

A Cross-Language Study on the Perception of [r-l]

—A Preliminary Report—

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1. INTRODUCTION

The aim of the present study is to investigate the perception of synthetic speech sounds of [r-l] continuum by speakers of different languages. It is generally known that speakers whose languages differ in phonological and phonetic inventories show some different characteristics in the perception of speech sounds. Among speech sounds, the study on the perception of /r/ and /l/ has attracted the interest of many phoneticians. Both [r] and [l] are often classified into the same category, 'liquid'. The number of the liquid phonemes differs in each language. The phonetic representations of the liquid phonemes also vary in each language. Although liquids tend to behave in similar ways in phonological rules in many languages, they are differently manifested in phonetic realizations and sometimes form a phonetically heterogeneous group.

There have been several reports on the experiments of the perception of [r] and [l] using synthetic speech sounds. Miyawaki et al. (1975) studied the effect of linguistic experience of English and Japanese on the perception of synthetic [r-l] continuum and mentioned that the difference of linguistic experience is specific to perception of speech mode. Furthermore, Mochizuki (1981) and Shimizu and Dantsuji (1983) carried out the experiments of speech perception to English and Japanese speakers by using natural and synthetic speech sounds and reported that English speakers perceive the [r-l] continuum categorically, while Japanese speakers do it continuously, and the difference of the perception mode can be attributed to the one of the linguistic function of the liquids in these languages. It is well known that the /r/ and /l/ contrast is functional in English but not in Japanese and different functions of the liquids in these languages cause some learning problem for Japanese speakers. It is also known that the overall performance levels on discrimination of the contrast by Japanese learners of English are closely correlated with their English proficiency and are improved by laboratory training (MacKain et al., 1981; Strange and Dittmann, 1984).

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Although the difference between English and Japanese speakers in the perception of [r-l] continuum has been well documented, the experimental data on other language speakers are very scarce, and it will be necessary to examine other language speakers in order to clarify the relationship between linguistic experience and the mode of speech perception. In the present study, we would like to examine how the differences of the linguistic function of liquids in English, Spanish, Hindi, Chinese, Korean and Japanese affect the perception of the synthetic [r-l] continuum and to report the results of identification and discrimination tests.

2. EXPERIMENTAL PROCEDURE

Subjects

The subjects composed of speakers from six language groups: English, Spanish, Hindi, Chinese, Korean and Japanese.

English: 7 native speakers of American English took part in the experiment. They had lived in Japan for a certain period, ranging from three months to three years.

Spanish: 4 native speakers of Spanish took part in the experiment. They were undergraduate students at UCLA.

Hindi: 2 native speakers of Hindi took part in the experiment. They were graduate students in physics and journalism at UCLA.

Chinese: 3 Chinese speakers (1 from Hong Kong, 2 from Mainland China) took part in the experiment.

Korean: 3 native speakers of Korean took part in the experiment. They were studying in Japan as foreign students. One subject was a graduate student at Kyoto University. The others were undergraduate students at Kansai University and at Momoyama-Gakuin University.

Japanese: 23 native speakers of Japanese took part in the experiment and were tested in a classroom. They were undergraduate students in an introductory phonetics class at Sugiyama Jogakuen University.

Stimulus Materials

The stimuli were prepared on the OVE III synthesizer at Haskins Laboratories. The 10 step [ra-la] stimuli differed in the frequency values of the second formant (F2) and the third formant (F3) within the initial state portions and the transition portions. F2 values varied in almost equal step from 951 to 1404 Hz and F3 values from 1488 to 3246 Hz. The first formant (F1) values were kept constant for 10 stimuli. It is well known that F3 is the strongest acoustic cue for the difference between [r] and [l]. However, it has been pointed out that not only F3 but also F2 is the effective cue for the differentiation of [r] and [l], and this has been confirmed by the experiment recently (Nakashima, 1986). Therefore, we adopted the stimuli differed in the frequency values of both F2 and F3 in our experiment. The stimulus with 1404 Hz of F2 and 3246 Hz of F3 was a good /la/, while the one with 951 Hz

of F2 and 1488 Hz of F3 was a good /ra/. The total duration was 377 msec.

Two types of tests were prepared: an identification test and an oddity test. In the former test, each stimulus was repeated 10 times, making the total presentation 100, and the stimuli were randomly arranged. The interstimulus interval was 1 sec. and the block interval was 10 sec. The oddity discrimination test consisted of 18 repetitions of each of 7 stimulus pairs (1-4, 2-5, 3-6, 4-7, 5-8, 6-9, and 7-10), totalling 126 trials in all. Stimulus pairs were arranged such that members were three steps apart along the 10 step stimuli. For each pair, trials were constructed by duplicating one member of the pair, and six permutations of each companion were included; i.e., for 1-4 pair, 1-4-4, 1-1-4, 4-1-1, 1-4-1, 4-1-4, and 4-4-1. All test materials were recorded in audio tape for presentation to subjects.

3. RESULTS

Results of the identification and discrimination tests can be shown in Figures 1-3.

Figure 1a shows the results of the pooled identification for English and Spanish speakers. Both subject groups show a similar pattern of identification curve. Subjects in both groups identified stimuli 1 to 5 as /ra/ and stimuli 8 to 10 as /la/, and showed an abrupt shift of the curve in the stimulus range from 6 to 8. The boundaries lie between stimuli 6 and 7, though there were slight discrepancies in both groups of subjects. Figure 1b shows the results of a pooled discrimination for both groups, and both subject groups showed a better performance in accuracy. The accuracy was below at 1-4 pair, but sharply rose to about 90% accuracy at the pairs which are considered to be in the phonetic boundary between /r/ and /l/. That is, both groups of subjects discriminated very well between stimuli drawn from different phonetic categories but very poorly between stimuli from the same phonetic category. Both identification and discrimination curves show that both subject groups identify the [r-l] continuum categorically.

Figure 2a shows the identification curves for Japanese and Hindi speakers. Unlike the results in Figure 1a, both Japanese and Hindi speakers showed a gradual shift of identification curve as the stimulus shifts from 3 to 8. Japanese subjects identified stimuli 1, 2 and 3 as /ra/ and stimuli 8, 9 and 10 as /la/ with 60-70% of identification rate, while Hindi speakers identified these stimuli with much higher rate than Japanese speakers. Figure 2b shows the discrimination curves for both language groups. Both subject groups discriminated the stimuli with an accuracy rate ranging from 50 to 70% across the continuum of stimulus set from the 2-5 pair. Although there was a moderate increase in discrimination of stimulus pairs 3-6, 4-7, and 5-8, there is no noticeable change in the accuracy percentage in both groups within and between categories. It can be said that these results indicate that Japanese and Hindi speakers perceive the [r-l] continuum continuously.

Figure 3a shows the identification curves for Chinese and Korean speakers.

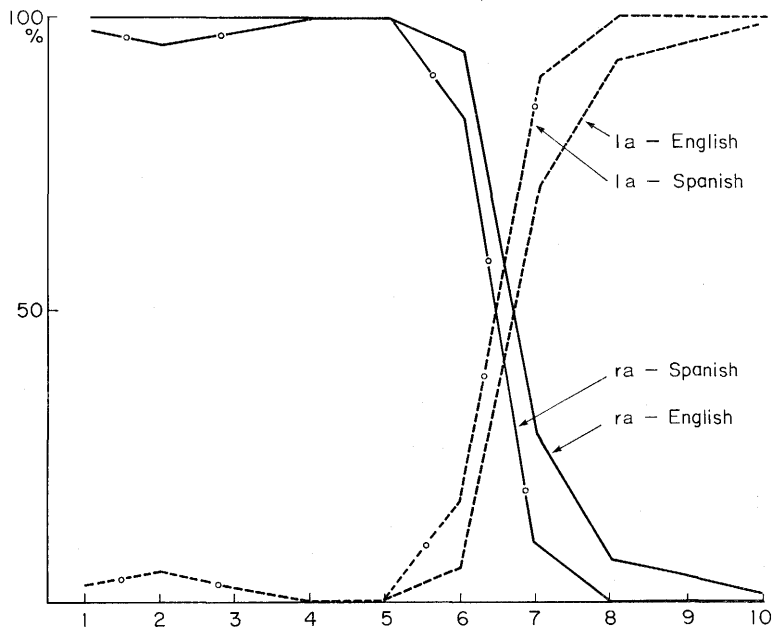


Fig. 1a. Pooled identification of English and Spanish speakers.

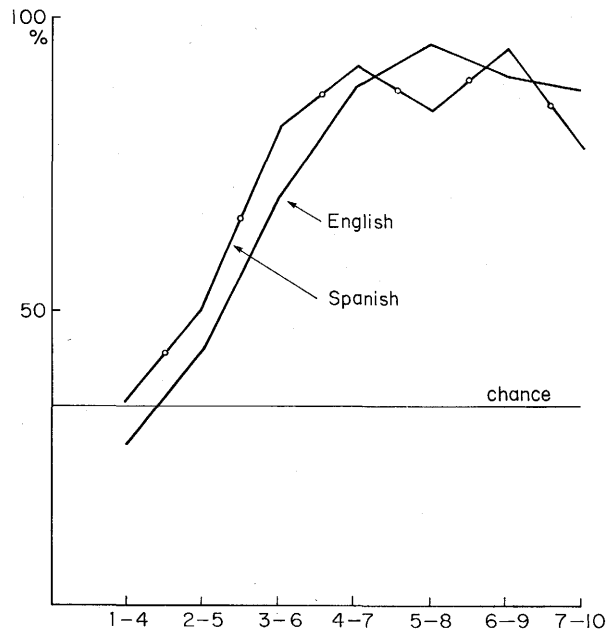


Fig. 1b. Pooled discrimination of English and Spanish speakers.

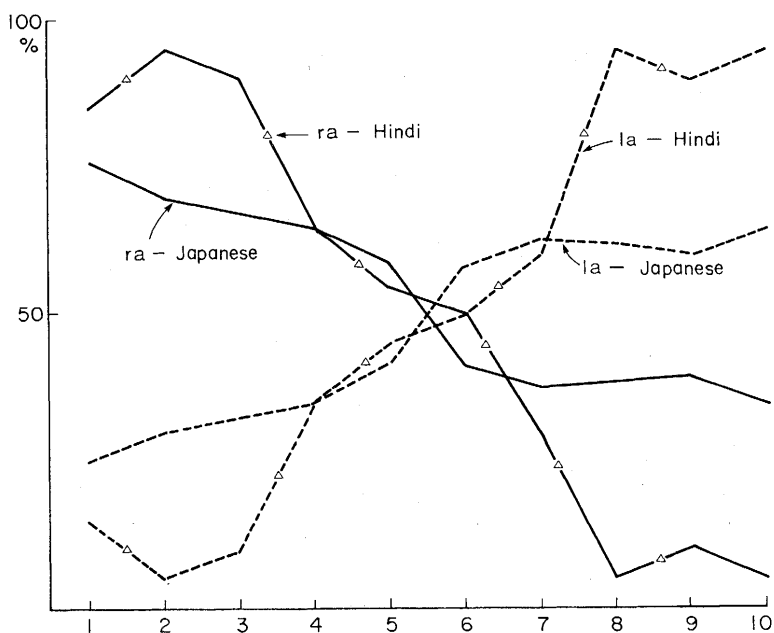


Fig. 2a. Pooled identification of Hindi and Japanese speakers

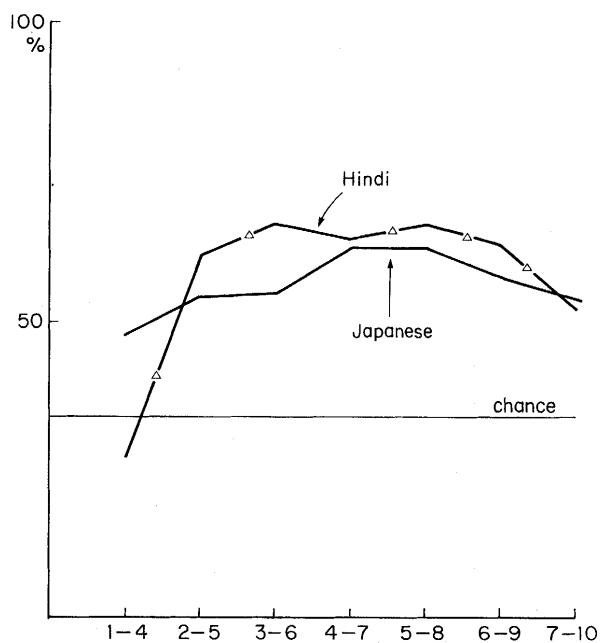


Fig. 2b. Pooled discrimination of Hindi and Japanese speakers.

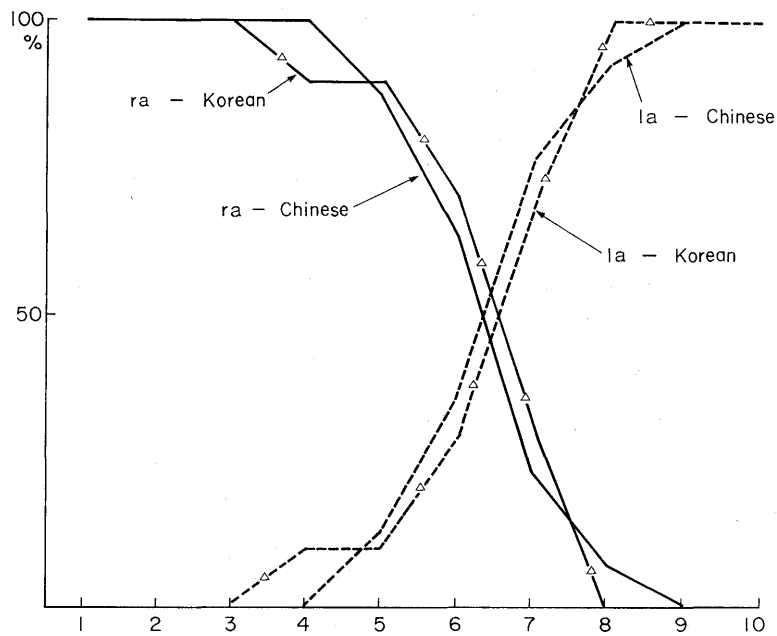


Fig. 3a. Pooled identification of Korean and Chinese speakers.

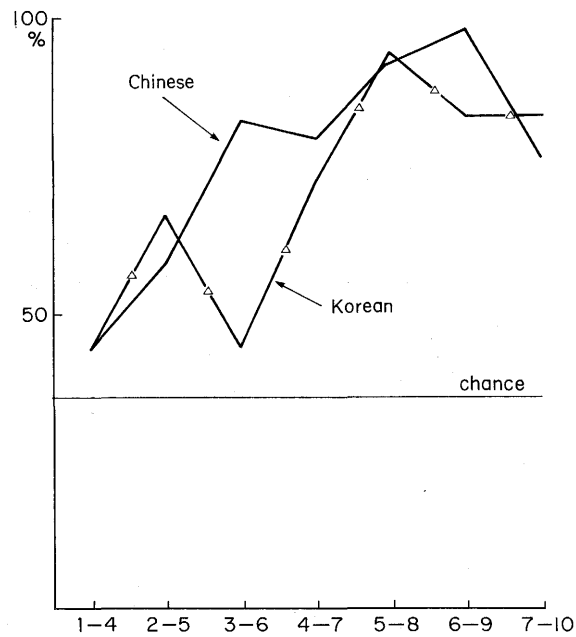


Fig. 3b. Pooled discrimination of Korean and Chinese speakers.

The curves are similar to the ones of English and Spanish speakers, but with less abrupt shift. The boundary between /r/ and /l/ lies between stimuli 6 and 7 for both groups of subjects. Figure 3b shows a pooled discrimination for the two groups. Both groups show sharp rise at the pairs of 5-8 and 6-9. Examining these results, it can be said that Chinese and Korean speakers perceive the [r-l] continuum with a near categorical manner.

4. DISCUSSION

One of the main concerns of the present study is to grasp the influence of the differences of the phonemic background of subjects in each language. English has two kinds of liquid sounds, namely, a lateral approximant [l] and a postalveolar approximant [ɹ]. The acoustic characteristics of the differences of [ɹ] and [l] are mainly ascribed to the differences of both the second and the third formants, as mentioned above. Spanish has four kinds of liquid sounds, namely, a voiced trill [r], a voiced tap [ɾ], a voiced dental lateral approximant [l̪] and a palatal lateral approximant [ʎ]. Hindi also has four kinds of liquid sounds, namely, a voiced trill [r], a voiced retroflex flap [ɽ] (loan words), a voiced lateral approximant [l] and a breathy voiced lateral approximant [l̥]. Chinese (Guoyu) also shows the phonological contrast between /r/ and /l/. So far as our subjects are concerned, the phonetic representation of /r/ varies from a retroflex approximant [ɹ] to a retroflex fricative [ʐ], while that of /l/ is an alveolar lateral approximant [l]. Korean has only one liquid phoneme and does not show the phonological contrast between /r/ and /l/. It is well known that the phonetic representation of Korean liquid phoneme shows the complementary distribution. Generally speaking, a flap [ɾ] occurs in the inter-vocalic position and a lateral approximant [l] occurs in the other positions. Japanese also has only one liquid phoneme, however, the allophonic situation of this phoneme is slightly different from that of Korean. Although a form of /r/ ("rhotic") occurs phonemically in Japanese, it is said to fit the criteria of flap [ɾ], and is more similar acoustically and articulatorily to the voiced dental alveolar flap [ɾ] than to the approximant [ɹ] in American English. It is also known to have both inter- and intra-speaker variations. Some Japanese use both a lateral approximant [l] and a flap [ɾ] as completely free variants. Some Japanese use a lateral approximant [l] in the word initial position and use a flap [ɾ] in the inter-vocalic position. Some use a lateral approximant [l] in each position. Others use a retroflex voiced stop [ɖ] in addition to these sounds.¹⁾

We have examined how speakers of six languages perceive the [r-l] continuum and how the differences of linguistic experience affect the mode of speech perception. Examining the results of identification and discrimination tests, it has become clear that the speakers of six different languages show different patterns of performance.

1) Cf. Amanuma, Ohtsubo and Mizutani (1985⁸), Sudo, Yoshioka, Kiritani and Sawashima (1983), Kohno (1982), Ohmura (1982), Nakashima, Kobayashi and Kakusho (1986a; 1986b), etc.

It can be said that familiarity with the [r-l] distinction has an impact on the perception of the continuum.

English and Spanish speakers show a peak of accuracy at the point where stimuli from different phonetic classes are being contrasted. These results are well predicted from the linguistic function of liquids in these languages, and those on English speakers replicate the earlier findings on the perception of synthetic [r-l] continuum (Mochizuki, 1981; Shimizu and Dantsuji, 1983). As can be seen in Figure 1b, however, the discrimination function by Spanish speakers is a bit different from English speakers and it is said that Spanish speakers use a wider range of acoustic dimension for their phonetic categorization.

Japanese and Hindi speakers showed a difficulty to discriminate [r] and [l] over the continuum. The results on Japanese subjects conform with the previous studies (Miyawaki et al., 1975) and are in harmony with what is known about linguistic function of the liquid in Japanese. The results for the Hindi subjects failed to meet our prospect. Hindi has four kinds of liquid sounds. We prospect that Hindi would show the categorical mode of the perception. The finding that Hindi speakers poorly discriminated [r] and [l] over the synthetic continuum might indicate that stimuli are not similar to the Hindi contrast of lateral and tap.²⁾

As shown in figures 3a, b, Korean and Chinese speakers discriminate the continuum in a near categorical manner. As mentioned above, Korean has no phonemic contrast between /r/ and /l/ and has only one liquid, which shows allophonic variations of [l] or flap depending on the phonetic environments. The finding that both subject groups showed a better performance in the discrimination task implies that the stimuli are similar to the allophonic variations of liquids in these languages and speakers in both language groups discriminate the synthetic continuum according to their allophonic variations.

These results of experiments indicate that different perceptual modes appeared depending on the phonemic functions of liquids in each language. The boundary between /r/ and /l/ differed systematically in languages, and the speakers having a phonemic contrast of /r/ and /l/ except Hindi speakers showed a clear categorical mode perception. It can be said as a general trend that the differences of linguistic experience cause those in the perceptual modes. For Hindi speakers, however, it can be considered that the phonemic contrast based on the manipulation of F2 and F3 frequencies in the synthetic continuum is 'foreign' to them and the contrast in Hindi liquids may be manifested by other acoustic parameters.

5. SUMMARY

The present study has been concerned with the perception of synthetic speech sounds of [r-l] continuum by speakers of different languages. Specifically, the

2) In regard to these results, Prof. Manjari Ohala commented that these subjects in Hindi might not have been able to understand what they were requested in the experiment.

study has examined how the differences of the linguistic function of liquids in English, Spanish, Hindi, Chinese, Korean and Japanese affect the perception of the synthetic continuum and has reported the results of identification and discrimination tests. So far as our subjects were concerned, the results have indicated that different modes of perception appeared depending on the phonemic functions of liquids in each language. The boundary between /r/ and /l/ differed systematically in each language and, as a general trend, the speakers having a phonemic function of /r/ and /l/ showed a categorical mode of perception and differences of linguistic experience cause those of perceptual mode.

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REFERENCES

- Amanuma, Y., Ohtsubo, K. and Mizutani, O., (1985⁸), *Nihon-go Onseigaku* (Japanese Phonetics), Kuroshio Shuppan, Tokyo. (in Japanese).
- Eimas, P. D., (1975), "Auditory and phonetic coding of the cues for speech: Discrimination of the [r-l] distinction by young infants," *Perception and Psychophysics*, Vol. 18, 341-347.
- Gillette, S., (1980), "Contextual variation in the perception of L and R by Japanese and Korean Speakers," *Minnesota Papers in Linguistics and the Philosophy of Language*, Vol. 6, 59-72.
- Kohno, K., (1982), "Nihon-jin ni yoru Eigo no /r/ to /l/ no Chouon oyobi Choukaku Shikibetsu," (Production and auditory identification of English /l/ and /r/ by Japanese) *Transactions of the Committee on Speech Research, The Acoustical Society of Japan*, S82-31, 241-246. (in Japanese).
- MacKain, K., Best, C. T. and Strange, W., (1981), "Categorical perception of English /r/ and /l/ by Japanese bilinguals," *Applied Psycholinguistics*, Vol. 2, 369-390.
- Miyawaki, K., Strange, W., Verbrugge, R., Liberman, A. M., Jenkins, J. J. and Fujimura, O., (1975), "An effect of linguistic experience: The discrimination of [r] and [l] by native speakers of Japanese and English," *Perception and Psychophysics*, Vol. 18, No. 5, 331-340.
- Mochizuki, M., (1981), "The identification of /r/ and /l/ in natural and synthesized speech," *J. Phonetics*, Vol. 9, 283-303.
- Nakashima, H., Kobayashi, T. and Kakusho, O., (1986a), "Nihon-jin Eigo Gakushuusha no Hassei ni yoru /r/, /l/ no Bunseki," (Analysis of /r/ and /l/ pronounced by Japanese who are studying English) *Onkyougakkai-ronshuu*, 1-2-9. (in Japanese).
- Nakashima, H., Kobayashi, T. and Kakusho, O., (1986b), "/r/, /l/ on no Seisei to Chikaku—Nihon-jin Hiken-sha o Taishou to shite—," (Production and perception of English /r/ and /l/ sounds for Japanese) *Denshiutsushingakkai-ronbunshuu*, SP 86-56, 39-44. (in Japanese).
- Ohmura, H., (1982), "Nihon-go Ra-gyou-on no Bunseki," (Acoustic analysis of Japanese /r/ in CV syllables), *Transactions of the Committee on Speech Research, The Acoustical Society of Japan*, S82-02, 9-16. (in Japanese).

- Sheldon, A. and Strange, W., (1982), "The acquisition of /r/ and /l/ by Japanese learners of English: Evidence that speech production can precede speech perception," *Applied Psycholinguistics*, Vol. 3, 243-261.
- Shimizu, K. and Dantsuji, M., (1983), "A study on the perception of /r/ and /l/ in natural and synthetic speech sounds," *Studia Phonologica*, Vol. 17, 1-14.
- Strange, W. and Dittmann, S., (1984), "Effect of discrimination training on the perception of /r-l/ by Japanese adults learning English," *Perception and Psychophysics*, Vol. 36, No. 5, 131-145.
- Sudo, M. M., Kiritani, S. and Yoshioka, H., (1982), "Nihongo Boin-kan /r/ no Chouon—Erekutoro-paratogurafi ni yoru Kansoku," (An Electro-Palatographic study of Japanese intervocalic /r/) *Transactions of the Committee on Speech Research, The Acoustical Society of Japan*, S82-30, 233-238.
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