ROLE OF BASAL GANGLIA FOR SPEECH RATE CONTROL : OBSERVATIONS FROM PATHOLOGY

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ABSTRACT - Speech rate was measured by having 29 patients with basal ganglia dysfunction (BGD) read a list of words. The patients showed, when compared with 10 controls : (i) a wide range in the figures for total duration, total word time (TWT), total pause time, mean, SD and variation coefficient of pause (VC), (ii) TWT significantly shorter, (iii) Pause VC higher. Intra-subject pause variability was a common symptoms in patients suffering from BGD.

The role of structures localized in basal ganglia for the control of speech rate has been clearly attested. Grewel (4) describing speech impairment associated with parkinsonism indicated that such patients employ extra long pauses and that the duration of each syllable is usually greater than normal. A particular speech behavior, i.e. uncontrolled rapidity, has also been noted and referred as "propulsive rate" (7), as "short rushes of speech" (3) or as "accélération paroxystique de la parole" (2). It seems, nevertheless, that not all patients with a Parkinson's disease diagnosis demonstrate a single "typical" speech impairment. According to authors like Canter (1) and Sarno (7) the rate of speech may be either fast or slow. In a previous study one of the authors of this paper found, in a sample of 81 patients with Parkinson's disease, 38 % with a rapid speech rate, 5 % with a slow one and the others with a normal rate (8). When, in place of clinical data, the effect of a stimulation of the thalamus ventro-lateral nucleus (in the course of stereotaxic operation for parkinsonism) is considered ; this was not always identical, both speech arrests and speech acceleration might be observed (5). The purpose of the present study was to examine, using measurement of phonation and pause time, whether or not patients with speech disorders related to Parkinson's disease were homogeneous. In addition, the same method was used to characterize speech rate in another group of patients with a symptomatology close to that of Parkinson patients, i.e. Progressive Supranuclear Palsy.

1. MATERIAL AND METHODS

1.1. Subjects

3 groups of French speaking male subjects entered the study : 1/ 22 patients with idiopathic Parkinson's disease (PD) who had never received L-Dopa therapy (or other specific treatment) with an age range of 50 to 79 (mean = 63 SD = 8) - 18 of the 22 patients belonged to the sample from which a perceptive description of speech was reported in a previous paper (8) ; 2/ 7 patients with typical features of Progressive Supranuclea Palsy (PSP), and especially no effect of L-Dopa, aged between 50 and 72 (mean = 61 years 4 months, SD = 5 years 1 month), and 3/ 10 controls, ranging age from 54 to 61 (mean = 59, SD = 4).
All subjects were at a cognitive and educational level which allowed reading without problem, except of a motor origin.

1.2. Material

The subjects were asked to read a list of words printed in a column on a sheet. This material was part of a more extended protocol including sentence reading, words repetition, automatic speech (numbers, months) and self-formulated speech. Speech was recorded in a sound-proof room, at the same time as an electroglottogram, using a two-channel tape recorder (REVOX A77).

1.3. Analysis of temporal patterns

Digital conversion of speech signal was performed at a sampling rate of 2 KHz Measurements were made from the integrated acoustic signal by a single operator (for all measures) using a mouse to determine the word limits on the screen. The time data were stored and further statistics obtained from the file. Statistical comparisons between groups (Student t test) were obtained for the following measures : total duration of the reading of the words list (TD), total word time (TWT), total pause time (TPT), ratio TWT/TD, mean of pause duration (MPT), standard-deviation of pause duration (SDPT), variation coefficient (VC = SDPT/MPT).

2. RESULTS

2.1. Comparison between Parkinson's patients and controls

The comparison of the group means comparison showed significantly shorter mean for total phonation time (TWT-t = 2.53 ; fd = 30 ; $p<.05$). The only other significant difference was for VC, i.e., on an average, a higher VC in the PD group than in controls (VC-t = -2.46 ; fd = 30 ; $p<.05$). There was actually a great heterogeneity in the pause duration of a given patient which was independent of the pauses duration as a whole (CV corresponded to the ratio SD/mean). It was striking that for all other measures the mean was close to PD and controls, but in the first group the range was very wide showing that there was an important variability in patients speech behavior.

2.2. Comparison between PSP patients and controls

The heterogeneity in patients pause duration for a single subject was confirmed in this group. When compared with controls SDPT and VC were, on the average, greater (SDPT-t = -3.38 ; fd = 16 ; $p<.01$. VC-t = -3.84 ; fd = 16 ; $p<.01$). Total word duration mean was shorter than in controls, but no significant difference was shown (note the PSP group small size). As noted for PD patients, speech behavior was different among patients with a higher variance than in controls.

2.3. Comparison between PD and PSP patients

No significant differences could be shown except for a higher SPDT in PSP than in PD patients (SDPT-t = -2.60 ; fd = 27 ; $p<.05$).

3. DISCUSSION

3.1. The data obtained in speech rate analysis in 2 groups of patients with basal ganglia dysfunction demonstrated a wide range in all parameters describing speech rate from very slow to very fast. Such a high variance in a group of patients is in agreement with data obtained in studies where self-formulated speech was juged by listeners (4, 7, 8). As far as the total pause duration (TPT) and mean pause duration (MPT) were concerned, the range was almost equally distributed on both sides of a mean not very different from that of controls. But for word duration (TWT) the duration was on the average shorter than in controls. One explanation for this might be that, conversely to pauses, words could not be lengthened beyond a certain limit. The words shortening which is obvious in at least part of the patients is not in agreement with Grewel's description (4) ; the shortening of phonation time (associated with an opposite pause lengthening) in PD patients who benefited of L-Dopa therapy (6) had seemed also to indicate that

the neurotransmitter defect led to slowing of word articulation.
In any case, the differences between patients for speech rate needs to be explained. Further research should test the possible relationship between the type of speech impairment and the clinical, biological and neuroanatomical features. Rough significant correlations has been described between the severity of speech impairment and that of other neurological symptoms in PD patients (8).
3.2. The only specific disturbance that differentiated patients from controls when means comparisons were computed was the intrasubject heterogeneity of pause duration (higher VC). Recalculating variation coefficient from Mawdsley and Gamsu's data on pauses between digits, in a counting task, it appeared that after L-Dopa therapy the pause variation coefficient dramatically decreased ($t = 3.28$; $df = 19$; $p<.01$). The defect in neurotransmitter seemed to have a reversible effect on the pause duration variance (in a same patient).
In tasks involving a periodicity it seems that nigrostriatal structures are necessary for the regularity of the rhythm.
3.3. Patients with PSP demonstrated the same intersubject variability as PD patients, and the same, even at a higher level, intrasubject pause variability.

4. CONCLUSION

There is a need for further research taking into consideration speech rate and rhythm characteristics in other modalities such as reading of sentences or paragraphs, repetition of words or sentences, spontaneous speech.
A first practical conclusion may be that any research on control of speech movements, of articulation or of prosody must be performed using either a sufficient number of subjects, or groups of patients defined on precise criteria (especially concerning speech rate and rhythm). A given medical diagnosis does not imply a single speech modification.

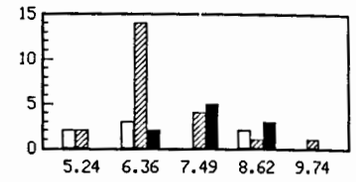

Fig. 1
Total phonation time (TWT) - Filled bars represent controls, stripped bars PD patients and clear bars PSP patients. Figures on X-axis correspond to the lower limit of each five classes of the histogram, on Y-axis they correspond to number of subjects.

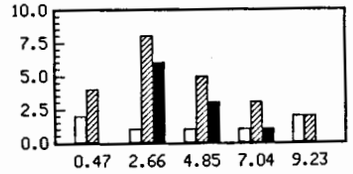

Fig. 2
Total pause time (TPT) - Same definition as in Figure 1

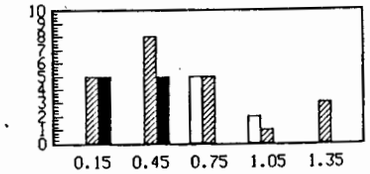

Fig. 3
Pauses variation coefficient (VC) Same definition as in Figure 1

Tableau I

Duration measurement (in second) - see definitions and comments in the text

	PD n=22	PSP n=7	CONT n=10
TD m	12,11	12,98	12,74
σ	4,18	4,54	2,00
TWT	7,27	7,13	8,32
	1,21	1,49	0,76
TPT	4,84	5,85	4,43
	3,32	3,95	1,66
TWT/TD	0,64	0,61	0,66
	0,15	0,20	0,08
MPT	0,44	0,53	0,40
	0,30	0,36	0,15
SDPT	0,25	0,54	0,15
	0,19	0,38	0,06
VC	0,79	0,98	0,42
	0,45	0,21	0,18

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