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The Pisan Vowel System of Read and Semispontaneous Speech. An Exploratory Contribution[*]

Abstract

Speech style is an important factor with respect to vowel reduction, and the availability of larger and more realistic samples of data allows the investigators to focus on connected speech processes. The main goal of the analysis reported on in this paper is to investigate the dynamics of vowel systems under speech style changes. Utterances of stressed vowels both in semispontaneous- and read speech were analysed; the data came from the speech of two young subjects from Pisa, recorded in the AVIP (*Archivio delle Varietà di Italiano Parlato*) project. Works with a similar experimental design are available for Castilian Spanish (Poch-Olivé & Harmegnies 1992, Harmegnies & Poch-Olivé 1992), Belgian French (Poch-Olivé & Harmegnies 1992), Portuguese (Delplancq et al. 1995-96), English (Deterding 1997) and Italian (Giannini & Pettorino 1993; Poch-Olivé & Harmegnies 1995). Duration, F1, F2, F3 and F0 of nearly 700 vowel utterances were measured. The data collected were presented in terms of F1/F2 diagrams on a Hz scale. As for duration, F1, F2, F3 and F0 sets of ANOVAs were run to test the effects of the variable 'speech style' for the seven vowels /i e ɛ a ɔ o u/. In order to estimate how peripheral the vowels were, the Euclidean distance of each vowel from the centroid of all vowels in both speaking styles were calculated, and statistical results of the values thus computed for each vowel and speech style were presented. The acoustic size of the vowel systems in both speech conditions was calculated: the space was largest in the read speech condition and smallest in the quasi-spontaneous speech condition. The formant and duration variabilities were further observed: a lowered differenciation of the sounds in the quasi-spontaneous speech was therefore noticed. The formants frequencies were finally processed by means of discriminant analysis, which confirmed that vowels in the F1/F2 space were more differenciated in laboratory- than in semispontaneous speech.

0. Research Goals

In the present study, the following questions are addressed: What are the methodological problems involved in the comparison between read and semispontaneous speech? What are the spectral and temporal differences between read and semispontaneous speech? Are certain speech sounds – vowels of the Pisan variety, for example – influenced by a specific independent variable (speech style)? We will therefore observe if in semispontaneous speech there is a schwa-like tendency, if there is a reinforced timbres variability, if there is an increased overlapping of the vowel clusters, and finally if the semispontaneous speech vowel system is less informative and less differenciated[1].

[*] Extended version of a poster presented at ASI 2002 (NATO Advanced Study Institute) *Dynamics of Speech Production and Perception*; June 24-July 6, 2002 Il Ciocco, Italy. The Summer School was supported by an ISCA and ASI grant. This paper has benefited from comments made by various people, including Pier Marco Bertinetto, Klaus J. Kohler, Louis Pols.

[1] Many studies focussing on the differences between read and semispontaneous speech are now available: see for instance Ladefoged, Kameny & Brackenridge (1976); ESCA (1991); Llisterri & Poch-Olivé (1992); Blaauw (1995); Lindgren & Lindblom (1996); Simpson & Pätzold (1996); Barry & Andreeva (2001).

Some caveats are necessary, since it is not easy at all to obtain identical spontaneous- and read speech material. In many studies spontaneously spoken material is used as a starting point and the written version is presented to be read out afterwards (Poch-Olivé & Harmegnies 1992, 1995; Harmegnies & Poch-Olivé 1992; Giannini & Pettorino 1993, Delplancq et al. 1995-96; Koopmans-Van Beinum 1992). In any case some weaknesses are evident: this choice solves part of the problem only if the original speech material is almost faultless grammatically and without hesitation and repetitions; the researcher is compelled to use only one speaker; this apparently safe experimental design does not permit however total control of all the variables involved[2]. A circular and somehow paradoxical problem has therefore to be faced: while we do study the vowel system of read speech and we do study the vowel system of spontaneous speech we still do not know how to compare these two different speech styles when more than one subject is involved in the experiment.

As for the acoustic literature on the Italian vowel system, it is founded on different kinds of speech material: in Ferrero (1972) vowels uttered in isolation and vowels embedded in pseudo-words are observed; in Ferrero et alii (1978) vowels uttered in word lists are observed; in Albano Leoni et alii (1995, 1998) vowels recorded from four regional TV news bulletins are measured. Both Giannini & Pettorino (1993) and Poch-Olivé & Harmegnies (1995) aimed at comparing spontaneous speech with read speech, but data came from only one speaker.

1. Experimental Design

1.1 Speech Material

We first have to define the notions 'connected speech' and 'read speech', at least with respect to the way we use them in the scope of this paper. The connected speech material recorded consisted of quasi-spontaneous dialogues (staged 'map tasks'). The scripted data consisted of acoustic records of isolated words and pseudo-words read once; in the word list the place-names uttered during the map task were also inserted; these place-names were read twice (see Appendix a-b). The word list was the same for the two subjects, apart from the place-names. The recordings were made in a sound-proof room at the Laboratorio di Linguistica of the Scuola Normale Superiore (Pisa)[3]. 706 tokens total (346 for the read speech, 360 for the semispontaneous speech) were measured.

1.2 Formant Frequency and Vowel Duration Measurements

Using the Multispeech software, the speech material was downsampled at 11025 Hz, and spectrographic analysis was performed using an LPC algorithm, Hamming window, and a frame lenght of 20 ms. Digital spectrograms were derived, using a pre-emphasis coefficient of 0.9; 14th order linear prediction was used for all data. Where any one of the formants

[2] E.g. variable position of the target word in the semispontaneous speech vs. 'fixed' position in the word list; heavy influence of prosodic context in the semispontaneous speech vs. slight influence of prosodic context in the word list.

[3] In the case of comparison between read and spontaneous speech we always have to mention and to keep in mind the situational dimension in which the talker has produced the (recorded) speech material. The situational dimension in our speech material was not varied (the material was all collected in a sound-treated room), but for the read speech corpus the speaker was alone in the room, whereas the connected speech corpus was collected when two subjects were speaking.

was incorrectly tracked, Long Term Average Power Spectrum, using the Fast Fourier Transform, was performed. The pitch analysis was made with the autocorrelation method (70-350 analysis range). The vowel boundary was set at the point of disappearance of the second formant; measures of F1, F2 and F3 were taken at vowel midpoint over three consecutive frames whose values were averaged; the measurements were all checked by visual inspection of linear-prediction-based formant tracks overlaid on spectrograms.

1.3 Focus Words and Non-Focus Words in Semispontaneous Speech

In the connected speech corpus function words[4], words embedded in sentences with interrogative intonation, and words embedded in overlapping turns were discarded. In 2.1-2.5 and 2.8 data from all semispontaneous speech tokens were compared with read speech tokens; but since vowels are strongly affected by prosodic context, a rather rough distinction between prominent and non-prominent words was made: in 2.6-2.7 vowels embedded in focus words were separated from the ones embedded in non focus words. Following the experimental design described in Sornicola & Maturi (1994), a token was classified as prominent on the basis of auditory and structural analysis.

2. Results

The general question is identifying the parameters in which semispontaneous speech differs from read speech (See Appendix d for the entire data on acoustic measurements).

2.1 Average Values of F1 and F2

In figures 1-2, average values of first formant are plotted against average values of second formant in both speech style conditions.

. Speaker S:

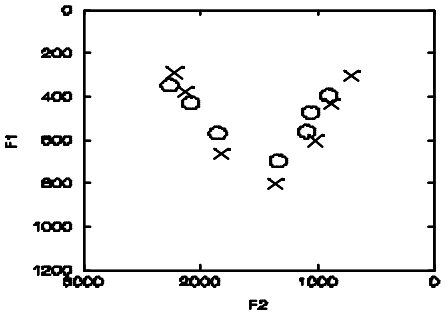


Figure 1.
Average values from read- ('X') and semispontaneous speech ('O').

[4] Regarding the reduction phenomena occurring in function words, see Aguilar, Machuca & Martinez (1991); Van Bergem (1993); Savy & Cutugno (1998).

. Speaker V:

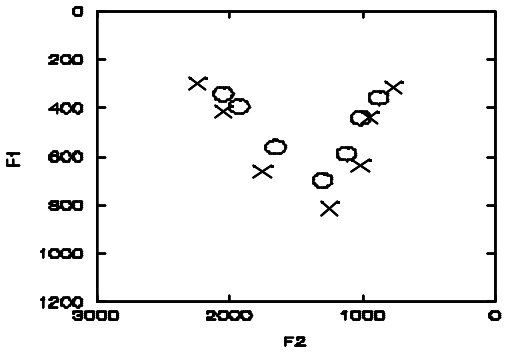


Figure 2.
Average values from read- ('X') and semispontaneous speech ('O').

2.2 Statistical Analysis

In order to estimate whether the connected speech vowel system was significantly different from that of read speech, sets of one-way ANOVAs were run to test the effects of the variable 'speech style' on the seven vowels, with duration, F1, F2, F3 and F0 as dependent variables (see Appendix c for the complete tables).

Speaker-Independent Findings:
Speech style seems to have the deepest influence on duration (read vowels are on the whole longer than connected vowels)[5] and on F1 (low and mid-low vowels in the read condition have higher values of F1, high vowels in the read condition have lower values)[6].

Speaker-Dependent Findings:
As for speaker S, speech style shows no effect on F3, reveals a slight effect on F2 and F0 but shows a considerable effect on the difference (F1-F0), in which it turns out to be significant for all vowels. As for speaker V, speech style shows a deep effect on F2: it turns out to be significant for all vowels but /o/. Speech style turns out to be significant also for front vowels and /u/ third formant. The difference (F1-F0) turns out to be significant for /a/, /ɛ/, /e/, /ɔ/. F0 is always higher in speaker S's read speech and is always lower in speaker V's read speech[7]; in both subjects pitch range is usually wider in connected than in read speech.

[5] Speech style turns out to be significant for all vowels, but /i/ of speaker V.
[6] Speech style t urns out to be significant for all vowels, but /o/.
[7] Mean F0 is highly speaker-dependent (Cf. Koopmans-Van Beinum 1992; Blaauw 1995).

2.3 Euclidean Distance

One might expect the read vowels to be more peripheral than the vowels from connected speech, partly because of the effects of coarticulation with the neighbouring consonants, and particularly because one would expect fluent speakers to economize somewhat in their vocal effort in connected speech. In order to estimate how peripheral the vowels were, the Euclidean distance (ED) in Hz of each point representing a measured vowel utterance in the experiment was calculated from the centroid of all vowels (this neutral reference point was calculated as the average value of F1 and F2, for each speaker)[8]. If the vowel space did, in fact, shrink, then these calculated distances, should decrease for each vowel, as the formant patterns would approximate the pattern of the neutral reference vowel.

. Speaker S:

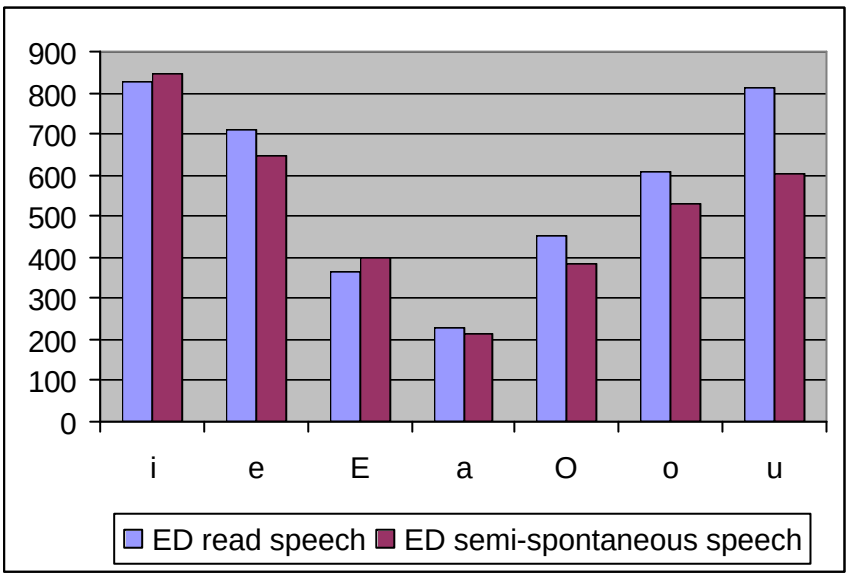


Figure 3.

[8] In Poch-Olivé & Harmegnies (1995) the Euclidean distance was calculated on the basis of schwa values; but since standard Italian has not phonological schwa, the centroid values (i.e. the grand mean of all measured formant frequencies of the vowel system per speaker) were preferred.

. Speaker V:

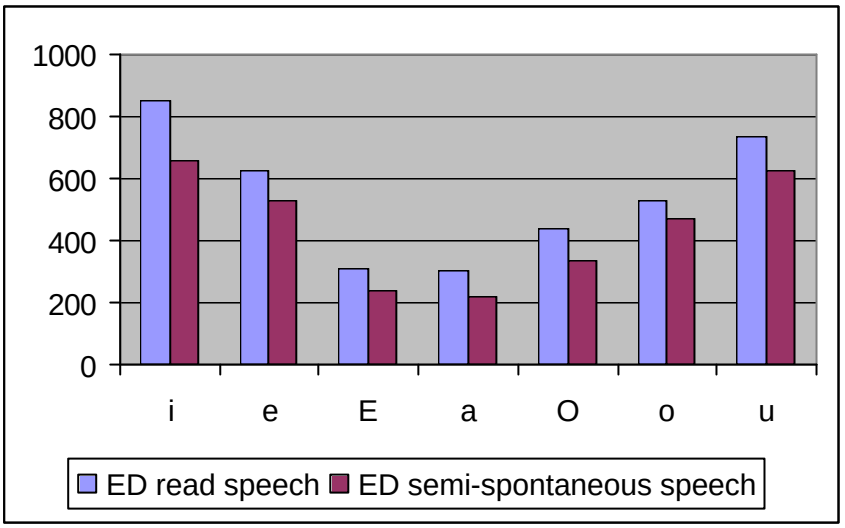


Figure 4.

In order to verify whether there was a schwa-like tendency, a centralization index (d)[9] was also computed for each inter style pair of vowels. To test the statistical significance of the average d in a specific set of sound pairs, the ANOVA test comparing ED of read speech to ED of connected speech was used (this procedure allows an assessment of the significance of the average d).

. Speaker S:

V	d	F	p (p < .05)
all vowels	-62	5,28 (1, 333)	.022
/i/	-23	0,17 (1, 52)	.674
/e/	60	1,82 (1, 27)	.188
/ɛ/	-37	2,29 (1, 63)	.135
/a/	13	0,62 (1, 92)	.432
/ɔ/	69	5,51 (1, 45)	.023
/o/	77	3,76 (1, 24)	.064
/u/	210	21,35 (1, 19)	.000

Table 1. Delta values, Anova test with probability under the null hypothesis ('p').

. Speaker V:

v	d	F	p (p < .05)
all vowels	93	19,11 (1, 369)	.000
/i/	194	28,11 (1, 44)	.000
/e/	98	10,24 (1, 34)	.003
/ɛ/	71	11,22 (1, 74)	.001

[9] The centralization index is the difference between the Euclidean distance from the observed vowel to centroid in read speech and the Euclidean distance from the observed vowel to centroid in spontaneous speech.

/a/	84	39,08 (1, 112)	.000
/ɔ/	102	13,83 (1, 39)	.001
/o/	55	1,66 (1, 30)	.207
/u/	113	7,43 (1,24)	.012

Table 2. Delta values, Anova test with probability under the null hypothesis ('p').

. Speaker S:

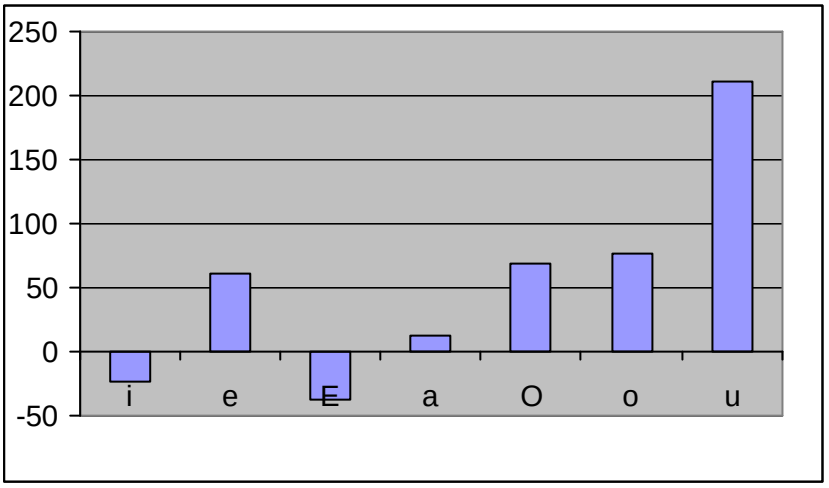


Figure 5. Delta values.

. Speaker V:

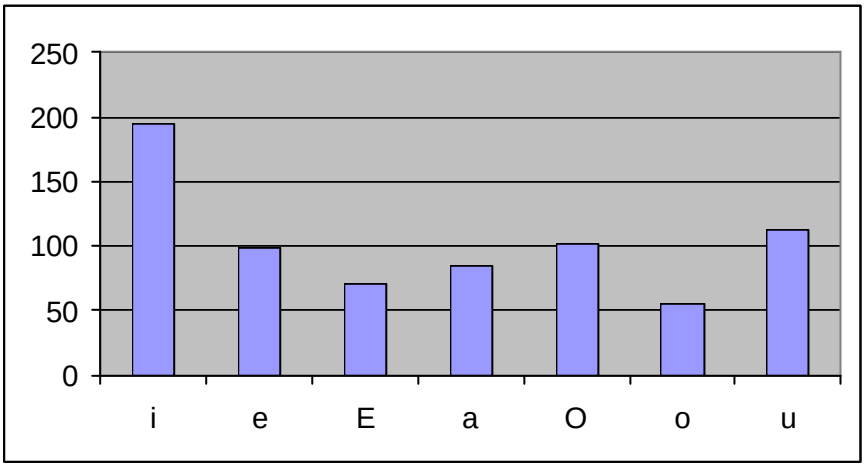


Figure 6. Delta values.

The distance to the centroid increases for the read tokens, but only for speaker V's data, in which centralization turns out to be significant for all vowels, but /o/. Speaker S shows some negative values of d; and centralization turns out to be significant only for two vowels (/ɔ/ and /u/). In addition, speaker S's d values indicate a more marked centralization in back vowels than in front vowels; whereas the opposite is found in speaker V's d values.

2.4 Formant Frequencies Variabilities

The standard deviations of the first formant values are systematically greater in connected speech than in laboratory speech.

. Speaker S:

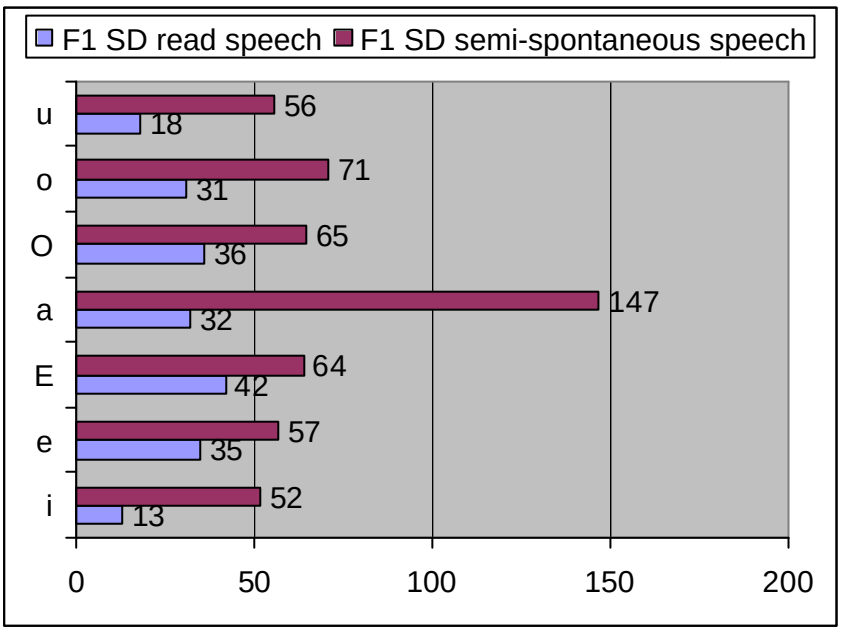


Figure 7. Standard deviations of the first formant values for each vowel in each style.

. Speaker V:

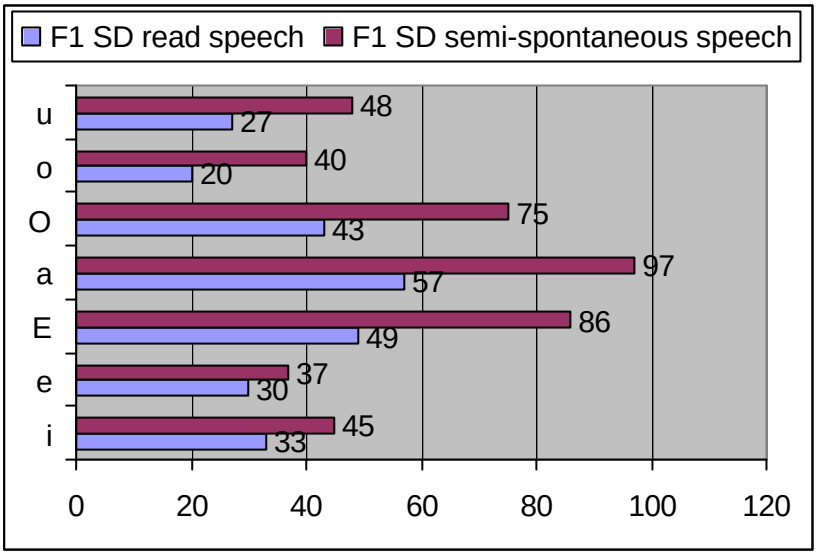


Figure 8. Standard deviations of the first formant values for each vowel in each style.

A similar tendency is found in duration values as well:

. Speaker S:

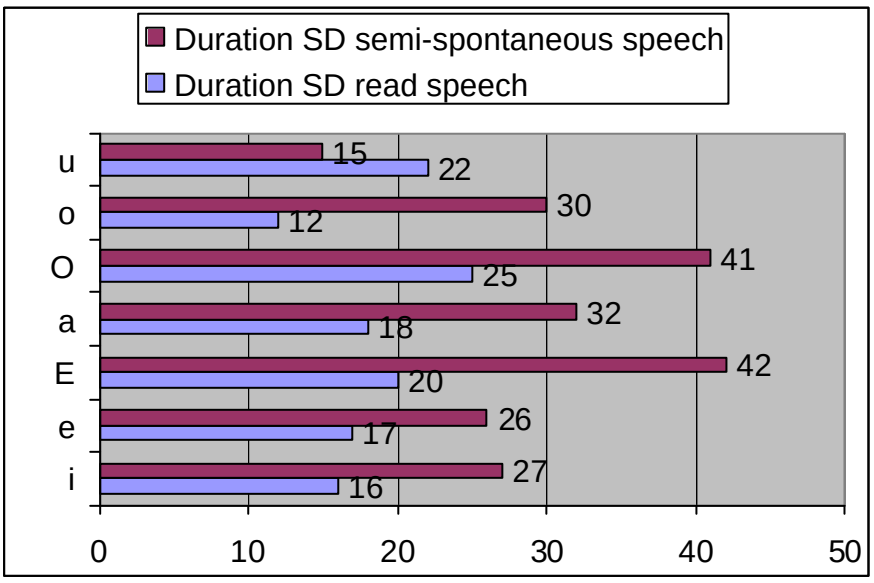


Figure 9. Standard deviations of duration values for each vowel in each style.

. Speaker V:

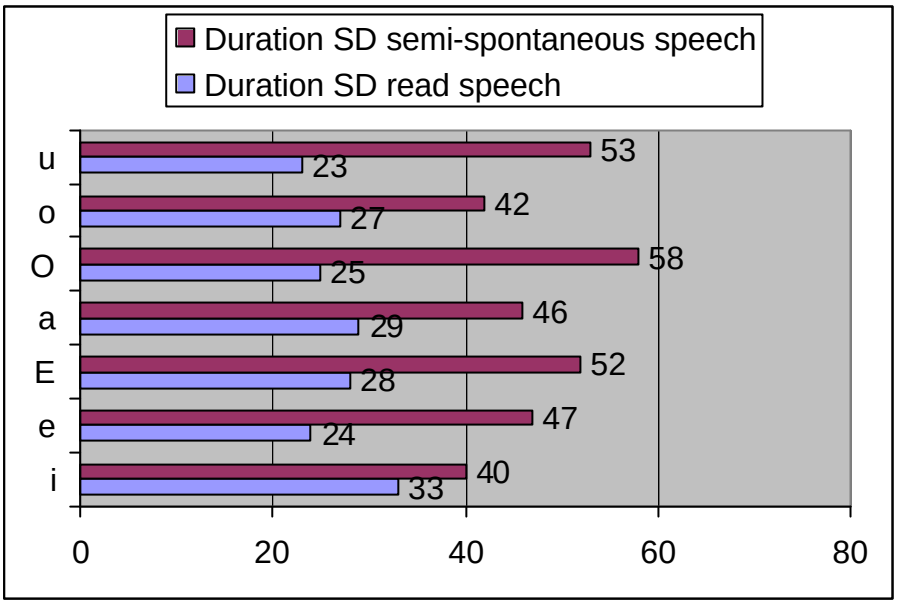
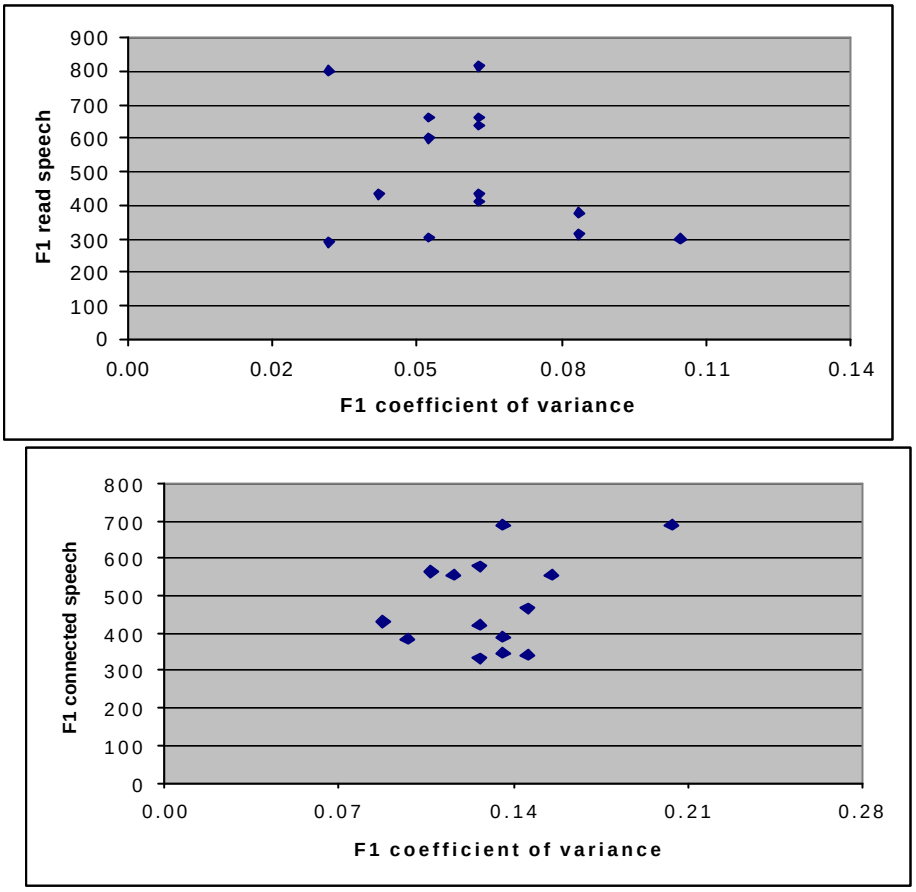


Figure 10. Standard deviations of duration values for each vowel in each style.

Some unclear results were found in F2, F3, and F0 standard deviation values (they are not systematically greater in connected speech than in laboratory speech[10]).

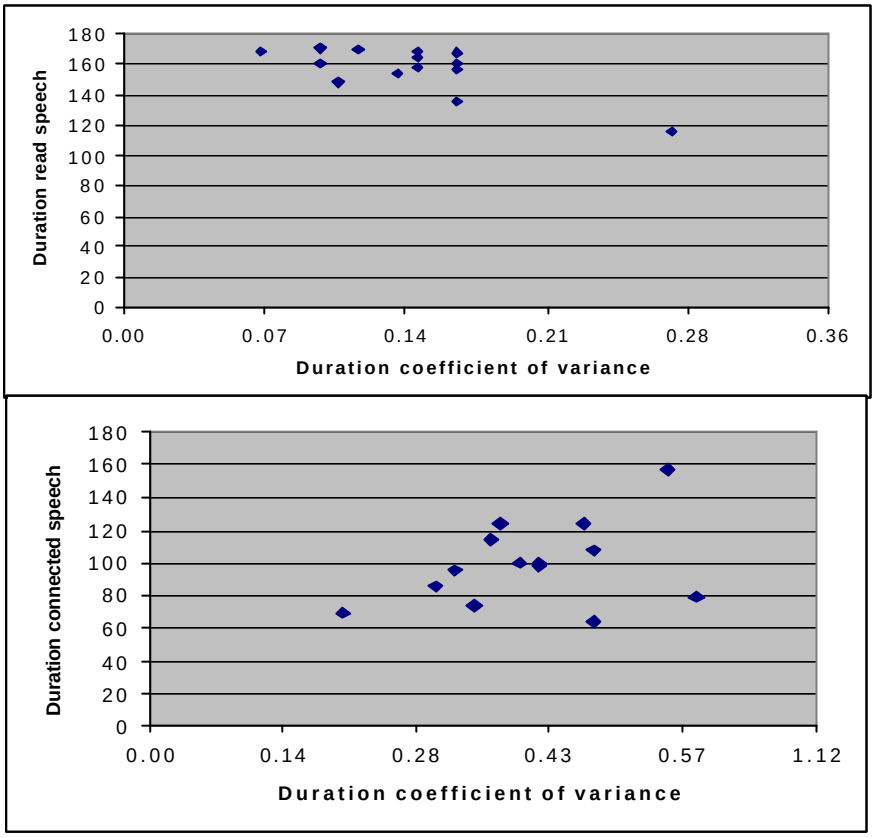
As an illustration of the contrast between read and semispontaneous speech, in Figures 11-12 F1 means of both speakers are plotted against their coefficient of variance for each phone class. As expected, the variance increases in the semispontaneous speech vowels (n.b. the orizontal scale of Fig. 12 is twice that of Fig. 11), whose means means cover furthermore a lower range.

[10] Similar findings are in Poch-Olivé & Harmegnies (1995: 410), concerning the Italian vowel system of spontaneous speech; and also in Delplancq, Harmegnies and Poch-Olivé (1995-96: 180), concerning the Portuguese vowel system of spontaneous speech.



Figures 11-12.

Figures 13 and 14 plot mean segmental duration of both speakers against their coefficient of variance for each phone class. As expected, the vowels from semispontaneous speech tend to be shorter and more varied than the vowels from read speech (n.b. The orizontal scale of Fig. 14 is three times larger than that of Fig. 13).



Figures 13-14.

2.5 Dispersions within Phonetic Categories

Centralization and increasing intra-cluster variability result in more overlapping formant distributions in the semispontaneous speech tokens (Figures 16 and 18).

. Speaker S:

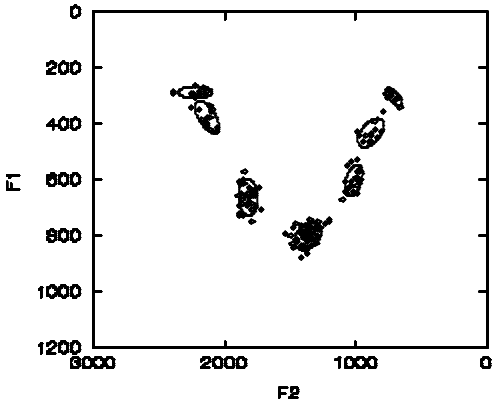


Figure 15. Regions (68% bivariate ellipsoids) of read speech vowels.

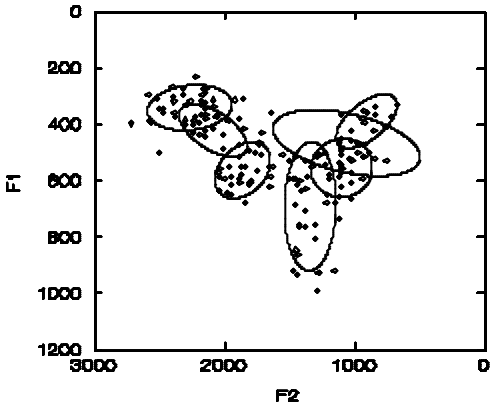


Figure 16. Regions (68% bivariate ellipsoids) of semispontaneous speech vowels.

. Speaker V:

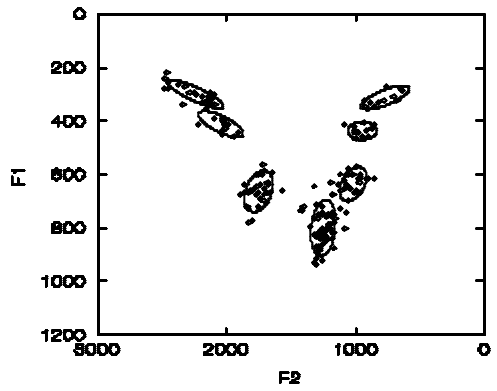


Figure 17. Regions (68% bivariate ellipsoids) of read speech vowels.

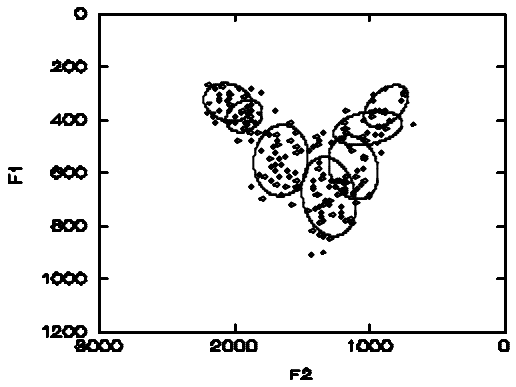


Figure 18. Regions (68% bivariate ellipsoids) of semispontaneous speech vowels.

2.6 Focus Words vs. Non-Focus Words in Semispontaneous Speech

The likelihood of segmental and suprasegmental reduction in stressed vowels seems to be inversely related to the degree of the perceptual salience of the words in which these vowels are embedded.

. Speaker S:

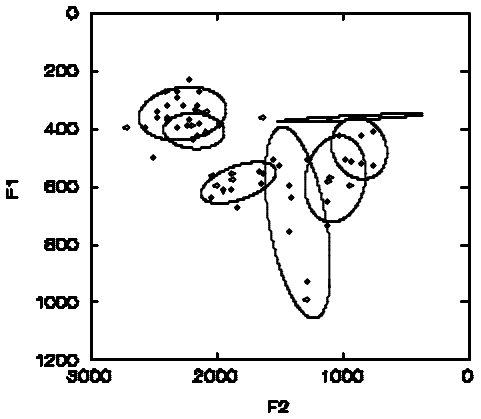


Figure 19.
Regions (68% bivariate ellipsoids) of semispontaneous speech embedded in prominent words.

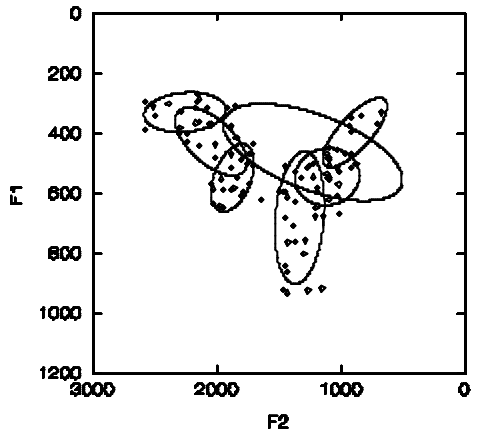


Figure 20.
Regions (68% bivariate ellipsoids) of semispontaneous speech embedded in non-prominent words.

. Speaker V:

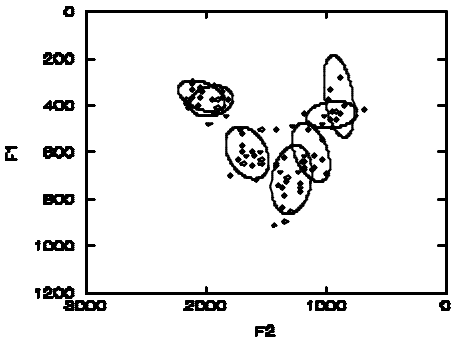


Figure 21.
Regions (68% bivariate ellipsoids) of semispontaneous speech embedded in prominent words.

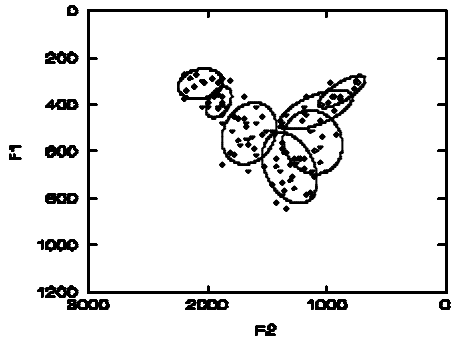


Figure 22.
Regions (68% bivariate ellipsoids) of semispontaneous speech embedded in non-prominent words.

2.7 Vowel Space

The area covered by the polygon defined by the mean F1 and F2 values of the seven vowels was calculated: this is a simple, but effective, way of characterizing the acoustic size of a vowel system. The vowel space defined by the vowels in each condition did differ in terms of area, and the overall area was obviously affected when the subjects changed speech style: the space was largest in the read speech condition and smallest in the quasi-spontaneous speech condition.

vowel space	Speaker S	Speaker V
read speech area	456371 Hz²	410199 Hz²
connected speech area	245177 Hz² (-47%)	213589 Hz² (-47%)
connected speech area (focus words)	310290 Hz² (-32%)	229701 Hz² (-44%)
connected speech area (non-focus words)	222437 Hz² (-51%)	199538 Hz² (-51%)

Table 3.

Speech style does have a profound effect on the overall vowel space, shrinking the vowel space by 47% from the read speech condition to the quasi-spontaneous speech condition (for both speakers). The patterns of the two subjects are quite similar: the vowel space of connected speech prominent tokens is always larger than the vowel space of connected speech non-prominent tokens.

2.8 Discriminant Analysis

The more overlapping formant distributions cause lowered recognition rates in spontaneous speech. In order to verify whether the semispontaneous speech vowel system was less informative and less differenciated, two discriminant analyses (one in connected speech, and one in lab speech) were performed, with the vowels as *a priori* categories and the formant values (F1 and F2) as discriminant variables[11]. The statistical distribution of the measurements was supposed to be Gaussian and the covariance matrix was hypothesized to be similar for the measurements of the vowels in each pair. Once the discriminant functions were computed, a recognition task was simulated in each subsample; from the linear discriminant analysis for the seven vowels categories, matrices showing how the vowel tokens were classified were obtained.

Errors are much more numerous with the semispontaneous samples than with the laboratory ones: the combined correct recognition rates are 98.2% and 96.6% in read speech and only 73.4% and 80.8% in connected speech. In the read samples, the confusion is only between two categories (e.g. /e/ and /i/; /o/ and /u/; /ɔ/ and /a/), whereas in the connected samples, the confusion involves three, four and even five vowel categories at time (e.g. /ɛ/, /e/ and /i/; /a/, /ɛ/, /ɔ/ and /o/).

A more marked difference between read and semispontaneous speech is in Speaker S's confusion matrices (98.2% vs. 73.4% combined correct recognition rates respectively): since this subject has the lowest centralization indices (see 2.3), timbres confusions do not turn out to be more likely in vowels with an important degree of centralization[12].

[11] R method of classification.
[12] See Delplancq, Harmegnies and Poch-Olivé (1995-96: 180); Poch-Olivé & Harmegnies (1992: 286).

. Speaker S:

V (%)	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
/i/	100	0	0	0	0	0	0
/e/	13.3	86.7	0	0	0	0	0
/ɛ/	0	0	100	0	0	0	0
/a/	0	0	0	100	0	0	0
/ɔ/	0	0	0	0	100	0	0
/o/	0	0	0	0	0	92.3	7.7
/u/	0	0	0	0	0	0	100

Table 4. CONFUSION MATRIX FROM THE SIMULATED VOWEL RECOGNITION TASK IN READ SPEECH. Actual groups are in rows, and predicted group membership in columns.

. Speaker S:

V (%)	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
/i/	95	2.5	2.5	0	0	0	0
/e/	71.4	21.4	7.1	0	0	0	0
/ɛ/	0	3	97	0	0	0	0
/a/	0	0	5.6	72.2	22.2	0	0
/ɔ/	0	0	0	13.6	81.8	4.5	0
/o/	7.7	0	7.7	0	46.2	15.4	23.1
/u/	0	0	0	0	9.1	27.3	63.6

Table 5. CONFUSION MATRIX FROM THE SIMULATED VOWEL RECOGNITION TASK IN CONNECTED SPEECH. Actual groups are in rows, and predicted group membership in columns.

. Speaker V:

V (%)	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
/i/	95.7	4.3	0	0	0	0	0
/e/	6.7	93.3	0	0	0	0	0
/ɛ/	0	0	100	0	0	0	0
/a/	0	0	0	98.3	1.7	0	0
/ɔ/	0	0	0	8.7	91.3	0	0
/o/	0	0	0	0	0	100	0
/u/	0	0	0	0	0	8.3	91.7

Table 6. CONFUSION MATRIX FROM THE SIMULATED VOWEL RECOGNITION TASK IN READ SPEECH. Actual groups are in rows, and predicted group membership in columns.

. Speaker V:

V (%)	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/
/i/	73.9	26.1	0	0	0	0	0
/e/	19	81	0	0	0	0	0
/ɛ/	0	7	86	4.7	2.3	0	0
/a/	0	0	8.9	87.5	1.8	1.8	0
/ɔ/	0	0	0	27.8	61.1	11.1	0
/o/	0	0	5.6	0	0	77.8	16.7
/u/	0	0	0	0	0	21.4	78.6

Table 7. CONFUSION MATRIX FROM THE SIMULATED VOWEL RECOGNITION TASK IN CONNECTED SPEECH. Actual groups are in rows, and predicted group membership in columns.

3. Conclusion

Some trends observed here were also mentioned in other acoustic studies:
i. the vowel space expands in read speech and contracts in semispontaneous speech;
ii. the vowel space expands in connected speech prominent words and contracts in connected speech non-prominent words;
iii. an increasing intra-cluster variability is observed in semispontaneous speech;
iv. more overlapping formant distributions are noticed in semispontaneous speech;
v. lower recognition rates are found in semispontaneous speech.

Nevertheless, some inconsistencies are evident, and quite serious methodological problems that may challenge the validity of some results have to be kept in mind. We can't simply assert that vowels from connected speech are always less peripheral, more variable and more scattered in the acoustic space, and neither is it possible to assert that the phenomena here described are language-dependent, since few languages have been studied from this particular point of view. In Standard Southern British English, Deterding (1997) finds that the difference between citation and connected speech is only statistically significant for the male speech and not for the female speech; Poch-Olivé and Harmegnies (1992) point out that Spanish and Italian vowels in spontaneous speech show centralization and increased probability of inter vowel confusion, but they point out as well that clear a centralization tendency is absent from French vowels; Delplancq et al. (1995-96) draw attention to the decrease of the surface occupied by the Portuguese vowels in the F1/F2 plane in spontaneous speech, whereas they find an increase of the surface occupied by the Italian and Spanish vowels in the F1/F2 plane in spontaneous speech. In Giannini & Pettorino (1993) data on Italian and Catalan vowel systems two opposite tendencies were found: in the spontaneous speech condition the Italian speaker showed a clear trend towards reduction, whereas the opposite was observed in the Catalan speaker[13].

Some results may be therefore vowel-dependent (certain speech sounds are supposed to be more stable than others)[14], or even speaker-dependent. Alternately, the effects may be associated with methodological artefacts such as the type of speech material and the experimental design. The latter interpretation indicates the need for further study.

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[13] See also Farnetani (2002) conclusive remarks, in which conflicting data are discussed.
[14] See Meunier & Floccia (1997).

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Appendices

a. Word List

An alternate pronunciation is marked between round brackets or in italics; place-names occurring in the word list and in the map task are labelled with “pl. n. / S” if they refer to speaker S’s utterances, and with “pl. n. / V” if they refer to speaker V’s utterances

pseudo-words:

. /a/: tata; tatà

. /ɛ/ or /e/: tèta (téte); tète (téte); tetè (teté); titè (tité)

. /i/: titi; tite; tutì; titì

. /ɔ/ or /o/: tòtu (tótu); tòto (tóto); tatò (tató); totò (totó)

. /u/: tutu; tutù

words:

. /a/: campo; parco; rapa; bagno; labbro; salma; data; ragazza; camion; gas; afa; banca; bar; pace; marcia; afgano; mamma; astro; sala; barra; calza; marzo; disfrenare; pappa; taglio; tanfo; casa; faggio; tram; salto; capsula; casco; *gag*; agitare; gambo; fan; palla; talismano; mancia; subtotale; sacro; capra; calco; aspro; reclamo; constatare; carne; gatto; acme; radar; salsa; scialle; clacson; basso; panca; farfalla; ambulante (pl. n./S); barche (pl. n./ S); verità (pl. n./ S); babà (pl. n./ S); zazà (pl. n./ S); arco (pl. n./ V); semaforo (pl. n./ V); ospedale (pl. n./ V); felicità (pl. n./ V); università (pl. n./V)

. /ɛ/: perfetto; esperto; avanscoperta; superstite; rette; bene; enel; ebbe; accento; senso; *bolscevico*; leggo; *senza*; *neve*; replica; riflesso; rebus; caffè; eczema; *gag*; testa; tungsteno; etna; selz; atleta; zero; tecnica; fratello; albergo (pl. n./ S)

. /e/: discreto; accredito; cera; penne; perché; pesa; *senza*; *neve*; elmetto; invece; messa; selce; vedo; bevve; esteso; abeti (pl. n./ S); ventitré (pl. n./ S); biciclette (pl. n./ V)

. /i/: giro; *bolscevico*; ritmo; esclusivo; disney; kit; cifra; film; uncino; alluminio; limpida (pl. n./ S); colibrì (pl. n./ S); piccolo (pl. n./ V); doremì (pl. n./ V); mimì (pl. n./ V)

. /ɔ/: sampdoria; oslo; approdo; ovest; coca; addome; sport; gnocco; colla; golf; esplodere; vietcong; nord; poso; roba; subconscio; dogma; *gol*; corpo; fosforo; automobili (pl. n./ S); portico (pl. n./ S); deposito (pl. n./ V); negozio (pl. n./ V); totò (pl. n./ V)

. /o/: corto; ascensore; colpa; rombo; corso; orma; zolfo; conto; *gol*; orlo; bolla; francobollo; rondini (pl. n./ S)

. /u/: upim; pubblico; footbal; iglù; buffo; gulag; acuto; punta; musica (pl. n./ V)

b. Tokens from Semispontaneous Speech

Speaker S:

. /a/: usare; vado; fame; valle; barca; barche; arriva; facciamo; faccio; larga; allargo; balla; diciamo; fatto; arrivato; arrivare; ritornato; tornando; risalgo; verità; ambulante; necessario

. /ɛ/: riprende; albergo; destra; esse; discoteca; verso; sempre; serve; bene

. /e/: rimané; te; vedo; abeti; parecchio; discesa; avevo
. /i/: sì; vicino; mica; fino; capito; tipo; continua; magazzino; giro; arrivo; omino; limpida; diritto
. /ɔ/: portico; qualcosa; negozio; no; colle; posso; trovo; cosa; però; sto; c'ho; so
. /o/: bisogna; rondini; ora; venditore; allora; sono; dopo; torna; fosse; come
. /u/: curva; scusa; punto; subito; sicura; tutto; oppure

Speaker V:
. /a/: passi; semaforo; ospedale; avanti; passà; parte; male; felicità; soltanto; angolo; passare; rubate; andare; ritornare; girare; fare; passarci; passando; angolo; verticale; metà; stando; esatto; arco; tornando; passando; bar; larga; carta; pratica; passa; ansa; passi; largo; base
. /ɛ/: verso; specie; destra; prendi; mezzo; (sud)est; vabbè; prendila; dovrebbe; senso; scèndere; scèndi; ecco; retto; bene; partenza; devi; riscèndi
. /e/: te; aggeggi; invece; biciclette; probabilmente; praticamente; perché; rigonfiamento; perfettamente; verticalmente; frega; riferimento; impresa; seguo
. /i/: giro; sì; sinistra; perpendicolo; gira; arrivo; gìrali [giragli]; piccolo; arrivi; prima; mimì; diritto
. /ɔ/: no; negozio; però; totò; deposito; c'ho; proprio; po'; so
. /o/: sopra; dopo; ancora; sotto; intorno; icona; sopra; intorno; come
. /u/: comunque; una; tutti; musica; dunque; giù; punto; sud; scusa

c. Tables 8-9. Sets of ANOVAs with probability under the null hypothesis ($p < .05$), testing the *effects* of the variable *'speech style'.*

. Speaker S:

v	F (F1)	p	F (F2)	p	F (F3)	p	F(F1F0)	p	F(F2F1)	p	F (F0)	p	F (D)	p
all v	28,14	.000	10,58	.001	1,19	.276	23,65	.000	19,8	.000	3,42	.065	549,2	.000
/i/	14,07	.000	0,45	.503	2,15	.148	15,74	.000	0,05	.808	0,568	.455	64,23	.000
/e/	7,08	.013	1,30	.264	2,11	.161	9,24	.005	2,99	.095	0,25	.618	118,4	.000
/ɛ/	57,46	.000	1,77	.188	1,65	.203	43,76	.000	27,80	.000	4,41	.040	46,32	.000
/a/	31,20	.000	1,82	.180	0,18	.671	24,94	.000	9,65	.003	14,16	.000	211,7	.000
/ɔ/	10,42	.002	6,59	.014	0,02	.870	9,27	.004	14,86	.000	0,002	.960	51,39	.000
/o/	2,35	.138	3,35	.079	0,17	.683	5,32	.030	1,83	.188	0,87	.358	136,1	.000
/u/	20,55	.000	18,46	.000	2,69	.117	17,55	.000	7,83	.011	1,17	.291	108,9	.000

. Speaker V:

v	F (F1)	p	F (F2)	p	F (F3)	p	F(F1F0)	p	F(F2F1)	p	F (F0)	p	F (D)	p
all v	15,95	.000	0,07	.782	5,79	.017	13,81	.000	2,56	.110	32,11	.000	115	.000
/i/	9,48	.004	28,17	.000	28,66	.000	2,74	.105	28,15	.000	4,57	.039	2,22	.143
/e/	4,62	.039	13,36	.001	42,05	.000	5,08	.032	6,56	.015	0,94	.339	35,39	.000
/ɛ/	42,05	.000	14,51	.000	16,51	.000	39,12	.000	0,18	.667	5,77	.019	27,15	.000
/a/	69,61	.000	8,93	.003	0,11	.741	82,37	.000	54,04	.000	11,64	.001	36,79	.000
/ɔ/	9,40	.004	14,28	.001	0,02	.871	9,18	.004	23,39	.000	3,23	.081	9,33	.004
/o/	0,09	.761	3,98	.054	3,06	.089	2,25	.146	2,39	.132	6,08	.020	23,5	.000
/u/	5,77	.024	6,76	.016	5,18	.032	3,73	.067	3,88	.060	3,10	.093	6,41	.018

d. Tables 10-23. Average values of F1, F2, F3, F0, D in Hz of read speech compared with connected speech

. Speaker S:

/i/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	14	14	14	14	14	40	40	36	40	40
mean	288	2228	3094	153	148	341	2267	2936	146	86
sd	13	78	223	14	16	52	209	376	33	27
c.v.	0.04	0.03	0.07	0.09	0.11	0.15	0.09	0.13	0.23	0.31
Min	265	2139	2697	128	121	228	1634	2411	106	31
Max	306	2397	3391	176	170	499	2714	3976	279	146
range	41	258	694	48	49	271	1080	1565	173	115

/e/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	15	15	15	15	15	14	14	8	13	14
mean	376	2137	2734	149	160	422	2088	2635	144	73
sd	35	56	76	11	17	57	158	248	34	26
c.v.	0.09	0.03	0.03	0.07	0.10	0.13	0.08	0.09	0.23	0.35
Min	306	2053	2578	126	136	363	1744	2354	102	39
Max	426	2252	2834	167	195	567	2305	3165	227	129
range	120	199	256	41	59	204	561	811	125	90

/ɛ/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	32	32	32	32	32	33	33	29	30	33
mean	664	1824	2627	142	170	562	1858	2579	133	114
sd	42	48	129	8	20	64	137	165	24	42
c.v.	0.06	0.03	0.05	0.05	0.12	0.11	0.07	0.06	0.18	0.37
Min	569	1722	2312	128	133	417	1497	2224	87	31
Max	749	1897	2844	156	204	674	2045	2835	197	173
range	180	175	532	28	71	257	548	611	110	142

/a/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	58	58	58	58	58	36	36	32	36	36
mean	801	1367	2469	142	171	690	1340	2450	132	96
sd	32	67	207	8	18	147	128	175	18	32
c.v.	0.04	0.05	0.08	0.06	0.10	0.21	0.09	0.07	0.13	0.33
Min	742	1199	1958	123	130	484	1104	2060	102	55
Max	876	1540	2803	160	210	990	1649	2746	169	169
range	134	341	845	37	80	506	545	686	67	114

/ɔ/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	25	25	25	25	25	22	22	21	21	22
mean	603	1017	2462	144	169	554	1097	2471	144	98
sd	36	42	159	9	25	65	150	206	28	41
c.v.	0.06	0.04	0.06	0.06	0.15	0.12	0.14	0.08	0.19	0.42
Min	530	966	2141	122	107	447	880	2049	116	44
Max	671	1103	2724	167	209	735	1451	2738	217	223
range	141	137	583	45	102	288	571	689	101	179

/o/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	13	13	13	13	13	13	13	11	12	13
mean	433	887	2332	146	169	466	1062	2309	139	64
sd	31	59	81	11	12	71	341	181	23	30
c.v.	0.07	0.07	0.03	0.07	0.07	0.15	0.32	0.08	0.17	0.48
Min	354	794	2248	117	149	311	754	2030	100	30
Max	467	988	2515	164	188	571	1855	2567	193	143
range	113	194	267	47	39	260	1101	537	93	113

/u/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	10	10	10	10	10	11	11	11	11	11
mean	304	714	2145	155	154	388	907	2252	163	69
sd	18	37	99	11	22	56	138	183	20	15
c.v.	0.06	0.05	0.05	0.07	0.14	0.14	0.15	0.08	0.12	0.21
Min	280	661	1970	139	118	490	1101	2483	187	91
Max	344	766	2312	173	192	331	674	1874	125	49
range	64	105	342	34	74	159	427	609	62	42

. Speaker V:

/i/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	23	23	23	23	23	23	23	22	19	23
mean	298	2248	2834	108	116	334	2051	2556	124	100
sd	33	138	181	22	33	45	112	166	27	40
c.v.	0.11	0.06	0.06	0.20	0.28	0.13	0.05	0.06	0.22	0.40
Min	218	2090	2339	75	61	269	1828	2365	85	41
Max	355	2486	3134	150	213	446	2205	3109	200	174
range	137	396	795	75	152	177	377	744	115	133

/e/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	15	15	15	15	15	21	21	21	15	21
mean	411	2048	2637	108	158	386	1932	2443	117	79
sd	30	105	109	25	24	37	85	70	23	47
c.v.	0.07	0.05	0.04	0.23	0.15	0.10	0.04	0.03	0.19	0.59
Min	336	1910	2432	87	128	297	1805	2252	78	34
Max	457	2338	2841	189	206	446	2148	2559	156	232
range	121	428	409	102	78	149	343	307	78	198

/ɛ/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	33	33	33	33	33	43	43	42	35	43
mean	663	1754	2480	104	160	554	1657	2347	117	108
sd	49	71	150	11	28	86	132	134	30	52
c.v.	0.07	0.04	0.06	0.11	0.17	0.16	0.08	0.06	0.26	0.48
Min	561	1575	2141	86	91	365	1348	2056	79	31
Max	782	1898	2770	126	205	720	1976	2593	206	221
range	221	323	629	40	114	355	628	537	127	190

/a/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	58	58	58	58	58	56	56	52	46	56
mean	814	1248	2343	106	168	690	1303	2356	119	124
sd	57	54	228	10	29	97	131	150	28	46
c.v.	0.07	0.04	0.10	0.09	0.17	0.14	0.10	0.06	0.24	0.38
Min	596	1082	1792	85	80	468	1062	2045	71	39
Max	937	1353	2724	133	233	909	1668	2719	185	232
range	341	271	932	48	153	441	606	674	114	193

/ɔ/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	23	23	23	23	23	18	18	16	15	18
mean	637	1017	2289	105	165	580	1124	2299	117	124
sd	43	65	216	10	25	75	115	120	30	58
c.v.	0.07	0.06	0.09	0.09	0.15	0.13	0.10	0.05	0.25	0.47

Min	571	855	1893	90	105	411	914	2056	73	44
Max	740	1124	2662	124	213	688	1371	2559	167	253
range	169	269	769	34	108	277	457	503	94	209

/o/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	14	14	14	14	14	18	18	16	13	18
mean	436	954	2237	108	157	432	1017	2327	121	100
sd	20	68	104	16	27	40	157	167	18	42
c.v.	0.05	0.07	0.05	0.15	0.17	0.09	0.15	0.07	0.15	0.42
Min	406	854	2045	79	99	367	679	2000	84	43
Max	468	1094	2393	137	205	491	1382	2559	149	176
range	62	240	348	58	106	124	703	559	65	133

/u/	rs F1	rs F2	rs F3	rs F0	rs D	cs F1	cs F2	cs F3	cs F0	cs D
N	12	12	12	12	12	14	14	13	11	14
mean	311	775	2182	115	135	349	882	2285	129	157
sd	27	112	89	22	23	48	98	131	17	53
c.v.	0.09	0.14	0.04	0.19	0.17	0.14	0.11	0.06	0.13	0.56
Min	268	635	2042	77	92	280	743	2058	106	35
Max	347	936	2337	146	179	434	1047	2468	155	192
range	79	301	295	69	87	154	304	410	49	157

d. Tables 24-37. Average values of F1, F2, F3, F0, D in Hz of connected speech prominent tokens compared with connected speech non-prominent tokens

. Speaker S:

/i/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	24	24	21	24	24	16	16	15	16	16
mean	348	2269	2934	136	100	330	2264	2938	161	67
sd	58	218	430	22	21	41	202	298	41	23
c.v.	0.17	0.09	0.15	0.16	0.21	0.12	0.09	0.10	0.25	0.34
Min	228	1634	2411	106	49	270	1923	2567	117	31
Max	499	2714	3976	180	146	404	2583	3845	279	106
range	271	1080	1565	74	97	134	660	1278	162	75

/e/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	3	3	1	3	3	10	10	7	9	10
mean	406	2210	2567	111	111	428	2052	2645	157	63
sd	29	85	.	13	17	66	168	266	32	17
c.v.	0.07	0.04	.	0.12	0.15	0.15	0.08	0.10	0.20	0.28
Min	381	2140	.	102	97	363	1744	2354	122	39
Max	438	2305	.	126	129	567	2241	3165	227	84
range	57	165	.	24	32	204	497	811	105	45

/ɛ/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	12	12	10	11	12	21	21	19	19	21
mean	586	1826	2677	130	143	549	1877	2527	134	97
sd	42	177	156	62	29	71	109	148	26	40
c.v.	0.07	0.10	0.06	0.17	0.20	0.13	0.06	0.06	0.19	0.41
Min	526	1497	2399	102	83	417	1710	2224	87	31
Max	674	2036	2835	187	173	647	2045	2822	197	163
range	148	539	436	85	90	230	335	598	110	132

/a/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	7	7	4	7	7	29	29	28	29	29
mean	724	1353	2493	134	122	682	1337	2444	132	90
sd	178	140	113	22	39	141	127	183	17	27
c.v.	0.24	0.10	0.04	0.16	0.31	0.21	0.09	0.07	0.13	0.30
Min	507	1116	2395	107	62	484	1104	2060	102	55
Max	990	1552	2655	169	169	932	1649	2746	163	142
range	483	436	260	62	107	448	545	686	61	87

/ɔ/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	7	7	7	7	7	15	15	14	14	15
mean	573	1056	2566	425	133	545	1117	2423	142	82
sd	80	130	179	37	45	58	158	208	24	29
c.v.	0.14	0.12	0.07	0.25	0.34	0.11	0.14	0.09	0.17	0.35
Min	507	925	2220	118	93	447	880	2049	116	44
Max	735	1272	2735	217	223	666	1451	2738	193	154
range	228	347	515	99	130	219	571	689	77	110

/o/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	6	6	6	6	6	7	7	5	6	7
mean	468	867	2332	340	83	464	1230	2281	150	48
sd	54	112	146	20	33	87	388	231	23	15
c.v.	0.12	0.13	0.06	0.15	0.40	0.19	0.32	0.10	0.15	0.31
Min	411	754	2125	100	48	311	921	2030	129	30
Max	526	1028	2567	154	143	571	1855	2515	193	71
range	115	274	442	54	95	260	934	485	64	41

/u/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	3	3	3	3	3	8	8	8	8	8
mean	363	947	2327	168	82	398	892	2225	161	64
sd	4	137	199	15	5	64	144	182	23	14
c.v.	0.01	0.14	0.09	0.09	0.06	0.16	0.16	0.08	0.14	0.22
Min	360	838	2102	151	77	331	674	1874	125	49
Max	367	1101	2483	180	87	490	1097	2441	187	91
range	7	263	381	29	10	159	423	567	62	42

. Speaker V:

/i/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	11	11	11	9	11	12	12	11	10	12
mean	359	2038	2537	140	104	312	2064	2575	110	97
sd	39	116	98	31	33	39	112	218	13	47
c.v.	0.11	0.06	0.04	0.22	0.32	0.12	0.05	0.08	0.12	0.49
Min	308	1828	2399	98	49	269	1874	2365	85	41
Max	446	2159	2719	200	146	388	2205	3109	127	174
range	138	331	320	102	97	119	331	744	42	133

/e/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	9	9	9	7	9	12	12	12	8	12
mean	382	1962	2440	117	96	390	1909	2446	117	66
sd	37	103	82	25	65	39	64	64	22	23
c.v.	0.10	0.05	0.03	0.21	0.67	0.10	0.03	0.03	0.19	0.35
Min	315	1817	2252	87	34	297	1805	2353	78	46
Max	433	2148	2525	156	232	446	2045	2559	150	106

range	118	331	273	69	198	149	240	206	72	60

/ɛ/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	17	17	17	16	17	26	26	25	19	26
mean	602	1662	2365	113	139	522	1654	2335	121	88
sd	69	112	131	30	54	83	145	137	30	39
c.v.	0.11	0.07	0.05	0.27	0.39	0.16	0.09	0.06	0.25	0.44
Min	480	1542	2068	79	50	365	1348	2056	80	31
Max	720	1976	2536	163	221	685	1875	2593	206	204
range	240	434	468	84	171	320	527	537	126	173

/a/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	24	24	24	22	24	32	32	28	24	32
mean	717	1290	2368	120	148	670	1313	2345	119	105
sd	93	107	106	29	40	97	147	181	28	42
c.v.	0.13	0.08	0.04	0.24	0.27	0.14	0.11	0.07	0.24	0.40
Min	503	1097	2136	71	39	468	1062	2045	78	43
Max	909	1433	2548	175	232	844	1668	2719	185	204
range	406	336	412	104	193	376	606	674	107	161

/ɔ/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	9	9	9	9	9	9	9	7	6	9
mean	600	1129	2275	115	162	560	1119	2331	119	87
sd	71	89	121	36	45	77	142	121	18	46
c.v.	0.12	0.08	0.05	0.32	0.28	0.14	0.13	0.05	0.15	0.53
Min	489	1004	2056	73	112	411	914	2205	96	44
Max	688	1281	2399	167	253	685	1371	2559	144	182
range	199	277	343	94	141	274	457	354	48	138

/o/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	10	10	9	7	10	8	8	7	6	8
mean	440	958	2314	120	129	421	1091	2343	122	64
sd	33	124	138	24	32	47	170	208	10	16
c.v.	0.07	0.13	0.06	0.20	0.25	0.11	0.15	0.09	0.08	0.25
Min	377	679	2079	84	61	367	891	2000	112	43
Max	490	1177	2559	149	176	491	1382	2548	139	89
range	113	498	480	65	115	124	491	548	27	46

/u/	p F1	p F2	p F3	p F0	p D	n-p F1	n-p F2	n-p F3	n-p F0	n-p D
N	4	4	3	4	4	10	10	10	7	10
mean	361	897	2169	123	110	344	876	2320	133	87
sd	69	50	96	19	54	40	114	122	17	54
c.v.	0.19	0.06	0.04	0.15	0.49	0.12	0.13	0.05	0.12	0.62
Min	280	857	2058	106	51	297	743	2079	109	35
Max	434	971	2228	150	180	400	1047	2468	155	192
range	154	114	170	44	129	103	304	389	46	157