EFFECTS OF PARKINSONIAN SYMPTOMS ON VOICED PALATALS

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ABSTRACT

In this paper, we focus on the case of palatal glides produced by ten French-speaking parkinsonian subjects. This research is a part of a project whose final aim is the building of a comprehensive study of the various ways in which Parkinsonian pathologies can exert influence on speech.

The acoustic analyzes (formants tracks in the DC-4000 Hz range) were performed by DSP 5500 and CSL 4300 kay stations.It revealed that the glides are characterized by alterations of the acoustic variation during the time-course of the segment production.

1. INTRODUCTION

The Parkinson disease is a degenerative pathology of the central nervous system and more precisely, of the motor cortex's sub-cortical structure. The subjects are characterized by muscular rigidity, body extremities trembling, a loss of the facial expression and/or more or less difficulties in walking, reading, speaking, that is to say in whatever action that requires a high degree of muscular control. However, the clinical pictures are quite variable; some of the subjects showing more particularely a trembling-dominant syndrom while others rather exibit a muscular rigidity-dominant syndrom.

During the last decades, several papers have been devoted to the study of the effects of Parkinson disease on voice. These speech disorders, early classified in the dysarthrias'group ([10]) have been studied and discribed during the sixties and seventies only on the basis of clinical observations. The findings drawn from these studies were often characterized by an important variability among papers and led to the use of the general term "monotonous" ([1], [7a], [7b], [7c]) or "hypokinetical" ([8]) in order to describe the Parkisonians'speech..

Since the seventies, important progress in the treatment have resulted in improved diagnosis techniques and new conceptual frameworks for the classification of the clinical pictures. Part of the observed variability among papers could thus be a consequence of the fact that Parkinsonian pathologies can now be viewed in terms of more refined nosological categories than it was the case before ([12]). Since the same moment, acoustical analyzes were conducted with the aim of building up a quantification of the clinical observations ([9], [14], [2]). Most of these studies have focused on specific aspects of speech like pitch, speech rate, intensity variations but, rarely enabling comprehensive view of the effects of the subject's state. Except some studies ([11], [25]), all of them were conducted using English-speaking subjects.

In this paper, we focus on the case of palatal glides produced by French-speaking parkinsonian subjects. Keeping in mind that Parkinsonian symptoms are all related to alteration of ability of controlling movements, those segments, that have received, up to now, few attention from the searchers, are specially interesting because they are among the rare phonemes of French that require the speaker producing a continuous variation of timbre during emission, and therefore continuous movements of the supralaryngeal articulators ([4], [5], [6]). In order to reveal the dynamical aspects of the subjects' production, we will focus on the formants frequencies evolutions in the time course of the segment production, and thereforel analyze the productions thanks to LPC driven formants tracking. The aim of this paper, which constitute a first, exploratory, essay in this field, is to point out several phenomena, the characteristics of which should be later on carefully studied. We therefore rather aim at revealing the existence of phenomena linked to the pathology under study than seek to describe and explain them.

2. SUBJECTS

Ten subjects (five males and five females), from 68 to 88 years of age (means = 77.8) have been selected. They were all French-speaking and suffered from an idiopathic form of the Parkinson disease (undergoing a Prolopa treatment). The means length of their illness was 8.2 years. For each of them, an anamnesis has been realized in order to describe the first symptoms and the characteristics of the disease's evolution. They have been classified into two categories: 1.subjects presenting a trembling-dominant syndrom and subjects presenting a muscular rigidity and akinesy-dominant clinical picture. Summary of the subjects'characteristics can be seen in table 1.

Subjects	Age	Sex	Dominant syndrom	Disease length
1	80	F	rigidity	10 years
2	68	M	trembling	6 years
3	77	M	rigidity	9 years
4	84	M	trembling	10 years
5	72	M	rigidity	20 years
6	88	F	rigidity	5.5 years
7	85	M	rigidity	5 years
8	76	F	rigidity	6 years
9	72	F	rigidity	1.5 years
10	76	F	trembling	9 years

Table 1. Subjects'characteristics.

3. RECORDINGS

On-site recordings of the subjects have been realized by means of a DAT portable unit. The microphone was allways positionned at a 15 cm-distance from the subject's lips.

4. CORPUS

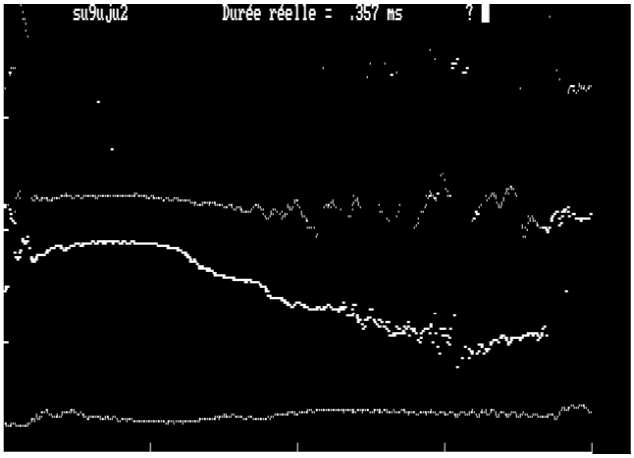
The subjects were asked to produce several utterances of sequences containing French phonemes /j/, /a/ and /u/ in various combinations. In this paper, we only study the utterances of sequences containing the palatal glide [j] either surrounded by two vowels [a] or by two vowels [u].

seq.	(v + [j] + v) 1	[aja]
seq.	(v + [j] + v) 2	[uju]

Table 2. Corpus.

The first sequence ([aja]) allowed us to test the effect of a wide movement on the aperture axis, involving jaw while the second sequence ([uju]) meant the starting up of a wide movement on the anteriority-posteriority axis, without major jaw use. Besides, choosing the same vowel at the beginning and at the end of the sequence allowed us to test the presence of the symetry in the movement - and so, in the formants tracks- found in the normal subjects'productions towards the acoustical [i] and then, from the acoustical [i] ([3]), in order to determine if the same phenomena appeared in the Parkinsonians'productions.

Because the majority of our Parkinsonians were no more able to read written stimuli , the sequences were orally presented in isolation



to the subjects who were asked to repeat them.

5. ANALYZES

Each [aja] and [uju] segment was digitized and first analyzed by a Kay-4300B unit. The formants tracks were computed by LPC, and the so-obtained values were thereafter transmitted to a PC computer. The tracks files were then time-normalized, by means of a specific routine, and finally printed. These printouts constitute the input of our analyzis.

In normal, French-speaking subjects' productions, the sonagraphic analyzes of the palatal sequences reveal systematically the presence of a continuous formantic structure characterized by the following sequence: 1.stable segment, corresponding to the initial vowel; 2.smooth formants variation towards the structure of a [i]-sound, followed by a smooth variation towards the formantic structure of the final vowel; 3. stable segment, corresponding to the final vowel.

The observation of the first and second formants tracks in Parkinsonian subjects reveals several kinds of anomalies, relative to normal subject's productions. These could be linked with the subject's pathological state and therefore be considered as singular clues contributing to setting up an acoustics-based description of the subject's clinical picture. They are listed below:

(S1) Unexpected initial timbre: the timbre of the initial part of the studied segment is different from the one of the expected vowel ([a] or [u]). In subject 9 [uju], for instance, the beginning of the segment has a 350 Hz F1 and a 1800 Hz F2, corresponding to a [y] quality in French (see Figure 1).

(S2) Unexpected medial timbre: the formantic structure of the medial part of the studied segment is not the one of a [i]-like sound. In subject 9 [uju], for instance, the medial part of the segment has a 350 Hz F1 and a 1500 Hz F2, corresponding to a [ϕ] quality in French (see Figure 1).

(S3) Unexpected final timbre: the timbre of the final part of the studied segment is different from the one of the expected vowel ([a] or [u]). In subject 9 [uju], for instance, the end of the segment has a 310 Hz F1 and a 1010 Hz F2, producing a timbre close to the one of a [o] quality in French (see Figure 1).

(S4) Microvariations in F1 tracks: the LPC tracks show local variations, notwithstanding the global tendency of the formant. In subject 2 [aja], e.g., a sinusal component seems to be added to the formant track overall tendency (see Figure 2).

(S5) Microvariations in F2 tracks: the LPC tracks show local variations, notwithstanding the global tendency of the formant (cfr supra and see Figure 2).

(S6) Variations of the rate of change during F2 ascending phase: the rate of change varies to a large extent during the first part of the segment. For instance, in subject 3 [uju], F2, at first, increases slowly (from 725 Hz up to 898 Hz, i.e., a 173 Hz difference in 111 ms), and then very quickly (from 898 Hz up to 1900 Hz, i.e., a 1002 Hz difference in 82 ms), (see Figure 3).

(S7) Variations of the rate of change during F2 descending phase: the rate of change varies to a large extent during the last part of the segment. For instance, in subject 1 [uju], F2, at first,decreases quickly (from 2679 Hz down to 1330 Hz, i.e, a 1349 Hz difference, in 125 ms), and then slowly (from 1330 Hz down to 933 Hz, i.e., a 397 Hz difference in 125 ms), (see Figure 4).

(S8) Formant track dropout: an momentaneous accident suddenly modifies in a dramatical way the formant track's stability or regular variation. In subject 4 [aja], e.g., the second formant in the [i]-like part of the production shows two consecutive dropouts from ca. 2.2 kHz to ca. 1.7 kHz (see Figure 5).

(S9) Disorganized formant track pattern: the formant pattern does not show any tendency of organization. In subject 5 [uju], e.g., no clear the formantic can be revealed (see Figure 6).

		timbre alterations			micro variations		rate of change		irregu-larity	
		S1	S2	S3	S4	S5	S6	S7	S8	S9
1	a						✔			
	u		✔				✔	✔		
2	a				✔	✔				
	u			✔	✔	✔	✔			
3	a			✔						
	u						✔	✔		
4	a	✔	✔		✔	✔			✔	
	u	✔			✔	✔	✔	✔		
5	a	✔		✔	✔					
	u	✔	✔	✔						✔
6	a		✔						✔	
	u		✔							
7	a	✔	✔	✔					✔	
	u	✔	✔	✔					✔	
8	a		✔						✔	
	u			✔			✔		✔	
9	a	✔								
	u	✔								
10	a			✔	✔					
	u				✔					

Table 3. Clinical signs (S1-S9) in the subjects' (1-10) productions.

Figure 1. Subject 9 [uju]

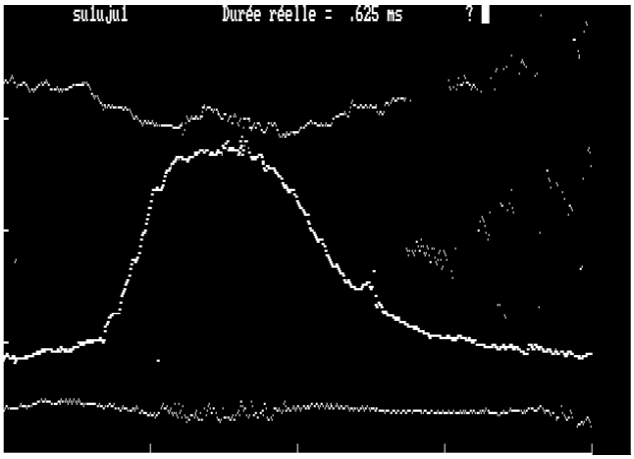


Figure 2. Subject 2 [aja]

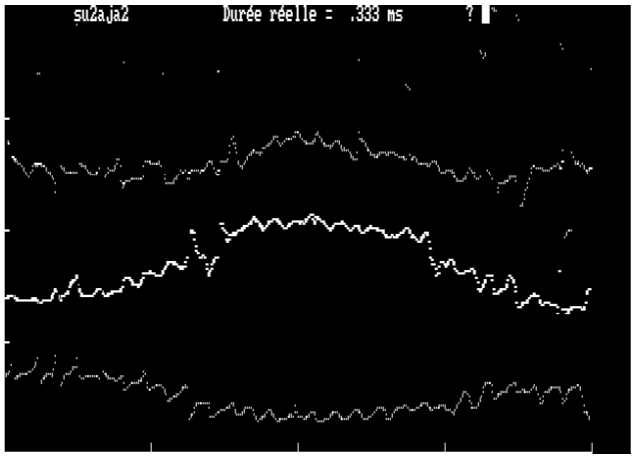


Figure 3. Subject 3 [uju]

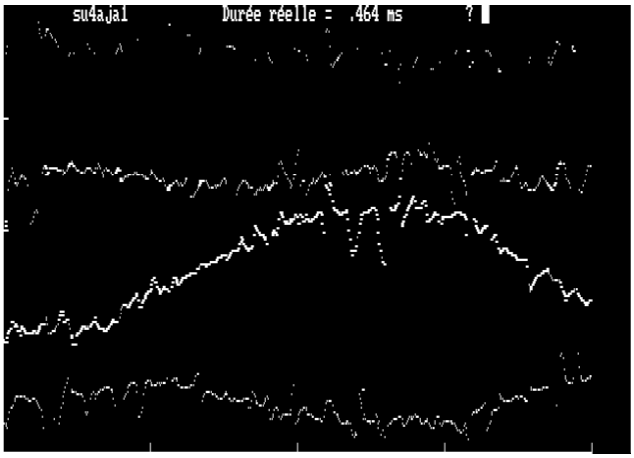


Figure 4. subject 2 [aja]

Fgure 5. Subject 3 [uju]

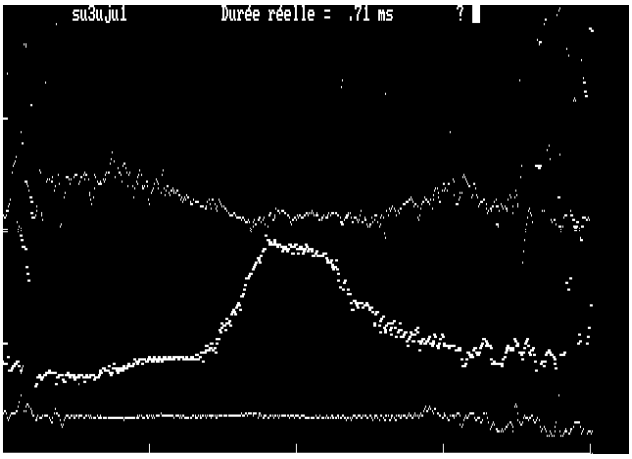
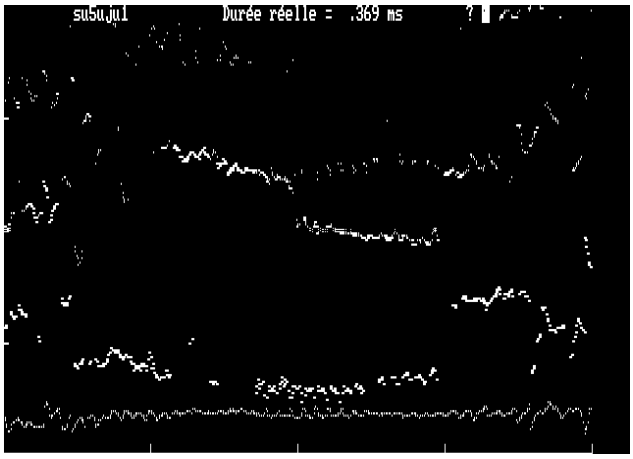


Figure 6. Subject 5 [uju]



Major timbre alterations are present in two subjects, i.e., subject 5 and subject 7, whose productions show either a clear vocalic structure without any similarity with the one expected for the segments uttered, or a complete disorganization of the pattern. These subjects are both characterized by a severe clinical picture, with dominant rigidity syndrom.

Subjects 4 and 9 exhibit altered initial timbre. Both are characterized by stamping, and difficulties in initiating large body movements.

Subjects 3, 8 and 10 show difficulties in reaching the expected final timbre. Apart from rigidity, their clinical pictures do not reveal striking clues of severity.

Subjects 1, 4, 6 and 8 are characterized by altered [i]-like quality of the medial part of the segment, that can consist either in [i]-undershoot (subject 1 and subject 4), or momentaneous breathiness.

Subjects 2 and 4 exhibit, in all their productions, microvariations of both formants. Subject 10 shows similar microvariation both in [aja] and in [uju], but only in F1. Subject 5 shows occasional such variations. It is to be pointed out, here, that the 3 subjects with systematic manifestation of microvariations are precisely the 3 subjects characterized by a trembling dominant syndrom.

Variations in the rate of frequency change are dominant in subject 1. They appear occasionally in subjects 2, 3, 4 and 8, essentially in the [uju] sequences. This acoustical characteristic suggest abrupt transition from a segment to another. This observation is well in line with the idea of an hyperkinetic behaviour, with weakened movement control.

Dropouts of the formantic tracks are generally associated with medial timbre alterations, and could possibly constitute LPC artifacts

due to breathiness.

6. CONCLUSIONS

In this paper, we have pointed out LPC-based acoustical signs in close relationship with clinical pictures. The disorganization of the formantic structure has been associated with severe cases having rigidity as a dominant syndrom. Variations in the frequency rate of change tend to appear in less severe cases of rigidity. Several local timbre alterations seem to be linked with specific problems of movement control. Microvariations of the formantic traces appear to be closely linked with the trembling syndrom.

As a matter of fact, these phenomena should be more carefully analyzed in further studies, and the question of their supposed relationships with articulatory strategies should be adressed.

Moreover, if some acoustically-based classifications (e.g., subjects with microvariations versus subjects without microvariations) seem to match with nosologically-based ones (e.g. trembling versus non trembling subjects), further research should take into account more refined distinction between the various clinical pictures.These considerations have led us to later develop a multidisciplinar joint study project, involving our phonetics laboratory, a laboratory of cognitive sciences (University of Toulouse-Le Mirail, France, [15]) and the neurology unit of university hospital (CHU Toulouse Purpan, France), with the aim of building up a comprehensive study of the various ways in which Parkinsonian pathologies can exert influence on speech.

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