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PATTERNS OF DYSARTHRIC MOVEMENTS IN PATIENTS WITH PARKINSONISM

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Introduction

In the last issue of our Annual Bulletin, we reported the results of an analysis of articulatory dynamics in dysarthric patients of cerebellar origin and amyotrophic lateral sclerosis. (Hirose, Kiritani, Ushijima and Sawashima, 1977) That research has been continued along the same line and the results of analytic studies on Parkinsonian dysarthria will be presented in the present paper.

Parkinson's disease was first described as a clinical entity by J. Parkinson in 1817. The disease was also called paralysis agitans, characterized clinically by a mask-like facial expression, a persistent tremor gererally found in the extremities and during slow movements. Later, there was a tendency to use the term Parkinsonism for a condition of hypokinesis of extrapyramidal origin, which is accompanied by rigidity and, in most cases, an alternating rest tremor. More recently, much has been disclosed about the biochemical properties of the extrapyramidal system and, in particular, the depletion of dopamine, which has been demonstrated in highest concentration in the striatum and the substantia nigra, is considered to be characteristic for Parkinsonism. This conclusion has been further attested by effective results of the administration of L-dopa to patients with Parkinsonism, and a good number of clinical re reports on the use of L-dopa have been accumulated in many countries.

Parkinsonism is often associated with disturbance of speech. A statistical study in Japan, for example, claimed that the incidence of disarthric manifestation in Parkinsonism was as high as 73% (Atarashi, 1959).

As for the features of the dysarthric patterns of Parkinsonism, many authors have described the loss of inflection or hypoprosody, hesitation, huskiness of voice and imprecise consonant articulation. In our own experience and impression of Parkinsonian speech, similar results were obtained although there seems to be a considerable difference in the criteria for prosodic abnormality when compared to the results of the other authors on patients speaking languages other than Japanese (Kumai, Ogawa, Shiraishi, Fukusako, Monoi, Tatsumi and Hirose, 1978).

Even though Parkinsonian dysarthria involves, to a considerable extent, the phonatory and respiratory levels, it was expected that application of our methods of analysis of articulatory movements could provide useful information for the understanding of the pathological characteristics of Parkinsonian dysarthria.

Procedures

1. Pellet tracking using an x-ray microbeam system

The strategy for the automatic tracking of the pellet on the moving articulators, such as the tongue, was essentially the same as reported in our previous paper (Hirose et al., ibid.). The data output was read into the core of a PDP-9 computer through an x-ray detector and an A/D converter.

For the purpose of off-line observations, a specially designed program was used in most cases to display the coordinate values for each pellet as functions of time.

2. Electromyographic (EMG) analysis

For EMG analysis, the same system as reported in our previous paper using hooked-wire electrodes was employed to examine the coordinative pattern of pertinent muscle pairs. The anterior digastric and the mentalis were selected as a representative pair for analysis.

3. Subjects and test words

Articulatory patterns were analyzed in 2 cases (a 59 year old male and a 61 year old male) with Parkinsonism, the final diagnosis of which was made before the present study at the Department of Neurology, Tokyo University Hospital. It was confirmed that both cases showed a characteristic Parkinsonian speech profile on acoustic evaluation.

In the x-ray study, the subjects were required to repeat Japanese monosyllables, /pa/, /ta/, /ka/, /teN/ and /paN/ separately at their fastest rate of speech.

Results

It was generally observed in both subjects that the range of movement was rather limited and that the frequency of a repetitive production of a monosyllable tended to increase gradually.

Figure 1 shows the patterns of movements of the lower lip for repetition of the monosyllable /pa/ with maximum utterance speed, comparing a normal subject with Subject 1 (the 59 year old male with Parkinsonism). In this figure, the X and Y coordinate values for the jaw are subtracted from those of the lip in order to observe the pattern of lip movements independently of the jaw. It is apparent that the frequency of repetition is rather similar in both cases (7.7 Hz on the average in Subject 1 and 7.4 Hz in the normal), but the range of movements is smaller, particularly in the Y coordinate value in Subject 1. In addition, the range gradually decreases throughout the repetition series until the movement finally stops.

Figure 2 illustrates the velocity of lip displacement in the production of a sequence of the syllable /pa/ by the same subjects as shown in Fig. 1. The velocity curves were obtained by differentiating the displacement values through the use of a pertinent computer program. In the normal subject, the values are quite consistent and high in both lip opening and closure. The maximum volocity of lip displacement in Subject I is almost equivalent to that of the normal subject, and it reaches approximately 200 mm/sec. However, the velocity gradually decreases

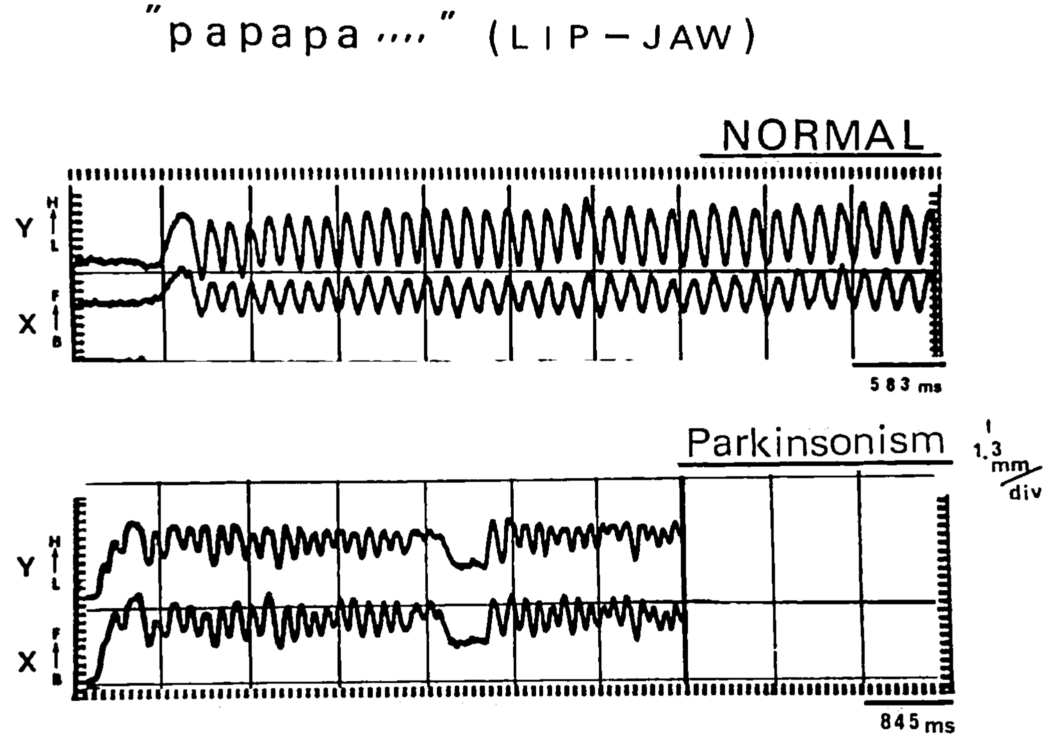

Fig. 1. Patterns of movements of the lower lip in the normal subject (upper) and in the Parkinsonian subject (subject I - lower) for repetitions of the monosyllable /pa/ displayed as time functions of X (back [B] to front [F]) and Y (low [L] to high [H]) coordinates. In this figure. the coodinate values for the jaw are subtracted from those of ahe lip so as to obtain the values for the displacement of the lip itself.

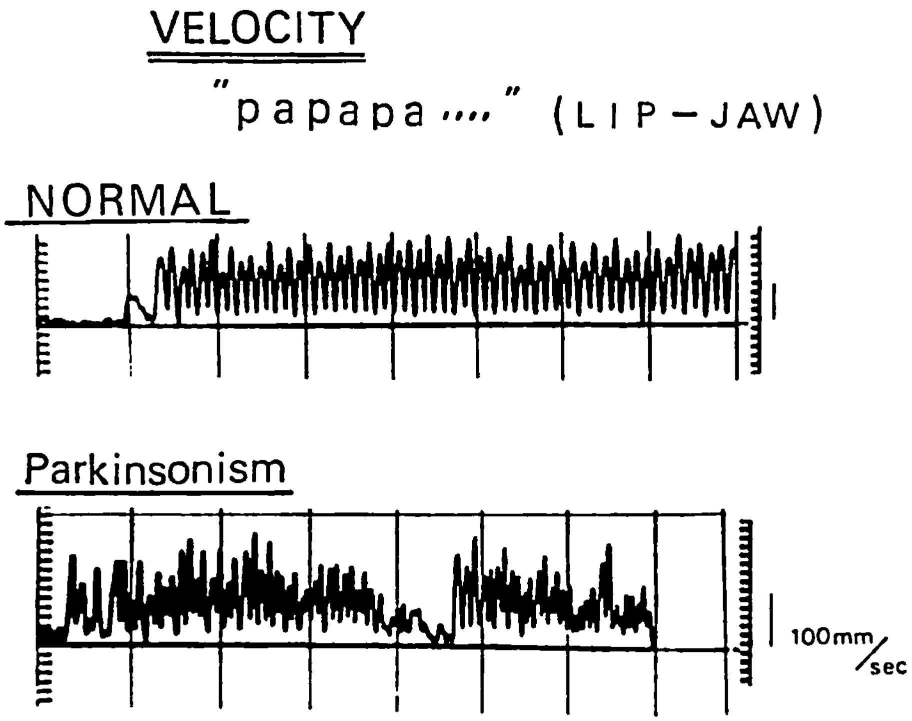

Fig. 2. Comparison of velocity of lip displacement in the normal subject (upper) and the Parkinsonian subject (subject I - lower) for repetitions of /pa/.

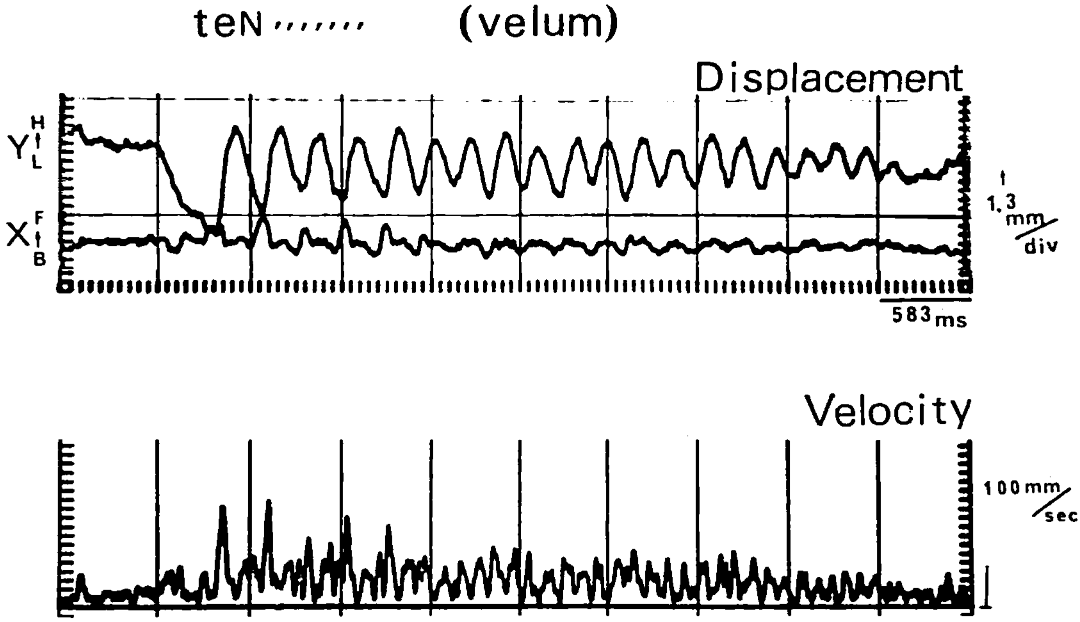

Fig. 3. An example of the patterns of velum movement and velocity in the Parkinsonian subject (subject II) producing sequences of /teN/ at the fastest rate of speech.

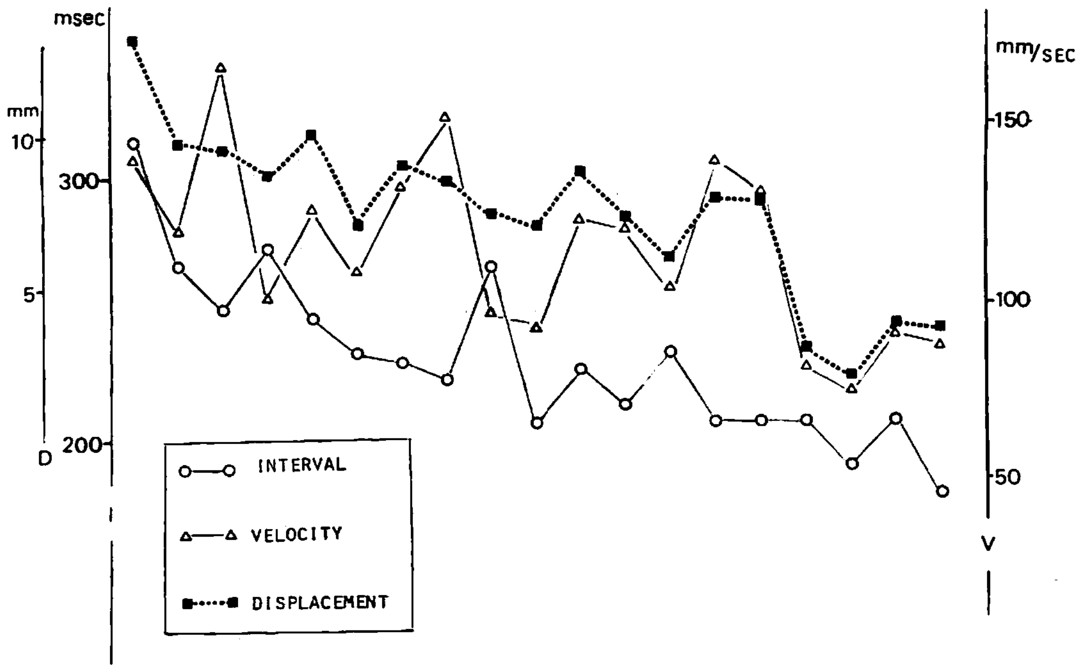

Fig. 4. Consecutive diagrams of the values of velocity and displacement of the velar movements in the sequences of /teN/ shown in Fig.3. The interval of each velar elevation is also plotted.

and becomes zero at the moment of intermittent cessation of lip movement.

A similar tendency of gradual decrease in the degree of displacement was also found in Subject II (the 68 year old male with Parkinsonism). Figure 3 shows the X and Y coordinates of a pellet attached to the nasal side of the velum during repetition of a mono-syllable /teN/ with fastest utterence speed, together with a velocity curve of the velar movements. The rate of repetition is 4.6 Hz on the average. As can be seen in this figure, the degree of velar displacement tends to decrease gradually. In other words, the velum lowering for the nasal consonant /N/ and the elevation for non-nasal consonant /t/ are both incomplete towards the end of the repetitions.

The pattern is demonstrated in more detail in Fig.4, where the degree of velar elevation and its velocity in each syllable shown in Fig. 3 are plotted consecutively. The interval between each velar elevation is also plotted in the same figure. It can be seen that the three curves gradually descend in the early part of the repetitions, while they become more or less horizontal around the rate of 5 Hz and descend again towards the end.

The pattern of lip and velum displacement of Subject II in the repetitive productions of the syllable /PaN/ are illustrated in Fig.5, in which two separate attempts made at a slow rate (3.4 Hz on the average) and a fast rate (6.9 Hz on the average) are compared. It can be seen that the velar movements are fairly consistent in both rate and displacement at the slower rate of repetition, while in the faster rate, the velar displacements become quite limited and irregular.

Figure 5.

Patterns of movements of the lower lip (L) and velum (V) in the Parkinsonian subject (sibject II) for repetitions of /paN/ in the slow (upper) and fast (lower) rates of utterance.

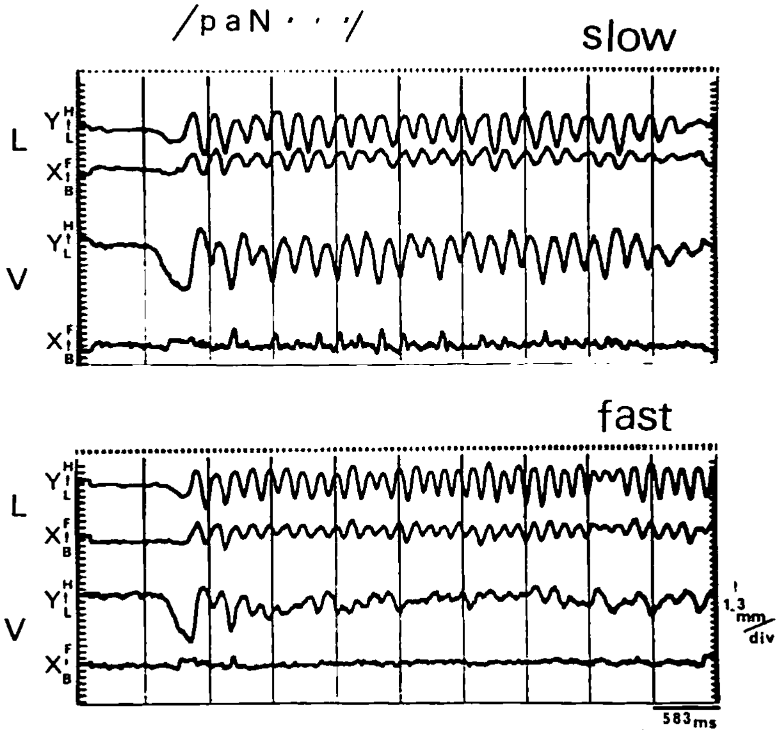

Figure 6 compares the patterns of velar movement for the repetitive production of the syllable /paN/ at three different rates of utterance: fast (6.9 Hz on the average), moderate (5.3 Hz on the average) and slow (3.4 Hz on the average). In this figure, the interval between each utterance is represented by a triangle, the base of which indicates the velocity of velar elevation and the height of which indicates the degree of displacement. It can be observed in this diagram that, at the fastest rate of repetition, the interval becomes inconsistent and fluctuating, and velar displacement and its velocity are both markedly reduced.

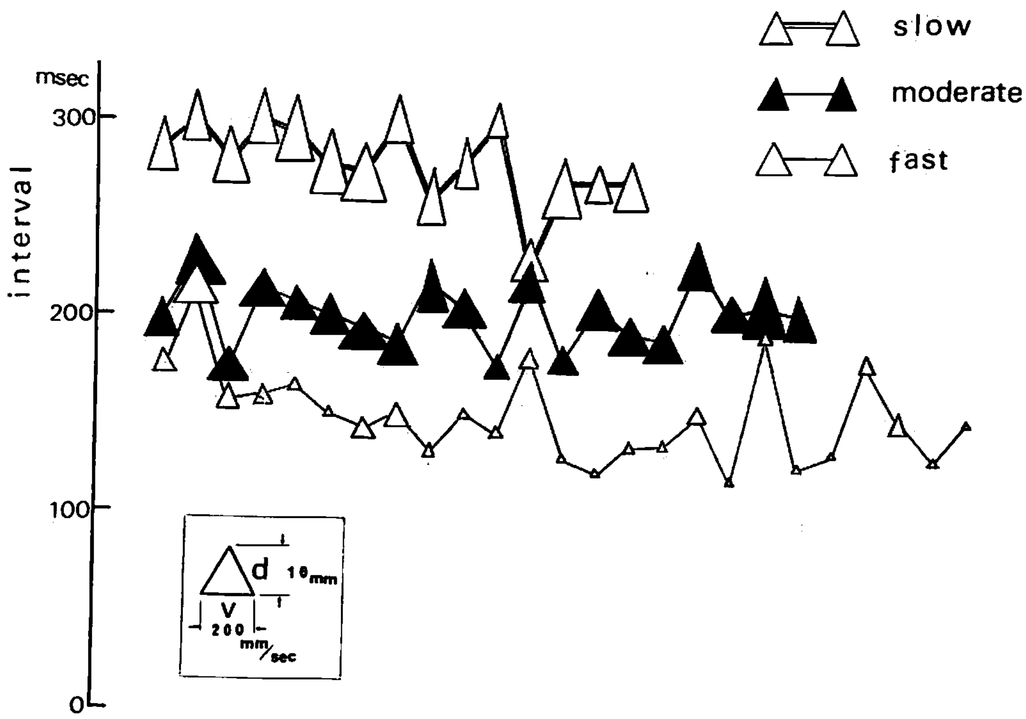

Fig. 6. Interval diagrams of the velar elevation in each attempt of repeating /paN/ in rhythmical fashion at three different rates of repetition. Each attempt is represented by a triangle where the height indicates the degree of vertical displacement and the vbase indicates the velocity of velar elevation.

Figure 7 shows an extreme example of a rapid decrease in the interval and displacement of lower lip movement for the repetitive production of the monosyllable /pa/ in Subject I. As illustrated in the lower part of the figure, the velocity of lip displacement also decreases rapidly.

In order to compare the representative pattern of articulatory movements among normal, ataxic and Parkinsonian subjects, interval diagrams are presented in Fig. 8, where the displacement and velocity of each attempt at lower lip elevation in the repetitive production of /pa/ are schematically shown in the form of a triangle as in Figure 6. In the normal subject, the rate, or the repetition interval, is quite consistent and there is almost no perturbation in the degree of displacement or in its velocity. In the Parkinsonian subject, the data of which are the same as shown in Fig. 7, there is a rapid reduction in the interval of repetition, and, as a result, the rate of repetition becomes higher than in the normal. At the same time, the values of displacement and velocity of lip elevation also rapidly decrease. In the ataxic subject, on the other hand, the interval of elevation movement of the lip is quite inconsistent and, in general, larger than normal. An inconsistency can also be noted in the degree of displacement and its velocity as well.

Figure 9 illustrates rectified and integrated EMG signals of the anterior digastric and the mentalis for the production of sequences of /pa/ in the normal subject and the Parkinsonian subject (Subject I). In the normal subject, the anterior digastric is active or jaw opening for the /a/ gesture and suppressed for jaw closing in the stop production. On the contrary, the mentalis comes active for the /p/ gesture and suppressed for the vowel segment. Both muscles thus show quick activation and suppression with apparent reciprocal EMG patterns between the two, which seem to be comparable to the coordinated articulatory movement in the repetitive productions of the monosyllable. In the Parkinsonian subject, both muscles also show quick activation and suppression in a regular fashion. However, the temporal reciprocity between the two is no longer maintained, but, rather, both muscles are activated synchronously. Incidentally, it was observed in the same subject that the disturbance of reciprocity took place only in rapid repetitions. In other words, the two muscles show a reciprocal mode of activation and suppression in a slower performance of repetitive movements such as simple opening and closing of the jaws and lips.

Comments

In the present study, it is revealed that abnormal patterns in the articulatory movements of Parkinsonian subjects are evidenced by a disturbance in rhythmic performance in the repetitive production of monosyllables. It has generally been assumed that, in Parkinsonism, articulatory movements tend to be slow and weak and, as a result, articulation becomes imprecise. It has also been claimed that some individuals may present an abnormally rapid rate of speech (Canter, 1967). The results obtained from the two Parkinsonian subjects in the present study seem to be comparable to the latter description.

Similar results have often been observed in finger-tapping examination. For example, Nakamura and his colleagues (1976) reported that the rate of finger tapping tended to become higher (up to 5 Hz) in Parkinsonian subjects even when they were asked to maintain a slower tapping

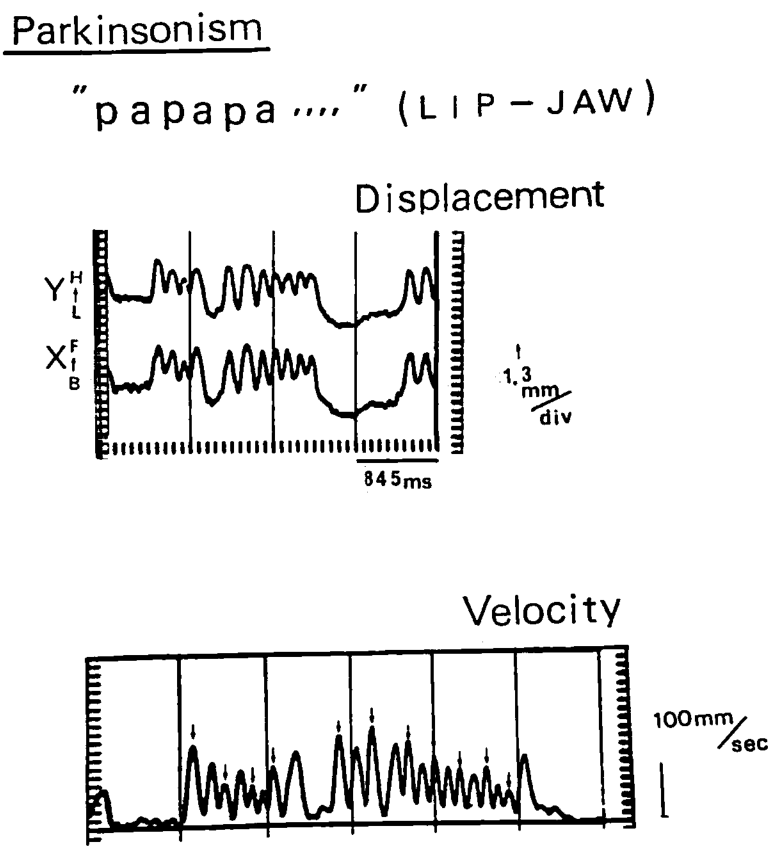

Figure. 7.
Patterns of lip movement and velocity in the Parkinsonian subject (Subject I) producing sequences of /pa/ at the fast rate of repetition.

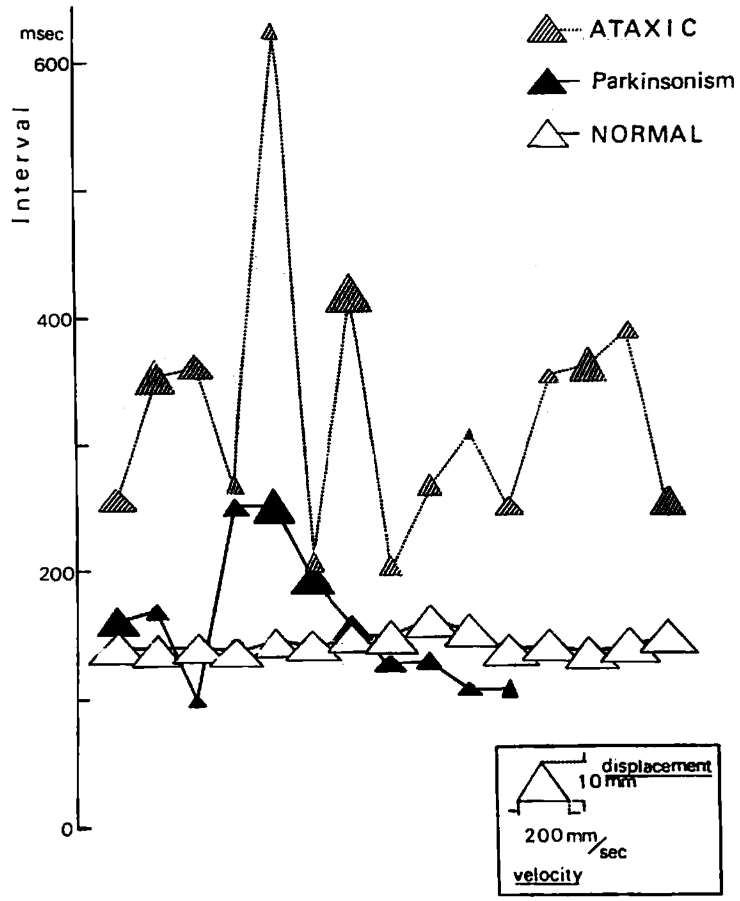

Figure 8.
Interval diagrams of repetitive closing movements of the lower lip for the sequences of /pa/ in the normal subject, the Parkinsonian subject (Subject I) and the ataxic subject. Each utterance is represented by a triangle, the base of which indicates the velocity of lip closing and the height of which indicates the degree of vertical displacement.

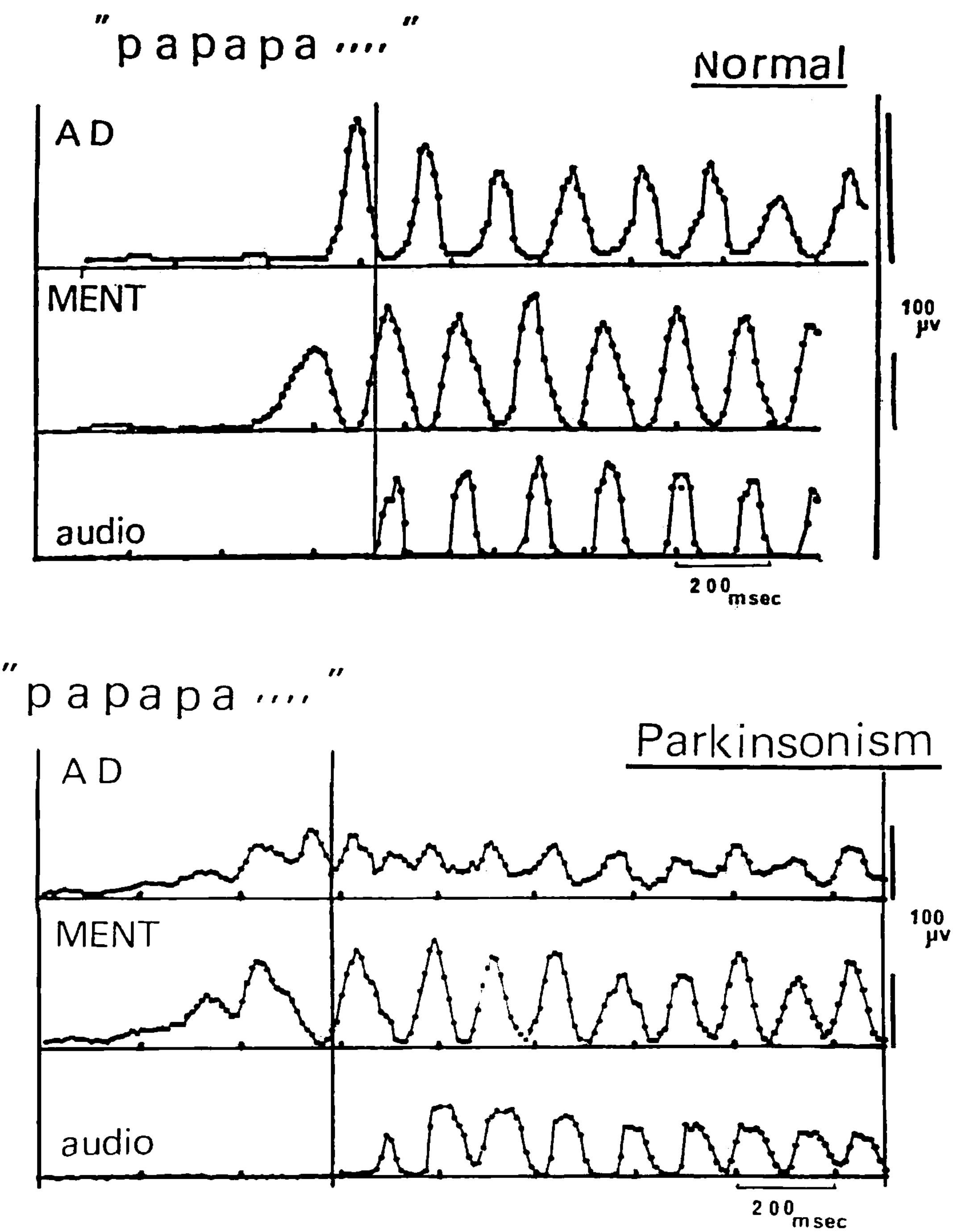

Fig. 9. Computer processed EMG curves of the anterior digastric (AD) and the mentalis (MENT) for repetitions of /pa/ in the normal subject (upper) and in the Parkinsonian subject (subject I-lower).

rate (2 Hz, for example). He called this tendency a "hastening phenomenon" and suggested that this phenomenon could be compared to the festination gait which is also common in Parkinsonism. The mode of the rhythm disturbance is quite different from that of ataxic subjects of cerebellar origin, in which an irregular breakdown of rhythmic performance is dominant. Thus, Nakamura and his colleagues claimed that the hastening phenomenon in Parkinsonism might be based on an abnormal release of the intrinsic oscillation mechanism in the central nervous system.

The function of the extraphyramidal system is still obscure. As for the function of the basal ganglion, Yoshida (1977) suggested its significance as an inhibitory system closely connected to the different areas of the cerebral cortex. It might be reasonable to conclude that the hastening phenomenon in Parkinsonism becomes manifest by a disturbance in the inhibitory function of the extraphyramidal system, if Yoshida's suggestion is acceptable. As a future project, the pattern of repetitive productions of monosyllables should be further examined under different rates of repetition, which should be pre-set by external auditory or visual stimuli given to the subject during the performance.

Hypokinetic patterns in Parkinsonism in terms of a reduction in the range of movements can be related to a deterioration in the reciprocal adjustment of the antagonistic muscles. Leanderson and his colleagues (1972) recorded EMG activities from several facial muscles in Parkinsonian subjects during the articulation of Swedish labial sounds, and found that there were persistent EMG discharges in the facial muscles indicating the loss of the reciprocal suppression between the functionally antagonistic muscle pairs. They also found that the persistent muscle contraction was effectively relieved by administration of L-dopa.

The synchronous discharge pattern observed in the present study between the anterior digastric and mentalis must be taken to indicate the loss of reciprocity which results in the reduction in the range of movements. Although there was no EMG evidence available for the levator palatini muscle of the present subjects, the apparent limitation in velar lowering in the repetitions of the monosyllable containing a nasal consonant would indicate that there was a persistent contraction of the levator.

The physiological mechanism of Parkinsonian rigidity is generally considered to be based on the abnormal muscle contraction in a persistent fashion, which possibly indicates an increase in the stretch reflex secondary to the hyperfunction of the gamma-system. Although the mechanism and significance of the gamma motor control on the muscles innervated by the cranial nerves are still open to debate, the analysis of the articulatory dynamics of pathological cases including Parkinsonism may provide a clue to the further understanding of the central motor control of the cranial nerve regions.

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