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PROSODY IN BROCA'S APHASIA
A PILOT STUDY

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Introduction

Broca's aphasia is predominantly characterized by disorders in the expression of spoken language, although its disturbances bear upon all language activities, and defective understanding of spoken and written language and agraphic disorders are often noted. The aphasic's speech usually is described as "slow","laboured'' and often "syllabic", and the prosody of his propositional production may be "greatly reduced". While the "flat intonation" or "monotonous speech" which may be attributed to a compression in prosody is generally mentioned in Broca's aphasia, some reports indicate an intact prosody or often an exaggerated prosody.

Recently acoustical approaches have been introduced to studies of prosodic disturbances. Ryalls (1982)[1] studied the intonation of 8 Broca's aphasics and normal subjects by spectrographically estimating their fundamental frequency (f_0) contours. He found that the patients with Broca's aphasia showed a significantly more restricted range of f_0 than normal subjects. His results also showed that there was no significant correlation between the length of production and the narrow f_0 range. On the other hand, it is known that the variance in f_0 increases in correlation with the speaking rate. Furthermore, the possibility has been suggested that prosodic disturbances may be a secondary effect resulting from voluntary effort for slowing and syllabicating speech in order to facilitate the control of articulation.

The present study will evaluate 1) the claim that Broca's aphasics exhibit a restricted range in f_0, and if so, 2) to what extent it can be attributed to the manner of speech production, specifically,the slow speech rate and syllabification, and 3) how the disturbance in prosody differs from that secondary to other central articulation disorders such as pseudobulbar dysarthria.

Method
Subjects

The subjects in this study included 2 Broca's aphasics, 1 case of pseudobulbab dysarthria and 8 normal adults who speak Tokyo dialect.

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Case 1 (Broca's aphasia)

The patient was a 65 year-old, right-handed male. On the morning of a day in March, 1983, his family realized that he could not speak. His state of consciousness was alert. He drove to a hospital by himself and after arrival right-hemiparalysis and difficulty in swallowing appeared. While the hemiparalysis of the right upper and lower extremities and swallowing difficulty were alleviated shortly after admission, he could not speak, although his speech comprehension was quite good. Neurological examination revealed a slight reduction in grip strength in the right hand and a slight hemiparetic gait in the right leg. Deep tendon reflexes were hyper in the right arm and leg. Babinsky was detected on the right. CT scan disclosed a low density area in the left frontal lobe but not extending beyond the central sulcus. He was diagnosed as having had a cerebreal infarction.

Case 2 (Broca's aphasia)

The patient was a 42-year-old right-handed female. In June 1982 upon return from work, her articulation was unclear and the movement of her right arm was reduced. Neurological examination revealed a conjugate deviation to the left, roving eye,and right hemiplegia including the face. CT scan revealed a high density area in the left putamen and this was diagnosed as a putaminal hemorrhage.

Case 3 (pseudobulbar dysarthria)

The patient was a 56-year-old right-handed female who had had a left putaminal hemorrhage in 1982. In February 1984, she again suffered from CVA trauma. Neurological examination indicated a left hemiplegia including the face and dysarthria. The case was diagnosed as a right putaminal hemorrhage.

Procedure

All subjects were asked to read sentences in their normal speech style, and their utterances were tape recorded. The stimluli were 6 different sentences consisting of 3 units of from 7 to 12 syllables. Additionally, normal subjects were asked to read the sentences according to the following 3 different speech styles: 1) slow speech rate, 2) syllabic speech (ie: elaborate isolation of syllables), and 3) slow and syllabic speech. These four styles of utterance were analyzed with respect to f_0 and duration. Pitch analysis was based on an LPC analysis and duration was determined from the sound waves referring to the formant pattern using a VAX 11-780 computer[2]. Each intonation contour was assessed the highest and the lowest frequencies of the steady state contour or "plateau", excluding the final syllable which is often devoiced or weak in intensity in Japanese and the f_0 value of which is thus less reliable. These plateaus

were not measured in a particular syllable but at the highest and lowest levels of the contour. The lowest value was then subtracted from the highest to obtain the f_0 range.

Results

Figure 1 shows the f_0 contours for the patients with Broca's aphasia and pseudobulbar dysarthria as well as for the normal subjects. As compared with the normal subjects,it can be noticed that the f_0 contour of Case 1 is flat and segregated. Generally, as f_0 becomes higher, the variance of f_0 more markedly increases[3]. Since the absolute frequency is usually greater for females than for males, the values of f_0 variance in Case 1 were compared only with the normal male subjects. The results indicated that the variance of f_0 in Case 1 was significantly smaller than that of the normal subjects ($t=6.6, p < .001$). Upon close observation of the f_0 contours, it was revealed that the relative pitch pattern throughout a sentence was preserved. Therefore, it is assumed that the compressed f_0 was a secondary effect of the slow and segregated speech.

A slow speech rate and elaborate isolation of syllables were noticed in Case 1. The total durations for the sentences in Case 1 were 230% to 300% of the average in the normal subjects. The f_0 contour showed that the intersyllable spaces were more frequent and longer than those for the normal subjects. Figure 2 shows an example of the f_0 variances in the 4 different styles of speech; 1) the usual style of speech, 2) slow speech, 3) syllabic speech and 4) slow and syllabic speech by the normal subjects. When the subjects spoke slower and/or syllabically, the value of the variance tended generally to decrease. It was also noted that syllabic speech appeared to produce a compressed f_0 more than did slow speech and, in turn, slow syllabic speech produced greater compression than did syllabic speech. Yet this tendency seemed to vary with the sentence features, for example, in accordance with the accent patterns. These results appear to support the hypothesis that the flat prosody observed in Broca's aphasics is not due to the loss of pitch faculty (linguistic disturbance), but rather due to a secondary effect resulting from slow and syllabic speech, which may be necessary to facilitate the control over articulation. However, the second patient with Broca's aphasia, whose speech rate was also slow (150% to 200% of the average for the normal subjects), showed a rich prosody which often gave the impression of exaggeration. The differences between these two patients are as follows. 1) The speech rate of the first case is slower than that of the second case, 2) the tendency toward syllabification is not typical of the speech of Case 2. This is consistent with findings that the compression of f_0 is more obvious in syllabic speech than in slow speech in normal subjects. Nevertheless, considering the differences in the location of lesion and the causal disease,for example,definite conclusions can not be drawn here. Moreover, Case 3, a patient with pseudobulbar dysarthria, displayed a rather flat f_0 contour and no syllabic segregation, while, on the contrary, a fusion between syllables was observed. The speech

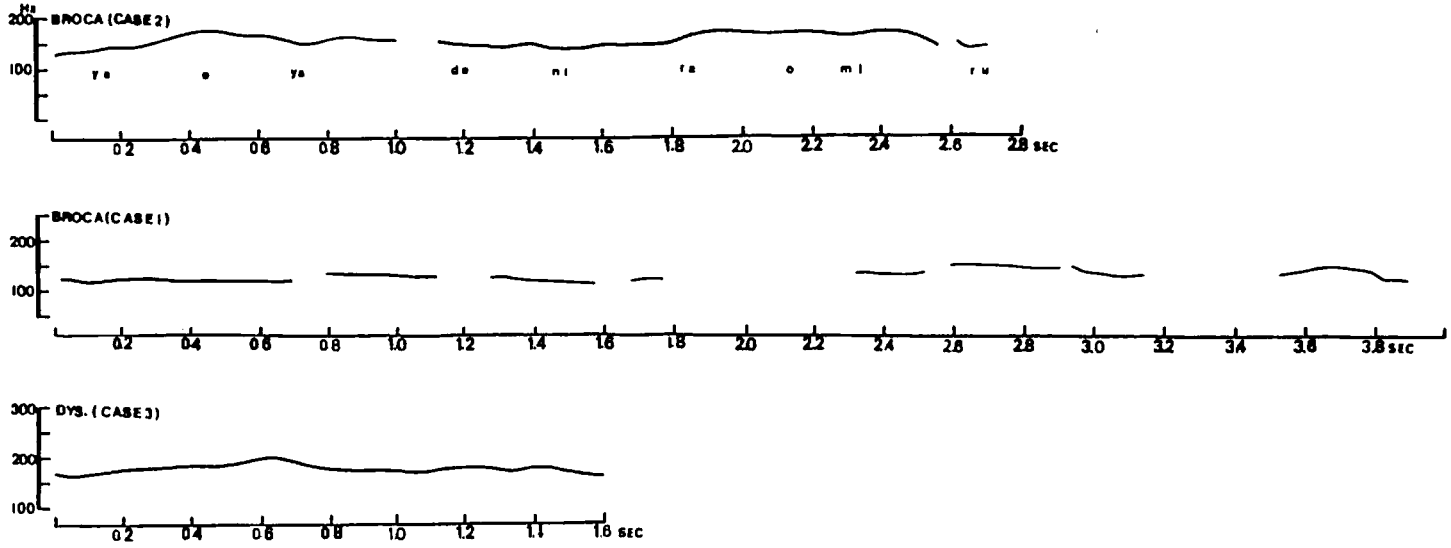

Fig.1a Examples of F_0 contour in two Broca's aphasics and a case of dysarthria.

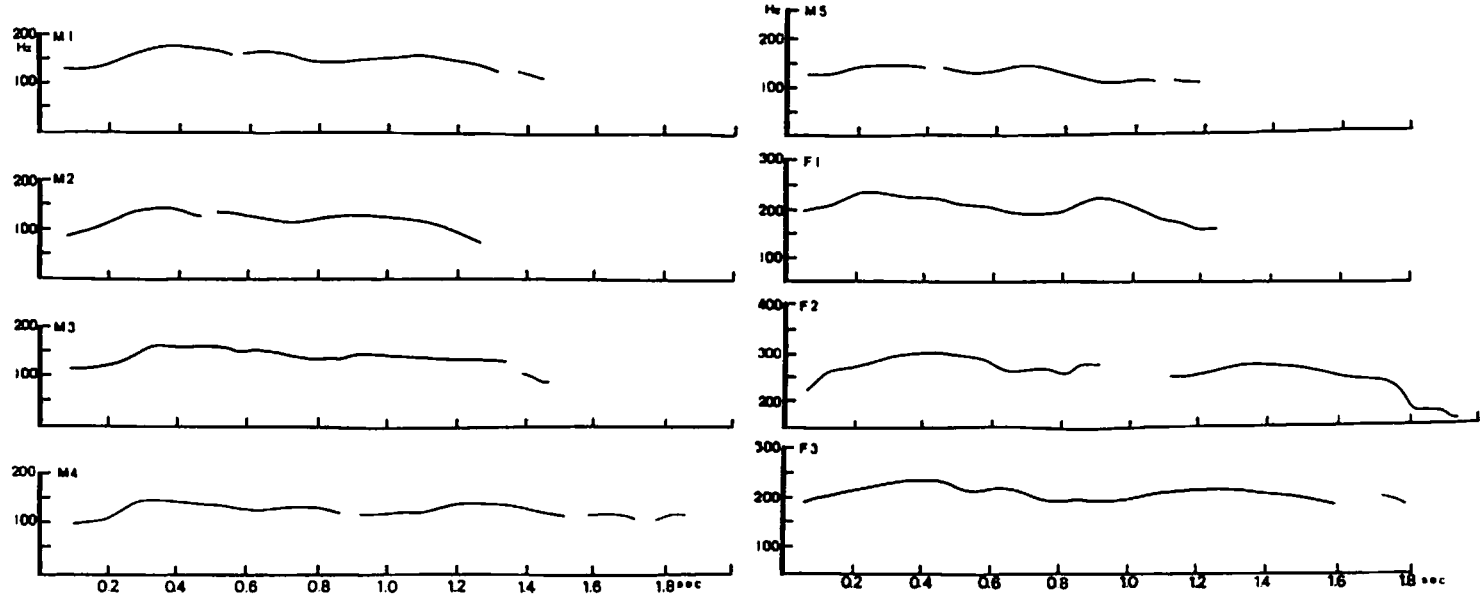

Fig.1b Examples of F_0 contour in normal subjects.

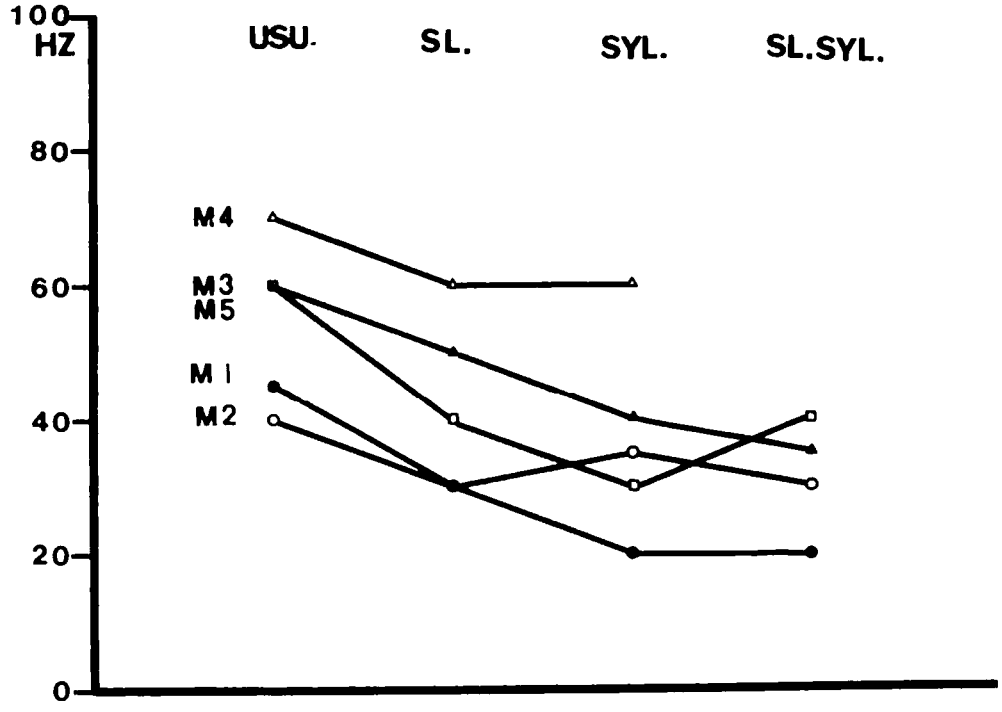

Fig.2 An examples of F_0 variances in 4 different styles of speech: 1) the usual style of speech(usu.); 2) slow speech(sl.); 3) syllabic speech(syl.); 4) slow and syllabic speech(sl.syl.) by the normal subjects.

rate of this case was within the normal range. This may suggest that some other motor disturbance in articulation can contribute to a restricted f_0 variance.

Table 1 shows the segmental duration of the three patients' utterance "yaoya de nira o miru" and those of the normal subjects which are comparable in terms of speech rate and speech styles. It has been reported that syllable durations in Japanese tend to be maintained equally from syllable to syllable. The results show a deviate durational pattern in the two Broca's aphasics. For example, the duration of "ni" in Case 2 is three times longer than that of "de". In Case 2 a prolongation of syllable duration occurs at the beginning of the sentences. On the other hand, a durational disproportion was not observed in Case 3, the dysarthric patient. This raises the possibility that in Broca's aphasia a distortion in durational pattern is a common prosodic disturbance characterizing this particular type of articulation disorder.

Discussion

Three factors, voice-loudness, relative subjective duration -- and voice-pitch, the closest physical correlates of which are, intensity, time pattern and f_0 contour, respectively-- have been suggested as prosodic features. The present paper focussed primarily on aspects of f_0 and segment duration. The results showed that flat prosody is not always observed in patients who exhibit symptoms indicative of Broca's aphasia. In Case 1, typified by slow and syllabic speech, a restricted range for f_0 was confirmed. In contrast, Case 2 showed a rich prosody which sounded remarkably exaggerated. This is inconsistent with the findings of Ryalls (1982)[1]. However, it should be noted that 5 out of 8 of his patients fell within + 1 SD of the normal average, and that the rest of his patients showed a restricted f_0 variance.

Monrad-Krohn(1947)[4] has defined dysprosody as a disturbance in the "prosodic faculty" which is a " faculty of spoken language" and "consists in correct placing of pitch and stress on syllables and words". They also introduced the concept of "aprosody(hypoprosody)" which is typical "in paralysis agitans". They, therefore, suggested that dysprosody is "a disorder of a higher functional level than the aprosody of paralysis agitans". On the other hand, Kent and Rosenbek (1982)[5] discribed their patients with apraxia of speech and ataxic dysarthria as having dysprosody, while Parkinsonian dysarthria and "right-hemisphere dysarthria" were defined by them as having aprosody. According to Monrad-Krohn's (1947)[4] definition, dysprosdy should show certain errors in the "placing of pitch or pitch pattern" which are not merely a reduction in quantity. Careful observation of f_0 contours in Case 1 revealed that the relational patterns across syllables are preserved. Danly, de Vill and Cooper (1979)[6] studied prosody in Broca's aphasics and found that the basic aspects of f_0 control were preserved, but that utterance-final lengthening was lost. In contrast to English,

	ya	0	ya	de	ni	ra	o	mi	ru	total
Case 1	17.7	9.1	6.7	2.0	5.6	8.3	4.6	6.5	3.5%	4.1sec
(pause)	4	4.5	5.2	15	1.5	2.4	6.9			
m3 syl.	6.3	6.3	7.0	6.7	6.3	7.2	4.7	7.2	5.3%	4.4sec
(pause)	6.6	4.7	3.1	5.5	5.5	6.3	5.8	5.2		
Case 2	7.1	8.7	9.5	6.0	19.0	12.3	8.2	15.5	5.4%	2.9sec
(pause)		2.2	4.1					1.9		
f2 sl.	12.0	11.3	7.7	9.7	11.0	10.8	10.9	11.4	5.2%	2.9sec
(pause)				6.7				1.9		
Case 3	13.0	10.5	10.7	10.7	23.2	13.3	11.6	9.0%	1.8sec	
(pause)										
f1 usu.	12.0	10.9	13.1	12.0	12.0	10.9	8.7	11.5	8.7%	1.7sec
(pause)										

syl:syllabic speech sl:slow speech usu:usual way of speech.

Table 1 An example of the segmental duration for two Broca's aphasics, a dysarthric patient and normal subjects.

the final syllable of a Japanese utterance tends to be shortened. This tendency, which was observed in our normal subjects, was present in Case 1, the patient with Broca's aphasia.

The f_0 contour of our pseudobulbar dysarthria patient also tended to be flattened. In contrast to the patient with Broca's aphasia,Case 1, who also showed flattening, her intersyllabic intervals for consonants and pauses were brief, often omitted and likely to be continously voiced throughout an utterance. Relative pitch pattern, however, also appeared to be preserved in the dysarthric patient. Thus, the disturbance in prosody, which is common to Broca's aphasia but not to pseudobulbar dysarthria, may not show a flat f_0 contour but will show an unbalanced, relative segmental duration. In the Japanese linguistic system, segmental duration is critical to meanings (ie: /i/"stomach" vs. /i:/"good"), and each mora (syllable) tends to share about equal duration in an utterance. On the other hand, as far as the relative pattern of f_0 is preserved, a reduction in the f_0 range does not seem to affect the impression of prosody as much as the durational pattern does in Japanese. The auditory impression for different types of prosodic disturbances should be the subject of future experimental studies in order to clarify which aspects of prosody contribute more to an impression of "normal speech". Finally, in a future study we hope to increase the number of cases as well as the types of disorders (particularly with regard to foci of lesions) beyond that used in the present pilot study.

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