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The Identification of Vowels with Variable Durations in Hearing-impaired Children

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The present study investigated the identification of monosyllable vowels with variable segmental durations and temporal order of same vowels in hearing-impaired children. As a result, it was suggested that the hearing-impaired children had difficulty identifying the vowels at 128-38, 4ms (mono syllable) and 89. 6-64ms (temporal order).

Key Words : auditory temporal information processing temporal (time) resolution hearing-impaired children duration identification of vowel

1. Introduction

In general, Humans can perceive the duration of event through each sensory unit. Concerning auditory perception, there included the perception of duration in speech sound and nonspeech sound.

Thomas et al. (1970)[16] examined the identification of vowels with variable durations in temporal order task. Then, it was indicated that normal listeners showed an adrupt drop in the percentage of a correct response between vowel segmental duration of 125 and 100ms. Fujisaki et al. (1970)[3] also reported a similar observation.

A poor speech perception ability in hearing-impaired children and adults had become an issue, it was then suggested that a temporal perception ability was not always related to the individual hearing level.[7),8)]

Ohta and Yoshino (1987)[5] examined the identification of temporally segmented vowels; they then indicated that although durations was over 50ms, they were insufficient for the correct identification of vowels for children with sensorineural hearing loss.

Yamada et al. (1987)[19] examined to the identification of one syllable vowel with variable durations in persons with sensorineural hearing loss; then, they reported that the identification score was the highest at 100-180ms and relatively longer durations were needed to identify vowels accurately.

Sato and Yoshino (1989)[13] reported the identification in speech sounds in hearing-impaired children for stimuls "/da/-/ta/" and "/daNgo/(dumpling)-/taNgo/(word)"with variable durations of initial portion of CV-syllable. These results suggested that hearing-impaired children had difficulty at categorizing voiced-voiceless sounds, if it were not for the considerable shortening in durations of initial portion of the CV-syllable.

In any experiments, it was found that whereas the identification score was stabilized regardless the change of duration of speech

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TAble 1. Hearing level of hearing-impaired children

Ss	Average H. Level	Hearing Level (dB: JIS 1982)					
		250(Hz)	500	1000	2000	4000	8000
1.	R. 82.5	75	85	80	85	NR	NR
	L. 66.3	65	65	65	70	70	NR
2.	R.101.3	90	100	105	95	90	95
	L. 72.5	45	50	75	90	80	NR
3.	R.105	90	95	105	115	120	105
	L.103	85	85	105	115	125	NR
4.	R. 68.8	75	65	70	70	90	NR
	L. 70	85	70	70	70	75	NR
5.	R. 87.5	70	70	90	100	105	90
	L. 83.8	75	80	85	85	85	90

sound in normal subjects, hearing-impaired subjects could not accurately be identified until the duration of speech sound and nonspeech sound had reached a given a length.

This study focused on the auditory identification of mono syllable Japanese vowels with variable segemental durations and temporal orders composed of the same vowels and fixed silent interval in hearing-impaired children. An auditory temporal information processing of hearing-impaired children in the identification of vowels with variable segmental durations was then carried out.

2. Experiment 1

Purpose of the experiment

The purpose of this experiment was to examine the identification of mono syllable Japanese vowels with variable segmental durations in hearing-impaired chidren.

Subjects

The normal hearing subjects were ten graduate and undergraduate students (5 males, 5 females) ranging in age between 20-29 years and six elementary school pupils (4 males, 2 females) ranging in age between 11-12 years. They evidenced normal hearing sensitivity by exhibiting bilateral thresholds better than 10dB (HL) at all test frequencies (250-8000Hz).

Table 2. Parameter of Vowel duration.

1	2	3	4	5
256	128	89.6	64	38.4 (ms)

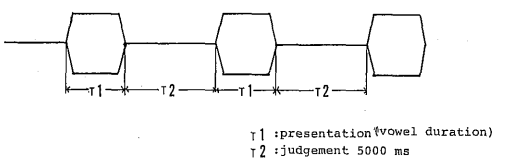

Fig. 1. Structure of presentation in Exp. 1

The hearing-impaired subjects were five children with sensorineural hearing loss (3 males, 2 females) ranging in age between 7-10 years. Their average hearing level were ranging between 66.3-105dB (HL) (Table. 1.). The hearing-impaired subjects were selected the hearing-impaired children whose the identification score of normal five vowels were more than 85%.

Subjects were receiving an auditory training and speech language training once or twice a week in a special class for children with moderate or severe hearing loss; Such children were attending a regular elementary school.

Method

A. Stimulus Preparation

Individual stimuli were five natural Japanese vowels (/a/,/i/,/u/,/e/,/o/) uttered by a normal hearing female. The stimulus succes-

sion were identification tasks which presented each vowels 7 times at random (Fig. 1). Parameters of segmental durations were showed in Table 2. Individual stimuli were edited by speech sound editing system which was controlled by a computer (DANAC-7000: 12bit quantification, sampling rate 20kHz) as durations, silent interval and intensity level were unified, and recorded in the tape-corder (SONY TC-8750-2).

B. Procedure

All stimuli were presented with AD-02 air conductional receiver (normal--right ear. H.I.--better ear) in acoustically isolated room with low ambient noise level for individual hearing. The level of stimuli was adjusted at 60dB (HL) in normal subjects and at more 10-40dB (HL) above individual speech reception threshold in hearing-impaired children by tape-deck (SONY TC-707-FC) and audiometer (RION AA-63-BN, 66-BN). All subjects wrote their responses on a specially prepared answer sheet.

Result

Fig. 2 shows the identification of mono syllable vowels with variable segmental duration. While normal hearing adults and children exhibited that the identification score did not vary regardless of the decrease in segmental duration, hearing-impaired children exhibited that the variability of identification score is markedly less than 64ms. In particular, S3 showed that the identification score were less than 75% at less than 128ms in segmental duration. Thus, such results suggested that S3 could not identify mono syllable vowels accurately with variable segmental duration so long as more than 256ms. However, S4, S5 showed that their identification scores would not vary regardless of the decrease in segmental duration. Their results showed that although they were children with sensorineural hearing loss with an inner ear disease, they improved the time resolution in auditory system as well as normal hearing adults and children.

Furthermore, on the identification of each vowel, while normal hearing adults and children did not vary in the identification score of each vowel, hearing-impaired children showed markedly variability of identification score with a decrease of segmental duration in vowel /i/,/u/ as a whole. Then, it indicated that hearing-impaired children had difficulty listening and identifying vowels /i/,/u/.

When the segmental duration was at a critical duration of 75% in the identification score of mono syllable vowel, results of hearing-impaired children were as follows: S1, 64ms, S2, 89.6ms, S3, 128ms, S4, 38.4ms and S5, 38.4ms.

3. Experiment 2

Purpose of the experiment

The purpose of this experiment was to examine the identification of the temporal order made of vowels with variable segmental durations.

Subjects

The normal hearing subjects were the same subjects as experiment 1.

The hearing-impaired subjects were 3 selected children with sensorineural hearing loss (1 male, 2 females) whose the identification scores of mono syllable vowel were more than 4/7 (57.1%) in each segmental duration in experiment 1.

Method

A. Stimulus Preparation

Individual stimuli were five natural Japanese vowels (/a/,/i/,/u/,/e/,/o/) uttered by a normal hearing female.

The stimulus succession was identification tasks of temporal orders each vowel were occurring once per patterns at random. The silent interval of temporal order was 128ms and the number of item was 5, thus fixed (Fig. 3). Parameters of segmental duration were the

same as in experiment 1 (256, 128, 89.6, 64, 38. 4ms). Individual temporal order were edited by speech sound editing system controlled by a computer (DANAC-7000); durations, silent interval and intensity levels were unified, and recorded in the tape-corder (SONY TC-8750-2).

B. Procedure

All temporal order were presented with AD-02 air conductional receiver (normal--right ear. H.I.--better ear) in an acoustically isolated room with low ambient noise level for individual hearing. The level of stimulus was adjusted at 60dB (HL) in normal subjects and at 10-40dB (HL) above individual speech reception threshold in hearing-impaired children by the tape-deck (SONY TC 707-FC) and the audiometer (RION AA-63BN, 66BN). All sibjects responded to the presentation of temporal order by talking.

Result

Fig. 4. shows the identification of temporal order of vowels with variable segmental durations. First, normal hearing adults and children showed that while vowel segmental duration was from 256ms to 89.6ms, the identification scores of temporal order were ranging between 80-90%. In particular, the score of identification of normal hearing children was more than one of normal hearing adults at 89.6ms in vowel segmental duration. And, when the segmental duration was at critical duration at 75% in the identification score of vowel temporal order, the result of both normal hearing adults and

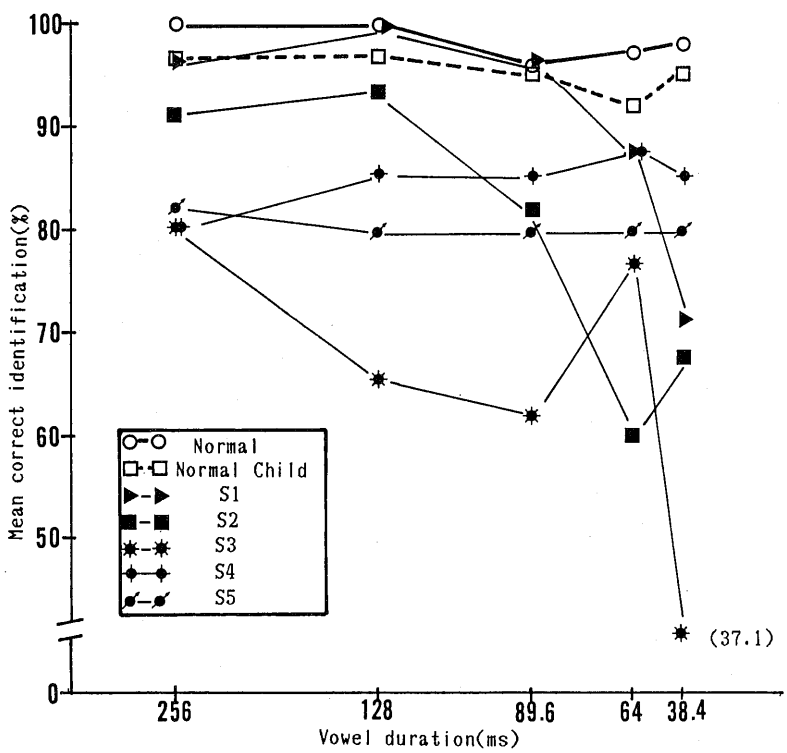

Fig. 2. Results of mean correct identification for mono syllable vowels.

children was 64ms, thus it was suggested that although vowel segmental duration was shortened, the correct identification of temporal order was possible for them.

Second, in hearing-impaired children, S1 and S5 showed a tendency to decrease the identification score at less than 89.6ms in vowel segmental duration. Furthermore, S5 showed that his identification score didn't make much difference from that normal hearing children

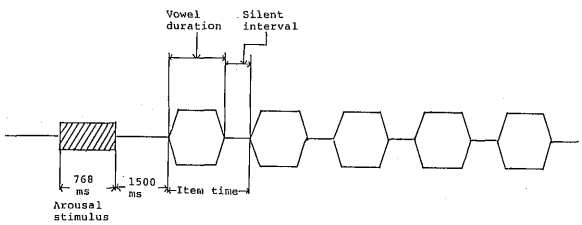

Fig. 3. Structure of vowel temporal order pattern

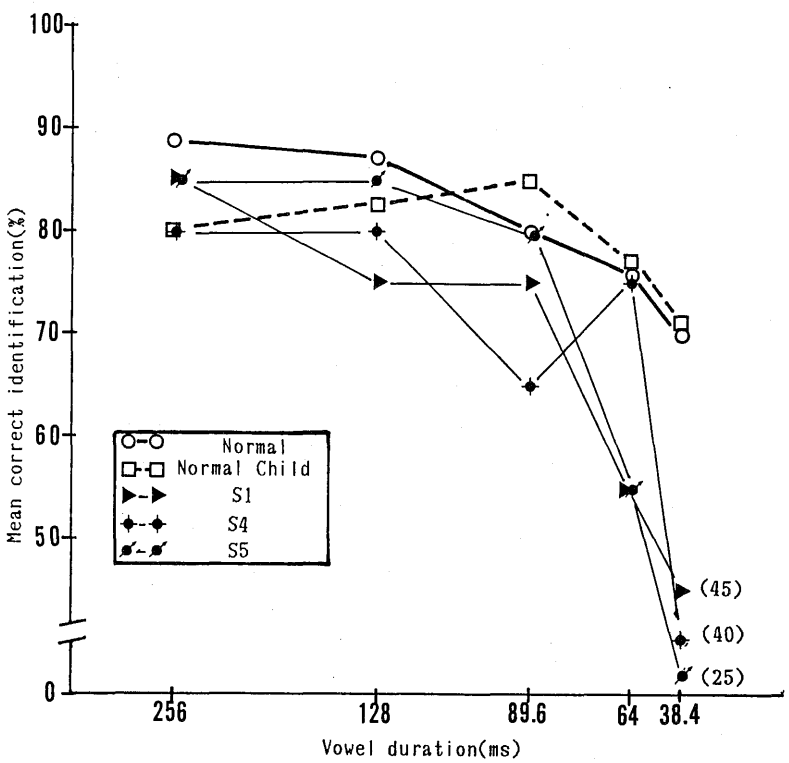

Fig. 4. Results of mean correct identification for vowel temporal order

and adults to 89.6ms, and showed higher identification score than normal hearing children at256ms and 128ms. It was thus suggested that S5's temporal information processing ranking was the same as normal hearing children and adults, for a given input condition. And, the identification score of S4 was 65% at 85.6ms and 75% 64ms respectively; it was thought that 64ms in vowel segmental duration was easy to identify and to compose the so-called "Gestalt" of the temporal order.

When the segmental duration was at a critical duration at 75% in the identification score of temporal order, results of normal hearing children and adults were 64ms (rate of presentation: 5.5items/s) and that of hearing-impaired children were as follows; S1, 89.6ms (5items/s), S4, 64ms (5.5items/s), S5, 89.6ms (5 items/s).

4. General Discussion

(1) The effects of segmental duration on the identification of vowels

In this study, two experiments were made on the identification of mono syllable vowel with variable segmental durations and vowel temporal order.

First, on the identification of mono syllable vowels, while normal hearing children and adults exhibited that the identification scores did not vary regardless of the decrease in segmantal durations of mono syllable vowels, hearing-impaired children (S1, S2, S3) showed that the identification scores fell markedly less than 64ms. This support obviously the former observation that in sensorineural hearing-impaired children, the relative longer duration is necessary for the accurate identification of vowels. And, in hearing-impaired children (S1, S2, S3), the identification scores were not uniformity at 256, 128, and 89.6ms in segmental duration, thus showing remarkable individual difference. In S3, particularly the identification scores at 128, 89.6ms were 65.7, 62.0% respectively, less than 75% except on 64ms (77.1%). Thus, it was suggested that S3 could not identify vowels accurately, until the segmental duration was more than 256ms. However, although the hearing level of S3 was considerably severe (105dB (HL)), he showed a relatively better score at 256ms (80%) in the identification of natural vowels (/a/,/i/,/u/,/e/,/o/); such result thought to be the fruit of his auditory learning. S4, S5 showed that although the segmental duration was reduced to 38.4ms, their identification scores would not vary. Then, it was considered that in the identification of mono syllable vowels with variable segmental duration, the hearing-impaired children who raise their hearing acuity (speech perception ability) by a proper fitting of hearing aid were not inferior to normal hearing children and adults in auditory temporal information processing.

Second, on the identification of tempora order of vowels with variable segmental duration, while normal hearing children and adults exhibited that the segmental duration of vowels was reduced to 38.4ms, their identification scores of temporal order were 71.7% and 70% respectively and would scarcely vary, hearing-impaired children exhibited that the identification scores of temporal order showed a tendency to reduce abruptly at 38.4ms. The hearing-impaired children showed relatively better scores (1: 71.4%, S4: 85.7%, S5: 80.0%) in mono syllable vowels (38.4ms), but in the experiment of temporal order which occurred successively in vowels with the silent interval (128ms), their identification scores were 45%, 40%, and 25% respectively (38.4ms). It was thensuggested that in hearing-impaired children, 38.4ms in segmental duration were short to identify the temporal order of vowels.

In previous studies, though it was reported that the cochlear damage which is said the cause of sensorineural hearing-impairement impaires one aspect of auditory temporal (time) resolution in the inditifications of apeech sound

with variable segment duration,[6] subjects in this study did not show such tendency in a given presentation condition. It was then suggested that their auditory temporal information processing (resolution) is improved to some degree through their auditory learning.

(2) The identification ability for temporal order of vowel with variable segmental duration.

Previous sudies found that, with respect to the identification ability for temporal order, the optimum speed for item alternation was 1 item per second (Preusser, Garner, and Gottwald 1970,[9] Preusser, 1972)[100]. On the other hand, one of hearing-impaired children was 3 items per second (Sato and Yoshino, 1987). Thus, while previous stidies docused on the identification ability of temporal order with variable silent interval, this study focused on one of temporal order with variable segmental duration. As a result, hearing-impaired children had the highest shadowing at 256ms (duration), that is, the speed for item altermation. Then, it showed that in the identification of temporal order of vowels with variable segmental duration, the optimum speed for item alternation was 3 item per second too. Such statement matched the observation of Sato Yoshino (1987).[11]

Hearing-impaired children showed the relatively stable scores to 128ms, thus proving the observation of Thomas, et al. (1970)[16] that the identification score was stable at more than 125ms.

In this study, hearing-impaired children (S1, S5) showed that scores reduced at than 64ms, showing they have difficulty identifying the temporal order at more than 5.5items per second.

5. Conclusion

In the experiment for the identification of vowel with variable segmental duration, it was suggested that the hearing-impaired children had difficulty identifying the vowel at 128-38.4ms (mono syllable) and 89.6-64ms (temporal order).

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