DAF EFFECTS ON STUTTERERS VOICE QUALITIES AND VOWELS SYSTEMS

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ABSTRACT

Five Frenchspeaking normal subjects and five Frenchspeaking 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 treatment 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 feed-back (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 stammerers'fluency [1,2,3]. Some authors suggested that the delay inducing the maximal trouble in normal subjects'speech 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 stammerers' speech.

It has been argued that these beneficial effects might be related to speech modifications 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 have nevertheless involved English language; very few information is therefore available about French. Moreover, topics like influence of the speaking style, or variations in the vowels systems structures have not been extensively investigated in this field.

In this paper we therefore study the repercussions of speaking styles changes and DAF delay variations on the vowels systems of Frenchspeaking subjects.

EXPERIMENTAL SETTING

Ten Frenchspeaking 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 go through, 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 varying conditions of auditory feedback: normal (condition 1) and 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 stocked on a Panasonic VHS video recorder.

A sample of 240 vowels was extracted from the recorded corpus. Only the French vowels /i/, /a/ and /u/ are taken into consideration in this paper. For each subject, each task, each condition, one vowel was analyzed. They were selected in order to minimize context effects: the only common anterior context was /k/ for the collected [i], and /p/ for [a] and [u].

RESULTS

We measured, for each vowel, its first and second formants at its center, by means of a Kay 5500 DSP sonagraph.

As suggested by figure 1, the formants values tend to be more central in the reading task than in the map task. This could be due to the fact that, in the reading task, speakers behave in more a humdrum way, since the speech act can, in this case, appear as rather useless; for the map task, on the contrary, they have to communicate information perceived as usefull to an interlocutor, who, moreover, is believed to be far from the place where the speakers are. The map task could, therefore, provoke hyperarticulated speech movements although the reading task could provoke hypoarticulation.

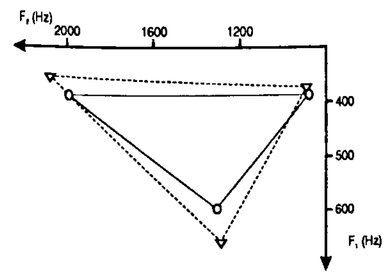


Figure 1. Average formants frequencies of the vowels in the reading- (circles) and the map- (triangles) tasks.

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 Harmegnies 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 beeing characterized by two first formants frequencies and two second formants frequencies.

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

$$f_{mels}=2595(1+\frac{700}{f_{Hz}}) \quad (1)$$

where f_{Hz} is the frequency in Hertz, and f_{mels} is the frequency in mels.

We thereafter computed a centralization index, δ, following equations (2) to (4):

$$ED_{map}=\sqrt{(F1-\bar{\phi}1)^2+(F2-\bar{\phi}2)^2} \quad (2)$$

$$ED_{read}=\sqrt{(f1-\bar{\phi}1)^2+(f2-\bar{\phi}2)^2} \quad (3)$$

$$\delta=ED_{map}-ED_{read} \quad (4)$$

where ED stands for Euclidean Distance, ϕ 1 and ϕ 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, δ 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.

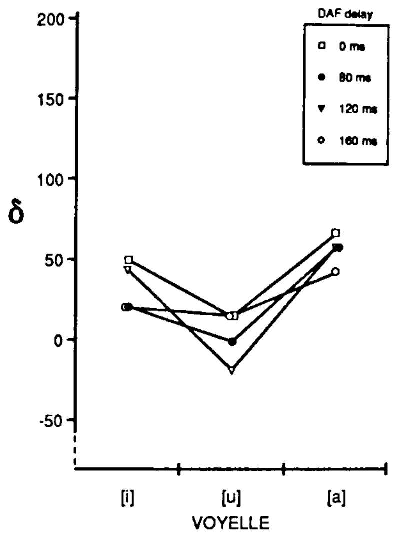
Back vowels seem, on the whole, less affected than front- and medium vowels. In normal speakers, [u] average δ value is close to zero, suggesting the existence of quasi invariant articulatory gestures, whatever the speaking style. For stutterers, [u] δ value is nevertheless hardly 6 times as great as 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").

	[i] m	[i] s	[u] m	[u] s	[a] m	[a] s
norm	34.4	45.7	3.5	94.7	58.6	45.4
stut	47.9	64.9	24.1	261.0	43.1	49.9
both	41.2	55.8	13.8	194.1	50.9	47.8

The open vowel [a] is the most influenced in normal speakers, but not in stutterers. In order to try to interprete those findings, it is important to notice that inter style differences in formants 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 stutters, 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 variablity of the centralization of [u] might be associated with more variable articulatory gestures in the pharyngo-laryngeal region.



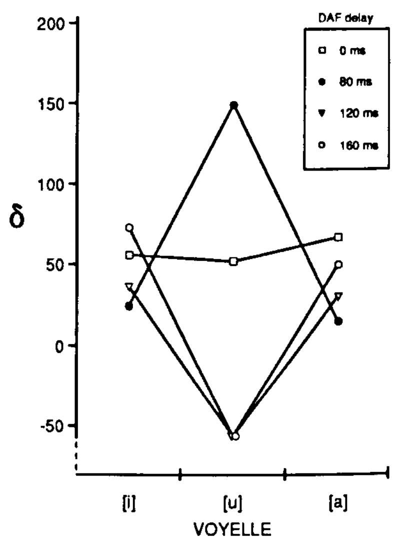


Figure 2. Average values of the δ centralization index in normal speakers (up) and stutterers (down), by vowel and DAF delay.

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 hyper-hypoarticulated speech axis, correlated with functionnal 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 reseach 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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