THE THREE DEGREES OF LABIALISATION OF THE FRENCH STEADY-STATE VOWELS
A study for 105 speakers

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ABSTRACT

We study frontal lip-opening shape for the 14 steady-state French vowels pronounced by 105 native speakers: A few well-known common facts are first confirmed.

Interestingly, data reveal that although French vocalic labiality is described in terms of a binary phonological feature (+/-round), articulatory processes show 3 degrees of labialization, i.e. rounded [-lab], rounded [+lab] and hyper-rounded [++lab]. Splitting of the traditionally labialized category does not seem to have been considered before.

Observation of the shape-factor variations (K2=A/B) shows that either a flat or a rounded frontal lip opening may be indiscriminately used for any class. Further, relating labial data to X-ray sagittal view of the vocal-tract leads to interesting remarks about compensatory behaviour in vowel production.

INTRODUCTION

It is a common fact that lips play a great part in speech production. As far as French is concerned, studies have been realized in various directions such as articulatory phonetics, E.M.G., coarticulation, acoustics, etc.: [3,4,5,6,9].

In 1980, an International Seminar on Labiality took place in Lannion-France [12], and the same year, the Institut de Phonétique de Grenoble issued a book named Labialité et Phonétique [2].

Since then, other studies have been published, either about descriptions [17, 19], E.M.G. [11,7], articulatory modelling [14,1,15], or data acquisition and treatment [20,13].

Some of these studies showed that behind the apparent simplicity of a mere binary phonological feature, i.e. spread vs rounded, there seemed to be a more complex activity of the lips, especially due to consonantal context.

For instance, a third degree of lip rounding for spread vowels labialized by consonants [j] and [g] was observed [9]. The same influence from bilabial consonant [b] was also described [18].

These phenomena are fairly systematic, but they are simply phonetic variants and are not phonologically pertinent.

Therefore, we would like to mention here other processes which seem to be also phonological and that do not seem to have been described before.

A few years ago [19], we already pointed out the decisive role of labialization for certain articulations, particularly for lower vowels such as [a, o, â].

One must admit that these vowels are produced with a rather similar tongue shape. Hence, the acoustical differentiation must come from other articulatory characteristics such as nasality or labiality:

- nasality for [a, 2] vs [â, 3].

Now, knowing that [3] and [â] have about the same degree of labialization, one must admit that [5] will have to be much more labialized than [â] in order to keep a difference. So, we had to accept the interesting evidence that there are undoubtedly 3 degrees of labiality for French vowels as opposed to the 2 commonly described. We called them:

[-lab] : [a]
[++]lab] : [5] (named "uper rounded")

Then, we noticed that all previous studies on French only included 4 or 5 vowels as opposed to the 15 in the vocalic system. Therefore, we decided to investigate more precisely in that field.

The present study deals with 14 steady-state vowels uttered by 105 native speakers of both sexes. As a whole, this amounts to 1238 realizations. Basic documents are frontal labial pictures. Shape acquisition and digitalisation are made using a graphic tablet linked to a computer. Data may be then easily processed.

The chosen parameters are those which proved to be the most pertinent in the above mentioned references (fig.1): Fig.1:

Frontal view of lip opening: parameters.

- A: horiz. spreading
- B: vertical opening
- S: interlabial area
- K2=A/B: shape factor
LINEAR VARIATION OF LIP AREA

First, our results confirm that there is a linear relation between lip area $S$ and the product $AxB$ (fig.2):

$$S = K_1 \times AxB$$ (1)

This equation was already proposed by FROMKIN(64) for the 12 American vowels pronounced by 5 subjects. It had since been verified for French by ZERLING(79a) for 7 vowels and 2 speakers, and by ABRY & BOE(86) for 5 vowels and 5 speakers.

Our data clearly confirms that the relation is independent of:
- the speaker and his sex,
- probably the spoken language,
- the sound and its context.

For our corpus, the average value of $K_1$ is about 0.71 against Fromkin's 0.70:

$$S = 0.71 \times AxB$$ (2)

THREE DEGREES OF VOCALIC LABIALIZATION

The utterances studied have been plotted in $(A,B)$ coordinates (fig.3). It appears that the commonly accepted binary labial feature is totally contestable in terms of articulation: the vowels are clearly divided into 3 groups, not into 2. The third group results from the division of the so-called "rounded" vowels into 2 uncontestable distinct categories.

Not even one single case of confusion does exist between groups [-lab] and [+lab]. We shall refer to these three categories respectively as:

1 - non-labialized
   - [-lab] = [i, e, è, a, E, oë]
2 - labialized
   - [+lab] = [oe, o, ë, ë, oe]
3 - strongly labialized
   - [++lab] = [y, o, u, o, 5]

It is remarkable that the three most frequent nasal vowels [E, ë, 5] should each belong to one separate category (fig.4). Only [oe] spreads across [-lab] and [+lab].

FRONTAL SHAPE OF LIP OPENING

For each picture the value $K_2 = A/B$ was computed. It may be considered as a shape coefficient that reveals the spreading (high values of $K_2$) or the rounding (low values) of the lip hole, whatever its size. All the values of $K_2$ have been plotted for each vowel (fig.5). One will notice that none of the vowels and consequently none of the categories appear to be characterized by one particular shape of the lip hole (i.e. one particular $K_2$ value). For each vowel, $K_2$ varies somewhat between the same limits.

On the opposite, it is to be noticed that very different lip holes may be used for each vowel, and therefore for each category, starting from a very flat opening down to a rather rounded one.

This definitely goes against the traditional "rounded" and "spread" terminology. Clearly, in articulatory phonetics and as far as the lip hole shape is concerned, terms like those we have been using would seem more accurate. Indeed, symbols such as [-lab], [+lab] and [++lab], and the associated descriptions given above, reflect more precisely strategies and not merely shapes.
DISCUSSION

A classification of French vowels according to the three degrees of labiality is given on fig.6. Horizontal separations have been added which depend on the general tongue position, and at times on nasality.

<table>
<thead>
<tr>
<th>labialization</th>
<th>-lab</th>
<th>+lab</th>
<th>++lab</th>
</tr>
</thead>
<tbody>
<tr>
<td>high &amp; back</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>high &amp; front</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>medium &amp; front</td>
<td>e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>medium or low &amp; pharyngeal</td>
<td>a</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nasal &amp; front</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>nasal &amp; back</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>286</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig.6: Articulatory characteristics of vowels: degree of labialization, tongue position and nasality.

First, it must be noticed that phonologically speaking, the labial binary feature is not invalidated, since vowels /i, e, E, E/ are respectively opposed to /y, o, oe, oe/ (dotted lines).

Yet, from an articulatory point of view, there are obviously three degrees of vocalic labialization in French, i.e. non-labialized, labialized and super-labialized.

Interestingly, one will observe on fig.6 the existence of several non-conventional oppositions which are yet based on labial feature (double arrows): [a-0], but also [oe-0], [o-o] and [a-3].

This can be admitted if one knows that tongue position can be very similar for both sounds of each pair. This has been previously described and acknowledged by [8,p.287-288]. The opposition [o-o] is particularly interesting since it looks like that of [E-oe], but is definitely realized with two respectively different degrees of labialization.

Further, it will be noticed that the same degree of labialization is generally associated to vowels of rather different lingual articulation, whereas similar tongue-shape require more distinct lip shape and opening.

The observations put forward here are particular to French vowels. As was said, they rather belong to the phonetical domain, eventhough they may sometimes be phonologically interpreted. Therefore, among the possible applications, one might for instance use them while teaching French language to foreigners, or include them in articulatory modeling commands.
REFERENCES