Patterns of Temporal Compression in Spoken Italian

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1. Introduction

According to many linguists (e.g. Classe, 1939; Pike, 1945; Abercrombie, 1965), languages can be classified by their rhythmic structures as stress timed (Germanic languages) or syllabic timed (Romance languages). A strong version of a stress-timing hypothesis for Germanic languages - that intervals between stressed-syllable onsets are isochronous - has been disconfirmed (e.g. Lehiste, 1973; Lea, 1974 among many others). This disconfirmation, coupled with evidence that listeners are insensitive to acoustic departures from isochrony in speech (e.g. Lehiste, 1973; Donovan and Darwin, 1979), has suggested that stress timing is, at least in part, a perceptual illusion.

However, some 'stress-timed' languages exhibit temporal structures that may support linguists' and other listeners' intuitions. Lindblom and Rapp (1973) report that stressed syllables in a word shorten substantially in the context of following unstressed syllables and weakly in the context of preceding unstressed syllables. This pattern of temporal compression, found also in Dutch (Nooteboom, 1973), English (Fowler, 1981; Huggins, 1978) and other languages, suggests a metrical foot structure in which unstressed syllables cohere with preceding stressed syllables. This durational compression is perceptible (Nooteboom, 1973), and may underlie the perceptual reports of stress timing. (See Dauer, 1980, for another explanation).

A strong version of a syllable-timing hypothesis for Romance languages is also disconfirmed (e.g. Navarro-Tomas, 1946, and see our Figure 1 below). Our research is designed to ask whether the linguists' reports that Romance languages, in particular Italian (cf. Bertinetto, 1981), are syllable-timed can be explained by patterns of temporal compression. Compression suggestive of syllable timing would include shortening of a vowel in the context of preceding and following intrasyllabic consonants. Our research tests predict that strong syllable-level compression, but, at most, very weak foot-level compression will occur in Italian.

2. Experiment

To test the first hypothesis (syllable-timing) we measured the duration of [a] in $C_0^2VC_0^2$ syllables. To test the second hypothesis (stress-timing), we used 14 stress patterns corresponding to real words or to noun-verb combinations of words. For each stress pattern, [a] was produced in reiterant versions ([da da...]) of the target words. The stress patterns realized four different conditions in which different numbers of unstressed vowels preceded and followed the target stressed [a], and in which the position of word boundary intervened between stressed and unstressed vowels or did not intervene. All utterances were spoken in a sentence frame.

For the syllables, the interval of periodicity for the vowel's voicing was measured from a waveform display. For the reiterant productions, vowel duration was measured as the interval between burst release and the first evidence of closure for the following consonant.

One subject, a native speaker of Italian who was naive to the purposes of the study, repeated each of the syllables three times. In addition, he repeated each stress pattern both in its real-speech and reiterant forms three times each.

3. Results

Figure 1 shows a weak and inconsistent effect of syllable structure on duration of the vowel. This outcome was not expected, based on the idea that temporal compression effects at the level of the syllable could explain reports that Italian is syllable-timed.

Figure 2 shows the effect of preceding and following unstressed vowels on a stressed vowel within a pair of word boundaries. The shortening effects are regular and asymmetrical like those occurring in Swedish and English. Figures 3 and 4 show anticipatory and backward shortening effects, respectively, when a word boundary intervenes between the stressed vowel and one or more of the unstressed vowels. Shortening is present but is weaker and less consistent than that shown in Figure 2.

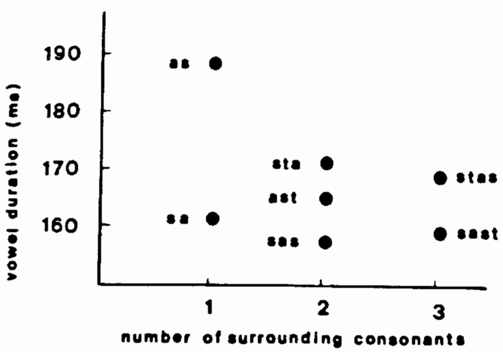


Figure 1. Syllable level. Effect of syllable structure on vowels duration.

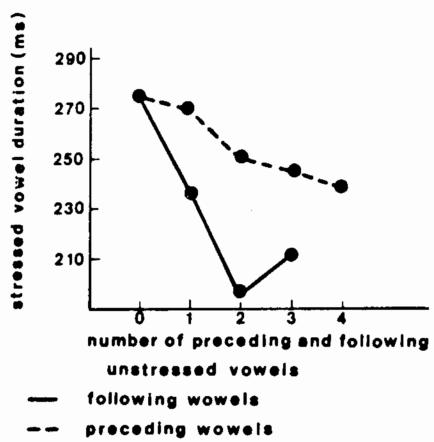


Figure 2. Inter stress interval. Within word boundary. Average duration of stressed vowels as a function of the number of preceding and following unstressed vowels with in the word.

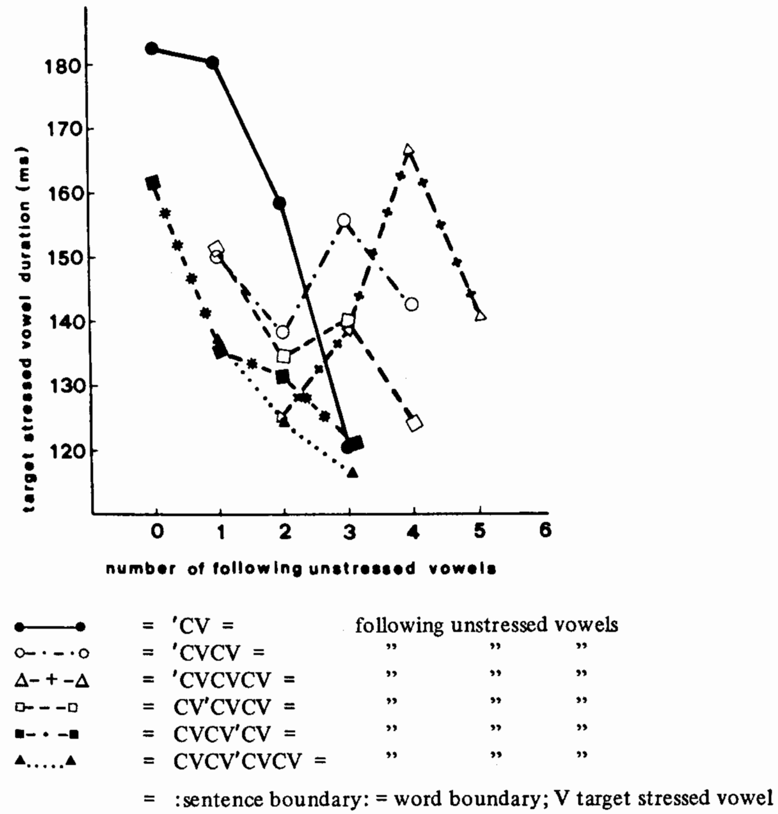
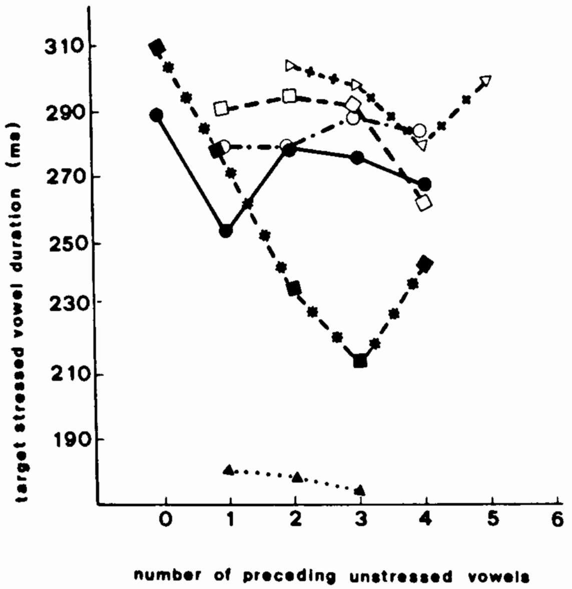


Figure 3. Inter stress interval. Across word boundary. Average duration of stressed vowels as a function of the number of following unstressed vowels across word boundary. Like in Fig. 4 six compression curves are plotted, one for each of the prosodic contexts on the left side of the word boundary (#).



= 'CV = preceding unstressed vowels 'C$\underline{V}$
= 'CVCV = " " " 'C$\underline{V}$
= 'CVCVCV = " " " 'C$\underline{V}$
= CV'CVCV = " " " 'C$\underline{V}$
= CVCV'CV = " " " 'C$\underline{V}$
= CVCV'CVCV = " " " 'C$\underline{V}$
= :sentence boundary: = :word boundary: $\underline{V}$:target stressed vowel

Figure 4. Inter stress vowel. Across word boundary. Average duration of stressed vowels as a function of the number of preceding unstressed vowels across word boundary.

4. Discussion

To compare the strength of compression effects in Italian with those reported for speakers of stress-timed languages, we submitted our foot- level data to modelling procedures similar to those described by Lindblom and Rapp (1973). The syllable-level data were not modelled because the vowels did not show regular shortening influences of surrounding consonants.

Lindblom and Rapp (1973) modelled patterns of temporal compression using the following formula: $D_0 = D_i/(1 + a)^{\alpha} (1 + b)^{\beta}$. Applied to stress vowels surrounded by various numbers of unstressed syllables, D_i is the duration of a stressed vowel in a monosyllable. In a polysyllable, this underlying duration is compressed by: 'a' the number of following unstressed syllables in a word; and 'b' the number of preceding syllables. α and β are parameters of anticipatory and backward compression. For Lindblom and Rapp's data, the best-fit values of α and β were .48 and .12, the asymmetry reflecting the foot structure of Swedish.

Fowler (1981) modified the model slightly, adding a parameter of final lengthening and counting unstressed vowels across a word boundary in the value of 'a' and 'b'. In her data, $\alpha = .6$ and $\beta = .07$ (average error, 9.3 msec per stressed vowel) for utterances produced to a metronome. For the same utterances without the metronome (Fowler, unpublished data) $\alpha = .5, .4$ and $\beta = .05, .09$, for two speakers (average error: 3 msec).

For our Italian speaker, we modelled two sets of utterances: those in which unstressed vowels are within the same word as the stressed vowel ($\alpha = .08$, $\beta = .07$, average error: 10 msec), and those in which some unstressed vowels are not ($\alpha = .17$, $\beta = .03$, average error: 11 msec). In accordance with our expectations, the speaker of Italian showed much weaker foot-level shortening (that is, the values of α are small) than speakers of two-stress-timed languages.

5. Conclusion

Consistent with our predictions, we found evidence for relatively weak compression at the level of the foot in Italian. Unexpectedly, however, syllable-level compression also was weak. Indeed, overall, stressed vowels in Italian showed rather weak shortening effects.

We hypothesize that Italian is reported to be syllable-timed for two reasons: first, unstressed vowels cause little foot-level shortening and second, reportedly (Bertinetto, 1981), unstressed vowels reduce less in Italian than in stress-timed languages

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References

Abercrombie, D. (1964). Syllable quantity and enclitics in English. In D. Abercrombie, D. Fry, P. MacCarthy, N.S. Scott and J. Trim (eds.), *In honour of Daniel Jones.* London: Longman.
Bertinetto, P.M. (1981). *Strutture prosodiche dell'italiano.* Firenze: Accademia della Crusca.
Classe A. (1939). *The rhythm of English prose.* Oxford: Blackwell.
Donovan, A. and Darwin, C. (1979). The perceived rhythm of speech. *Proceedings of the Ninth International Congress of Phonetic Sciences,* **2**, 268-274.
Dauer, R. (1980). Stress timing, syllable timing and isochrony. *Linguistic Society of America Annual Meeting.*
Fowler, C.A. (1981). A relationship between coarticulation and compensatory shortening. *Phonetica,* **38**, 35-40.
Huggins, A.W.F. (1978). Speech timing and intelligibility. In: J. Requin (ed.), *Attention and performance VII.* Hillsdale, N.J.: Lawrence Erlbaum Assoc., 279-298.

Lea, W.A. (1974). Prosodic aids to speech recognition: IV. A general strategy for prosodically-guided speech understanding. *UNIVAC Rep. No. PX10791.* St. Paul, Minn.: Sperry Univac, DSD.

Lehiste, I. (1973). Rhythmic units and syntactic units in production and perception. *JASA,* **54**, 1228-1234.

Lindblom, B. and Rapp, K. (1973). Some temporal regularities of spoken Swedish. *PILUS,* **21**, 1-59.

Navarro-Tomas, T. (1946). *Estudios de Fonologia Española*. New York: Las Americas.

Nooteboom, S.G. (1973). Perceptual reality of some prosodic durations. *J. of Phonetics,* **1**, 25-45.