

Dept. for Speech, Music and Hearing  
**Quarterly Progress and  
Status Report**

**Front vowels in Parisian  
sociolects**

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journal: STL-QPSR  
volume: 18  
number: 2-3  
year: 1977  
pages: 001-007



**KTH Computer Science  
and Communication**

<http://www.speech.kth.se/qpsr>



## I. SPEECH ANALYSIS

## A. FRONT VOWELS IN PARISIAN SOCIOLECTS

Odette Mettas\* and Gunnar Fant

Abstract

A spectrographic study of front vowels in Parisian French has been carried out with the view of investigating differences between female sociolect upper-class and neutral pronunciation. The study was based on recordings from natural conversation. The formant data are normalized so as to remove the influence of possible anatomical variations, e. g. average vocal tract length. It is found that the sociolect subjects aim at more extreme [i] and [e] vowel targets than the neutral group. This feature of articulatory tenseness is also apparent in adjacent dental and palatal consonants, which are produced more close and attain greater duration than in the neutral group. A non-uniform normalization technique, Fant (1975), is adopted for converting the female data to the most probable equivalent male data thus allowing a comparison with other languages.

Introduction

In previous articles, Mettas (1970), Mettas, Fant, and Stålhammar (1971), Landerey and Mettas (1973), the phonetic qualities of some vowels (/A/, /ã/ /õ/) of two Parisian sociolects were investigated. The purpose of the present study is to compare the front vowels [i], [e], [ɛ], [a], [ə] of these two sociolects applying normalization techniques (Fant, 1975) to spectrographic data.

Subjects

This study is concerned with female subjects of age 18-30. It will be recalled that in Sociolect 1 subjects belong to two close social groups - aristocracy and upper middle-class ("haute-bourgeoisie") - and are characterized by their long established social position in Paris. In Sociolect 2 (neutral pronunciation), speakers are middle-class Parisians ("bourgeoisie").

Speech material

The vowels analyzed were extracted from recorded spontaneous conversations of four speakers in Sociolect 1 and three speakers in Sociolect 2. As often as possible we chose for analysis vowels having the same consonantal frame in both sociolects.

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It was previously mentioned (Mettas, 1973) that, among the various realizations of the vowels in Sociolect 1, the [i] and [e] often seem to have a more close - sometimes a more open - articulation from an auditory point of view than in the neutral pronunciation. Vowels analyzed in the present study belong to the first type. It was also mentioned that the [ɛ] sometimes seems to tend towards [a], which is not the case of the vowels analyzed here.

It should also be observed that most of the [a] vowels of Sociolect 1 were sampled from unstressed words within a rhythmical group. In a stressed position [a] is usually pronounced with a more posterior sound (Mettas, Fant, and Stålhammar, 1971). In the neutral group, half of the [a] sampled for analysis are stressed vowels, the other half being unstressed. The position of the [a] vowel did not affect the audible quality and the systematic differences in formant frequencies were found to be small.

It must be added that the [ə] vowels analyzed were in most cases the [ə] of hesitation, which explains the long duration of most of them.

#### Formant frequency measurements

Spectrograms of the words were made by means of the Voiceprint spectrograph using the broadband pass filter of 300 Hz. The first three formants of the vowels to be compared were measured for each speaker in each group. To minimize variations related to coarticulation samples were taken at locations where such contextual influences were judged to be minimum, i. e. where formants were closest to target values.

Formant frequency values F1, F2, and F3 of the vowels analyzed for each subject are tabulated in Table I-A-I together with the duration (D) of each vowel.

The errors in measuring formant frequencies from the broad-filter (300 Hz) are estimated to be larger than the  $F_0/4$  given by Lindblom (1961) for male voices and by Karlsson (1975) for rather low frequency  $F_0$  females. When  $F_0$  becomes of the order of 300 Hz the Sonagraph broad filter shows harmonics instead of formants and the interpretation of the spectrograph pattern becomes difficult. Formant asymmetries together with the specific Sonagraph pre-emphasis might cause systematic errors

Neutral speakers	/i/	/e/	/ɛ/	/a/	/ø/					
CR	j'en suis partie D	cuisine D	pour me coucher D	quelques années D	avant Sèvres D	l'hôtel D	c'est ça D	voilà D	mes vacances D	parce que D
F <sub>1</sub>	450 ms	350 ms	500 ms	450 ms	550 ms	600 ms	600 ms	625 ms	450 ms	450 ms
F <sub>2</sub>	2900 173	2600 150	2350 352	2350 210	1950 90	2000 181	1700 188	1650 113	1750 113	1700 225
F <sub>3</sub>	3450	3350	3050	3100	3100	3100	3050	3000	3025	2850
F <sub>1</sub>	administratives ms		et j'en suis partie ms	comptabilité ms	au lycée de Sèvres ms	ça fait treize ans ms	ça fait ms	c'est assez varié ms	je devais avoir ms	j'en suis partie à ms
F <sub>2</sub>	450 ms		450 ms	450 ms	600 ms	550 ms	550 ms	550 ms	400 ms	400 ms
F <sub>3</sub>	2700 285		2400 300	2300 315	1950 173	2200 188	1700 75	1800 75	1900 60	1850 83
F <sub>1</sub>			trop avancé pour les ms		elle s'occupe elle de ms		d'abord ms			
F <sub>2</sub>			450 ms		550 ms		600 ms			
F <sub>3</sub>			2300 450		1950 113		1800 75			
F <sub>3</sub>			3000		3000		3050			
FrD	état d'esprit ms	Yougoslavie ms	il a été élevé ms	a influencé ms	au Touquet ms	dans la treizième ms	communle ms	je la connais moi ms	je dis à ms	à quand ms
F <sub>1</sub>	400 ms	400 ms	500 ms	500 ms	600 ms	600 ms	800 ms	800 ms	550 ms	550 ms
F <sub>2</sub>	2550 249	2500 136	2250 166	2100 60	2150 150	2100 150	1800 98	1850 105	1800 150	1700 143
F <sub>3</sub>	3300	3300	2850	2850	2750	2850	2900	2900	2700	2550
F <sub>1</sub>	d'ici ms	dis ms	au lycée ms	j'ai été ensuite ms	Claude Monnet ms	Mme Marquet ms	état d'esprit ms	à Paris ms	en Egypte à ms	
F <sub>2</sub>	400 ms	400 ms	450 ms	450 ms	600 ms	550 ms	700 ms	850 ms	500 ms	
F <sub>3</sub>	2400 83	2550 352	2300 196	2300 166	1900 120	2150 113	1900 68	1800 68	1900 60	
F <sub>3</sub>	3300	3350	2950	2950	2700	2850	3050	2850	2750	
F <sub>1</sub>	venu à Paris ms		j'ai déménagé ms		l'accent anglais ms		parce que ça ms			
F <sub>2</sub>	400 ms		450 ms		550 ms		800 ms			
F <sub>3</sub>	2600 173		2250 83		2050 60		1850 68			
F <sub>3</sub>	3250		2900		2300		3050			
BA	juste en face d'ici ms		totalemnt inversé ms	les notes ont été inversées ms	mauvaises ms	lycée Montaigne ms	communle ms	just en face ms	atelier de ms	
F <sub>1</sub>	500 ms		500 ms	400 ms	550 ms	550 ms	850 ms	700 ms	550 ms	
F <sub>2</sub>	2250 37		2400 75	2350 113	2150 188	2200 120	1750 136	1750 75	1750 60	
F <sub>3</sub>	3100		3050	2950	3000	2800	2750	2750	2800	
F <sub>1</sub>			je suis allée travailler ms	d'abord à l'école ms	je les ai faites ms	c'était juste ms	faites d'abord ms	totalemnt ms		
F <sub>2</sub>			425 ms	450 ms	550 ms	550 ms	650 ms	700 ms		
F <sub>3</sub>			2450 75	2400 83	2100 120	2250 210	1750 75	1800 83		
F <sub>3</sub>			2900	2900	2850	3000	2750	2800		

Table I-A-IA

Sociolect speakers		/i/				/e/				/ɛ/				/ɔ/						
GdG	vécu ici	D	milieu chic	D	marqué par	D	je suis née	D		D	dans le seizième	D	enfin y a	D	dans l'aristocratie	D	snobisme de	D	prennent le parti	D
F <sub>1</sub>	350		350		500		350				850		850		900		450		450	
F <sub>2</sub>	2550	136	2550	120	2500	60	2450	75			2350	300	1950	98	1950	45	1700	52	1700	68
F <sub>3</sub>	3950		3750		3100		3400				3050		2950		3000		3100		2850	
F <sub>1</sub>	le parti	ms	excessif	ms	dans cette maison	ms	vécu	ms	ou accent anglais	ms	seizième	ms	d'ailleurs	ms	cher ami	ms	oui	ms		
F <sub>2</sub>	300		400		350		350		650		600		700		800		500			
F <sub>3</sub>	2550	203	2550	173	2500	128	2350	68	2400	150	2300	105	2000	68	1800	90	1750	225		
F <sub>3</sub>	3600		3900		3150		3050		3000		3100		3000		2800		2800			
F <sub>1</sub>	snobisme	ms			excessif	ms							Sainte-Marie-de-Passy	ms						
F <sub>2</sub>	300				350								750							
F <sub>3</sub>	2550	136			2400	68							2200	45						
F <sub>3</sub>	3650				3150								3150							
PRC	à Paris	ms	Sainte-Marie	ms	ensuite j'ai été	ms	ville et	ms	ma dixième	ms	vers	ms	y a un tableau	ms	de la petite ville	ms	à Paris jusque	ms	c'est-à-dire	ms
F <sub>1</sub>	400		400		500		550		600		600		750		600		450		500	
F <sub>2</sub>	2900	277	2900	264	2650	150	2500	188	2450	105	2100	136	1800	83	1900	75	1700	376	1650	300
F <sub>3</sub>	3800		3850		3350		3300		3250		3200		3300		3200		3200		3150	
F <sub>1</sub>	oussi	ms	la petite ville	ms	j'ai été en	ms							et alors la j'ai	ms	jusqu'à	ms	vers	ms	était oussi	ms
F <sub>2</sub>	350		450		500								700		700		500		450	
F <sub>3</sub>	2900	285	2750	264	2500	45							1800	68	1800	90	1600	322	1550	528
F <sub>3</sub>	3850		3700		3300								3100		3150		3200		3200	
F <sub>1</sub>	filles	ms											par cœur	ms						
F <sub>2</sub>	400												650							
F <sub>3</sub>	3000	210											1750	37						
F <sub>3</sub>	3900												2950							
CPdM	le tennis	ms	à la piscine	ms	nous avons déménagé	ms	des années	ms					dépend des années	ms	pendant des années	ms				
F <sub>1</sub>	325		350		450		450						600		550					
F <sub>2</sub>	2575	203	2550	188	2700	249	2700	150					2200	75	2250	68				
F <sub>3</sub>	3550		3500		3150		3500						3250		3200					
F <sub>1</sub>	snobisme	ms			et le tennis	ms							nous avons déménagé	ms	à la clinique	ms				
F <sub>2</sub>	2500	98			500	60							650		700					
F <sub>3</sub>	3550				2500								2000	113	2000	83				
F <sub>3</sub>					3200								2900		3050					
F <sub>3</sub>																				
NS	je suis mariée depuis	ms	dix ans	ms	janvier	ms	je suis mariée	ms	laisse dévorer	ms			dernières vacances	ms			habitué à un quartier	ms	je suis mariée	ms
F <sub>1</sub>	450		400		450		500		550				900				500		450	
F <sub>2</sub>	2450	270	2450	150	2400	98	2400	203	2100	90			1850	68			2000	249	2000	128
F <sub>3</sub>	3450		3500		3250		3050		2900				2750				2725		2700	
F <sub>1</sub>	moi oussi d'ailleurs	ms			mois de janvier	ms											depuis	ms	dernières vacances	ms
F <sub>2</sub>	450				500												500		500	
F <sub>3</sub>	2450	52			2350	150											2150	90	1900	120
F <sub>3</sub>	3150				3300												2800		2700	

Table I-A-IB

of the order of maximally  $F_0/4$ . Rapid variations of  $F_0$  with respect to  $F_1$  and  $F_0$  might provide a confusing pattern to resolve. Taking all these considerations into account we feel that  $F_0/2$  is a more realistic estimate of a maximum error. On the other hand, in our study the observed spread of the measured formant frequencies in various utterances of one and the same speaker and vowel is rather modest, the standard deviation in  $F_1$  being of the order of  $F_0/10$ , which can be taken as an indication of consistency of the investigator and that the instrumental errors are within reasonable limits. The standard deviation of  $F_2$  and  $F_3$  over all subjects and utterances is of the order of  $F_2/20$  and  $F_3/20$ .

#### Normalization procedure

Mean values of  $F_1$ ,  $F_2$ , and  $F_3$  have been calculated for each separate vowel within both sets of sociolects. The averaging of subject data has been performed with weight factors proportional to the number of measurements for each subject. These simple averages are tabulated below.

Table I-A-II.

Average formant data. Unnormalized. N = neutral, S = sociolect

	[i]		[e]		[ε]		[a]		[ə]	
	N	S	N	S	N	S	N	S	N	S
$F_1$	418	375	459	451	567	609	698	720	481	479
$F_2$	2562	2642	2321	2493	2078	2282	1779	1950	1793	1792
$F_3$	3301	3679	2960	3233	2929	3083	2940	3050	2816	2947
$F_{3S}/F_{3N}$	1.114		1.092		1.053		1.037		1.047	

As a first step towards normalization we compute the ratios of sociolect  $F_3$  to the neutral group  $F_3$ . As seen in Table I-A-II this ratio  $F_{3S}/F_{3N}$  has a mean value of 1.046 for [ε][a][ə] and 1.103 for [i] and [e]. The former value reflects the overall differences between the speakers' vocal tract lengths, Nordström and Lindblom (1975), Fant (1975), whilst the higher value for [i] and [e] appears to reflect a sociolectal difference. A simple uniform normalization is sufficient for correcting the sociolect data so as to make it comparable to the neutral group. To this extent we divide all sociolect formant frequencies by the factor 1.046. The results are given in Table I-A-III and in Fig. I-A-1.

Table I-A-III.

Average formant data. Sociolect data normalized to match neutral data by a -4.6 % reduction.

	[i]		[e]		[ε]		[a]		[ə]	
	N	S	N	S	N	S	N	S	N	S
F <sub>1</sub>	418	356	459	430	567	581	698	687	481	457
F <sub>2</sub>	2562	2520	2078	2379	2078	2178	1779	1861	1793	1710
F <sub>3</sub>	3301	3510	2929	3084	2929	2941	2940	2910	2816	2812

In order to make these data comparable to average male data we can apply the non-uniform scaling technique developed by Fant (1975). The first step is to estimate the difference in vocal-tract size factor. The F<sub>3</sub> of the maximally open vowel [a] averaged over N and S in Table I-A-III is 2925 Hz which is exactly 17 % above that of the reference F<sub>3</sub> = 2500 Hz for male voices, Fant (1975). A normalization from the average F<sub>3</sub> = 2935 of [ε] would have given almost the same result.

We thus have shown that a "neutral" group of French female speakers (neutral data and normalized sociolect data in the present study) has a reference F<sub>3</sub> of 17 % above that of the reference male F<sub>3</sub> in the six language study carried out by Fant (1975) which is the same as the female-to-male ratio in that study. In other words, the "neutral" group of speakers in our material has the same average vocal-tract length as that of the Fant (1975) female population, whilst the sociolect group (F<sub>3</sub> of [a] = 3050 Hz) has 5 % shorter vocal tracts.

For a maximally precise non-uniform normalization we would use the formula

$$F_{nn} = \frac{F_n}{\left(1 + \frac{k_s}{17} k_n \frac{1}{100}\right)} \quad (1)$$

where F<sub>nn</sub> is the normalized formant frequency F<sub>n</sub>. The size factor k<sub>s</sub> = 22 % for the sociolect group and 17 % for the neutral group. In this case it is simpler to normalize the sociolect data in two steps, the first being that of the uniform reduction of 4.6 % already performed in Table I-A-III and then to perform the standard female-male translation by

$$F_{nn} = \frac{F_n}{(1+k_n/100)} \quad (2)$$



# FEMALE PARISIAN FRENCH

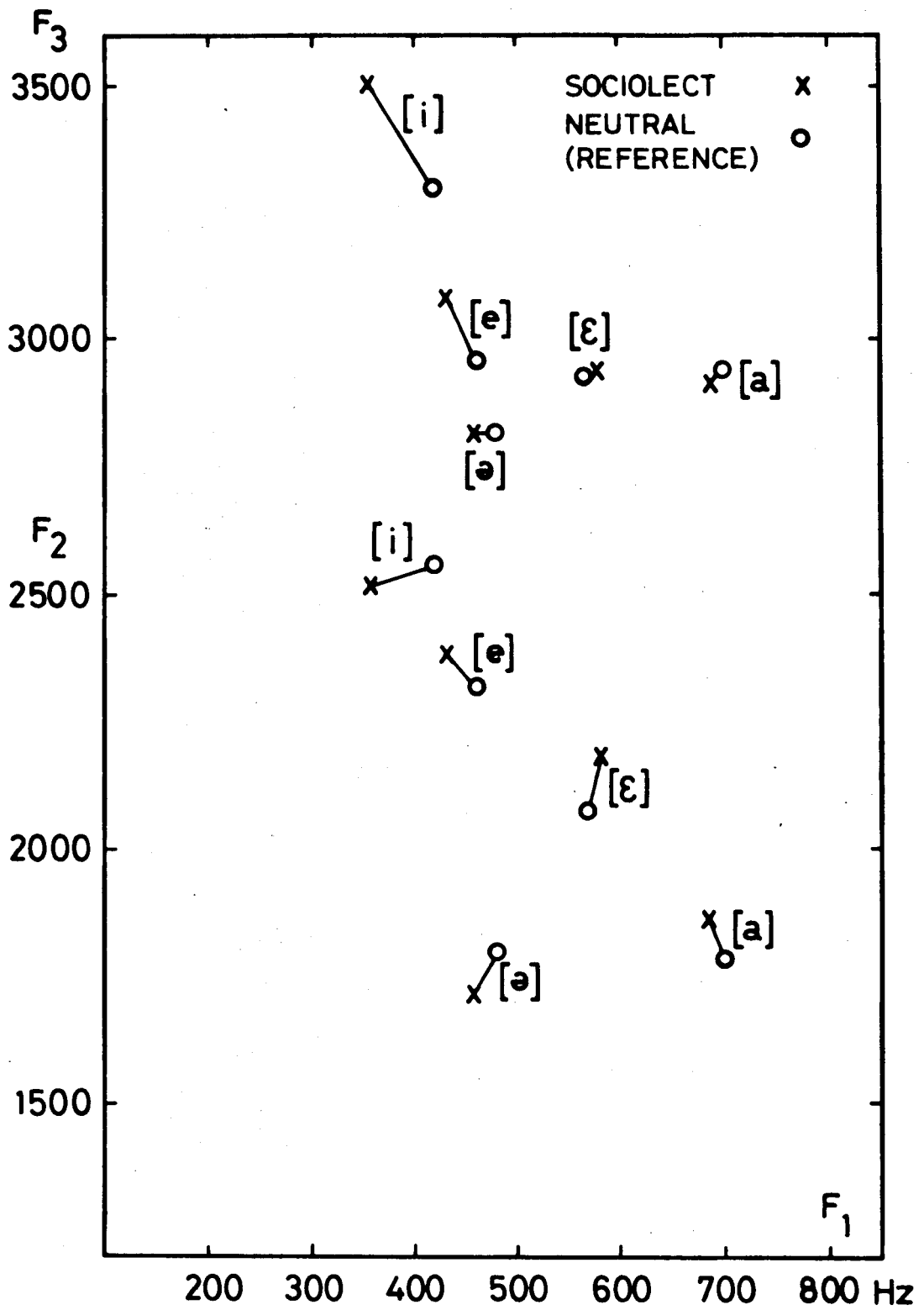


Fig. 1-A-1. Sociolect vowels normalized to the same vocal tract length as the neutral group of female subjects.

The specific formant- and vowel-dependent factors  $k_n$  have to be interpolated from the reference data given by Fant (1975) on the basis of a first estimate of  $F_{nn}$  from  $k_n = k_s = 17\%$ . This step and the following calculation of the normalized formant-frequency values generate the following data.

Table I-A-IV.

	[i]		[e]		[ε]		[a]		[ə]	
	N	S	N	S	N	S	N	S	N	S
$k_{n1}$	10	8	12	11	19	19	19	20	6	6
$k_{n2}$	22	21	22	22	18	18	17	17	17	17
$k_{n3}$	18	13	18	18	20	20	17	17	17	17
$F_{n1}$	380	330	410	388	477	488	587	572	453	431
$F_{n2}$	2100	2083	1902	1950	1761	1846	1520	1590	1533	1462
$F_{n3}$	2798	3106	2509	2614	2441	2450	2512	2487	2407	2403

### Discussion

There are two aspects that we may discuss. One is the relation of sociolect to neutral pronunciation which can be seen from Fig. I-A-1 and which naturally remains the same after normalization to standard male formant, Fig. I-A-2. The overall impression is that the sociolect speakers show a tendency to produce extreme limits of the vowels. The perceptually important upper formant of the vowel [i] is F3 which is 200 Hz higher in the sociolect. This characteristic and the 62 Hz lower F1 document a more close and a more advanced tongue articulation, possibly with a greater spread of the lips in the sociolect [i]. This feature of articulatory tenseness is also apparent in adjacent consonants [z], [s], [j], [ʃ] which are pronounced more closed and attain greater duration than in the neutral group. However, the tenseness of the vowel appears to be independent of the consonantal frame. There is a similar but smaller difference in the [e] data whilst the data are more similar, perhaps with a larger spread of the lips in the sociolect as judged from the higher F2. The measures corroborate the auditive impression one gets when hearing the [i] and [e] which have been analyzed. The [a] vowels do not differ much. However, some of the sociolect variants are higher in F2. This is true especially of several [a] analyzed (Sainte-Marie-de-Passy, dépend des années, etc.), which corroborate the auditive impression once again: the vowel seems to tend towards [æ].

# FEMALE - MALE NORMALIZED PARISIAN FRENCH VOWELS

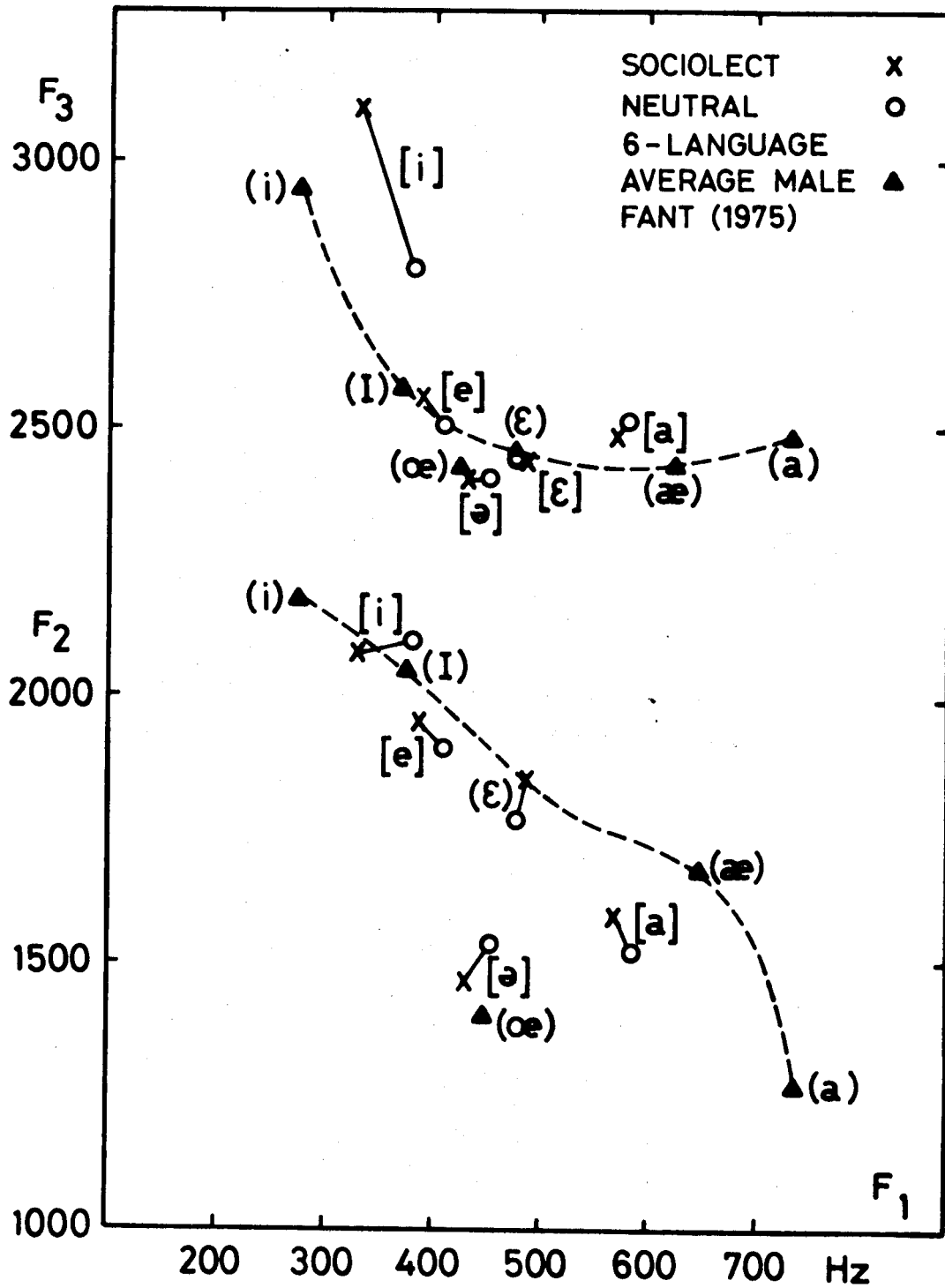


Fig. I-A-2. Parisian female vowels normalized to male standard and compared to Fant (1975) six language average male data.

The consequences of the non-uniformity of the [a] vowels in the neutral group with respect to stress position has been evaluated. We have found that in stressed positions the [a] vowels attain on the average 70 Hz higher  $F_1$ , 50 Hz lower  $F_2$ , and 60 Hz lower  $F_3$  than in unstressed positions. The effect on our normalizing procedure is of the order of 0.4 % in the sociolect/neutral scale factor which is marginal only.

With regard to duration, it may be observed that some vowels are very long, others very short in both sociolects. In fact, duration can vary a great deal in a French conversation, owing to several factors (position of the word in the sentence, hesitation in the speaker's thought, etc.). Therefore it would be difficult to say whether there is any correlation between the duration of a vowel and the formant patterns. Furthermore, the great variability does not permit a representative estimate of the difference in sociolect and neutral vowel duration.

From Fig. I-A-2 we may in addition extract some information on the relation of these French vowels to the Fant (1975) male reference vowels. The first condition to bear in mind is that the latter pertain to isolated or otherwise stressed words whilst the present French study is concerned with connected speech. Coarticulation and vowel reduction can therefore be expected to influence the data appreciably and what we see is actually effects similar to those reported by Fant, Stålhammar and Karlsson (1974). Thus, in terms of  $F_1$  and  $F_2$  the French [i] vowels are closer to the reference [I] than to [i]. However, the high  $F_3$  remains a specific characteristic. The French [e] is quite similar to the reference male [æ] whilst the French [a] is a centralized version of an [æ] vowel.

Most vowel formant studies refer to male subjects. This study is an exception with female subjects only. It would be of interest to have groups of males from the two sociolects included in a future study to compare with the data we have derived by a female-male normalization of our female data. It is not evident that males display the same sociolect patterning as females.

We also need a more complete set of vowels. With comparable data on both females and males it is possible to obtain further experience on the outcome of the normalization procedure. Meanwhile we have to be content with the transformed female data which occupy reasonable positions within the male reference  $F_1$ ,  $F_2$  and  $F_1$ ,  $F_3$  diagrams.

Remarks about vowels [u] and [o]

Data on vowels [u] and [o] have not been included in this study, since we lacked strictly comparable populations of subjects and utterances. The following tabulation from Mettas (forthcoming) exemplifies formant frequencies of female [u] and [o] for one sociolect subject and one subject from the group of neutral pronunciation.

	Neutral		Sociolect	
	[u]	[o]	[u]	[o]
F <sub>1</sub>	435	490	390	430
F <sub>2</sub>	1030	930	800	865
F <sub>2</sub> -F <sub>1</sub>	595	440	490	435

It can be seen that the formant frequency distance between [u] and [o] is rather small in both subjects, the main difference being found in F<sub>2</sub>-F<sub>1</sub>. The sociolect subject has typically lower F<sub>1</sub> and F<sub>2</sub> than the neutral subject indicating more pronounced liprounding. Also the [u]-[o] contrast is smaller in the sociolect than in the neutral pronunciation.

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