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DURATIONAL EFFECTS ON EVALUATION OF PROSODIC ABNORMALITY
A Preliminary Study

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Introduction

It is known that both Broca's aphasia and dysarthria involve prosodic disturbances. Previously we reported on fundamental frequency contours of Broca's aphasia and pseudobulbar a dysarthria[1]. The findings of that study indicated that a) reduced range of fundamental frequency, heretofore supposed to be the main reason for monotony, was not always observed in Broca's aphasia; and b) the flattening of F0 contours did not distinguish tne prosodic disturbance in Broca's aphasia from that of pseudobulbar dysarthria. Segmental durations were also studied. The results revealed that patients with Broca's aphasia exhibited a deviated durational pattern resulting from the prolongation of sounds and syllabification.

Kent and Rosenbek (1983)[2] studied the acoustic patterns of 11 patients with "apraxia of speech", which is thought to characterize the speech of Broca's aphasia. Their results indicated a variety of segmental and prosodic abnormalities including slow speaking rate, reduced intensity variation across syllables, slow and inaccurate movements of articulators, poor coordination of articulators and errors of selection or sequencing of segments. Kent and Rosenbek (1983) attribute the slowed speaking rate to two factors: 1) "articulatory prolongation", which they define as a lengthening of steady-state segments and the intervening transitions; and 2) syllable segregation" which is a pattern of temporally separated or isolated syllables.

In contrast with rapid advances in the acoustic analysis of prosodic disturbances, the aspects of prosody which contribute most to the impression of "normal speech" have not yet been clarified. The present study will investigate the effects of segmental durations and flattening of pitch on the impression of prosody.

Methods

Stimuli: Two different sentences each consisting of three phrases were analyzed on the basis of an LPC analysis. Most of the consonatts contained in the stimuli were voiceless plosives which allowed syllables to be easily separated by their soundless

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period (see Figure 1). The prolongation of both syllable duration ("articulatory prolongation") and silent period ("syllabic segregation") has been suggested as a major factor in prosodic abnormality. In our study, either the syllable duration or the silent period was lengthened or shortened. Secondly, in order to evaluate prosodic abnormality, we also examined the relative position of the lengthened or shortened syllable within the stimuli. In some stimuli, all of the syllable durations or silent periods were lengthened (doubled or tripled) or shortened (to half, or to its minimum syllable duration). In other stimuli, only the first, second or last syllable of each phrase was modified in length (doubled, tripled or halved).

Three kinds of stimuli were synthesized by changing the fundamental frequency (F0): 1) an F0 contour across syllables totally flattened to its mean F0; 2) a reduction of F0 variance across syllables by half; and 3) an F0 contour within syllables flattened to its mean. A total of 48 stimuli, including two original speech sumples, were synthesized using a Vax 11-780 computer[3)] and the output was recorded.

Procedure: Twenty normal subjects, none of whom were knowledgeable about speech disorders, were asked to listen to the stimuli and evaluate them on the following dimensions: a) bizarreness; b) nonfluency; c) laboriousness; d) monotony; e) excessive variation in loudness; f) excessive variation in speech rate and g) speech rate. A three-step evaluation--for example,for bizarreness; normal,slightly bizarre and bizarre-- was used for all dimensions except for speech rate, which was based on a five step evaluation: slow, slightly slow, normal, slightly fast, fast.

Initially, the two original stimuli were presented as standards of normal speech so as to minimize the distorted impression which might occur due to LPC analysis or synthesizing. Each stimulus was repeated twice, and pauses for evaluation followed.

Results

The discussion in this paper will focus on the dimensions of bizzarreness, nonfluency, and monotony, which have often been used to describe the speech of Broca's aphasia.

a) Syllable duration vs. silent period

As a whole, changes in syllable duration increased the score on all dimensions more than did changes in silent periods. For example, Figure 2 shows the total number of subjects according to each category of the bizarreness dimension. The results indicate that more subjects perceived the stimuli to be bizarre when syllable durations were lengthened or shortened. This tendency was consistent despite sentence differences and diferent degrees

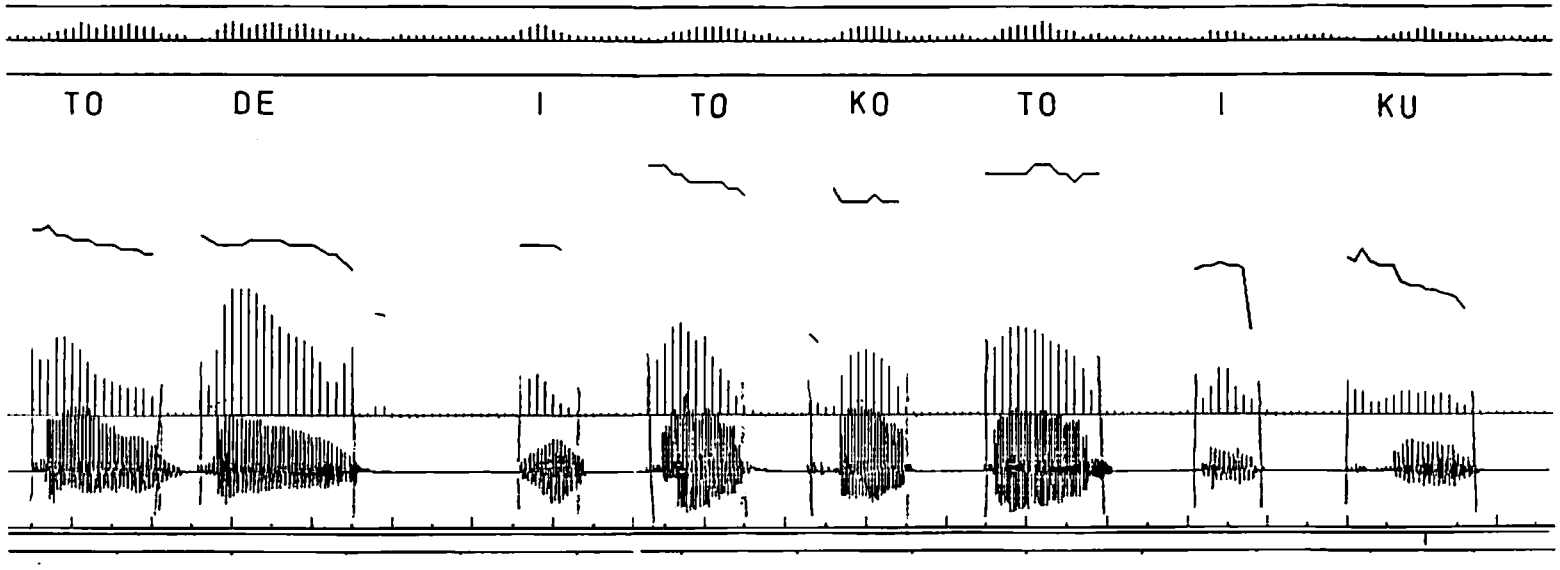


Figure 1

The figure shows sentence 1 used in this study based on LPC analysis

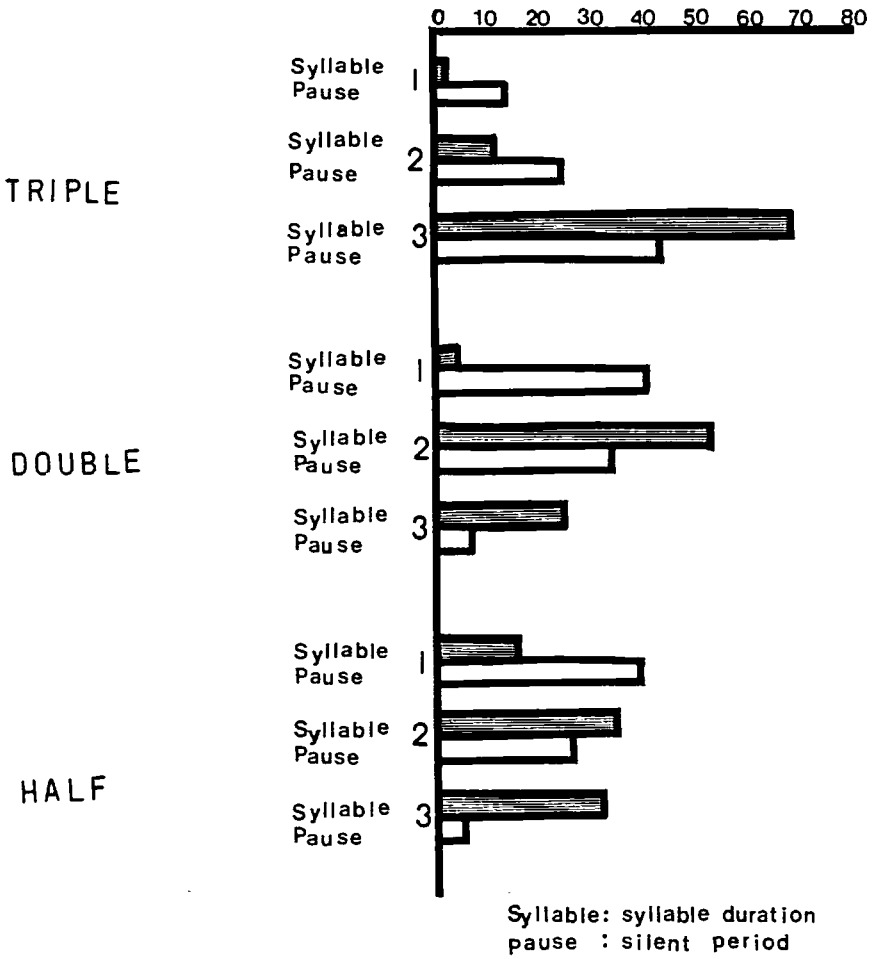


Figure 2

The total number of subjects for each category of the bizarreness dimension

of modification (i.e., doubled, tripled or halved).

b) Degree of change

Figure 2 shows that the subjects considered a stimulus to be bizarre when syllable durations or silent periods were prolonged to triple the original length rather than when lengthened to double or shortened to half. This tendency was also observedfor the dimensions of nonfluency and monotony. However, shortening of silent periods did not increase the value of these dimensions as much as did lengthening them to double.

c) Position of modification

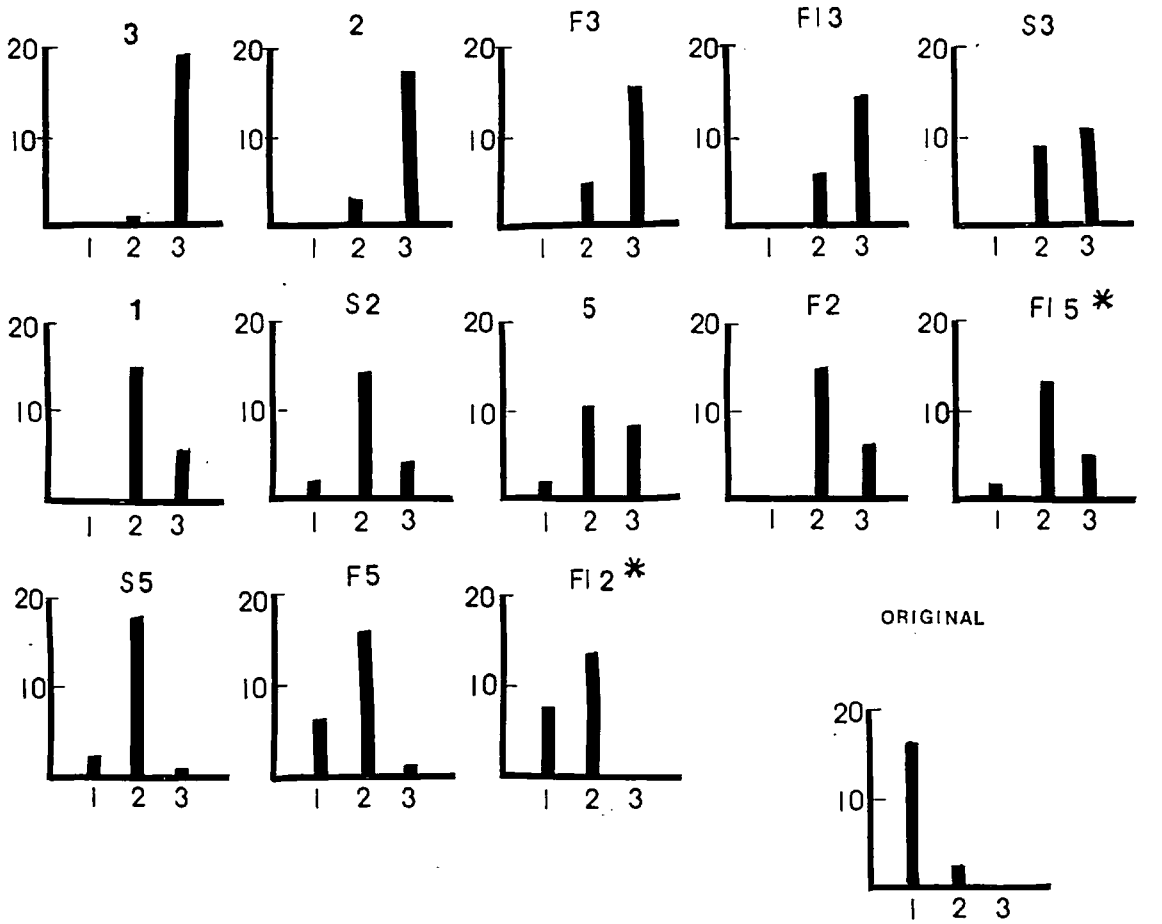
The positional factor, that is, the location within the stimuli of the lengthened or shortened durations seems to interact with other factors such as degree of change, length of change (i.e., shorter or longer), type of duration (i.e., syllable duration or silent period) or sentence difference. Figure 3 shows the number of evaluations of bizarreness according to modification of syllable durations in sentence 1. A common tendency for the two sentences is that shortening the last syllables of each phrase increased the impression of bizarreness, while lengthening them did not alter their value or even resulted in a more normative value in comparison with the others.

On the other hand, with either lengthening or shortening the silent period after the last syllable in each phrase, the stimuli elicited a less bizarre score than did other stimuli. Figure 4 shows the results of the evaluation of nonfluency. Positional effects on the impression of nonfluency are rather ambiguous. However, lengthening the first syllable durations of each phrase to triple tended to increase the impression of nonfluency, although their shortening does not seem to have had a definite influence. On the other hand, with regard to modification of the silent period, the impression of nonfluency increased only when the lengthened silent period succeedes the first or second syllables. When the shortened or modified durations occured in the final silent period of each phrase, it exerted little influence on the impression of the normality of the speech.

Other positional effects were observed for the impression of irregular variations in speech rate. The impression of dysprosody increased when modification of the stimuli occured in parts rather than throughout, and with lengthening of the second syllables or shortening of the last syllables. Modification of the silent periods seems to have had little influence on this impression.

d) Duration vs. pitch

Because the type of stimuli for pitch modification was limited in the present study, it is difficult to extract any definite tendency. Although altering the F0 contour to make it totally flat (to its mean) through an entire sentence tended



F: first syllable modification

S: second syllable modification

FL:final syllable modification

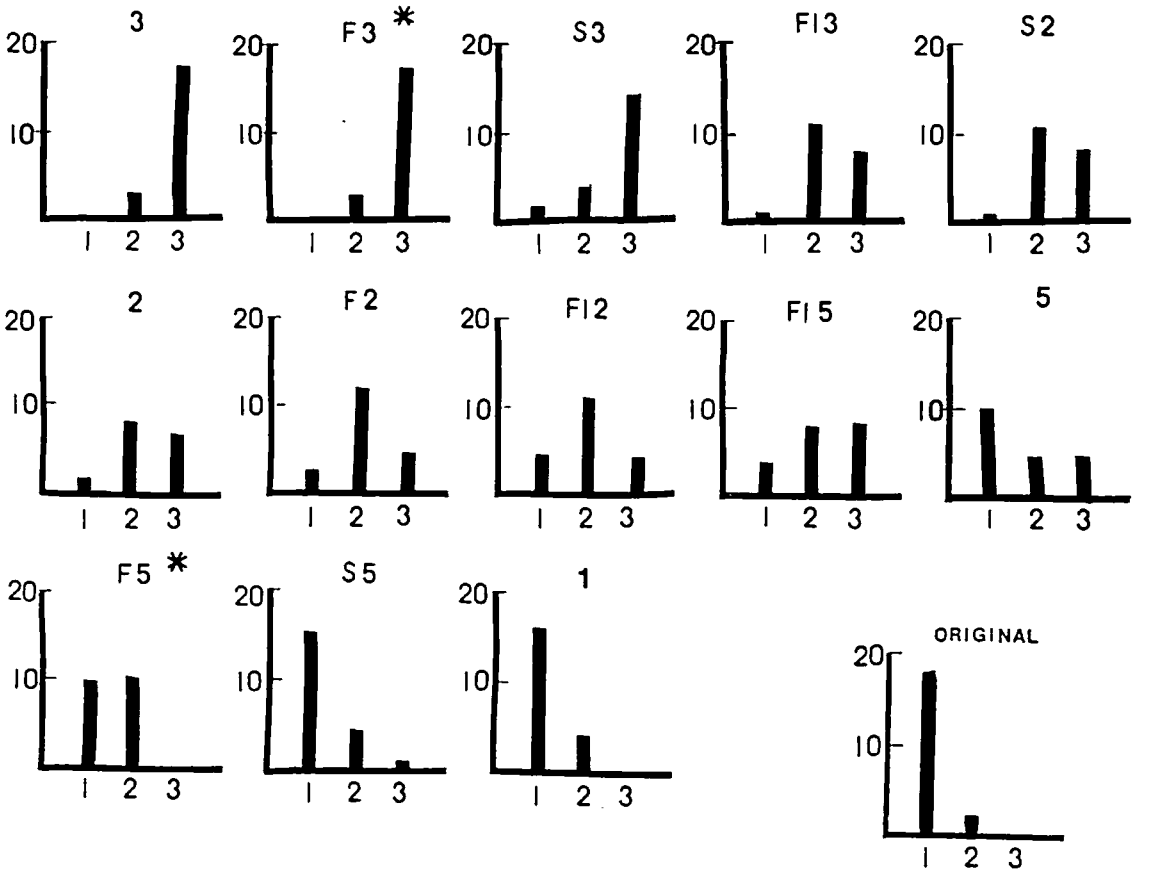
3: tripled

2: doubled

5: halved

Figure 3

The number of evaluations of bizarreness for each stimulus in sentence 1



syllable duration modification

F: first syllable modification

S: second syllable modification

FL:final syllable modification

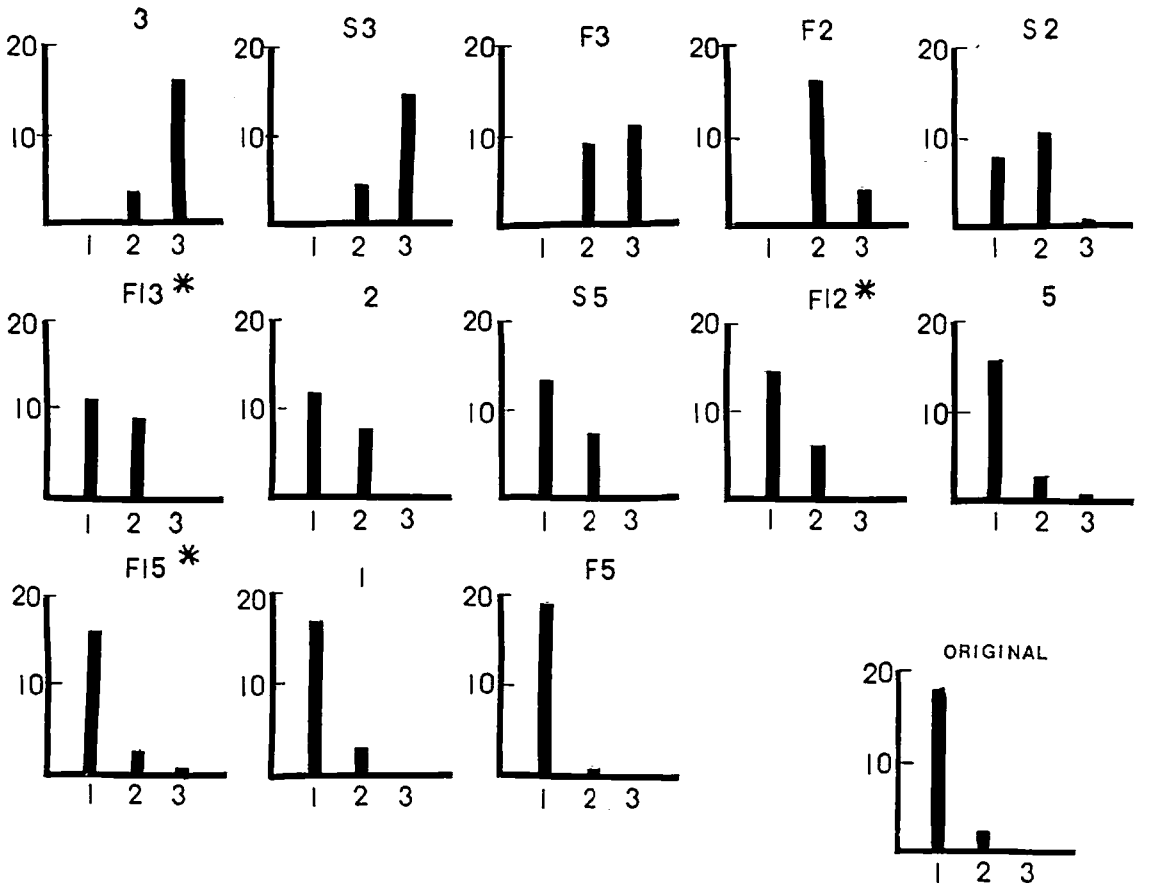
3: tripled

2: doubled

5: halved

Figure 4

The number of subjects for each stimulus in the nonfluency dimension



silent period modification

F: first syllable modification

S: second syllable modification

FL:final syllable modification

3: tripled

2: doubled

5: halved

Figure 4

The number of subjects for each stimulus in the nonfluency dimension

to increase the impression of bizarreness and monotony, stimuli with restricted F0 variance and constant F0 within each syllable yielded relatively normal values in all dimensions. For example, Figure 5 shows the results of the evaluation for monotony, which is often thought to be influenced by pitch change. It should be noted, however, that the stimuli with a reduced F0 variance, which would be comparable to the actual speech of Broca's aphasia or dysarthria, does not increase the impression of monotony so much as does lengthening of syllable durations. In addition, the scores for monotony were higher when all syllables were prolonged than when only some are modified or when silent periods were altered.

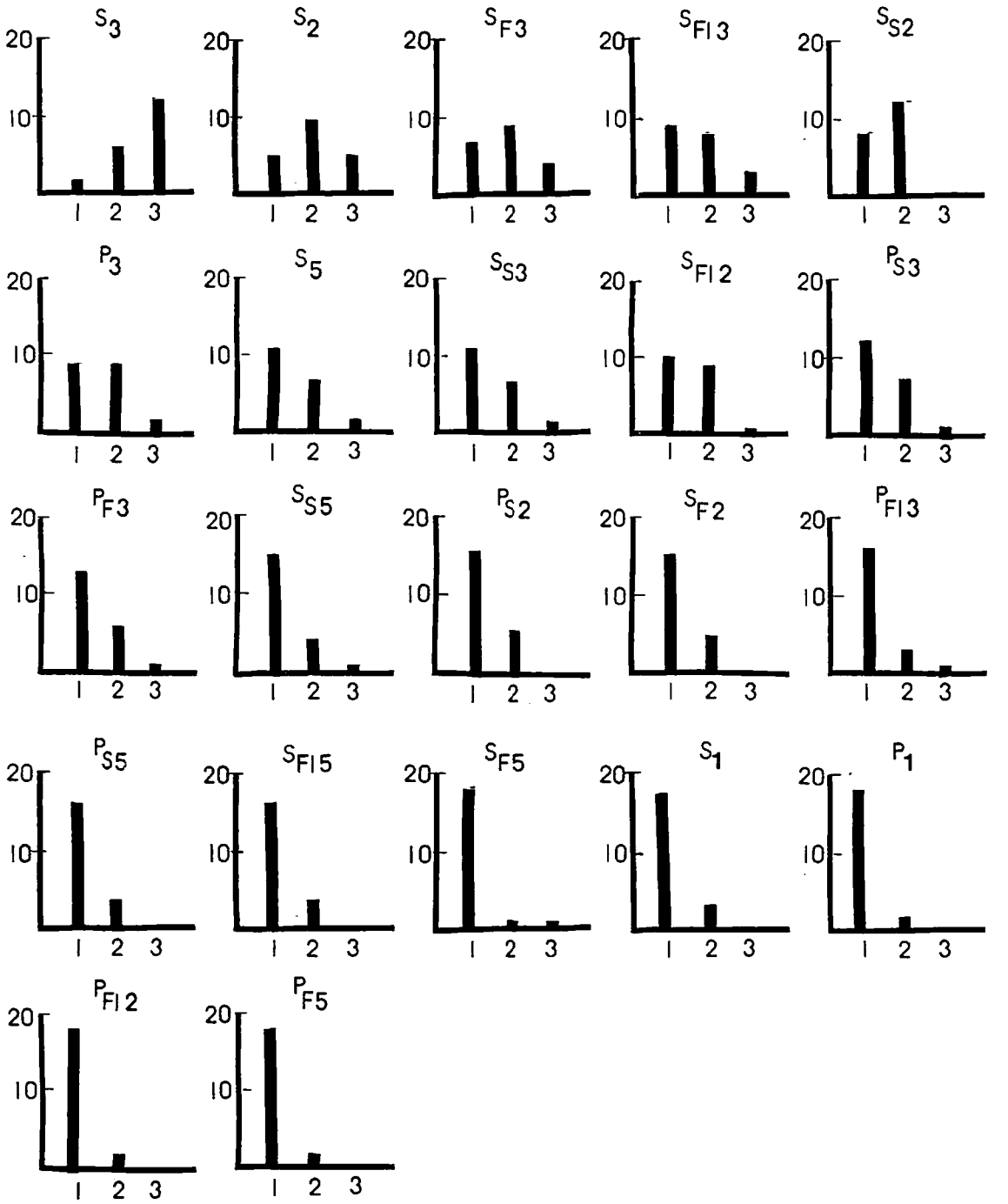
e) Correlations among evaluational dimensions

Dimensions which obtained a higher correlational value (Cramer's V) are, in descending order of effect, bizarreness and nonfluency, nonfluency and laboriousness, monotony and speech rate (negative), and bizarreness and excessive variation in speech rate. These facts indicate that the subjects tended to evaluate an utterance as bizarre when they perceived nonfluency or excessive variation in speech rate. On the other hand, the impression of monotony increased when the utterances were perceived to be slower.

On the othe hand, correlational values for nonfluency and monotony, and bizarreness and monotony were relatively low. This raises the possibility that the impression of monotony and that of nonfluency or bizarreness are somewhat independent. In other words, our subjects attributed a bizarre quality to utterances which elicited the impression of nonfluency and excessive variation in speech rate more than they did to those which were considered monotonous.

Discussion

The concept of "fluency" occupies an important role in aphasia. The major subdivision of the aphasic syndromes is based on "fluency". Since Broca's aphasia is the most typical type of non-fluent aphasia, "Broca's aphasia" is a term sometimes used interchangeably with "non-fluent aphasia". The prosodic disturbances often mentioned in Broca's aphasia are a slow speaking rate due to prolongation of syllable durations and intersyllabic pauses and reduced pitch and variation of intensity. In Japanese, intensity variation should not have so much influentce on prosody as it does in stress accent languages such as English. In the present study, therefore, we focused mainly on durational aspects, such as prolongation and syllabification, and secondarily on pitch in reference to its effects on prosody-- especially the dimensions of nonfluency, monotony and bizarreness. Among these dimensions, bizarreness might represent the most total impression of the severity of prosodic disturbances.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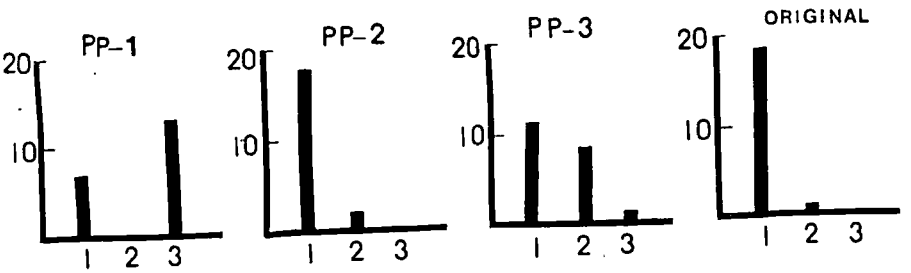

L: syllable duration modification

P: silent period modification

1: first syllable modification

2: second syllable modification

FL: final syllable modification

3: tripled

2: doubled

5: halved

Figure 5

The evaluation of monotony
for each stimulus in sentence 2.

Our results showed that nonfluency correlates to bizarreness more than monotony does, which suggests that the monotonous dimension might not contribute to the impression of bizarreness so much as does that of nonfluency. Further, with regard to monotony, It was observed that reduced pitch variation does not increase the impression of monotony as much as does prolongation of syllable durations.

Second, in our study, modification of syllable durations resulted in greater evaluation toward abnormality in all dimensions than did alteration of silent periods. This indicates that prolongation rather than intersyllabic pauses might cause dysprosody. However, it should be noted that the consonants used in this study were voiceless plosives, and consequently silent periods were present from the first. Sentences without intersyllable silent periods should be used as a control to clarify this possibility in future studies.

Third, some positional effects of modification were observed. For example, shortening the last syllable durations in each phrase tended increase the impression of bizarreness while lengthening them did not appear to affect it. On the other hand, lengthening of the first syllables in a phrase tends to increase the evaluation of nonfluency, although shortening them does not seem to exert any influence. These tendencies appear to reflect normal durational patterns in that the first syllable of a word is shorter, while the last one is longer than the others[4]. Since this pattern is observed in isolated word situations, factors such as careful articulation, pauses after each phrase and a small number of phrases in a sentence might result in a similarity between the stimuli used in this study and some isolated word conditions. In addition, the silent periods after the last syllables in each phrase, so-called " pauses", are naturally subject to change in duration.

References

1) Konno,K.,Sugishita,M. and H.Hirose (1984);Prosody in Broca's aphasia;A pilot study,Ann.Bull.RILP,18,169-177.
2) Kent,R.D. and J.Rosenbek (1983);Acoustic patterns of apraxia of speech,JSHR.,26,217-224.
3) Imagawa,H.,Kiritani,S.,Sekimoto,S.andS.Saito(1984);Interactive LPC analysis synthersis program on Vax with an attached array processor,Ann. Bull. RILP,18,5-11.
4) Sagisaka,Y. and Y.Yohkura (1980);Characteristics of segmental durations in connected speech,Transaction of committee on speech research, Acoust.Soc.Japan,s80-34.