DAF EFFECTS ON STUTTERERS VOICE QUALITIES
AND VOWELS SYSTEMS

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ABSTRACT

Five French-speaking normal subjects and five French-speaking stutterers have been recorded in two
conditions (reading task and map task), under four DAF delays. The formants
frequencies of vowels /i/, /a/ and /u/ have been measured. Their statistical
analysis suggests important
articulatory changes in stutterers
between the two conditions under the
80 ms delay.

INTRODUCTION

In 1950, Lee found out that a
delayed auditory feedback (DAF) can
induce a speech trouble ("artificial
stuttering") in normal subjects. This
effect is now known as the Lee-effect.

On the other hand, other studies showed that DAF can improve
stammers’ fluency [1,2,3]. Authors suggested that the delay
inducing the maximal trouble in normal subjects is within the
120-160 ms range. It is generally estimated that a DAF delay of ca. 80
ms causes the most spectacular effects on stammers’ speech.

Different researchers have argued that these effects might be related to
speech modulations induced by DAF, such as extension of the production
length, slackening of speech, and increase of the fundamental frequency
[1,2,3,4,5].

Most research in this field has nevertheless involved English language; very few information is
dedicated to French, which is less affected than front- and medium
vowels. In normal speakers, /u/ is the least affected vowel, while /i/ and /a/
are taken into consideration in this paper, since they are affected by DAF.

In this paper we will therefore study the
repercussions of speaking styles
and DAF delay variations on the
vowels systems of French-speaking
stutters.

EXPERIMENTAL SETTING

Ten French-speaking male subjects
have been recorded. Five were normal,
although the other five suffered from
stuttering.

Two kinds of tasks were presented to
the subjects. In the first one ("reading task"), the experimenter had
the speakers read an extract drawn from a modern French novel. In the
second one ("map task"), the subjects were asked to explain to a remote
interlocutor how to travel from a
given city to another. For this
purpose, they were given a map
indicating the names of the cities to
reach, the types of roads, the
special details (bridges, rivers,..), etc.
The imaginary travel and the map
were specially conceived to have the
subject speak as much as possible.

Each task was carried out under
differing conditions of auditory
feedback: normal (condition 1),
delayed auditory feedback (DAF
conditions). Three delays were used,
i.e., 80 ms (condition 2), 120 ms
(condition 3), and 160 ms (condition 4).

Each subject had therefore to read
4 texts and to describe 4 journeys.

The delay was obtained by means of the
Kay CSL 4300 DAF routine. All
the recordings were performed in a
sound proof room at the Phonetics
Laboratory of the University of Mons,
by means of a Neumann U87 P 48
microphone, connected to a Sony 501
ES PCM coder. The digitized sounds
were stored on a Panasonic VHS
video recorder.

A sample of 240 vowels was
extracted from the recorded corpus.

In order to evaluate the centralizing
tendencies, and to assess their
dependances upon the speakers types
(normal vs stutters) and the DAF
durations (0 ms, 80 ms, 120 ms, 160
ms), we processed them in a way
inspired of Harmenegies and Poch [6,7].

Each vowel from the reading task was
paired with the same vowel from the
map task, drawn from the same
subject, under the same DAF
condition. We therefore obtained 120
pairs of vowels (10 speakers x 3 vowels
X 4 DAF delays), each pair being
characterized by two first formants
frequencies and two second formants
frequencies.

The results are calculated as average
formants frequencies of the vowels in
the reading- (circles) and the
map- (triangles) tasks.

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The formants values were converted
to mels, prior to the statistical
processing, by means of formula (1):

\[ f_{mel} = 2595 \left[1 + \frac{700}{f_{Hz}} \right] \]

where \( f_{Hz} \) is the frequency in Hertz, and \( f_{mel} \) is the frequency in mels.

We thereafter computed a
centralization index, \( \delta \), following
the equations (2) to (4):

\[ ED_{map} = \sqrt{(f1-\phi_1)^2+(f2-\phi_2)^2} \]

\[ ED_{read} = \sqrt{(f1-\phi_1)^2+(f2-\phi_2)^2} \]

\[ \delta = ED_{map} - ED_{read} \]

where \( ED \) stands for Euclidean Distance, \( \phi_1 \) and \( \phi_2 \) are the grand
means of the first and second formants across the whole data base,
\( F \) symbolizes formants values for the
map task, \( f \) for the reading task,
and overlining denotes averaging.

As can be observed in table 1, which
gives a statistical summary of the
computed values, \( \delta \) is positive in all
cases, confirming an overall tendency
of the formants values to centralize in
reading speech, relative to speech
under the map task.

Back vowels seem, on the whole,
less affected than front- and medium
vowels. In normal speakers, /u/ average
\( \delta \) value is close to zero, suggesting the
existence of quasi invariant
articulatory gestures, whatever the speaking style. For stutterers, [u] δ value is nevertheless hardly 6 times as great as the one for normal speakers; it seems therefore that articulation of the back vowels can be affected by speaking style in stutterers, although it is not the case in normal subjects. This could be related to efforts involving the pharyngo-laryngeal area, that stutterers mobilize in their attempts to compensate for difficulties encountered in controlling laryngeal production.

Table 1. Values (means "m" and standard deviations "s") of the δ centralization index in normal speakers ("norm") and stutterers ("stut").

<table>
<thead>
<tr>
<th></th>
<th>[i]</th>
<th>[u]</th>
<th>[a]</th>
</tr>
</thead>
<tbody>
<tr>
<td>norm</td>
<td>34.4</td>
<td>45.7</td>
<td>3.5</td>
</tr>
<tr>
<td>stut</td>
<td>47.9</td>
<td>64.9</td>
<td>24.1</td>
</tr>
</tbody>
</table>

The open vowel [a] is the most influenced in normal speakers, but not in stutterers. In order to try to interpret those findings, it is important to notice that inter style differences in formant values of [a] involve F1 (average difference of 65 Hz) quite more than F2 (average difference of 12 Hz). Greater centralization of [a], relative to the other vowels, could therefore be interpreted in terms of more important differences in aperture degrees. In other words, normal subjects seem able to change their degrees of [a] aperture more than the stutterers, under the effect of varying speaking styles.

As figure 2 shows, DAF in normal speakers does not sensibly affect the overall variation profile of δ. In stutterers, on the contrary, a striking difference between centralization profiles under various DAF conditions is to be found. The 80 ms delay seems to arouse spectacular differences, specially involving vowel [u]. This finding could be in agreement with previous research on DAF usefulness in stammer treatment: it is generally found that a DAF delay in the 50 ms - 100 ms range improves stutterers fluency. In the case of this research, inter style increased variability of the centralization of [u] might be associated with more variable articulatory gestures in the pharyngo-laryngeal region.

CONCLUSION

The data presented in this paper confirm previous observations [6,7] about the effects of speaking styles on the speech signal. As in those works, the characteristics of formants spaces suggest variations along an hypoaarticulated speech axis, correlated with functional aspects of speech in the communication situation. Here, reduction of the F1/F2 space is associated with the reading task, although speech under the conative task is characterized by increased spreading of the formants values.

In normal subjects, the variation in DAF delays does not change the overall inter style variation profile. In stutterers, on the contrary, the relationship between centralization values is modified by the delay. The 80 ms delay provokes phenomena that are not to be found with other delays.

Further research should investigate the reasons for that specific effect and try to relate the findings with claims that 50-100 ms DAF delays help stutterers improve their speech production.

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REFERENCES


