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CHANGES IN THE SPEECH OF SPASTIC DYSARTHRIC PATIENTS AFTER TREATMENT BASED ON PERCEPTUAL ANALYSIS

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1. Introduction

Methods of treatment for dysarthric patients may be divided into four types: (1)speech therapy for basic motor speech processes (articulation-resonance, prosody, phonation); (2)a physiological approach to the impaired speech mechanism; (3)application of instrumentation, including palatal lift prosthesis, amplification, DAF, etc.; and (4)developing alternative means of communication (Darley, et al.[1], Shibata[2], Rosenbek[3], Fukusako[4]). Systematic investigations into the specific efficacy of each method are sparse despite the necessity of information for planning adequate therapy. In recent years, there have been several reports on this issue (for spastic dysarthria --Simpson, et al.[5]; for flaccid dysarthria --Netsell, et al.[6]; for ataxic dysarthria --Yorkston, et al.[7]; for Parkinson's Disease --Robertson, et al.[8]; for dysarthria resulting from closed head injury --Hartman, et al.[9], Bellaire, K.,et al.[10]).

With regard to spastic dysarthria of a mostly cerebrovascular origin, the following studies have been reported. Michi, et al.[11] reported on 37 dysarthric patients with a velopharyngeal insufficiency who were treated with a palatal lift prosthesis (PLP). The results indicated that speech intelligibility improved significantly (by more than 10%) in 15 patients, slightly in 3, remained unchanged in 13, and deteriorated in 2. Yoshida, et al.'s case study[12] involves a 45-year-old man with spastic dysarthria and dysphagia following cerebral infarct. Throughout 12-months of speech therapy and treatment with PLP, his speech disturbance as well as dysphagia improved. Simpson, et al.[5] describe a long-term treatment and changes in symptoms in a 58-year-old man with severe dysarthria secondary to basilar artery thrombosis. A variety of treatments toward modifying his speech as well as velopharyngeal function, brought about significantly improved communication and quality of life. Reports by Furusawa, et al.[13,14] present patients with pseudobulbar palsy due to cerebrovascular accident (CVA) whose

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conversational intelligibility and eating ability improved

through physical therapy for the impaired speech mechanism. Among these reports, evaluations of speech intelligibility or conversational intelligibility are used as a measure for assessing changes in the speech of spastic dysarthria after treatment. Intelligibility is an overall index of speech performance. There have been no reports on changes in the speech characteristics of spastic dysarthria using comprehensive measures for analytic aspects of speech.

The purpose of the present study is to investigate changes in the speech characteristics of spastic dysarthria after treatment using a perceptual analysis.

2. Methods

(1) Subjects

The subjects were 24 patients with spastic dysarthria secondary to CVA who had been enrolled in speech therapy at the Speech Pathology Service of the Tokyo Metropolitan Geriatric Hospital. None of the subjects had other types of speech or language disturbance (e.g., aphasia, apraxia of speech, acquired stuttering). The diagnosis of spastic dysarthria was established on the basis of medical information, case history and speech examination. The severity of speech impairment at the beginning of treatment was mild for 2 patients, moderate for 14 patients, and severe for 8 patients. The mean age of the patients was 61.6 years, with a range of 21 to 80 years. Twenty-one patients were males, and 3 were females. Seven of these 24 subjects were judged to have a mild intellectual deficit evidenced by low scores on the Kohs cubic test and clinical observations. Fifteen patients had had a single CVA episode, but the others had multiple episodes. Ten patients were right hemiplegic, 4 were left hemiplegic, 8 were double hemiplegic, and the remaining 2 had no motor dysfunction. The time period between the onset of dysarthria and the beginning of treatment was 1 to 3 months for 13 patients, 4 to 6 months for 5 patients, 7 to 12 months for 2 patients, 13 to 24 months for 2 patients and 25 to 36 months for 2 patients. Thus, 75 % of the patients were at less than 6 months post onset.

(2) Treatment

The treatment procedures are summarized in Table 1. A combination of two or three types of therapy was usually employed for each patient. Treatment was focused on the improvement in functional speech. No patient was included who was treated exclusively by a physiological approach to the speech musculature. Patients who were treated with a palatal lift prosthesis were not included, either. All the patients were given individual speech therapy with assigned practice at home. One therapy session generally lasted 30 minutes, and the frequency of

Table 1 Speech Therapy for Dysarthria

mode of therapy	content
"Systematic" articulation therapy	"Systematic" articulation therapy nearly corresponds to traditional articulation therapy developed by Van Riper and Emerick[15]. This method is generally applied to patients with functional articulation disorder, cleft palate speech and other various articulation disorders. The hallmark of this mode lies in its sequencing of activities for (1)identifying the standard sound and discriminating it from its error; (2) correcting the sound errors; and finally (3) stabilizing the correct production and transferring the new speech skill to everyday communication. This process is usually carried out first for the standard sound in isolation, then in the syllable, in the word and finally in sentences.
Mora-by-Mora attack with finger-counting gestures	The mora is a linguistic unit, and which corresponds nearly to a syllable. The patient is asked to speak using finger-counting gestures for each mora, so that individual moras are produced deliberately and separately and adjacent moras are not elided. Attention should be given to separating words into their component moras. This method is systematically conducted first for words, then for sentences, and finally for conversational speech.
"phrase-by-phrase" attack	One of the methods for slowing the rate of speech. The patient is asked to speak individual phrases separately. The "phrase-by-phrase" attack is performed first for short sentences, then for paragraphs, and finally for conversational speech. The phrase corresponds to a Bunsetsu in Japanese grammar. The Bunsetsu structure consists of one conceptual word followed by several functional words. Thus, the "phrase-by-phrase" attack is carried out in terms of a Bunsetsu-by-Bunsetsu attack with our patients.
physiological approach for the impaired movement of speech mechanisms	Various physiological or nonspeech approaches in order to reduce the effects of the impaired movement of the speech mechanisms. The patient is trained to modify the range, force, rate, and timing of the motion performed by the speech organs such as the mandible, lips, tongue, soft palate etc. Practice is usually carried out for these organs in isolation as well as in coordination.
miscellaneoous	The patient is instructed to overarticulate so as to prevent the slighting of phonemes for syllables. Practice on the adjustment of pitch, loudness, voice quality, and prosody etc.

treatment was 1 to 3 times a week. The time period between the beginning and the termination of treatment was 2 to 3 months for 13 patients, 4 to 6 months for 10 patients, and 9 months for one patient.

(3) Assessment of speech characteristics

Speech samples were rated by five experienced judges using a perceptual analysis of the speech characteristics. An assessment of speech characteristics using perceptual analysis for Japanese speakers was devised by Fukusako, et al.[16] based on the studies of Darley, et al.[17, 18] and Hirose[19]. Twenty-five speech and voice characteristics were selected, each of which has been given a short name as well as a description in Table 2. These 25 factors consist of 23 analytical dimensions pertaining to voice, prosody and articulation-resonance (No.1-23), and two overall or general impression dimensions (No.24, 25): Bizarreness and Intelligibility. Each patient's performance with regard to each dimension was rated through the use of a five-point equal intervals scale of severity, with 0 representing normal speech and 4 representing a very severe deviation from normal. Intelligibility was evaluated using the traditional five-point intervals of scale of severity: 1 representing normal speech and 5 representing a very severe deviation from normal. In each patient, a two-minute tape-recorded sample of either spontaneous speech or a reading from the passage "The north wind and the sun" was obtained before and after treatment. Five judges fully experienced in this perceptual analysis of dysarthric speech (4 speech and language pathologists and 1 otolaryngologist), listened to a series of speech samples edited in random order, and recorded independently their severity rating with regard to each dimension.

(4) Reliability

Both interjudge reliability and temporal reliability in these judgments were measured.

First, with respect to interjudge reliability, a comparison was made for the ratings of the five judges of the 48 speech samples on the 25 dimensions --a total of 1200 sets of five ratings. The agreement of the five judges was determined by the distance of disagreement. It was found that 97.4% of the sets fell within one scale value.

Second, to determine the stability of the judgments, 12 speech samples were scaled twice with an interval of two to three months on each of the 25 dimensions. The five judges agreed with themselves on two independent ratings within one score value from 97.9% to 99.3%. This level of reliability was considered to be generally satisfactory. The means of the five ratings were used in all of the statistical treatments.

3. Results

Table 2 Dimensions used in this study (Fukusako, et al.[16])

	No.	Dimension	Description
Voice	1	Harsh voice	Voice is harsh, rough, and raspy.
	2	Breathy voice	Voice is breathy and thin.
	3	Asthenic voice	Voice is asthenic and weak.
	4	Strange-strangled voice	Voice (phonation) sounds strained or strangled(an apparently effortful squeezing of the voice through glottis).
	5	Pitch level	Pitch of voice sounds consistently too low or too high for an individual's age and sex.
	6	Pitch breaks	Pitch of voice shows sudden and uncontrolled variation(falsetto breaks).
	7	Loudness level	Voice is insufficiently or excessively loud.
	8	Loudness decay	There is progressive diminution or decay of loudness.
	9	Alternating loudness	There are alternating changes in loudness.
	10	Voice tremor	Voice shows shakiness or tremulousness.
Prosody	11	Rate	Rate of actual speech is abnormally slow or rapid.
	12	Increase (Decrease) in rate	Rate increases(decreases) progressively within given segments of connected speech.
	13	Variable rate	Rate changes from slow to fast.
	14	Prolonged intervals	There are prolongations of phonemes or intersyllable intervals. Duration of phonemes or syllables may be either prolonged or shortened.
	15	Irregular breakdown in the duration of phonemes	There is intermittent, non-systematic breakdown in the duration of phonemes.
	16	Short phrases	Phrases are short (possibly because inspirations occur more often than usual). The speaker may sound as if he has run out of air. He may produce a gasp at the end of a phrase.
	17	Monopitch and Monoloudness	Voice is characterized by monotony of pitch or loudness. Voice lacks normal pitch and inflectional changes or normal variations in loudness.
	18	Repeated phonemes	There are repetitions of phonemes.
Articulation-resonance	19	Hypernasality	Voice sounds excessively nasal. Excessive amount of air is resonated by nasal cavities.
	20	Nasal emission	There is nasal emission of the air stream.
	21	Distorted vowels	Vowel sounds are distorted throughout their total duration.
	22	Imprecise consonants	Consonant sounds lack precision. They show slurring, inadequate sharpness, distortions and lack of crispness.
	23	Irregular articulatory breakdown	There is intermittent non-systematic breakdown in accuracy of articulation.
Overall	24	Bizarreness	Degree to which overall speech calls attention to itself because of its unusual, peculiar or bizarre characteristics.
	25	Intelligibility	This is a rating of the overall intelligibility or understandability of speech.

(1) Improved Dimensions

Figure 1 shows the changes in the mean values for each of the 25 dimensions expressed as a form of a profile before and after treatment. The abscissa indicates the 25 dimensions, and the ordinate shows the mean values. The solid line represents the ratings pretherapy and the dotted line represents the ratings post-therapy. A value of zero represents normal performance. Thus, values plotted further from the base line represent larger deviations from normal performance.

It is evident from Fig.1 that a decrease (improvement) in mean scale value occurred for two overall impression dimensions: Intelligibility and Bizarreness. In addition, improvement was apparent on dimensions pertaining to articulation-resonance, as well as pertaining to voice or prosody. In other words, improvement through treatment was observed not only in general dimensions but also in all aspects of speech performance.

When a decrease in scale value of 0.5 or higher was taken as an indication of improvement before and after treatment, the patients showed improvement for an average of 4 dimensions. The number of improved dimensions ranged between 1 to 12 when examined individually. It should be noted that all of the patients showed an improvement in at least one dimension. Table 3 shows the number of cases showing improvement in each dimension. Improvement was observed in 18 patients for Intelligibility, followed by 15 for Distorted vowels, 14 for Imprecise consonants and 14 for Bizarreness. Among these four dimensions, 2 dimensions pertained to overall impression and the other 2 belonged to the analytical dimension of articulation. It was noted that four patients showed improvement in Intelligibility but not in Bizarreness. The fifth to the eighth rankings in improved dimensions were for Rate--slow, Loudness decay, Monopitch and monoloudness and Short phrases, being limited to prosody except for Loudness decay. Hypernasality, Nasal emission and Asthenic voice were equally ranked as ninth. Among these 3 dimensions, the former two pertained to dimensions of resonance, and the last pertained to the dimension of voice quality. The 12th to 18th rankings in improved dimensions were those of voice as well as prosody.

(2) Changes in severity

Table 4 shows the amount of change in severity (sum of scale values of Bizarreness and Intelligibility) as well as fdegree of improvement, for 24 patients after treatment. The degree of improvement ranged from -0.60 (showing a tendency of deterioration) to 5.40 in severity. The patients' changes in severity were divided into three groups: namely, unchanged, improved and greatly improved, according to the following criteria. A decrease in scale value of less than 1 was classified

Fig.1 Changes in mean profile on 25 dimensions before and after treatment.

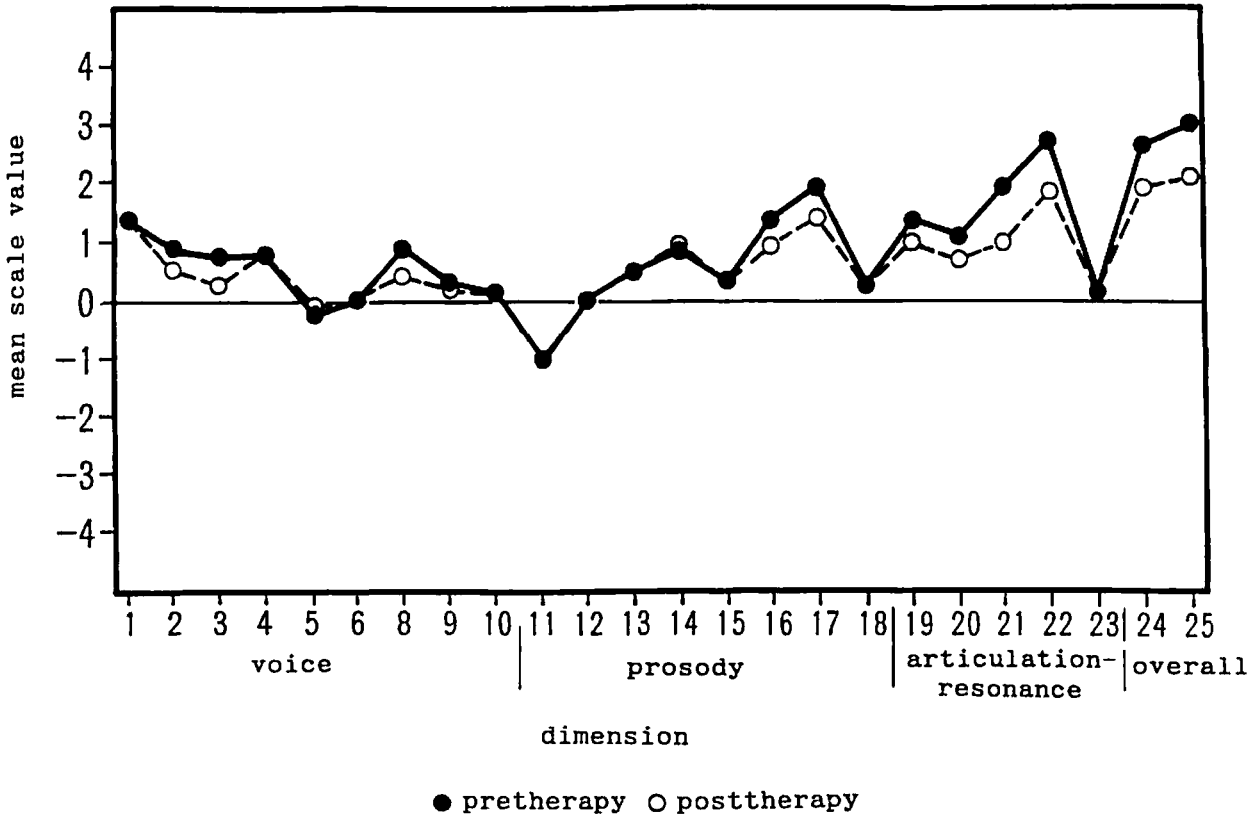


Table 3 Number of cases showing improvement* in each dimension

*Improvement indicates a decrease in a scale value above 0.5 on each dimension before and after treatment.

Rank	No.of cases	Dimension
1	18	Intelligibility
2	15	Distorted vowels
3	14	Imprecise consonants
3	14	Bizarreness
5	11	Rate--rapid
6	10	Loudness decay
6	10	Monopitch and monoloudness
8	8	Short phrases
9	7	Hypernasality
9	7	Nasal emission
9	7	Asthenic voice
12	5	Breathy voice
12	5	Variable rate
14	4	Pitch level--low
15	2	Harsh voice
15	2	Prolonged intervals
15	2	Irregular breakdown in duration of phonemes
18	1	Decrease of rate
18	1	Repeated phonemes

Table 4 Changes in severity(sum of the scale values of Bizarreness and Intelligibility) before and after treatment

No.	cases Name(age,sex)	severity before (A)	after (B)	degree of improvement (A)-(B)	category
1	I.K.(70, M)	3.40	2.60	0.80	unchanged
2	S.W.(57, M)	3.40	3.00	0.40	unchanged
3	T.S.(68, M)	4.00	3.40	0.60	unchanged
4	Y.F.(64, M)	4.00	2.60	1.40	improved
5	T.T.(62, M)	4.20	3.80	0.40	unchanged
6	T.S.(80, M)	4.20	4.60	-0.60	unchanged
7	Y.S.(53, F)	4.20	3.00	1.20	improved
8	K.K.(62, M)	4.40	3.60	0.80	unchanged
9	H.K.(47, M)	4.60	2.20	2.40	significantly improved
10	T.M.(67, M)	4.80	3.00	1.80	improved
11	H.M.(72, M)	5.00	2.80	2.20	significantly improved
12	E.M.(65, M)	5.40	3.80	1.60	improved
13	K.I.(60, M)	5.40	4.40	1.00	improved
14	N.Y.(60, M)	5.60	1.80	1.80	improved
15	M.T.(73, M)	5.60	4.40	1.20	improved
16	A.E.(73, M)	5.80	5.80	0.00	unchanged
17	Y.N.(46, M)	7.20	3.40	3.80	significantly improved
18	M.Y.(74, M)	7.20	4.80	2.40	significantly improved
19	T.T.(76, M)	7.40	5.00	2.40	significantly improved
20	M.Y.(75, F)	7.60	7.00	0.60	unchanged
21	S.Y.(51, M)	7.80	6.60	1.20	improved
22	M.U.(21, F)	8.20	2.80	5.40	significantly improved
23	K.T.(30, M)	8.40	3.20	5.20	significantly improved
24	J.Y.(72, M)	8.60	7.00	1.60	improved

as unchanged; a decrease in scale value of more than 1 but less than 2 was classified as improved; and a decrease in scale value above 2 was classified as greatly improved. Of the 24 patients, 8 patients were categorized as unchanged, while improvement was observed in 16 patients (approximately 70%), 7 of whom were categorized as significantly improved.

The mean value of the degree of improvement was 0.60 for the mild groups, 1.11 for the moderate groups and 2.83 for the severe groups. That is to say, the more profoundly speech performance was impaired pretherapy, the more prominent the degree of obtained improvement was post therapy.

As for the influence of age, the mean value of the degree of improvement was compared between the younger group (younger than 59) and the older group (older than 60). Seven patients who belonged to the younger group showed more improvement (mean value =2.80) than 17 patients in the older group (mean value =1.17). However, it should be noted that the mean values for severity were different in the two groups before treatment: 6.26 for the younger group and 5.44 for the older group.

As for the influence of the time period post-onset, 14 patients in the early-post-onset group (started therapy within 4 month-post-onset; mean value in severity pretherapy = 5.24), showed a post-therapy improvement of 1.30. Ten patients in the late-post-onset group (started therapy after 4 month-post-onset; mean value in severity pretherapy = 6.28) showed a post-therapy improvement of 2.12. Thus, there was no tendency for the degree of improvement to be greater for the patients whose treatment had started earlier.

As for the influence of single versus multiple episodes, the mean value of the degree of post-therapy improvement was 1.53 for 15 patients with a single episode (mean value in severity pretherapy =5.35), while 9 patients who had had two or more CVAs showed a value of 1.82 (mean value in severity pretherapy = 6.22). This difference was not statistically significant.

As for the influence of intellectual deficit, post-therapy improvement was 1.48 for 17 patients without intellectual deficit (mean value in severity pretherapy =5.06), while it was 2.03 for 7 patients with an intellectual deficit (mean value in severity pretherapy =7.17). No apparent difference was revealed as to degree of improvement between patients with and without intellectual dysfunction.

As for the influence of the period of treatment, the mean value of the degree of post-onset improvement was 1.12 for 13 patients with less than 4 months of treatment (mean value in severity pretherapy =5.28), while it was 2.25 for 11 patients with more than 4 months of treatment (mean value in severity pretherapy =6.15).

(3) Deteriorated dimensions

Table 5 shows the dimensions on which the patients showed an increase (deterioration) in scale value above 0.5 before and after treatment. Deterioration was observed in 5 patients for Prolonged intervals, in 3 patients for Strange-strangled voice, in two for the dimensions including Pitch level--high, Rate--slow, and Monopitch and monoloudness, and in one for Variable rate and Repeated phonemes.

It is worth noting that deterioration in Prolonged intervals was recognized exclusively for patients treated through the Mora-by-Mora attack with finger-counting-gestures.

In the following section, four cases are presented, who represent different patterns of changes in profile.

Case 1. Improvement generally in the analytic dimensions of voice, prosody and articulation-resonance

E.M., a 65 year-old man with left hemiplegia and speech disturbance due to his first CVA, visited the Speech Pathology Service of the Tokyo Metropolitan Geriatric Hospital at 2 months post-onset. As a result of a speech examination, he was diagnosed as having moderate spastic dysarthria. Six-months of speech therapy, namely "Systematic" articulation therapy as well as a "phrase-by-phrase" attack was conducted three times a week.

Figure 2 shows the changes in E.M.'s profile, in the analytic dimensions of voice (Harsh voice, Asthenic voice, Pitch level --high, and Loudness decay), prosody (Rate--slow and Short phrases), and articulation-resonance (Hypernasality, Nasal emission, Distorted vowels and Imprecise consonants) as well as in overall dimensions.

Case 2. Improvement mainly in the analytic dimensions of prosody and articulation-resonance

M.U., a 21 year-old woman, had been under medical treatment at the hospital for systemic disease since she was nineteen years old. At the age of twenty she sustained a CVA associated with systemic disease. Residual deficits included double hemiplegia as well as speech and voice disturbances. Intensive rehabilitation services, except speech therapy, over about a two-year period produced significant improvement in motor functions and the activities of daily living. When the patient was able to commute as an outpatient at 23 months post onset, she visited the Speech Pathology Service of the Tokyo Metropolitan Geriatric Hospital for the treatment of her communication disorder. Speech and language evaluation revealed severe spastic dysarthria as well as voice disorder (high-pitched voice). "Systematic" articulation therapy was carried out over a 6-month period, twice a week for the first three months, then once a week for the remaining three months.

The results were dramatic. Figure 3 presents changes in the

Table 5 Number of cases showing deterioration* in each dimension

*Deterioration indicates a gain in a scale value above 0.5 on each dimension before and after treatment

Rank	No.of cases	Dimension
1	5	Prolonged intervals
2	3	Strange-strangled voice
3	2	Pitch level--high
3	2	Rate--slow
3	2	Monopitch and monoloudness
6	1	Variable rate
6	1	Repeated phonemes

Fig.2 Changes in the profile of E.M., showing general improvement in the analytic dimensions of voice, prosody and articulation-resonance.

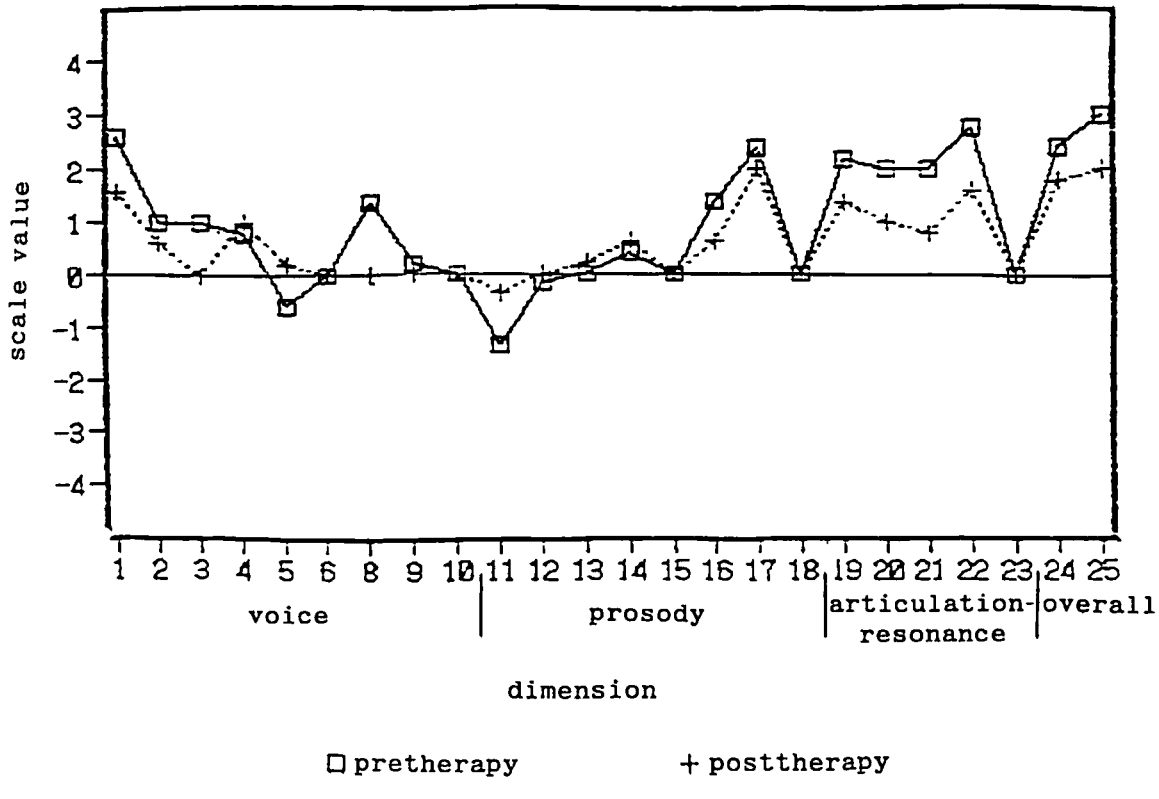
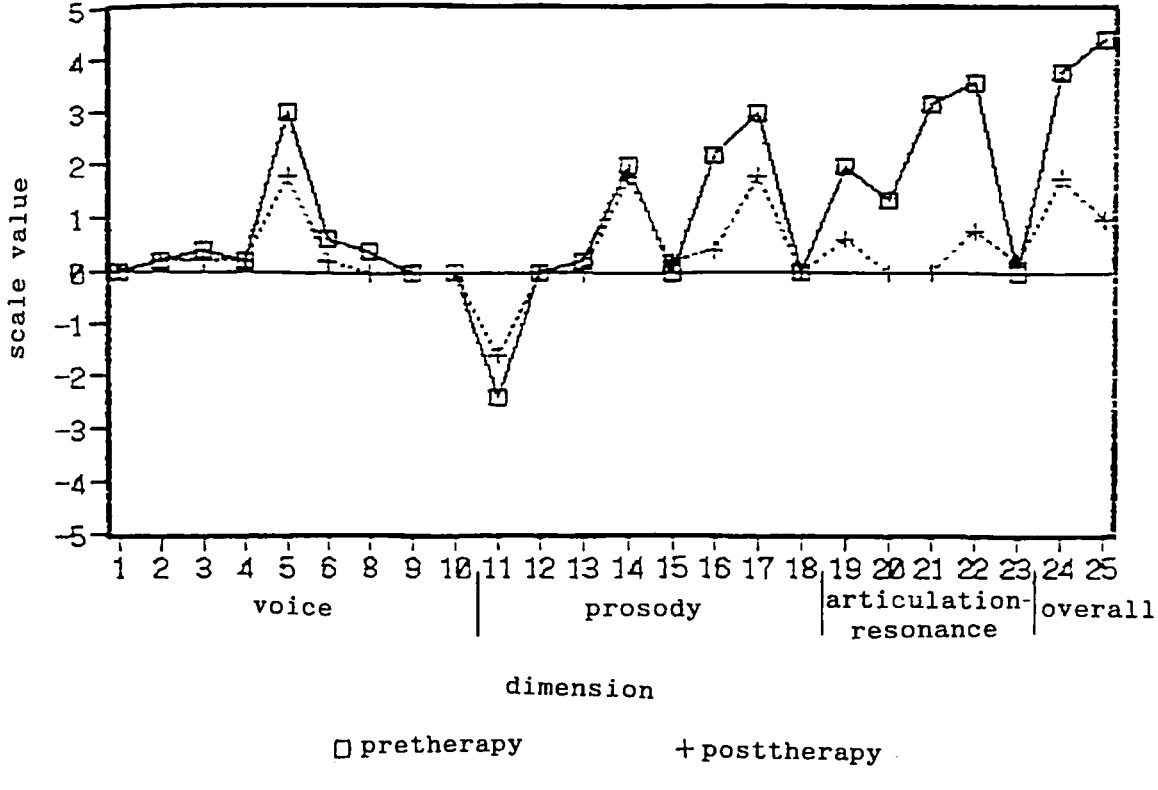


Fig.3 Changes in the profile of M.U., showing improvement mainly in the analytic dimensions of prosody and articulation-resonance.



profile of M.U. after treatment, showing an improvement in the overall dimensions of 5.40 of scale value on severity overall, together with improvements in the analytic dimensions of prosody (Rate--slow, Short phrases, and Monopitch and monoloudness), and articulation-resonance (Hypernasality, Nasal emission, Distorted vowels, and Imprecise consonants). Additionally, the high-pitched quality of her voice was ameliorated without specific voice therapy.

Case 3. Improvement exclusively in the analytic dimensions of prosody

M.T., a 73 year-old man, with right hemiparesis and speech disorder secondary to his first CVA, visited the Speech Pathology Service one month after onset. Overarticulation and a physiological approach to the impaired movement of the speech mechanisms were performed three times a week over a 6-month period.

As shown in Figure 4, post-therapy improvement was observed exclusively in the dimensions of prosody (Rate--slow, Variable rate, Prolonged intervals, and Monopitch and monoloudness). Changes in overall dimensions were relatively unremarkable (1.20 of scale value on severity), although this amount of decrease was classified as improved.

Case 4. Improvement and deterioration in the analytic dimensions

H.M., a 72 year-old man, with right hemiparesis and moderate spastic dysarthria resulting from his first CVD, visited the Speech Pathology Service at four months post-onset. A Mora-by-Mora attack with finger-counting-gestures was performed twice a week over a 3-month period.

As a result, a significant improvement of 2.20 of scale value on severity was observed. However, examination of the two overall measures revealed that improvement occurred only in Intelligibility but not in Bizarreness as shown in Figure 5.

Concerning the analytic dimensions, not only prominent improvement but also definite deterioration was observed. The improvement was in the dimensions of Hypernasality, Distorted vowels, Imprecise consonants (articulation-resonance), Loudness decay (voice), Variable rate, Prolonged intervals and Irregular breakdown in duration of phonemes (prosody). Before treatment he had a tendency for the distinction of each syllable in speech to become unintelligible as his speaking rate increased. This tendency remained partly even after treatment, as seen in his irregular breakdown in duration of phonemes. On the other hand, deterioration was recognized in the dimensions of Rate--slow, Prolonged intervals, and Monopitch and monoloudness, most prominently in Prolonged intervals.

4. Discussion

Fig.4 Changes in the profile of M.T., showing improvement exclusively in the analytic dimensions of prosody.

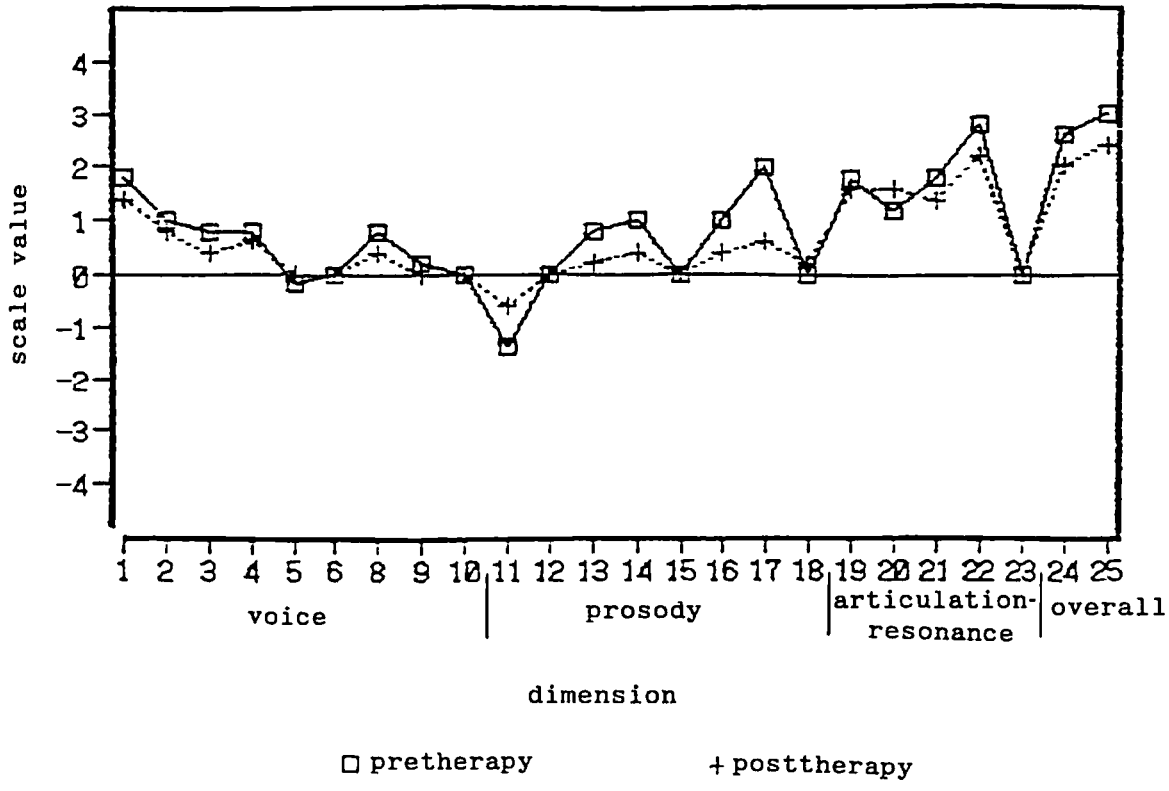
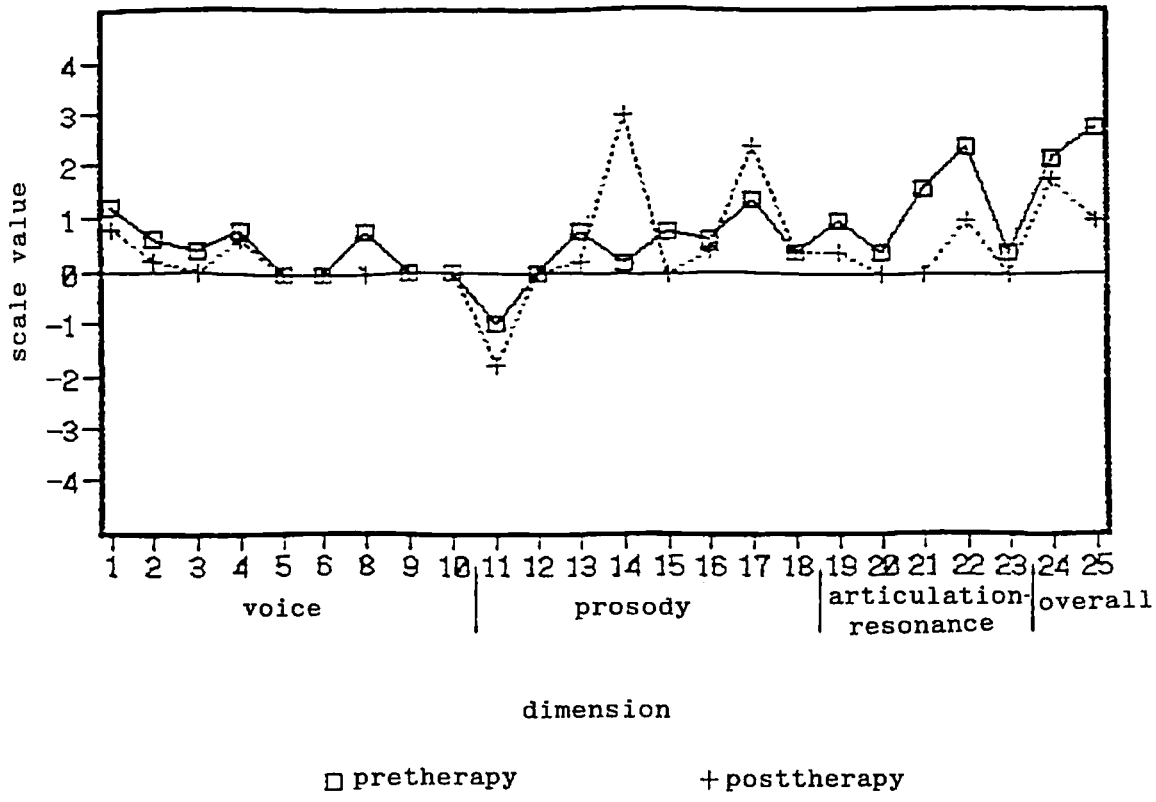


Fig.5 Changes in the profile of H.M., showing improvement as well as deterioration.



(1) Effects of speech therapy for spastic dysarthria

Our results demonstrated that 16 out of 24 spastic dysarthric patients (approximately 70%) showed improvement in severity through speech therapy. Caution should be exercised in interpreting our results. First of all, we have not had been able to use a group study design to determine the effects of speech therapy. Secondly, we should take the characteristics of our present subject population into consideration. That is to say, only two cases were mild, and the most severe cases were excluded. So the above mentioned figures should be interpreted to represent a general tendency for a limited population of spastic dysarthric patients about whom a judgment of candidacy for speech therapy was made in our clinic. Usually, the effects of speech therapy for dysarthric patients depend upon the mode, period and frequency of treatment, as well as other related factors. In the present investigation one or more modes of therapy were carried out for each patient, and the period and frequency of treatment varied for each patient. Therefore, our findings should be taken conservatively to indicate the "general" efficacy of speech therapy for spastic dysarthria.

Concerning changes in the analytic aspects of speech post-therapy, it is worthy of note that improvement occurred in the broad dimensions covering articulation-resonance, prosody and voice. Most improvement was noted in the dimensions of articulation such as Distorted vowels and Imprecise consonants. This is probably due to the therapy method, since the emphasis of treatment for dysarthric speakers in the present study was placed on the amelioration of articulatory errors. The next dimensions showing the greatest improvement were those representing prosody, except for one dimension. There is a possibility that this tendency is not irrelevant to the method of treatment used for the present subject group. The modes of therapy through which the patients were treated, for example, the "phrase-by-phrase" attack and Overarticulation, might have influenced the prosody of our dysarthric speakers. Furthermore, improvement in either resonance or voice might suggest that the modes of therapy used in the present report brought about secondary effects on the manner, rate and timing of phonation as well as articulation-resonance. On the other hand, among the dimensions which deteriorated, a deterioration in Prolonged intervals was present exclusively for the patients treated through the Mora-by-Mora attack with finger-counting-gestures. Therefore, this finding seems to suggest that the negative effect was necessary in achieving intelligible speech. The remaining dimensions which deteriorated should be investigated in future studies.

It is possible that the present results concern various factors in addition to individual differences. Among these factors, first of all, we should consider whether the changes in speech obtained through the treatment resulted from a spontaneous recovery and/or the effects of the speech therapy. Concerning

spastic dysarthria, there have been no reports regarding the time period of spontaneous recovery or the nature of improvement due to spontaneous recovery. In the case of aphasia, which is similar to dysarthria in terms of being a communication disorder secondary to brain damage, spontaneous recovery generally persists throughout the first three months post-onset. If we generalize this tendency to dysarthria, it is reasonable to attribute some of the improvement observed in the present study to spontaneous recovery. Thirteen of our 24 patients were at less than 3 months post-onset when the treatment was started. As for the relationship between improvement in speech and age, the number of subjects was too small to treat the data statistically. Besides, it was impossible to examine the influence of the period of treatment on the changes in the patients' speech, since in a number of patients, the termination of the speech therapy was not determined by clinicians but by various reasons including discharge from the hospital or debilitating conditions. Additionally, the patients in the present study were selected because speech therapy for spastic dysarthria was indicated for them, regardless of intellectual deficit or severity of speech impairment at the beginning of the treatment. We cannot ignore the severity of the impaired movement of the speech musculature, upon which a prognosis of dysarthric speech is likely to depend, although this factor was not taken into consideration, either, in this report. How these factors concretely influence changes through therapy in dysarthric speakers remains for future studies.

(2) Implications of a perceptual analysis of dysarthric speech before and after treatment

Changes in the performance of dysarthric patients after treatment are evaluated in various ways, such as speech pathological evaluation, aerodynamic examination, acoustical analysis, investigation of speech mechanisms, clinical observation etc., according to the purpose or mode of speech therapy. In previous reports, speech condition has been assessed by speech intelligibility (%) (Simpson, et al.[5], Yorkston, et al.[7], Michi, et al.[11], Kallen, et al.[20]), conversational intelligibility (interval scale of severity) (Yoshida, et al.[12], Furusawa, et al.[13,14]), rate of speech (words per minute) (Yorkston, et al.[7], Hanson, et al.[21]) and perceptual analysis (Rubow, et al.[22], Day, et al.[23]).

As far as spastic dysarthria is concerned, overall measures such as speech intelligibility and conversational intelligibility have been used. Intelligibility is one of the most important measures reflecting the efficacy of communication. In fact, improvement in Intelligibility, which was evaluated based on auditory impression in this report, was present for a great number of patients in our present study. In addition to this measure, we used Bizarreness as another overall dimension. As a result, it was revealed that 4 of the 24 patients showed improvement in Intelligibility but were unchanged in terms of Bizarreness. This finding indicates the relative independence of

Bizarreness and Intelligibility, and that the use of these two overall measures is beneficial in an overall assessment of dysarthric speech.

An analysis of perceptual characteristics is the most valuable measure of speech characteristics for the purpose of differentiating different types of dysarthria (Fukusako, et al.[16], Darley, et al.[17], Hirose[19], Carrow, et al.[24], Zyskie, et al.[25]). But there have been no reports where changes in the speech of spastic dysarthria after treatment were examined by perceptual analysis, although changes in speech due to Parkinson's Disease (Rubow, et al.[22]), or Wilson's Disease (Day, et al.[23]) have been studied by the same method. Our results for these 24 spastic dysarthric patients using perceptual analysis demonstrated that (1)improvement after treatment occurred not only on intelligibility but also on all aspects of speech; (2)deterioration was present in certain dimensions in exchange for gain in intelligibility in some patients; and (3)the dimensions in which improvement was shown and the degree of improvement varied from patient to patient.

In general, a perceptual analysis of dysarthric speech has the following disadvantages; First, because of the ceiling and floor effects, it is not necessarily sufficient to assess the changes in speech of the most severe patients or milder patients (the present results show it is impossible to evaluate clearly changes for mild patients). Second, the use of five-point intervals for a scale of severity on each dimension is relatively rough in measuring changes in speech characteristics through treatment. Thus, in addition to perceptual analysis other measurements would seem to be recommended for some patients, for example assessment of rate of speech, inspection of the number of inspirations during reading aloud, aerodynamic examination, acoustical analysis etc.

Nevertheless, it can be tentatively concluded that perceptual analysis is useful for the purpose of evaluating changes in the speech of spastic dysarthria after treatment, as well as for differentiating among types of dysarthria.

5. Summary

This study examined changes in the speech of spastic dysarthria after treatment using a perceptual analysis. Twenty-four subjects (mean age, 61.6 years) secondary to cerebrovascular accident enrolled in individual speech therapy for more than two months. The results are summarized as follows:

(1) The 7 dimensions showing most decrease (improvement), with a scale value of more than 0.5 after treatment, were Intelligibility, Distorted vowels, Imprecise consonants, Bizarreness, Rate--slow, Loudness decay and Monopitch and monoloudness.

(2) Improvement in severity (sum of the scale values of Bizarreness and Intelligibility) after treatment was observed for

16 of 24 patients (70%), and a prominent improvement was noted for 7 patients.

(3) The more profoundly speech performance was impaired before treatment, the more improvement was obtained.

(4) On the other hand, an increase (deterioration), with a scale value of more than 0.5 after treatment, was seen on dimensions of Prolonged intervals, Strange-strangled voice, Pitch level--high, etc.

(5) The dimensions on which improvement was shown and the degree of improvement varied from patient to patient.

(6) Implications of a perceptual analysis of dysarthric speech upon the measurement of the efficacy of treatment were discussed.

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References

1) Darley, F.L., Aronson, A.E. and Brown, J.R.: Motor Speech Disorders, p.270-278. W.B. Saunders Co., Philadelphia, 1975.
2) Shibata, S.: Dysarthria, p.155-240. In Sasanuma, S. (ed.) Speech and Language Disorders, Ishiyaku Syuppan Co., Tokyo, 1975. (in Japanese)
3) Rosenbeck, J.C. and Lapointe, L.L.: The Dysarthria; Description, Diagnosis and Treatment, p.251-310. In Johns, D.F. (ed.) Clinical Management of Neurogenic Communicative Disorders, Little, Brown & Co., Boston, 1978.
4) Fukusako, Y.: Dysarthria; Treatment, p.101-132. In Fukusako, Y., Itoh, M. and Sasanuma, S. (eds.): Manual of Speech Pathology and Audiology, Ishiyaku Syuppan, Tokyo, 1984. (in Japanese).
5) Simpson, M.B. Till, J.A. and Goff, A.M.: Long-term treatment of severe dysarthria: A case study. J. Speech Hearing Dis., 53, 433-440. 1988.
6) Netsell, R. and Daniel, B.: Dysarthria in adults; Physiological approach to rehabilitation. Arch. Phys. Med. Rehabil., 60, 502-508. 1979.
7) Yorkston, K.M. and Beukelman, D.R.: Ataxic dysarthria; Treatment based on intelligibility and prosodic considerations. J. Speech Hearing Dis., 46, 394-404. 1981.
8) Robertson, S.J. and Thomson, F.: Speech therapy in Parkinson's Disease; a study of the efficacy and long term effects of intensive treatment. Br. J. Dis. Commun., 19, 213-224, 1984.
9) Hartman, D.E., Day, M. and Recora, R.: Treatment of

dysarthria: A case report. J. Commun. Dis., 12, 167-173, 1979.
10) Bellaire, K., Yorkston, K.M. and Beukelman, D.R.: Modification of breath patterning to increase naturalness of a mildly dysarthric speaker. J. Commun. Dis., 19, 271-280, 1986.
11) Michi, K., Yamashita, Y., Imai, S., Arisawa, Y. and Suzuki, N.: The use of Palatal Lift Prosthesis with velopharyngeal insufficiency resulting from acquired neurologic disease. Jpn. J. Logop. Phoniatr,, 29, 239-255, 1988. (in Japanese)
12) Yoshida, T., Hirano, M. and Fujio, M.: Dysphagia and dysarthria resulted from cerebrovascular accident; a case study. Jibiinkooka, 34, 108-110, 1988. (in Japanese)
13) Furusawa, M. and Yamakawa, M.: Prespeech therapy for the patients with pseudobulbar palsy due to cerebrovascular accident. Physical Therapy & Occupational Therapy, 18, 353-355, 1984. (in Japanese)
14) Furusawa, M. and Yamakawa, M.: Physical therapy for the patients with pseudobulbar palsy due to cerebrovascular accident. Physical Therapy & Occupational Therapy, 21, 58-61, 1987. (in Japanese)
15) Van Riper, C. and Emerick, L.: Speech Correction; An Introduction to Speech Pathology and Audiology (7th edition), p.188-216, 1984.
16) Fukusako, Y., Monoi, H., Tatsumi, I.F., Kumai, K., Hijikata, N. and Hirose, H.: Analysis of dysarthric speech based on auditory impressions. Jpn. J. Logop. Phoniatr., 24, 149-164, 1983. (in Japanese)
17) Darley, F.L., Aronson, A.E. and Brown, J.R.: Differential diagnostic patterns of dysarthria. J. Speech Hearing Dis., 12, 246-269, 1969.
18) Darley, F.L., Aronson, A.E. and Brown, J.R.: Clusters of deviant speech dimensions in the dysarthrias. J. Speech Hearing Dis., 12, 462-469, 1969.
19) Hirose, H.: Speech Disorders--From the Standpoint of Logopedics and Phoniatrics--, p.214-232. In Kirikae, I. Approach to the Disorders of the Central Nervous System, Kanehara, Tokyo, 1973. (in Japanese)
20) Kallen, D., Marshall R.C. and Casey, D.E.: Atypical dysarthria in Munchausen syndrome. Br. J. Dis. Commun., 21, 377-380, 1986.
21) Hanson, W.R. and Metter, E.J.: DAF as instrumental treatment for dysarthria in progressive supranuclear palsy: a case report. J. Speech Hearing Dis., 45, 268-276, 1980.
22) Rubow, R. and Swift, E.: A microcomputer-based wearable biofeedback device to improve transfer of treatment in Parkinsonian dysarthria. J. Speech Hearing Dis., 50, 178-185, 1985.
23) Day, L.S. and Parnell, M.M.: Ten-year study of a Wilson's Disease dysarthric. J. Commun. Dis., 20, 207-218, 1987.
24) Carrow, E., Rivera, V., Maudlin, M. and Shamblin, L.: Deviant speech characteristics in motor neuron disease. Arch. Otolar., 100, 212-218, 1974.
25) Zyskie, B.J. and Weisiger, B.E.: Identification of dysarthria types based on perceptual analysis. J. Commun.