevos programas de est(u)dio. ST [u] replaced by noise.

Sentence 5: Una band(a) de traficantes de niños que pagava trescientos cincuenta dólares por cada menor robado a familias pobres y luego los ofrecía en adopción a extranjeros, fue desarticulada en Honduras. PST1 [a] replaced by noise.

Sentence 6: Un comunicado oficial expedido en la víspera, sostiene que el secuestro y muerte del ex-ministro Durán, resaltan la actitud criminal de quienes conforman la autodenominada Coordinadora Guerrillera, y constituye una muestra aberrante de violación de los derechos humanos, que no tiene ni puede tener justificación algun(a). PST1 [a] replaced by noise.

