ACOUSTICAL CHARACTERIZATION OF A PALATINE PLATE

F. Plante (*), C. Berger-Vachon (**), I. Kauffmann (*), L. Collet (*).

(*) Hôpital E. HERRIOT, Lyon, France
(**) Université Lyon I, Villeurbanne, France

ABSTRACT

In this communication, the authors perform a first analysis of the effects of a palatine plate on the phonation. The first four formants of the french vowels /a/, /i/, /u/, /ə/ have been studied.
The acoustical differences between the two configurations are pointed out.

1. INTRODUCTION

During the last few years, the phonatory pathology have been heavily studied. A good cooperation between scientific and medical teams is necessary to achieve efficient investigations. Under this assumption, a voice processing laboratory had been implanted in the otorhinolaryngology department of the Edouard Herriot hospital of Lyon, and in one place all the necessary skills to study these pathologies are met.
Several ways can be taken to perform these investigations [2,3]. The analysis of the acoustic wave had been chosen, as it is harmless for the patient.
The voice pathology is a very wide topic [5] and complex mecanisms are involved. The speech processing method described in this paper had been tested in a very simple situation in order to assess its efficiency : the presence or the absence of a palatine plate in a patient suffering of a palate agenesia should modify the phonation. This acoustical study had been carried out for its connection with velar incompetency. The patient who collaborated with this study is a 54-year old woman. Differences between the two cases (with or without the plate) come only from the palatine plate and are free of the patients' diversity.
The analysis of the influence of the pathology can be done with two techniques :
- the discrimination : the separation of a pathological voice from a normal voice is studied,
- the characterization : parameters quantifying normal and pathological voices are evaluated.

These two means do not imply absolutely the same tools.
In a preceeding work [4] we have seen that cepstral coefficients led to the best classification results, but they cannot be easily interpretated when phonatory mecanisms are involved. This present paper is aimed to point out the influence of the palatine plate on some classical parameters of the voice. The first four formants of the voice had been studied for the cardinal and the neuter (the "schwa") french vowels.

2. MATERIAL AND METHODS

To avoid coarticulation problems, vowels had been spoken in a standard context; the sentence is "C'est *x* ça" (this is *x* that), where *x* is the vowel. The patient spoke forty-three times the sentence with the plate, and also forty-three other times without the plate. The recording was made in an anechoic room.
The signal coming from the tape was then filtered (10 KHz) and sampled (20 KHz) on a data acquisition card. Samples were kept on the hard disk of a micro-computer for futher analysis. The I.L.S software (Interactive Laboratory System) had been used. Firstly , vowels had been marked in the signal and a sliding linear prediction analysis (LPC) was performed; the LPC was made on a 10 ms window, moved by 4 ms steps over the vowel (120 ms). Consequently 28 analyses were obtained and each analysis led to a set of LPC coefficients [1]. The average of the 28 sets gave the final representation of the utterance.
A fundamental question is raised by the way of processing the data : is a shift due to the formant values (coming from the LPC) or is it due to the speech variability ? The problem is even more harder when pathological voices are considered.
In this work the utterances which led to abnormal coefficients had been removed out of the study. We have labelled "abnormal" the utterances leading to detached values far from the average; distributions had been plotted for this purpose. Eventually four utterances were removed for the /a/ and the /i/, eight for the /u/ and thirteen for the /ə/.

3. RESULTS

Table 1 shows, for the four vowels, the average of the formant values. In each cell of the table the first figure is for the utterance without the plate, and the second (in italic) is with the plate. The asterisk (*) indicates that the difference between the two figures is not significant.

Table 1 : Average values of formants

	F1	F2	F3	F4
/a/	832 *571*	1647 *1445*	2776 *2332*	4158 *4057*
/i/	*279 **305*	*1621 **1584*	2613 *2859*	3778 *4137*
/u/	319 *282*	*1229 **1229*	2616 *2513*	*4069 **4007*
/ə/	567 *435*	2025 *1884*	2990 *2647*	*4251 **4182*

4. DISCUSSION

Only /a/ leads to a significant difference for the four formants. This result agrees with a preceeding study which stated that the /a/ gives the best discrimination [4].
The behaviour of the vowel /i/ is unlike the three other vowels. The value of the fomants are lower without the plate and the biggest difference occurs with the third (F3) and the fourth (F4) formants. For the other vowels /a/, /u/ and /ə/ the third, mostly, and the first formants are also modified.
It must be kept in mind that none of the two situations is normal; when the patient wears her palatine plate, the nasal and buccal cavities are parallel leading to a nasalisation with formants

and antiformants. Figure 1 shows a representation of the vowels in the (F1,F2) plane. The utterances with the plate lead to formants close to a normal nasality (300-500,1000 Hz).

4.1 Vowels /a/, /u/ and /ə/

The decrease of the first formant is more important for the /a/ (261 Hz) and the /ə/ (132 Hz) than for the /u/ (26 Hz). This drop can be attached to the nasal formant, N1 (250-300 Hz), and there is a confusion between F1 and N1. The same situation occurs for the /u/; the resulting peak is still in the same range. On the contrary, for the /ə/ and the /a/ the merging of N1 and F1 lowers strongly the position of the peak.

The drop of the second formant, can come from the antiformant lying in the 2200 Hz range. This drop is lighter for the /u/ than for the /a/ (202 Hz) and for the /ə/ (141 Hz) probably because the second formant is not in this range.

The third formant indicates, for the vowels, the rounding of the lips; dramatic drops can be underlined for the /a/ (440 Hz), and for the /ə/ (330 Hz). The diminution wich was observed is, so far, difficult to explain. This drop could be linked to the opening of the vowels (as it is more important for the /a/).

Generally the fourth formant is said to be "speaker dependant". The drop is significant only for the /a/ (101 Hz).

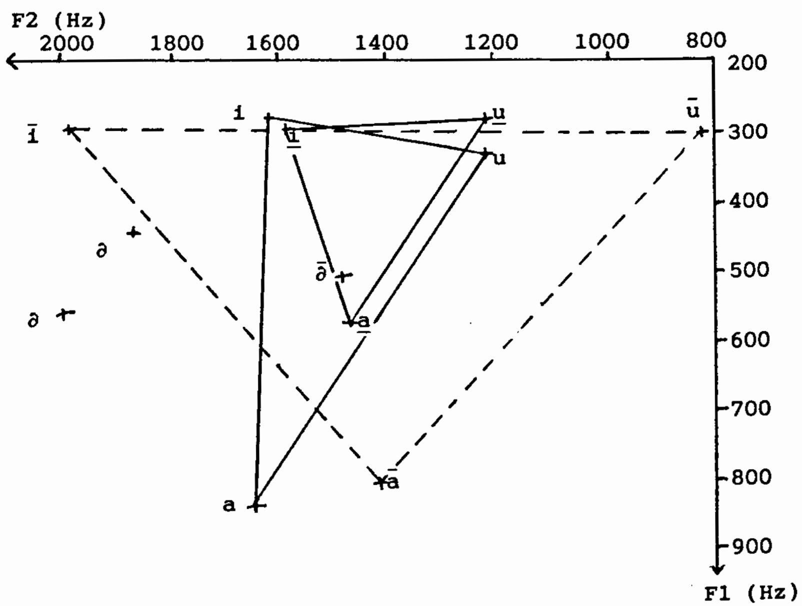

Figure 1 : Schematic vowels representation in the (F1,F2) plane. Vowels spoken with the plate are underlined; vowels overlined are for normal phonation. The third case is without the plate.

4.2 Vowel /i/

The behaviour of the /i/ is much peculiar. The first and the second formants are not significantly modified. The first nasal formant is in the range of the first buccal formant; therefore their merging does no lead to a significant modification of F1. The 2200 Hz antiformant does not have a great influence on the value of F2. It can be pointed out that the second formant of the /i/ is not as high as usual (normal values are about 2000 Hz). This /i/ has the values of a normal /Y/.

The third formant is pulled up (246 Hz) under the influence of the 2200 Hz antiformant.

5. CONCLUSION

The presence or the absence of the palatine plate do not have the same influence over all the vowels formants, but the two situations can be acoustically distinguished. Some more work is needed to provide a more accurate analytical description of the influence on the spectrum of the mecanisms involved in the phonation with a palatine plate : higher formants can be considered and the bandpass of the formants have their own information too.

The best discrimination, on an acoustical ground, can be performed with the utterance of the vowel /a/; this is worthy to be more deeply studied, when velar incompetency will come under scrutiny.

6. REFERENCES

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