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PATTERNS OF DYSARTHRIC MOVEMENTS IN PATIENTS WITH AMYOTROPHIC LATERAL SCLEROSIS AND PSEUDOBULBAR PALSY

Hajime Hirose, Shigeru Kiritani and
Masayuki Sawashima

Introduction

In 1978 and 1979 issues of this Bulletin, the results of an analysis of articulatory dynamics in dysarthric patients were reported by the present authors. As a followup to this investigation, the present report aims at presenting the results of analysis of dysarthric patterns of amyotrophic lateral sclerosis (ALS) and pseudobulbar palsy (PBP).

ALS, often described as flaccid-spastic paralysis, is a specific disorder characterized by progressive degeneration of both upper and lower motor neurons. In most cases, the muscles of the extremities are widely involved, but not infrequently the bulbar musculature is also involved. In such cases, the speech of the patient becomes progressively dysarthric. As the clinical features of the dysarthric patterns of ALS, Darley et al. (1975) have described imprecise consonants, hypernasality, harsh voice quality, slow rate and monopitch to be the five most dominant items detected by acoustic evaluation.

PBP, also known as spastic paralysis, is a disease of the upper motor neurons in which voluntary movements are affected to various extents. Clinically, it has been described that spastic paralysis impairs the speed and force of muscular contraction and reduces the range of movements. The disturbance can affect different levels of speech production, i.e. the respiratory, phonatory and articulatory levels. From the standpoint of speech pathology, Darley et al. reported that the speech of patients with PBP was characterized mainly by imprecise consonants, monopitch, reduced stress, harsh voice quality and monoloudness. They also noted some degree of hypernasality and slow rate of speech.

The studies of Darley et al. thus suggested that phonatory features were rather significant for characterizing both ALS and PBP and that articulatory patterns might be more or less similar between the two categories. Our earlier study (Fujibayashi et al., 1977) based on acoustic judgment of speech samples obtained from patients with PBP and ALS also indicated that there existed a high correlation in the rating score for acoustic judgment items between the two groups. We concluded that at least acoustically the two groups of patients are quite similar to each other.

As presented in our previous reports (Hirose et al., 1978 and 1979), application of our methods to analyze articulatory dynamics using an X-ray microbeam system is expected to provide useful information for the understanding of the pathological characteristics of different types of neurological diseases. In the present study, further attempts have been made to apply our method to analyzing articulatory patterns of selected patients of ALS and PBP.

Procedures

1. Pellet tracking using an X-ray microbeam system

The procedure for 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. 1978). The data output was read into the core of a PDP-11/34 computer through an X-ray detector and an A/D converter. For the purpose of off-line observation, a specially designed program was used to display the coordinate values for each pellet as functions of time. In selected samples, velocity of pellet movement was also obtained by means of special computer processing.

2. Subjects and test utterances

Articulatory patterns were analyzed in two ALS cases (34-year-old female and 53-year-old male) and two PBP cases (55- and 64-year-old males), definite diagnosis having been made at the Department of Neurology, Tokyo University Hospital, prior to the present study. It was confirmed at our Speech Clinic that all cases showed characteristic speech profiles on acoustic evaluation.

In the X-ray study, the subjects were required to repeat the Japanese monosyllables /pa/, /ta/, /ka/, /teN/ and /paN/ separately at their fastest rate of speech. They were also required to utter several meaningful words embedded in a frame sentence, but the results of analysis of the latter session will not be included in the present report.

Since the two subjects in the same pathological group showed essentially the same dynamic patterns, the data obtained from one of the two will be presented as representative of the pair.

Results

It was generally observed in all subjects examined in the present series that single and repetitive articulatory movements were very slow and the range of movement was limited, whereas regularity of repetitive movements was usually maintained.

Figure 1 shows the patterns of lower lip and jaw movements for repetition of the monosyllable /pa/ at a maximum repetition rate, comparing a normal subject with subject MN, the 53-year-old male with ALS. It can be seen that the rate of repetition is very slow in MN (3.5Hz average) as compared with that of the normal (7.2Hz average). It is also apparent that the jaw displacement in the production of the sequence of /pa/ is minimal in the normal subject, while there is a considerable jaw movement for the labial articulation in the ALS subject.

Figure 2 compares the patterns of the lower lip movements for repetition of /pa/ in the ALS subject and in subject TS, the 64-year-old male with PBP, with the normal subject. For the normal subject, the curves are obtained for the maximum rate of repetition and for the slower rate. In this figure, the X and Y coordinate values for the jaw are subtracted from those of the lower lip so as to illustrate the patterns of the lip movements independently of those of the jaw. It is apparent that the rate of repetitive lip movements is slow in the two pathological cases (3.5Hz average in MN and 2.1Hz average in TS). It can also be seen that, although the rate is almost

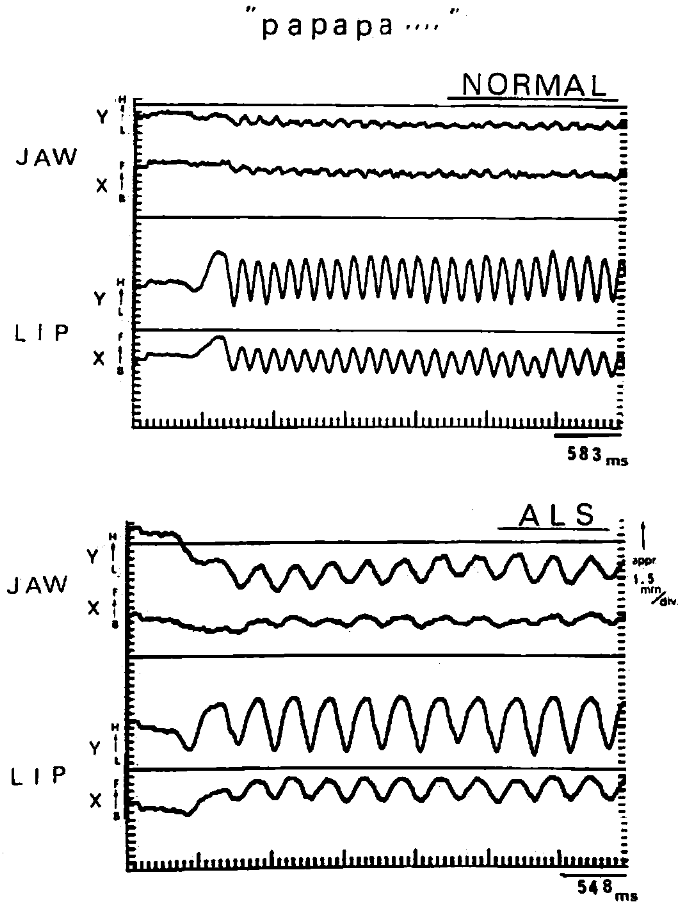

Fig. 1 Patterns of movements of the lower lip and the jaw in the normal subject (upper) and in the ALS subject (lower) for repetitions of the monosyllable /pa/ displayed as time functions of X (back [B] to front [F]) and Y (low [L] to high [H]) coordinates.

equivalent to that of the slow repetition of the normal subject (3. 8Hz average), the general patterns of the repetitive movements in the pathological cases are quite different from those of the slow rate articulation in the normal. Namely, the patterns of slow repetition in the normal are characterized by a prolongation of the closure duration, and the velocity of lip displacement itself appears to be unchanged from that of fast repetition. On the other hand, there is generalized slowness of displacement in the pathological cases. A more precise estimation of displacement velocity will be presented below.

The tendency toward "jaw dependency" is also noted in tongue articulation in the pathological cases. Figure 3 (a) shows the patterns of tongue tip and jaw movements of subject TS for repetition of /ta/. When the X and Y coordinate values for the jaw are subtracted from those of the tongue tip, it is apparent that the range of the independent tongue tip movement is very limited (Fig. 3 (b)).

Figure 4 illustrates the patterns of movements of the tongue dorsum, velum and jaw for repetition of /ka/ at a maximum repetition rate, comparing the normal subject with subject MN. It is again shown that the rate of repetition is much faster and the jaw displacement is unremarkable in the normal subject. It is also seen in the normal subject that the velum elevates at the onset of the repetitive production of /ka/ and stays at the same level thereafter. It appears that each /k/ closure is accomplished by simple upward displacement of the tongue dorsum in the normal subject, whereas in subject MN, upward and forward displacement is observed. This would indicate that the tongue dorsum moves not only upward but also forward for /k/ closure in this case, and returns to the opposite direction for the following vowel /a/. It must also be noted in this subject that both peak (for /k/ closure) and bottom (for /a/) values of the X coordinate of the tongue dorsum for each successive /ka/ gesture gradually shift forward during the repetition of /ka/. Incidentally, the jaw shows moderate amounts of vertical movement during repetition of /ka/, but its effect on the coordinate values of the tongue dorsum cannot be simply estimated. It is worth noting here that the velum of subject MN shows up-and-down movements synchronously with tongue dorsum movements for /ka/ production. In other words, the velum tends to drop, or cannot maintain the elevated level, for each post-consonantal vowel period. In this particular example, the subject repeats /ka/ production only six times, after which the velum falls to the resting level presumably for inspiration, and the repetition is started again.

Figure 5 compares the patterns of velar movements for the repetition of the monosyllable /teN/ at the maximum repetition rate by the normal subject and subject MN. It can be seen again that the rate is slower in subject MN (3. 5Hz average) than in the normal (5. 8Hz average). It is also shown that the peak value of the Y coordinate representing the degree of velum elevation for /t/ of each /teN/ gradually becomes lower during the repetitive production. This finding can be taken as an indication of increasing nasality during the successive production of the monosyllable.

Table 1 shows the values of the maximum velocity and its standard deviation (SD) for the pertinent articulators in the production the monosyllables for the normal and pathological cases. As reported earlier, the velocity was obtained by differentiating the coordinate values through use of a computer program in which linear approximation was made for seven

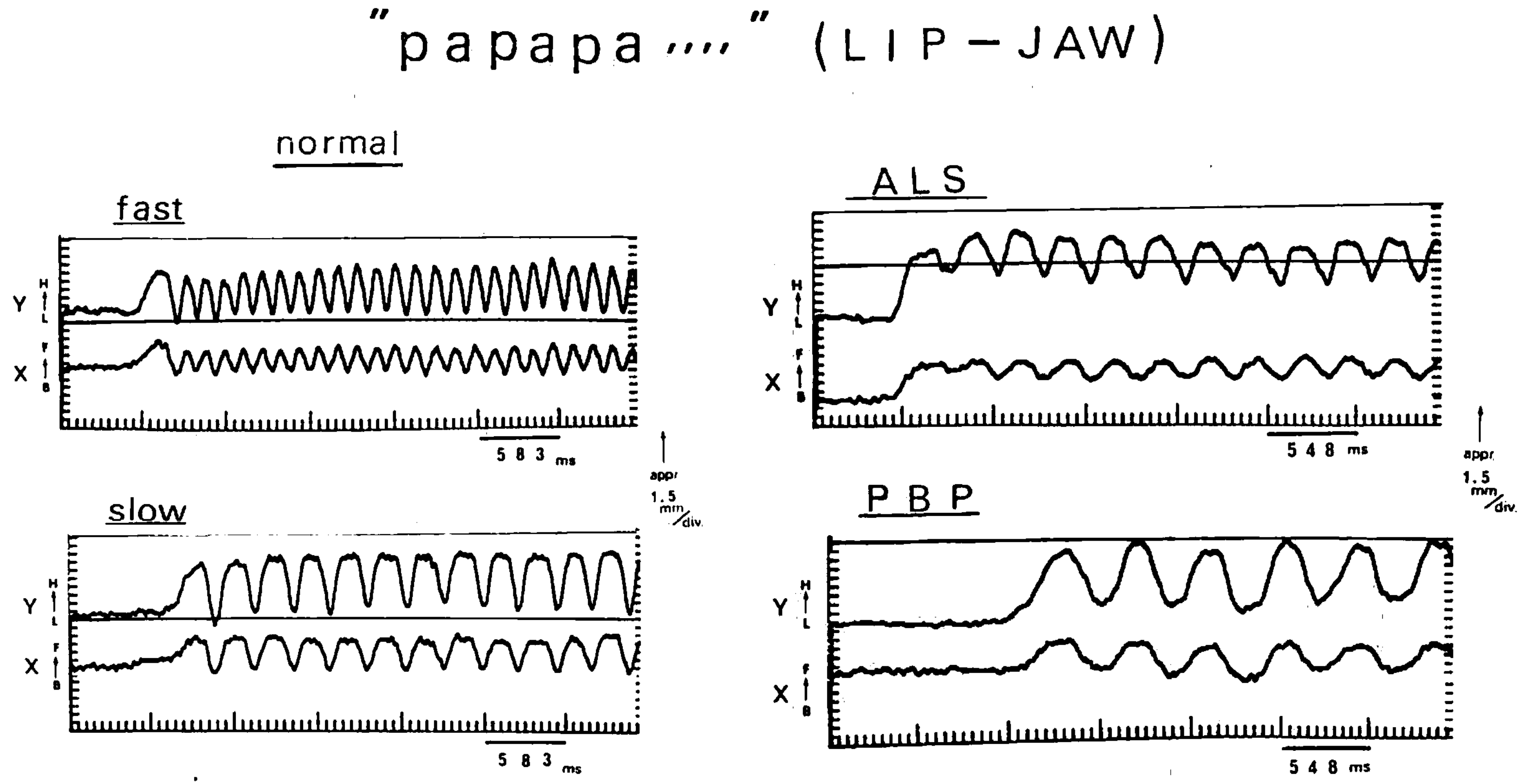

Fig. 2 Patterns of movements of the lower lip in the normal subject repeting the monosyllable /pa/ at a fast rate (left-upper) and at a slow rate (left-lower), in the ALS subject (right-upper), and in the PBP subject (right-lower). In this figure, the coordinate values for the jaw are subtracted from those of the lower lip so as to obtain absolute values for the displacement of the lip.

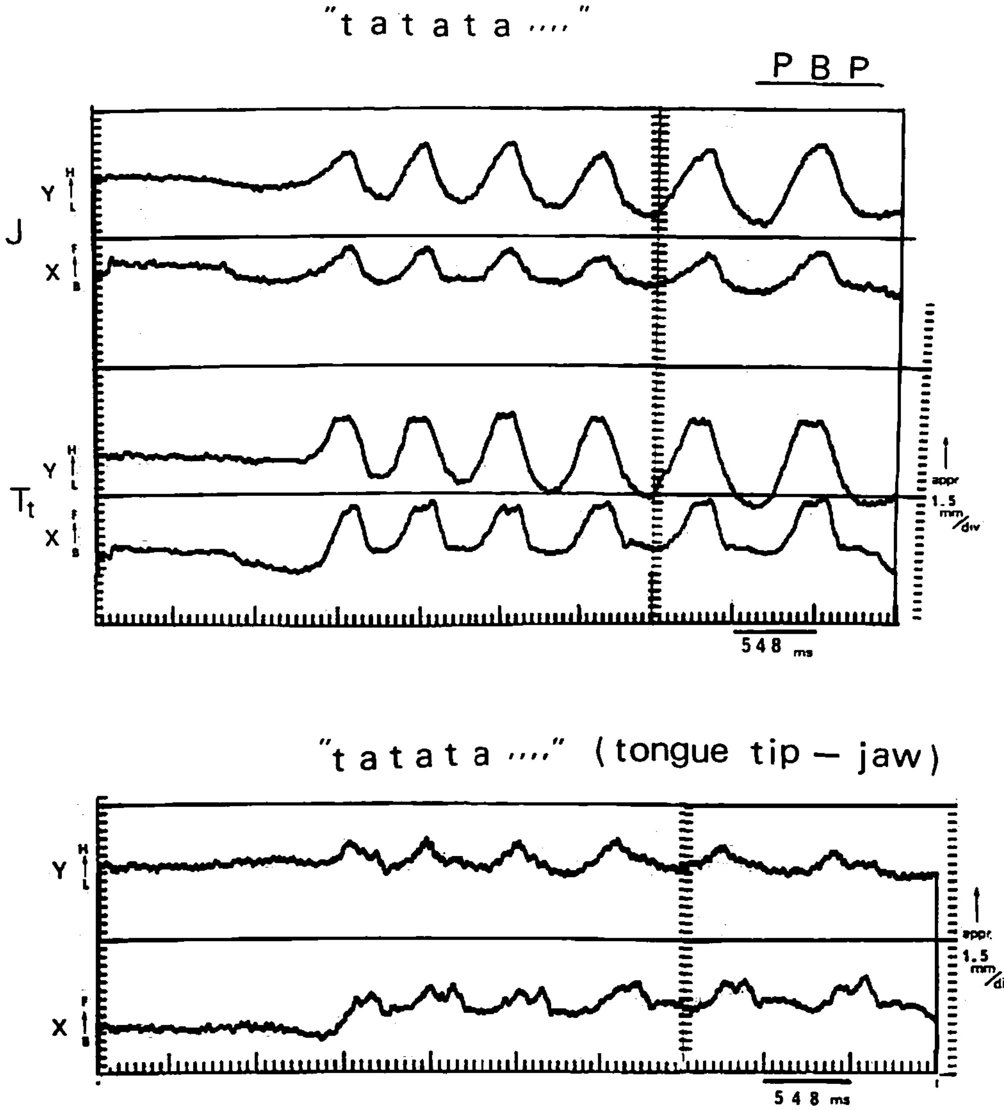

Fig. 3(a) Patterns of movements of the tongue tip and the jaw in the PBP subject repeting the monosyllable /ta/.

(b) The same recording illustrated after subtracting the coordinate values for the jaw from those of the lower lip.

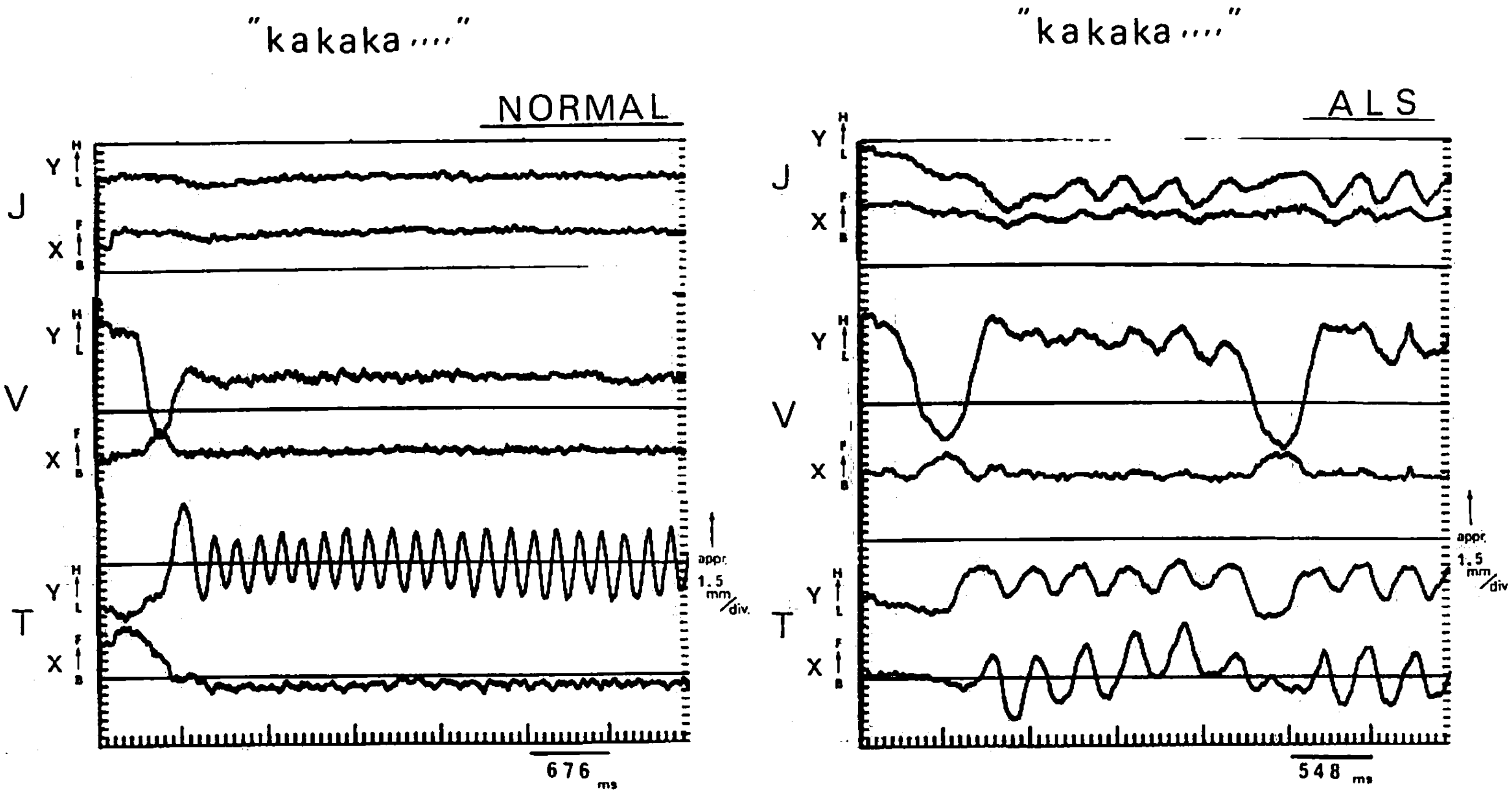

Fig. 4 Patterns of movements of the tongue dorsum, velum and jaw for repetition of the monosyllable /ka/ in the normal subject (left) and in the ALS subject (right).

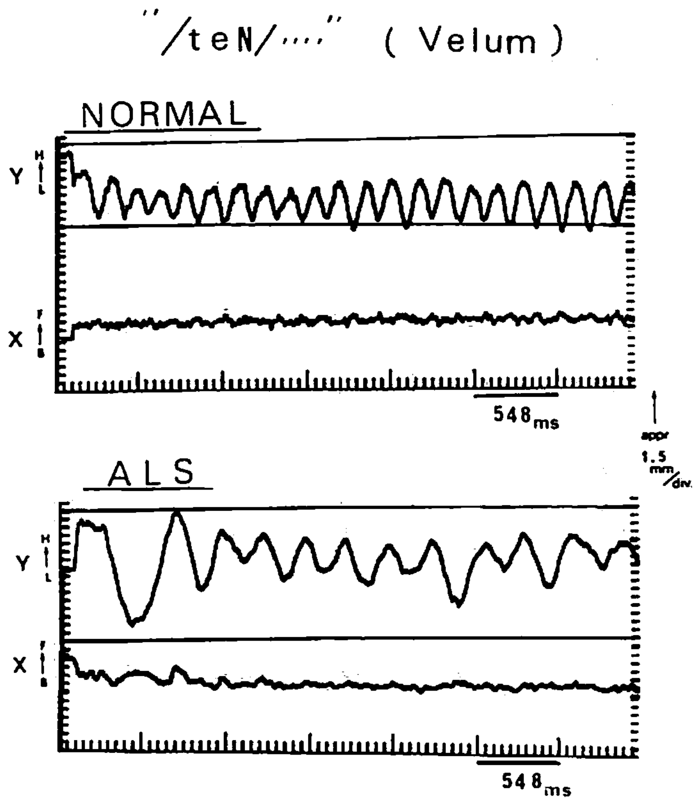

Fig. 5 Patterns of movements of the velum in the normal subject (upper) and in the ALS subject (lower) for the repetition of the monosyllable /teN/.

consecutive frames to represent the trajectory of the pellet within that very short period of time. It can be seen that the maximum velocity of each articulator is considerably low in the pathological cases. Still, the SD's are within the range comparable to those of the normal.

Comments

The patterns of articulatory movements in ALS and PBP subjects are found to be characterized by general slowness represented mainly by sluggish displacement of the articulators for the production of each sound or sound sequence. The velocity of each articulator is also found to be low as compared to that of normal subjects. On the other hand, consistency of the dynamic pattern in articulatory gestures is generally preserved, as seen in the repetition of the monosyllables. The values of the maximum velocity of the articulators are also fairly consistent. This feature is clearly different from that of ataxic patients, who often present slow movements associated with marked inconsistency of dynamic patterns of articulatory gestures (Hirose et al., 1978).

			range	(mean)	SD	(%SD)
Lip (repetitions of /pa/)						
HH	(normal)	closure	18.8-25.4	(22.2)	1.9	(8.5)
		release	14.0-20.7	(16.5)	2.6	(15.9)
MN	(ALS)	closure	9.4-12.9	(11.4)	1.2	(10.6)
		release	8.5-12.3	(10.5)	1.4	(13.4)
YA	(ALS)	closure	6.7-11.0	(9.3)	1.6	(16.9)
		release	6.5-11.2	(9.3)	1.3	(14.2)
TS	(PBP)	closure	7.1-11.9	(10.3)	1.9	(18.1)
		release	10.1-12.8	(11.3)	0.8	(7.0)
Velum elevation (repetitions of /teN/)						
MS	(normal)		12.3-20.4	(17.7)	2.6	(14.5)
HH	(normal)		12.5-18.6	(16.3)	1.9	(11.7)
MN	(ALS)		8.8-15.4	(10.9)	2.1	(19.0)
YA	(ALS)		4.3- 7.4	(6.1)	1.1	(17.5)
TS	(PBP)		7.6-12.7	(11.3)	1.6	(13.8)
CK	(PBP)		5.4-11.8	(9.4)	2.0	(21.4)
Tongue dorsum (repetition of /ka/)						
HH	(normal)	closure	15.0-22.7	(18.2)	2.5	(13.6)
		release	12.1-20.4	(16.8)	2.1	(12.4)
MN	(ALS)	closure	8.6-13.9	(12.4)	1.7	(14.0)
		release	8.9-13.7	(11.5)	1.9	(16.5)

Table 1. Values of the maximum velocity of the articulators and their standard deviation (SD).

It is also found that lip and tongue articulations are often accompanied by jaw displacement which is rather atypical in the normal subjects. This is probably an evidence of compensatory articulation in which tongue or lip gesture is compensated by jaw movements. Clinically, it is usually the case that jaw movement is well preserved even in advanced cases of ALS or PBP. The finding of "jaw dependency" in the present series may indicate the presence of voluntary effort of compensation in the pathological cases.

The gradual shift of tongue position and the tendency toward the lowering of the velum during the repetitive production of the monosyllables are likely to be due to easy fatigability of the articulatory muscles, often described as progressive weakness, during movements.

The abovementioned dynamic features can be considered as the causes of imprecise consonant articulation, vowel distortion, bradylalia, hypernasal voice quality and nasal emission, all of which are known to characterize the clinical profiles of these cases. It must be noted here that these clinical patterns and articulatory characteristics are common in these two different neurological categories of ALS and PBP. In other words, although the two pathological groups must be and can be distinguished on a neurological basis, at least the articulatory dynamics are very similar. In this sense, these two groups may be combines as "paralytic" dysarthria only for simplification in describing their articulatory characteristics. In any case, our method of analysis of articulatory dynamics can further be applied for a more precise description of pathological pictures in each case.

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