SOME ACOUSTIC DATA ABOUT THE THREE BASQUE SIBILANTS

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Txillardegi

1 — Basque has **three voiceless sibilants**:

1.1 [s], predorso-alveolar, usually written «z» in Basque.

Its pronunciation varies from dialect to dialect. Normally it is very strident, especialy in the Eastern dialects of the Basque area.

1.2 [ś], retroflex, usually written «s» in Basque.

In the Western dialects (Biscaian) the normally contrastive phonemes /z/ and /s/, merge into an apico-alveolar [ś], very close to Castillian «s». But in America and South of Spain, Span. /s/ is pronounced as [$\underset{c}{s}$]. Basque being in contact with Castillian, the interference pushes the Basques to utter /s/ as apico-alveolar. But old people, especially in the East of the country, pronounce «s» as a retroflex [$\underset{c}{s}$].

1.3 [ʃ], predorso-prepalatal (or alveo-palatal); usually written «x» in Basque.

1.4 For normal Basque we can write:

$$s = \begin{bmatrix} + \text{ distr.} \\ + \text{ ant.} \end{bmatrix}$$

$$s' = \begin{bmatrix} -\text{ distr.} \\ -\text{ant.} \end{bmatrix}$$

$$ʃ = \begin{bmatrix} +\text{ distr.} \\ -\text{ant.} \end{bmatrix}$$

1.5 *There are the correlative affricates,* [ts] , [tś] , [tʃ] , *respectively written in Basque* «tz», «ts», and «tx».

Not exactly in the same way; but «tz» and «ts» merge in Biscaian dialect.

1.6 It seems that [ś] and [ʃ] sound alike to foreigners, or so. But Basques distinguish them without any difficulty:

«seme» [śeme] (= son) vs. «xeme» [ʃeme] (= dear son)

As Amado Alonso pointed out longtime ago ('Consonantes de timbre sibilante en vasco baztanés', 1922) [ś] is perceived, by French speaking people, as intermediate between Fr. «ss» and Fr. «ch»; and by Spanish speaking people, as intermediate between their own «s» and French «ch».

It would be interesting to find out the truth of those old assertions, by means of the acoustic spectra of the three contreastive sibilants.

2 — **Spectrograms**

We recorded the sibilants of four Basque informants living now in California (Reno and Los Angeles):

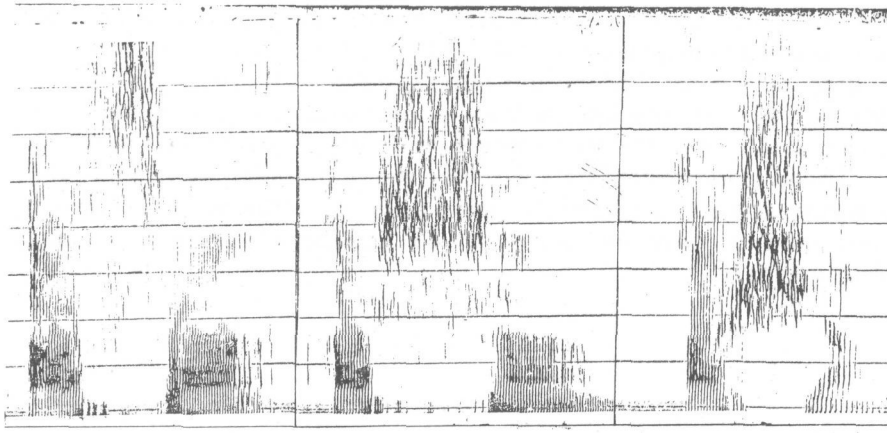
1 - J.F. - Female.
2 - G.A. - Male.
3 - A.E. - Male.
4 - J.L. - Male.

G.A. is a Biscaian native speaker; so he has a tendency to merge [s] and [ś] into [ś]. We must keep this fact in mind (even if he tried to distinguish the sounds for our purpose).

2.1 We recorded at U.C.L.A. (Phonetics Laboratory; 1982, Nev. 28) these Basque real words:

«hazi» [asi] (= to grow).
«hasi» [aśi] (= to begin).
«gaxo» [ga ʃ o] (= sick).

Previously we recorded (Inf. 1, J.L.) the stems: *«aza, asa, axa»*. And we obtained the following spectrograms:



(Inf. J.L.)

We found, as expected, that the noise-band goes down from [s] to [ʃ]. The sonagraph Kay Electrometrics, Type B/65, gave us for each sound:

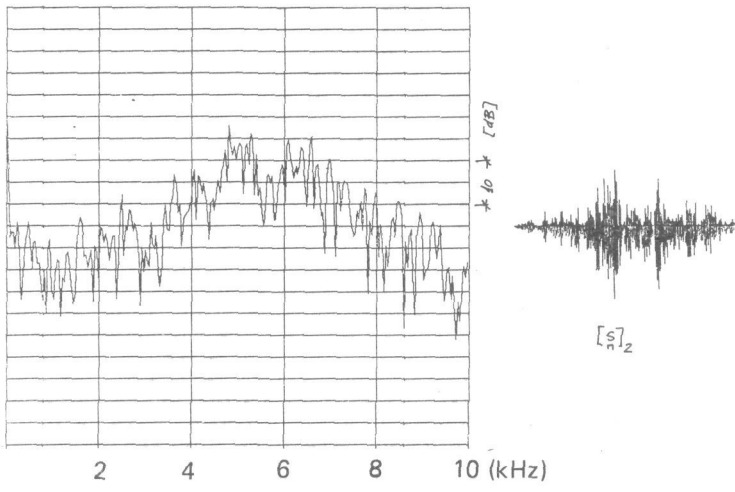
[s] (in «aza») 6,000 [Hz]
[ś] (in «asa») 3,500 [Hz]
[ʃ] (in «axa») 2,200 [Hz]

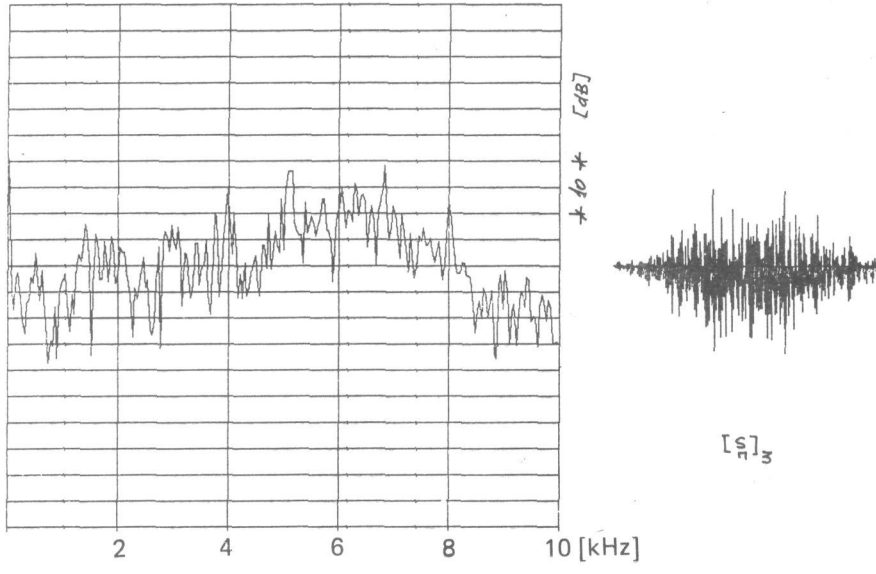
But we could not know the distribution of the energy in the different frequencies: even the blackness of the successive bands is proportional to the intensity [dB] for each frequency band, this is not enough to give any accurate data about the intensity/frequency spectrum.

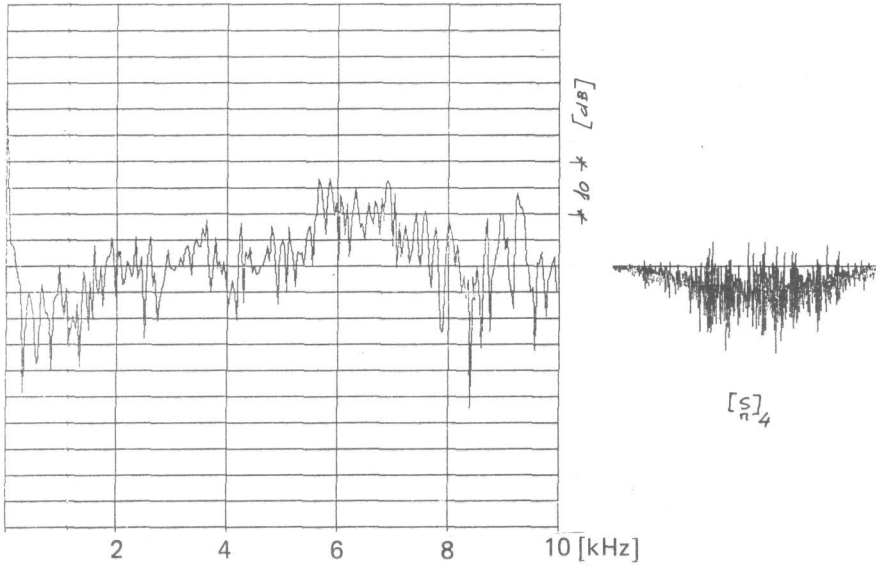
On the other hand, the spectrograms for the female speaker (especially for [s]) became really very weak, almost white; because the main energy of the sound is probably above 8,000 [Hz]; and even above 10,000 [Hz].

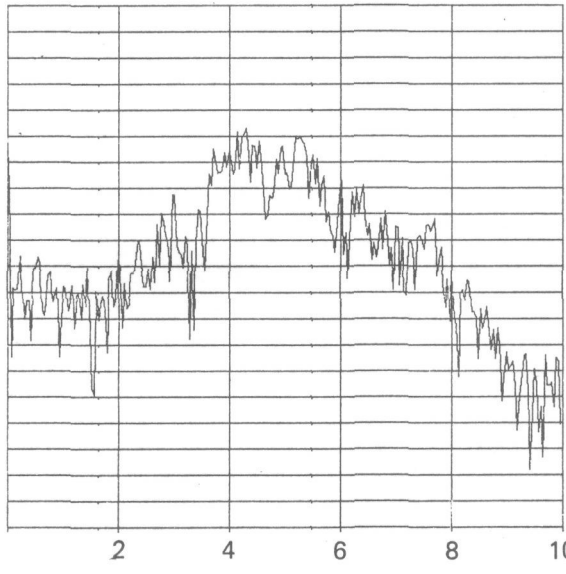
2.2 So, to obtain a more accurate spectrum of the formants, we decided to go to those spectra *directly from the wave form*, through the *computer* LSI 11/23, and the program for *Fourier analysis*; the utterances being played to it at half speed. Following this program, written by Hector Javkin, and after storage of the fricative data on floppy diskettes, the Critical Band analysis gave us the eleven spectra endosed here (the first sibilant was lost within the calculations).

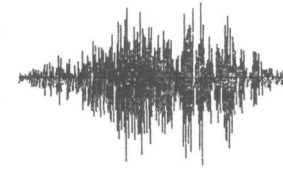
The mathematical filters simulate the human ear assymetry; with a slope, at each band, of 27 [dB/octave] towards the low frequencies, and a different slope of 43 [dB/oct] towards the high frequencies.



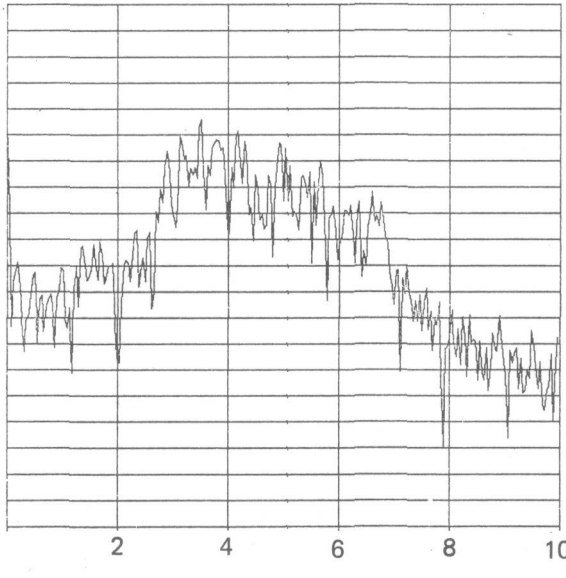

+10 +
[dB]
2
4
6
8
10 [kHz]
[s]u 3

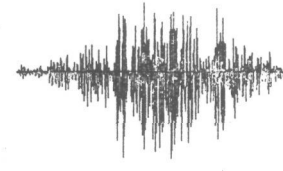

+10 +
[dB]
2
4
6
8
10 [kHz]
[s]u 4



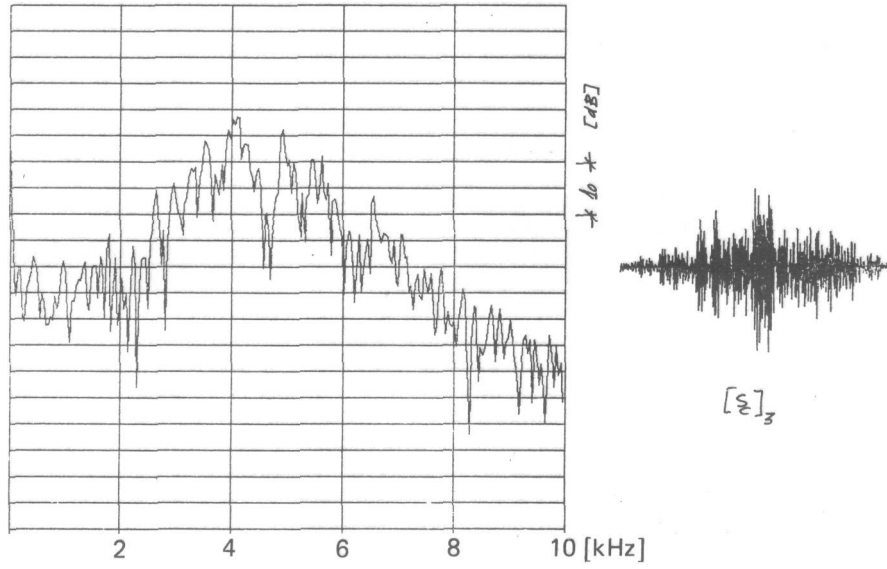


[ʃ]₁

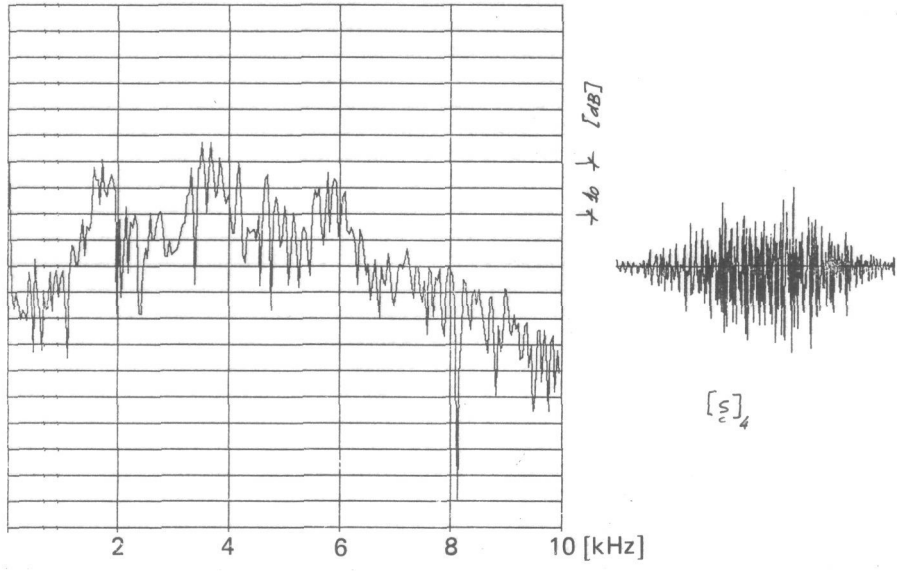




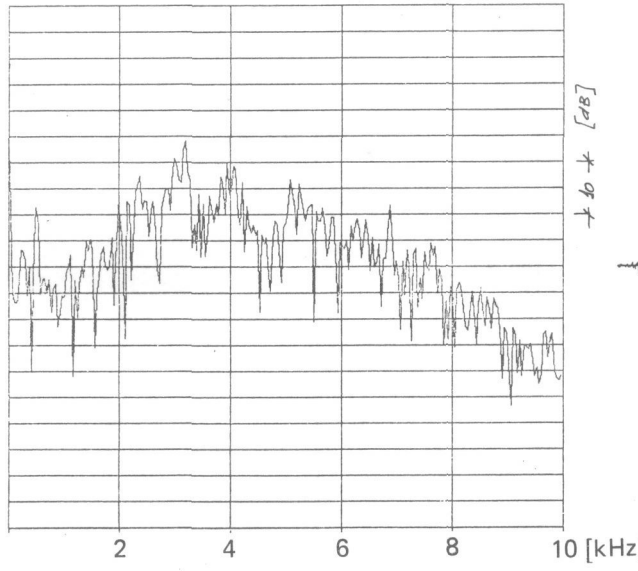
[ʃ]₂

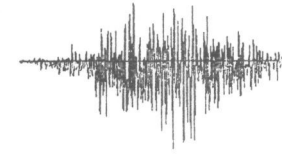


[ʃ]3

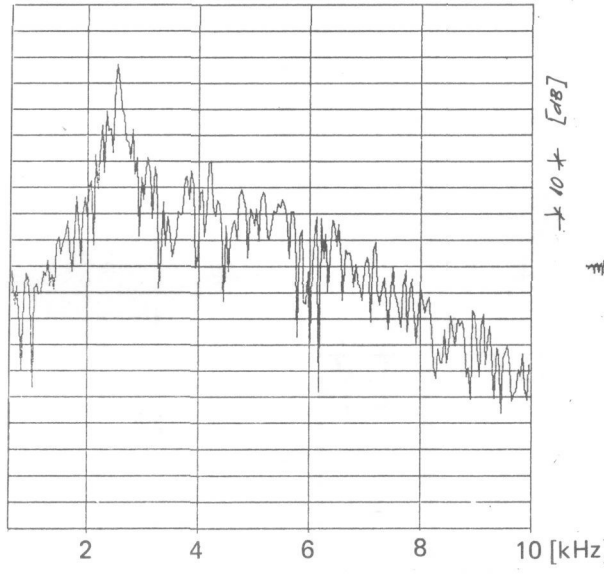


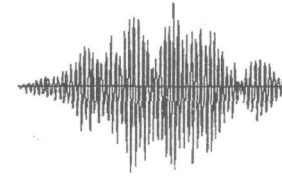
[s]4



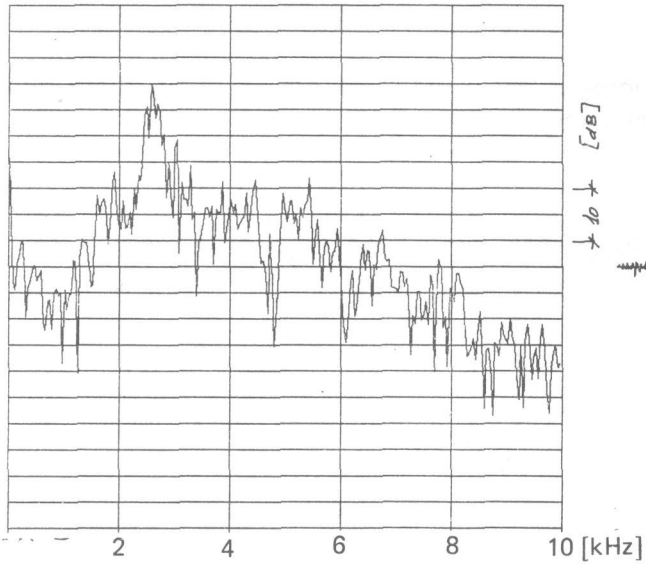


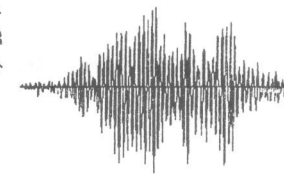
[ʃ]$_1$



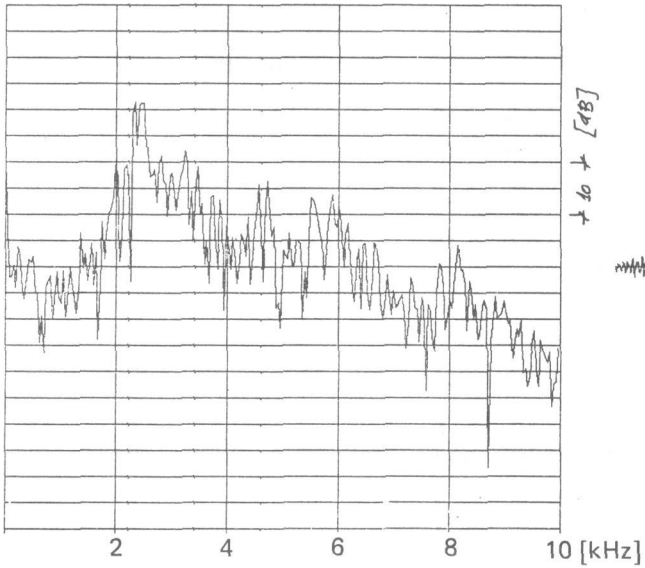


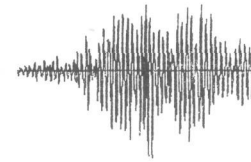
[ʃ]$_2$





[ʃ]$_3$





[ʃ]$_4$

3 — The computer results

3.1 In order to compare the results, we are grouping them into average curves. (Male inf.: 2, 3 and 4).

/z/ [s]

	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
2	—10	— 8	— 3	+ 4	+15	+13	+ 9	+ 0	— 7	—15
3	— 8	+ 0	— 1	+ 0	+ 7	+ 7	+ 3	+ 0	— 7	—11
4	— 9	— 1	+ 0	+ 1	+ 1	+10	+ 7	— 4	+ 2	— 6
	— 9	*— 3*	*— 1*	*+ 2*	*+ 8*	*+10*	*+19*	*— 1*	*— 4*	*—11*

(These values are *relative* intensities, in [dB] for each frequency).

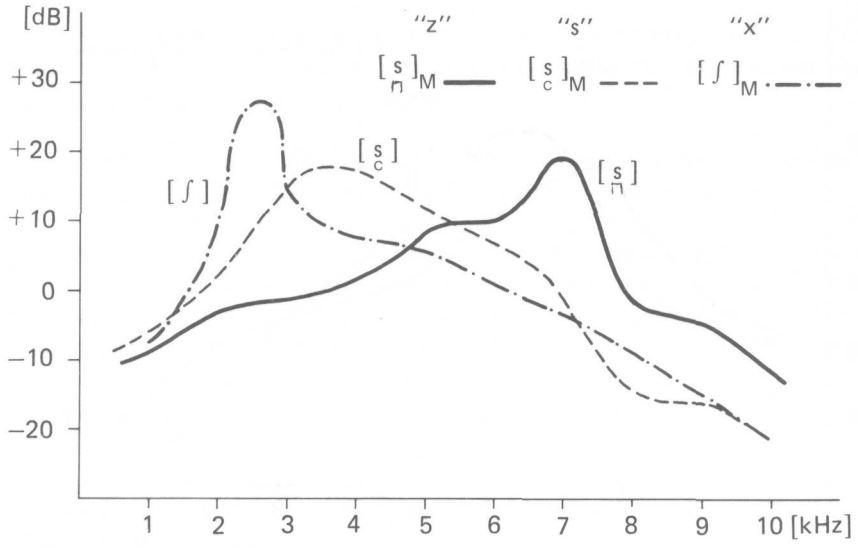
/s/ [ś].

	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
2	— 9	— 2	+15	+14	+13	+ 6	— 1	—15	—19	—22
3	— 6	— 2	+10	+20	+18	+ 8	+ 2	— 8	—16	—22
4	— 4	+12	+10	+16	+ 6	+ 8	— 1	—20	—12	—20
	— 6	*+ 3*	*+15*	*+17*	*+12*	*+ 7*	*+ 0*	*—14*	*—16*	*—21*

/x/ [ʃ]

	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
2	— 6	+14	+10	+10	+ 6	+ 0	— 1	—12	—16	—22
3	— 8	+ 8	+20	+10	+11	+ 1	+ 0	— 8	—16	—20
	— 6	+ 4	+16	+ 1	+ 0	+ 3	— 6	— 6	—14	—20
	— 7	*+ 9*	*+15*	*+ 7*	*+ 6*	*+ 1*	*— 2*	*— 9*	*—15*	*—21*

And we obtain the diagram:



The peak of intensity maximum is different for the three:

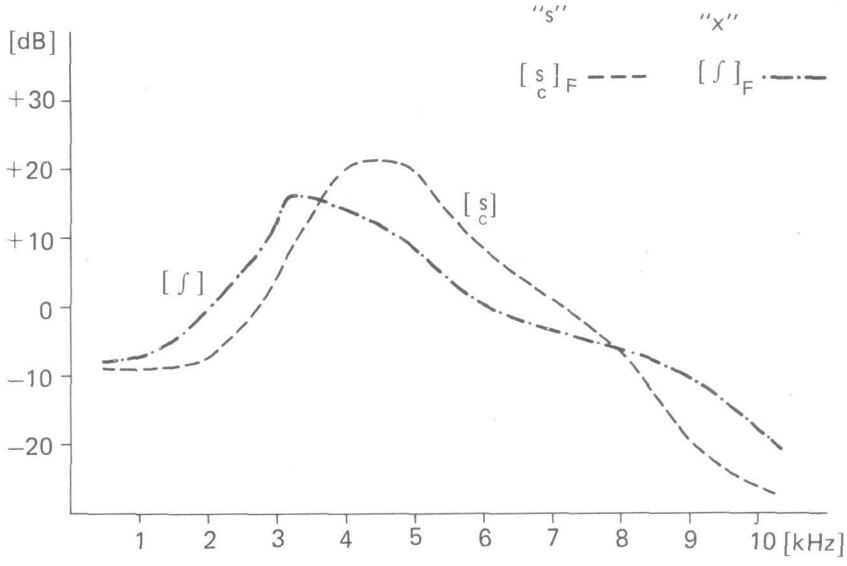
[s] 7,000 [Hz]
[s] 3,600 [Hz]
[ʃ] 2,500 [Hz]

The curve shows a very clear peak in [ʃ]; the two others being less marked. Their form is different for each of them.

3.2 Female results:

	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
[s]	— 9	— 7	+ 4	+20	+20	+ 8	+ 1	— 6	—20	—26
[ʃ]	— 7	+ 0	+12	+14	+ 9	+ 0	— 3	— 6	—10	—17

and we have the curves:



I don't know why the peak is less clear here than for the male informants. But the relative position is the same, and the general shape is similar.

If we compare the frequencies of the peaks (female and male), we have:

$$\text{for } [\,{}^{s}_{c}\,] \qquad \triangle = \frac{4500}{3600} = 1.25$$

$$\text{for } [\,\int\,] \qquad \triangle = \frac{3200}{2500} = 1.28$$

It seems to be a systematic deviation related to the relative sizes of the vocal tract; the coefficients (1,25 and 1,28) being slightly high, but rather normal.

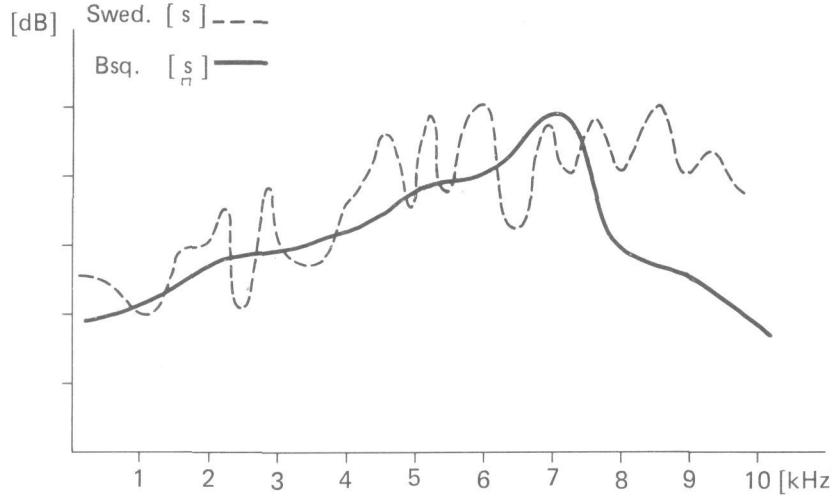
4 — **Basque and Swedish sibilants**

It is unusual in Europe to find a language having *three* contrastive sibilants. I think the only one in that situation is Swedish. And we are giving some comparisons.

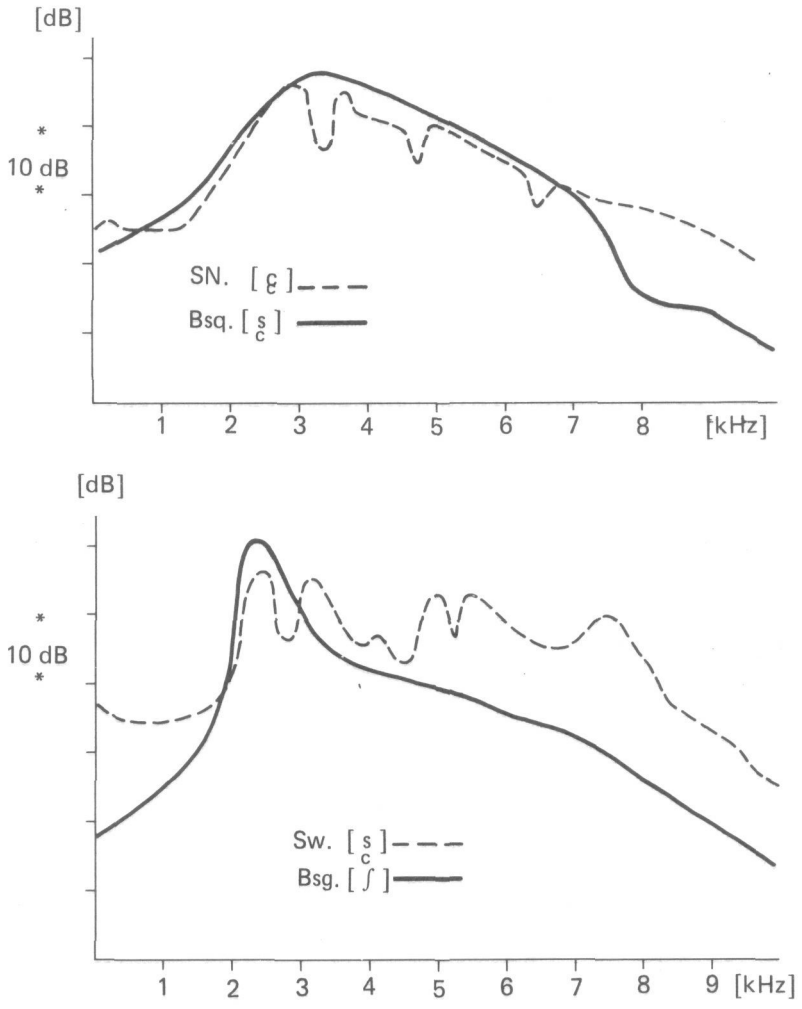
The data about Swedish come from *'Speech Sounds and Features'*, spectra of Fig. 17, page 62; Gunnar Fant, M.I.T., 1973.

When I listened tothese three sibilants, performed by Gunnar Fant himself, I found them rather different from the Basque ones. But now it is possible to compare them (the [s] sound-spectrum is «not typical», in his opinion (p.61)). Ours are provisional, of course.

We are giving here the curve-couples, for [s̻], [s̺] and [ʃ] s̻ .



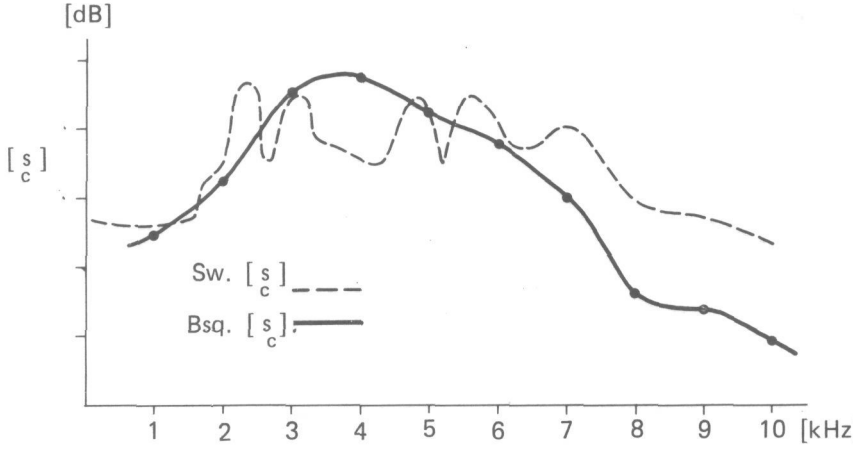
From an acoustical point of view, the sounds are not far from each other.



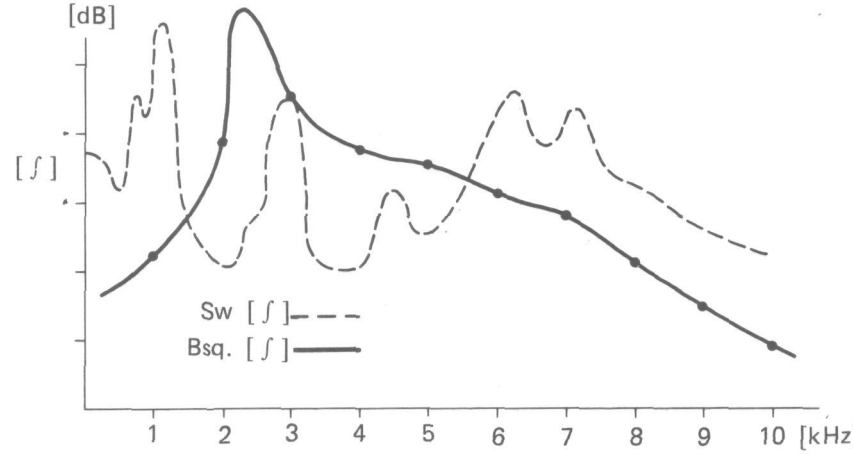
Basque [s̬] and Swedish [ɕ] seem very close to each other. Bsq. [ʃ] and Sw. [s̬] are relatively similar as well; but the Sw. sound does not have the peak Basq. has between 2000 and 3000 [Hz].

When I listened the sound, I had the impression of a more palatal fricative than ours.

Los Angeles, 1982, March 20th.



It seems that Bsq. [ʂ] does not have this sort of hole between the two plateaus of 2,000-3,000 [Hz] and 4,600-5,600 [Hz]. Apparently Basque has a peak that Swedish does not have; belonging to different cavities.



Same remarks: the curves are quite different. The very clear peak of the Basque alveo-palatal does not exist in Swedish. When I listened the sound, I had the impression of a sound more palatal (further back) than ours.

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