THE WORD LEVEL INTERPLAY OF STRESS, COARTICULATION, VOWEL HEIGHT AND VOWEL POSITION IN ITALIAN

MARIO VAYRA

Scuola Normale Superiore
56100 Pisa, ITALY

CAROL A. FOWLER

Dartmouth College, Hanover, NH 03755, USA
Haskins Laboratories, New Haven, CT 06511

ABSTRACT

The experiment investigates the effects of stress and transsyllabic vowel-to-vowel coarticulation in Standard Italian. The study replicates evidence from our previous work on Italian and English of strong influences on unstressed vowels of their flanking stressed vocalic context. In Italian as in English, coarticulation has stronger effects on the front-back dimension than on vowel height. In contrast to English, however, coarticulatory influences in Italian are symmetrical in direction. As for stress, in the present study, we find effects of stress only on vowel opening, not along the front-back dimension. Interestingly, effects of stress on F1 interact with effects of a vowel's position in a word or utterance. We find that a stressed vowel is produced with a decreasingly extreme jaw position throughout the word or utterance. This may point to a suprasyllabic organization of jaw trajectories in Italian speech.

INTRODUCTION

Our study was designed to investigate three aspects of the articulatory organization of Italian speech: vowel-to-vowel coarticulation, word-level compensatory shortening and spectral differences between stressed and unstressed vowels. It was suggested in part by the outcome of our previous work (Vayra, Fowler and Avesani /15/), in which we compared measures of vowel-to-vowel coarticulation and shortening in Standard Italian and English. That cross-language comparison wes of interest in light of evidence linking coarticulatory and durational shortening patterns of English to the presumed rhythmic character of the language.

English is traditionally identified as a "stress timed" language according to a timing typology that classifies all languages into those, such as English, that are said to have a tendency for strong or stressed syllables to be evenly timed, and others, including Italian (called "syllable timed"), in which syllables are said to recur at regular intervals.

The description of English as stress-timed is consistent with several aspects of its prosodic structure. English words are sometimes described as being composed of "feet" consisting of a stressed syllable and zero, one or two following unstressed syllables (e.g. Selkirk /12/; Bolinger /2/).(Following Selkirk and others we will call a foot like that with the stressed syllable first: "left dominant"). Compatibly, measures of coarticulatory influences of stressed on unstressed syllables and of shortening of stressed vowels due to neighboring unstressed syllables are both asymmetrical, they correlate, and both mirror the left-dominant foot structure of words (Fowler /5/). That is, stressed vowels coarticulate (at least on the front-back dimension) more with, and are shortened more by, following than preceding unstressed syllables. Fowler /5/ has interpreted these findings as evidence that coarticulatory influences by vowels reflect "coproduction"—that is,overlap of the stressed vowels' production by unstressed syllables in the same foot. Because a following unstressed vowel "covers over" the trailing edge of a stressed vowel, the stressed vowel is measured to shorten and it exerts a coarticulatory influence on the unstressed syllable to the extent that the syllable shortens it.

If the coarticulatory and shortening patterns just described for English do, in fact, reflect its presumed foot structure, then they should not be found in languages identified as syllable timed. Instead, shortening should be confined to the syllable and should serve to maintain equal syllable durations. In syllable-timed languages, if vowel-to-vowel coarticulation occurs at all, it should not reflect a foot structure, either left or right dominant.

The findings from previous studies of spoken Italian, including our own, do not support this picture of a syllable timed language. Nor do they give any clear picture of the timing structure of Italian. Researchers have found shortening of a vowel as consonants are added to the syllable (Farnetani and Kori /4/; Vayra, Avesani and Fowler /13/). However, the shortening is not consistently found (see also Bertinetto /1/). Moreover, it is asymmetrical with stroger shortening effects of following than of preceding consonants in the syllable (Farnetani and Kori /4/; Vayra, Avesani and Fowler /13/). Maddieson /9/ reports that this asymmetrical shortening pattern is widespread in the world's languages and is not especially associated with syllable-timed languages.

Just as Italian shows only weak and inconsistent shortening at the syllable level, it also shows weak and inconsistent evidence of a foot structure. Nespor and Vogel /10/ invoke a left-dominant foot structure to explain patterns of syllable stress in Italian words. Compatibly, den Os /11/ (see also Farnetani and Kori /3/; Vayra /14/) report evidence of reduction of unstressed vowels in Italian— ostensibly a characteristic of stressed-timed languages— and Koopmans-van Beinum /8/ finds evidence of vowel reduction in spontaneous spoken Italian, Dutch and Japanese as compared to vowel quality in more formal styles of speech.

Despite these findings, patterns of vowel-to-vowel coarticulation and shortening in Italian do not consistently reflect a stress-timing tendency (Vayra et al. /15/. Among three talkers we examined in our earlier study, one showed an asymmetrical coarticulation and shortening pattern similar to those found in English, one showed the reverse asymmetry in both coarticulation and shortening, and the other showed an asymmetry in coarticulation opposite to that in his shortening patterns. For none of the three talkers were measures of coarticulation and shortening correlated.

Talkers in that study were Piedmontese speakers of Standard Italian. One hypothesis we considered as to why patterns of coarticulation and shortening were idiosyncratic to each talker was that the prosodic differences in their pronunciation reflected the presence in the spoken Standard of ongoing conflictual processes of adaptation — outside Tuscany —to the morphophonology of the Florentine-based Standard system (represented in the orthography). Accordingly, in the present study, we examine patterns of vowel-to-vowel coarticulation among Florentine speakers of Standard Italian. In addition, we looked at effects of stress on vowel quality among these speakers. The experiment was designed to ask whether we would see consistent evidence of a foot structure in in the coarticulatory and shortening patterns of these talkers, and, if so, whether the same talkers would show evidence of vowel reduction in absense of stress.

EXPERIMENT

Our subjects were two female (S and F) and one male (N) native speakers of the Florentine variety of Standard Italian. Each of them produced several tokens each of 18 different bisyllabic nonsense words and 27 trisyllabic nonsense words. The bisyllabic words were versions of "VbV", in which the Vs were /i/, /a/ and /u/ and in which stress was either on the first or the second syllable of the nonsense word. The trisyllables were versions of " VbVbV ", again using all combinations of /i/, /a/ and /u/ for the two Vs,and using all possible patternings of one stressed and two unstressed syllables. The talkers produced the nonsense words in isolation; we analyzed three tokens of each word type spoken by each talker.

We used the ILS system at Haskins Laboratories to measure center frequencies of F1 and F2 of the vowels. The measures we report were also taken from vowel midpoints. In addition, vowel durations were made from waveform displays. These latter measures have not yet been analyzed, however, and so we report our findings on the formant measurements only.

In this report,too, we will present just a subset of our findings using F1 and F2 as measures. We have found, in general, that vowel-to-vowel coarticulatory effects are largely confined to the front-back dimension (that is, to measures of F2) rather than to the height dimension (F1), and so we report just F2 measures of coarticulation. For its part, stress has its major effect on F1 (see also /3/),and so we confine our exposition of stress effects to its effects on F1.

Coarticulation and F2.

We focused on three kinds of findings relating to vowel-to-vowel coarticulatory effects. First, we looked generally for effects of a context vowel (/i/ /a/ or /u/ on F2 of a target neighboring /a/. Next we asked whether any such effect were asymmetrical so that carryover effects of a preceding vowel were larger or smaller than anticipatory effects of a following vowel. If carryover effects are larger than anticipatory effects, then, as in English, coarticulatory effects in Italian and in these types of words in spoken Italian would mirror their presumed metrical left-dominant foot structure (Nespor and Vogel /10/). Finally we asked whether coarticulatory influences are affected by the stress of either the context (coarticulating) vowel or of the target /a/ vowel.

Tables 1 and 2 present the findings that address these issues. All three speakers showed significant and large effects of context vowels on F2 of a neighboring /a/. Across the talkers, this main effect of context vowel accounted for 11-35% of the total variation in F2 of the target vowel in bisyllables and 27-37% of the variation in F2 of the target vowel in trisyllables. Neighboring /i/ raised F2 of /a/ as compared to its value in the context of /a/ and /u/; /u/ generally lowered F2 as compared to its value in the context of /a/.

As for asymmetries in coarticulatory effects, no talker showed a significant asymmetry in either the bisyllables or the trisyllables. However one talker showed a marginal tendency in trysyllables for anticipatory effects of a context vowel to exceed carryover effects (p= .06), and, in general, talkers

showed numerical differences in coarticulation favoring an anticipatory over carryover coarticulation (see Table 1). Thus, no talker showed a significant tendency for coarticulatory asymmetries to reflect a left-dominant foot structure. This finding is similar to our earlier findings on speakers of the Piedmontese variety of Standard Italian; however, speakers in the present study were more consistent one with the other than in our previous experiment.

TABLE 1

Bisyllables

	Carryover			Anticipatory		
	/i/	/a/	/u/	/i/	/a/	/u/
S	1671	1625	1653	1632	1563	1537
F	1433	1434	1388	1441	1413	1360
N	1313	1262	1210	1393	1276	1217

Trisyllables

	Carryover			Anticipatory		
	/i/	/a/	/u/	/i/	/a/	/u/
S	1651	1621	1572	1711	1621	1560
F	1406	1337	1330	1443	1337	1282
N	1305	1218	1160	1298	1218	1191

Table 1. F2 of /a/ in the context of preceding (carryover) and following (anticipatory) /i/, /a/ or /u/

Table 2 shows the interaction of stress and coarticulation on trisyllables. In that table, we have subtracted our F2 measure of the target vowel /a/ when it is in the context of /a/ from its value in the context of /i/. A positive difference, then, reflect the expected fronting effect of /i/ on /a/. We have presented the difference scores for three stress conditions separately. In the first column, the target /a/ vowel is stressed; in the second column, the context (coarticulating) vowel is stressed; in the third column neither is stressed. (So, nonwords i'baba and a'baba contributed to the first column of difference scores; 'ibaba and 'ababa contributed to the second column; iba'ba and aba'ba contributed to the third column). The table reveals two interesting findings. One is that there are essentially no coarticulatory influences of unstressed /i/ on stressed /a/. A second is that influences on unstressed /a/ are as large from unstressed neighboring vowels as from stressed neighboring vowels. This interaction between stress and contest vowel was significant for two talkers and marginal (p= .11) for a third. These findings are interesting in showing that, in these words, only unstressed vowels are subject to coarticulatory effects, but they receive coarticulatory influences from neighbors regardeless of their neighbor's stress level. The first finding is similar to effects found in English. Unfortunately, we do not have data on English words comparable to those on which the second finding were obtained.

TABLE 2

	Stressed vowel		
	Target /a/	Context /i/,/a/	Neither
S	17	130	106
F	11	121	164
N	26	84	141

Table 2. F2 of /a/ in the context of /i/ minus F2 of /a/ in the context of /a/. Data average over direction of coarticulatory influences and represent trisyllables only.

Stress and F1.

To examine reduction of unstressed vowels, we looked only at the utterance "aba" and "ababa" with all stress patterns. Table 3 presents our findings.

We find highly significant effects of stress on F1 of /a/, such that stressed /a/ is a more open vowel (with a higher F1) than is unstressed /a/. These are significant for two talkers in the bisyllables and marginal (p = .06) for the third. They are significant for all talkers in the trisyllables. Moreover, the effects of stress tend to be quite substantial, accounting for 5-35% of the total variability in F1 in our analysis of the "aba" words across the three talkers and 60-79% of the variance in F1 in "ababa" words. Thus, as others have found (e.g. den Os /11/), we find that in Italian, as in stress timed languages, unstressed vowels (at least the vowel /a/) are subject to reduction.

An unexpected finding in this analysis was a significant effect of vowel position in the word on F1. In bisyllables, all three talkers had lower F1s for final than for initial vowels; the difference was significant for two talkers and marginal for the third (p = .08). In trisyllables, the effect was significant for all talkers, but it interacted with vowel stress. Table 4 shows this interaction. For all three talkers, F1 of stressed vowels decreases monotonically across the word, while F1 of unstressed /a/ is highest in word-initial position and lowest in medial position. The interaction is significant for two of the three talkers, but the pattern is present in all three sets of means.

TABLE 3

	Bisyllables		Trisyllables	
	Stressed	Unstressed	Stressed	Unstressed
S	1125	925	1093	932
F	1002	916	993	875
N	722	761	801	734

Table 3. Effcts of stress on F1 of /a/.

DISCUSSION

If Italian, like English, has left-dominant foot structure in words, the feet are not reflected, here, in coarticulatory asymmetries. Instead, in the words we examined, coarticulation is largely symmetrical, with a weak, but fairly consistent, numerical tendency to favor anticipatory coarticulation. We have not yet analyzed our measures of durational shortening to determine whether they reflect the left-dominant foot structure or else reflect the coarticulatory near symmetry (or else do neither). Discovering how shortening is patterned in these words may help to clarify the relation of shortening to coarticulation and to metrical structure in words. In particular, it may help to determine whether the convergence of all three patterns in English is or not accidental.

Although coarticulatory patterns in F2 do not suggest a foot structure ostensibly characteristic of stress-timed languages, nevertheless, effects of stress itself on articulation of vowels are similar to its effects in stress-timed languages. Stressed vowels are not subject to coarticulatory influences from neighboring vowels along the front-back dimension and unstressed vowels are less open than stressed vowels. A new finding was that stressed vowels exert no stronger coarticulatory effects on their neighbors than do unstressed vowels.

One way to capture these findings is to suggest that, as compared to unstressed vowels, stressed vowels in Italian speech are relatively impervious to two kinds of influence: coarticulatory influences along the front-back dimension due to neighboring vowels (and possibly to consonants as well), and influences on the height dimension due either to the closed jaw position of neighboring consonants or else to a disposition for the jaw to return to a rest position.

TABLE 4

	Stressed			Unstressed		
	I	M	F	I	M	F
S	1178	1112	989	1144	803	850
F	1052	986	942	972	794	859
N	877	800	725	794	701	705

Table 4. The interaction of stress and position on F1 of syllables in initial (I), medial (M), and final (F) position in trisyllables.

A final interesting finding was of a "position effect" on opening for /a/ across a word. Stressed /a/s were progressively less open in later syllables of words. One hypothesis we have entertained to account for the effect (see Table 4) is that it is an utterance-level (as opposed to word-level) phenomenon that is analogous in some ways to declination in fundamental frequency. That is, just as (other things equal), fundamental frequency declines over the course of an utterance, largely following the decline in subglottal pressure (e.g. Gelfer, Harris, Collier and Baer /6/), so do excursions of the jaw from its rest position decline. Both declination and our position effect, then, might reflect an articulatory system that in some sense "winds up" at the beginning of an utterance and then "runs down" gradually as the utterance proceeds. Perhaps compatible with this view is a weak tendency for our talkers' productions of stressed /i/ and /u/, two closed vowels, to open increasingly across the syllables of a bisyllable or trisyllable.

REFERENCES

/1/ P.M. Bertinetto, "Ancora sull'Italiano come lingua ad isocronia sillabica". Studi linguistici in onore di G.B. Pellegrini, Pisa, 1981.

/2/ D. Bolinger, Intonation and its parts, London, 1986

/3/ E. Farnetani, S. Kori "Lexical stress in spoken sentences....". Quaderni del Centro Studio Ricerche Fonetica, I, Padova, 1982, 106-133.

/4/ E. Farnetani, S.Kori "Effects of syllable and word structure on segmental durations in spoken Italian". Quaderni..., III, Padova, 1984, 143-187

/5/ C.A.Fowler, "A relation between coarticulation and compensatory shortening". Phonetica, 38, 1981, 35-50.

/6/ C. Gelfer, K. Harris, R.Collier, T.Baer, "Is declination actively controlled?". I.Titze, ed., Vocal Fold Physiology:..., Iowa City, IA, 1985.

/7/ T. de Graaf, F. Koopmans-van Beinum, "Vowel contrast reduction in terms of acoustic system contrast in various languages". Proc. Institute of Phonetics. Amsterdam University, 1984, 41-52.

/8/ F. Koopmans-van Beinum, "Systematics in vowel systems". M.van den Broecke, V. van Heuven, W. Zonneweld, eds., Sound structures...Dordrecht, 1984.

/9/ I. Maddieson, "Phonetic cues to syllabification". V. Fromkin, ed., Phonetic Linguistics...., Orlando, 1985.

/10/ M. Nespor, I.Vogel, "Clash avoidance in Italian", L.I., 11, 1979, 467-482.

/11/ E.den Os, "Vowel reduction in Italian and Dutch", Phonetica, 42, 1985.

/12/ E. Selkirk, "The role of prosodic categories in English word stress". L.I , 1980, 563-605.

/13/ M. Vayra, C.Avesani, C. Fowler, "Patterns..." M. van den Broecke, A.Cohen, eds., Proc. Xth Int. Congr. Phon. Scien., Dordrecht, 1984, 541-546.

/14/ M. Vayra, "Effects transyllabiques de coarticulation... ", XIVè J.E.P., G.A.L.F., Paris, 1985.

/15/ M. Vayra, C.A. Fowler, C. Avesani, "Word level coarticulation and shortening in Italian and English speech". Studi di Grammatica Italiana, in press. Also, Haskins Laboratories Status Report, in press.