

Changes in Prosodic Characteristics after Speech Therapy for Patients with Motor Speech Disorders

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Abstract

For two types of motor speech disorder patients, one with amyotrophic lateral sclerosis (ALS), and one with olivoponto-cerebellar atrophy (OPCA), two different speech therapy methods, the Silverman method (facilitation of loud phonation) and the intonation emphasis method were used to examine the effectiveness of speech therapy. Acoustic analyses revealed wider F0 ranges in the post-therapy speech with both methods for the two patients. In perceptual experiments, the intonation emphasis therapy received the best evaluation for four speech features (intonation, articulation, voice quality, low abnormality), followed by the Silverman method in the ALS patient. In the OPCA patient, however, varied perceptual scores were obtained for the four speech features. Although the number of the subjects was limited in this study, the results indicated that the F0 ranges were widened by speech therapy but the effectiveness of each therapy method for improving various speech features might be different depending on the etiology of the disorders.

1. Introduction

Motor speech disorders is defined as “speech impairment caused by lesion or dysfunction of the motor control centers of the peripheral or central nervous system or a combination of both systems”[1]. Two classes of speech disorder, dysarthria and apraxia of speech are included in motor speech disorders. Dysarthria, which is the main interest of our research is “a group of speech disorders characterized by disturbances in the dimensions of strength, speed, tone, steadiness, accuracy, and range of movement in the muscles of the speech mechanism” [1]. Essential factors for speech production such as respiration, phonation, articulation, resonance, and/or prosody may be affected depending on the etiology of dysarthria (i.e. neurological disorders).

The goal of speech therapy for dysarthria is to improve overall communication skills of the patients including various speech skills such as voice, articulation and prosody. Numerous number of literature on the treatment of dysarthria can be found [1-10]. Ramig (1997) reported that “Lee Silverman method”, in which the patients were instructed to speak loudly as if shouting was effective to improve not only the vocal loudness but also articulation and prosody of the various types of dysarthric speech. The explanation for the effectiveness of the method was that the overall speech effort levels of the patients were raised as the vocal effort was increased. Because of the simplicity of the instruction and therapy procedure and the remarkable effectiveness, Lee

Silverman method seems to be widely used by speech pathologists.

Many reports on the prosodic approach as a therapy method can be found [4-10]. It seems quite possible that speech therapy focusing on prosodic features is effective for some types of Japanese dysarthric patients because the proper F0 changes for word accent and intonation are essential for Japanese language, which is characterized by a word-pitch accent. But only a few clinical researches on prosody management for Japanese dysarthric patients have been reported [9,10]. Management of intonation did not seem to be systematically used in their speech therapy procedures.

The purpose of the present study was to examine the effectiveness of two kinds of speech therapy methods, the Silverman method and the intonation emphasis method, for patients with dysarthria. As our ultimate research goal is to develop an efficient speech therapy program to improve the speech of the patients with motor speech disorders, the present study could be considered as an initial step for the whole research.

2. Methods

2.1. Speakers

Two patients served as speakers. One of the speakers was a 47-year-old male with amyotrophic lateral sclerosis (ALS), exhibiting moderate voice and speech problems. The other speaker was a 63-year-old female with olivoponto-cerebellar atrophy (OPCA), exhibiting mild voice and speech problems.

2.2. Speech therapy

Two types of speech therapy methods were used for both speakers. One was the Silverman method, in which the patients were instructed to speak very loudly as if shouting. The other method was the intonation emphasis method, in which they were encouraged to use exaggerated intonation patterns with wider pitch ranges. The ALS patient was trained with the Silverman method first followed by the intonation emphasis method but for the OPCA patient, speech therapy was conducted in the reverse order. For the therapy sessions, 5 short sentences with various prosodic patterns were used and the training time was 5 minutes for each method.

2.3. Recording procedures

Audio recordings were made for each subject in the following periods: (1) before speech therapy, (2) 10 minutes after one therapy method, and (3) 10 minutes after the other therapy method. Between two therapy sessions and the subsequent

audio recordings, 30 minutes' intervals were taken in order to reduce some remaining effects of the first therapy.

For the speech sample, a clinically used passage "Sakura", which had 8 sentences and 227 moras was used for reading. Recordings were made in a soundproof room using a sound level meter (Ono Sokki LA-5111 with an electret condenser microphone MI-1233). The speech data were digitally recorded at the sampling frequency of 48kHz using DAT (SONY, TCD-D10 PROII).

2.4. Acoustic analyses

Acoustic analyses were made for pitch extraction using CSL4300B Multi Speech (Kay) with the 10 kHz sampling rate.

2.5. Perceptual experiments

The recorded speech data were used as the auditory stimuli for the perceptual experiments. Three speech therapists (ST) served as listeners to make perceptual judgments for three kinds of speech data for each subject in the paired comparisons. The pairs were (1) the baseline data versus speech after the Silverman method, (2) speech after the intonation emphasis method versus speech after the Silverman method, and (3) speech after the intonation emphasis method versus the baseline data. For each pair, the listeners judged which speech was better regarding four speech features based on auditory impressions. The features were "good intonation", "clear articulation", "good voice quality", and "low abnormality".

3. Results

3.1. Acoustic analyses

The F0 ranges for the ALS speaker in three conditions were compared. Fig.1-3 are the audio waveforms and F0 contours of the starting part of the whole speech sample "sakurawa chuhgokuya himarayanimo arimasuga" (Although cherry blossoms also grow in China and Himalayas)" in three conditions (the baseline speech, speech after the Silverman method, and speech after the intonation emphasis method). Notable F0 changes were seen in some parts such as "chuh" and "nimo" (in arrows) in post-therapy speech (Fig.2, 3), when compared with the baseline speech (Fig.1). The part "chuh" started with higher F0 followed by a steeper fall in speech data after each therapy (Fig.2, 3) than in the baseline speech. In case of "nimo", F0 was remarkably raised and sharp F0 decreases followed in speech after each therapy (Fig.2, 3), while it was relatively flat in the baseline (Fig.1). Similar patterns were seen in many other parts of the speech samples with this speaker. When the two therapy methods were compared, relatively wider F0 ranges were observed in the intonation emphasis method than in the Silverman method.

For the patient with OPCA, wider F0 ranges were seen in two kinds of the post-therapy speech than in the baseline speech although the differences were not so remarkable as the ALS patient. In the falling pitch pattern of "chuh", the F0 levels were higher when started followed by relatively greater F0 decrease in post-therapy speech (Fig.5, 6) than in the baseline speech (Fig.4). And the similar patterns were observed in the speech samples of "nimo" with this patient.

Throughout the reading, the F0 was higher in the post-therapy speech than in the baseline speech. No significant differences

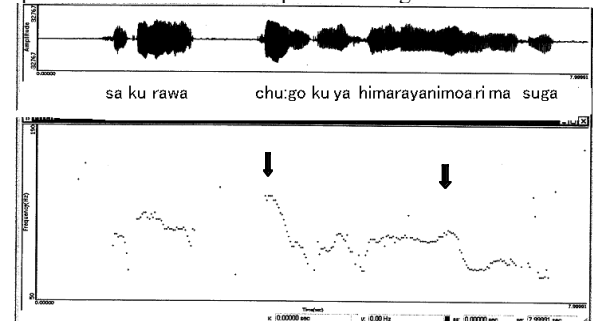


Figure 1: Baseline speech of ALS patient in utterance of "sakurawa chuhgokuya himarayannimo arimasuga"

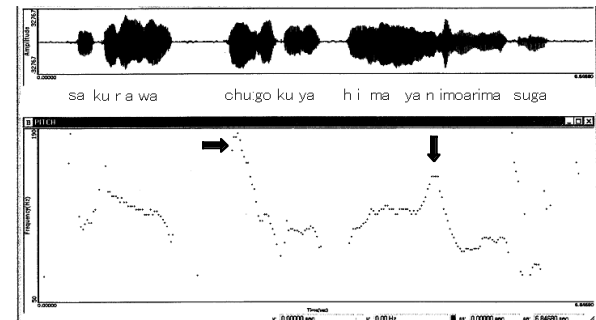


Figure 2: Speech after Silverman method by ALS patient in utterance of "sakurawa chuhgokuya himaraynimo arimasuga"

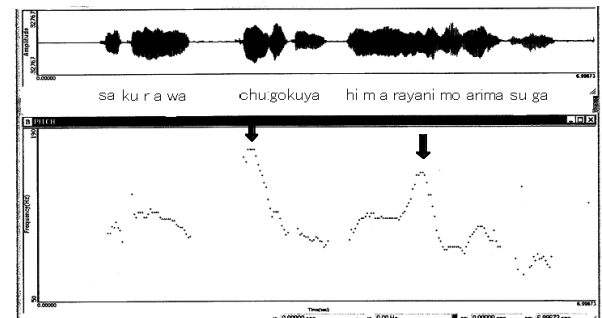


Figure 3: Speech after the intonation emphasis therapy by ALS patient in utterance of "sakurawa chuhgokuya himarayannimo arimasuga"

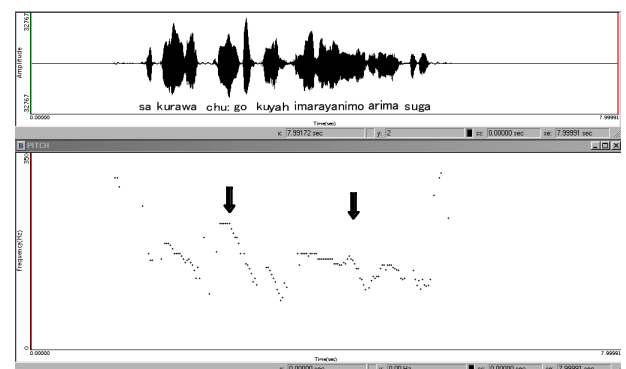


Figure 4: Baseline speech of OPCA patient in utterance of "sakurawa chuhgokuya himarayannimo arimasuga"

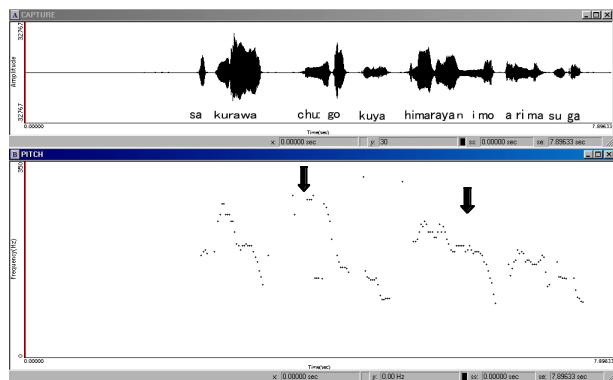


Figure 5: Speech after the intonation emphasis method by OPCA patient in “sakurawa chuh.. nimo arimasuga”

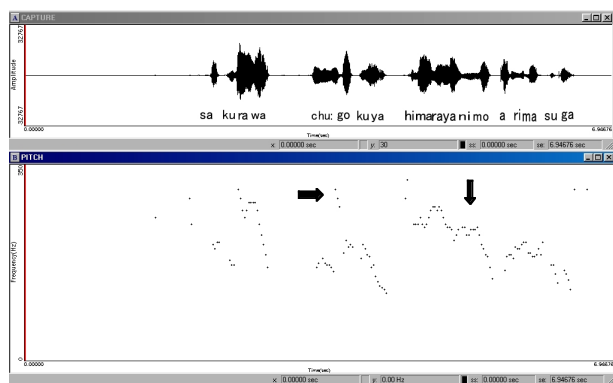


Figure 6: Speech after the Silverman method by OPCA patient in “sakurawa chuh.. nimo arimasuga”

were observed between the two therapy methods.

3.2. Perceptual judgments

Fig.7 shows the perceptual judgments by the three ST listeners for the ALS patient’ speech. Each asterisk indicated one “vote” by the listeners in a comparison of a pair of speech samples. For example, in the comparison of the baseline speech and the Silverman method concerning the feature of “appropriate intonation”, the latter speech had three asterisks because the three listeners judged it better than the baseline speech. Perfect agreements of the listeners were obtained for the four speech features. For these features (“appropriate intonation”, “clear articulation”, “good voice quality”, and “low abnormality”), two post-therapy speech samples (the Silverman method and the intonation emphasis method) were perceived as better ones than the baseline speech. The speech after the intonation emphasis method was judged to be better than the speech after the Silverman method concerning the four speech features.

Fig.8 shows the perceptual judgment for the OPCA patient. Some variability was found among the listeners and the evaluation scores were different for the three kinds of speech samples, depending on the speech feature parameters. The Silverman method had good evaluation scores for the features of intonation and articulation, and the intonation emphasis method received higher evaluation for voice quality than the baseline speech and speech after the intonation emphasis method. The baseline speech was perceived as less abnormal than post-therapy speech samples with this patient.

	Baseline	Silverman	Baseline	Intonation	Silverman	Intonation
Intonation	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *
Articulation	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *
Voice quality	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *
Low abnormality	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *

*: “vote” by ST

Figure 7 : Perceptual judgments for ALS speaker by 3 speech therapists

	Baseline	Silverman	Baseline	Intonation	Silverman	Intonation
Intonation	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *	* * *	<input type="checkbox"/>
Articulation	<input type="checkbox"/>	* * *	*	* *	* *	*
Voice quality	*	* *	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *
Low abnormality	* * *	<input type="checkbox"/>	* * *	<input type="checkbox"/>	* * *	<input type="checkbox"/>

*: “vote” by ST

Figure 8 : Perceptual judgments for OPCA speaker by 3 speech therapists

4. Discussion

The goal of speech therapy for patients with motor speech disorders is to improve the efficiency of communication by (1) improving speech intelligibility, (2) reducing the abnormal impression of speech, and (3) decreasing the pains and difficulties associated with speech production. It is difficult to find therapy methods that are effective to change these three demands together. Therefore, clinicians choose a method that is useful to change the most important and available aspect for a patient. For Japanese patients, proper and sufficient prosodic changes as well as good voice and articulation are important for efficient communication for two reasons: (1) Japanese is a pitch accent language, and proper F0 variations are essential to convey correct word meanings, (2) with insufficient F0 ranges the patients' speech have monotonous and abnormal auditory impression in general.

In this study, as speech therapy methods that have a possibility to change the F0 ranges and to improve the communication efficiency of the patients with motor speech disorders, the Silverman method and the intonation emphasis method were selected after the literature search and clinical experiments with our patients. The two patients, one with ALS and the other with OPCA were available volunteers for our study. They had typical speech characteristics for ALS and OPCA. The ALS patient's speech was characterized by imprecise consonants, monopitch, slow rate, rough voice quality, and occasional hypernasality. In the OPCA patient's speech, imprecise consonants, excess stress, irregular articulation breakdown, irregular temporal duration of the syllables, and harsh voice quality were perceived. Their overall speech intelligibility was not very poor but some words were not identifiable. Speech therapy was strongly recommended to them not only for the above-mentioned reasons but also for the fact that both ALS and OPCA were progressive diseases and their speech would be deteriorated in future.

The results of the acoustic analyses for the two patients showed wider F0 ranges in the post-therapy speech than in the pre-therapy speech, indicating that both speech therapy methods were effective for expanding the F0 range. In the ALS patient, the F0 ranges were wider after the intonation emphasis method than after the Silverman method, but in the OPCA patient, the differences between the two methods were not significant. It was assumed that for the ALS patient, who had moderate severity of the disorder and demonstrated typical monopitch speech characteristics, exaggeration of pitch by the intonation emphasis method was beneficial to widen the F0 range. For the OPCA patient, on the other hand, obvious monopitch was not present in pre-therapy speech, and therefore, remarkable changes might not have been observed in the post-therapy speech.

In the perceptual experiments, the patients' speech was evaluated based on the auditory impressions for four speech features, "good intonation", "clear articulation", "good voice quality", and "low abnormality" for two reasons: (1) it has been known that dysarthric speech characteristics are well described with these features, and (2) it was assumed that the effects of therapy could be easily detected with these features. Different results were obtained for the pre- and post- therapy speech in the two patients. In the ALS patient's speech, the post-therapy speech received better evaluation than the pre-therapy speech and the speech after the intonation emphasis therapy was perceived as the best one for the four speech

features. By the emphasis of intonation, the patient's speech was improved possibly because the more the laryngeal muscle activities were required for F0 adjustments, the higher the activities of the muscles for articulation. As a consequence, clearer articulation, as well as better intonation and voice quality was perceived. It was suggested that the improvements of these three speech features resulted in the reduction of the abnormal impression of his speech.

The changes in the OPCA patient's speech in the pre and post therapy conditions were interesting but difficult to explain. As the patients of OPCA usually have difficulties in muscle coordination, exaggeration of vocal loudness and F0 ranges might have evoked the poorer coordination of her speech organs, resulting in worse perceptual evaluation for some speech features in pre or post therapy speech conditions. It was suggested that different speech outcomes could be obtained after using different speech therapy methods even if the methods hold one immediate goal, working on prosody and/or voice, in common.

5. Conclusions

Speech therapy using the Silverman method and the intonation emphasis method was found effective to improve the F0 ranges and perceptual evaluation of dysarthric speech. The present study is still on a preliminary stage, and additional experiments with more patients should be conducted to find out the best therapy methods for specific types of motor speech disorders.

6. References

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