

Cross Language Study of Perception of Dental Fricatives in Japanese and Russian

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ABSTRACT

The characteristics of Japanese fricatives and Russian fricatives were compared in two ways: (1) by spectrographic analysis and (2) through perception tests of Japanese fricatives by Russian subjects and of Russian fricatives by Japanese subjects. In the case of Japanese, /sj/ is characterized by a higher F2O and lower NF than /s/. In Russian, /s'/ has nearly the same NF as /s/ and is characterized by a higher F2O than /s/. On the other hand, /ʃ/ has nearly the same F2O as /s/ and a lower NF than /s/. In Russian subjects, there was a tendency for some of the /sj/ sounds to be identified as /s/. Japanese subjects showed a large confusion between /s'/ and /ʃ/. These results can be explained by the boundaries of native language.

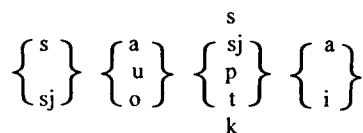
INTRODUCTION

Japanese has two dental fricatives /s/ and /sj/ (which is, phonetically, generally transcribed as [ʃ]) and Russian has three dental fricatives /s/, /s'/ and /ʃ/. When Japanese study Russian and when Russians study Japanese, Japanese fricatives /s/ and /sj/ and Russian fricatives /s/, /s'/ and /ʃ/ interfere with each other. This paper describes the results of acoustic analyses of Japanese and Russian fricatives and the results of perception tests.

ACOUSTIC ANALYSIS Experimental procedure Japanese speech samples

The speech samples were com-

posed of the following 48 bi syllabic words including nonsense words. The target syllables were word initial syllables.



In the above list, the words containing the syllables /si/ or /ti/ were excluded because these syllables are phonetically realized as [ʃi] or [tʃi]. These bi syllabic words were uttered by three male speakers. These 48 speech samples were analyzed.

Russian speech samples

The Russian speech samples for the acoustic analysis were 45 words which have the syllables /sa/, /su/, /so/, /s'a/, /s'u/, /s'o/, /ʃa/, /ʃu/, /ʃo/ in the word-initial position. These words were produced by three male speakers of the Moscow dialect.

Method of analysis

Two acoustic parameters were measured using a spectrograph analysis program on a personal computer. One parameter was the frequency of the peak power in the fricative noise spectrum (NF). The other parameter was the onset frequency of the second formant transition of the following vowel (F2O). For measuring the formant, the speech samples were sampled at 10kHz with an accuracy of 12 bits per sample, and FFT analyses were performed. F2O were measured by visual inspection of the spectrogram.

As for noise frequency, the speech samples were sampled at 20kHz and the central parts of the noise periods were extracted using a 51.2-ms Hamming window. NF were determined by visual inspection of the spectrum.

Results

The results of the acoustic analysis are shown in Fig. 1. In the case of Japanese, /sj/ is characterized by a higher NF and lower F2O than /s/. In Russian, /s'/ has nearly the same NF as /s/ and is characterized by a higher F2O than /s/. On the other hand, /ʃ/ has nearly the same F2O as /s/ and a lower NF than /s/.

In this figure, it is clear that Japanese /s/ and /sj/ and Russian /s/, /s'/ and /ʃ/ all exhibit the coarticulatory effect. Both Japanese and Russian words, when followed by vowel /o/, NF and F2O are lower than vowel /a/. However, in vowel /u/, in Japanese NF and F2O are nearly the same as vowel /a/, while in Russian, NF and F2O are close to vowel /o/. As mentioned above, in vowel /a/, Japanese /sj/ is located between Russian /s'/ and /ʃ/ on the NF-F2O plane, but in vowel /o/ and /u/, Japanese /sj/ is located near Russian /s'/.

PERCEPTION TESTS

Perception test of Japanese sounds by Russian subjects Speech samples

The Japanese speech samples for the perception test were the words which were used in acoustic analysis. These words were sampled at 20kHz and stored in a computer. They were presented to the subjects in random order at intervals of 2s.

Subjects

The subjects were 27 Russian students who had studied Japanese for 1 month in Russia. They were in-

structed to identify the initial consonant in each word as either /s/ or /sj/.

Results

Table 1 shows the confusion rates between /s/ and /sj/. The over-all error rate is not so large, but there was a tendency that some of the /sj/ sounds to be identified as /s/. But the reason for this type of error is not clear at present and further acoustic analysis of these sounds and perception tests of synthesized sounds are necessary.

Perception test of Russian sounds by Japanese subjects

Speech samples

The Russian speech samples for the perception test were the words which were used in the acoustic analysis. These words were sampled at 20kHz and presented to the subjects in random order at intervals of 2s.

Subjects

The subjects were 38 Japanese students who had studied Russian for 2 months in Japan. The subjects were instructed to identify the initial consonant in each word as either /s/, /s'/ or /ʃ/.

Results

The results are shown in Table 2. It can be seen in the Table 2 that the Japanese subjects showed a large confusion between /s'/ and /ʃ/, but the confusion between /s/ and /ʃ/ and the confusion between /s/ and /s'/ were very small. Data in Fig. 1 suggests that on the NF-F2O plane the Japanese phonetic boundary forms an oblique line. The upper left region is /s/, and the lower right region is /sj/. Both of the Russian fricatives, /s'/ and /ʃ/, are located in the region of Japanese /sj/. The above results can be considered as a natural consequence of this acoustic pattern.

Another point to be noted in

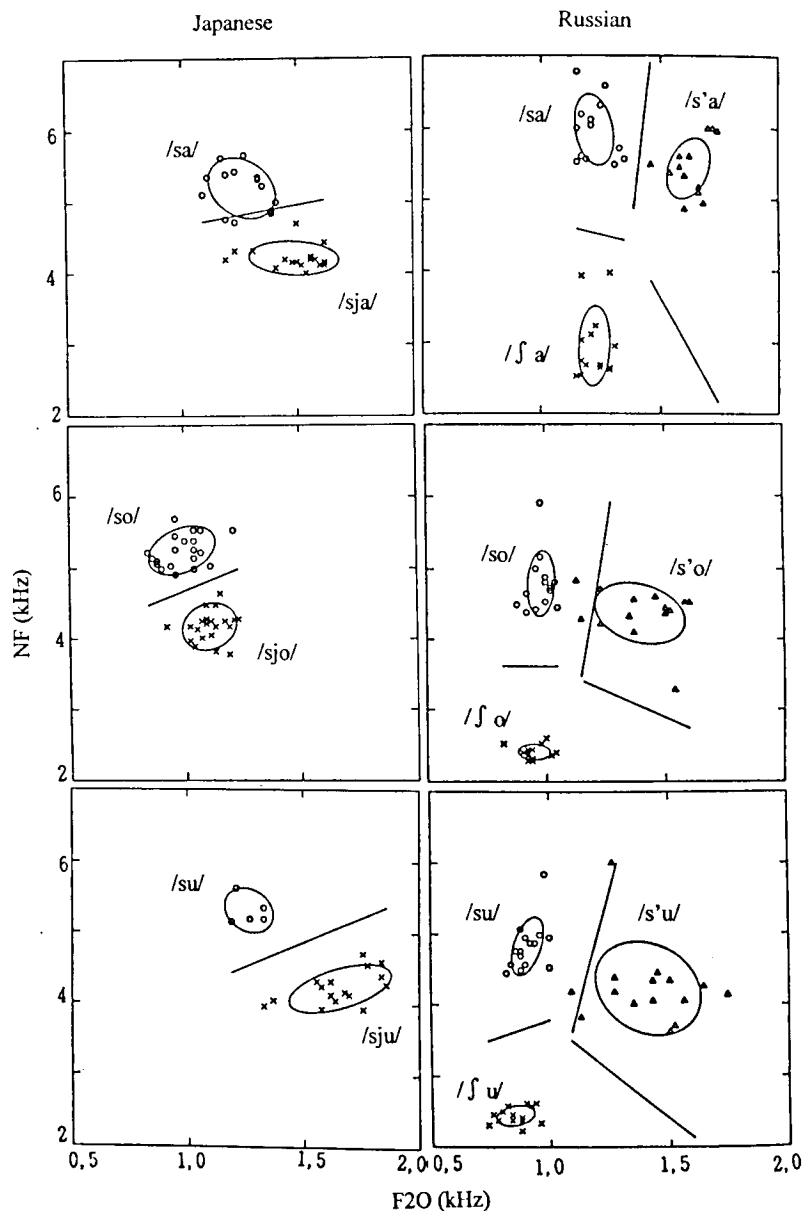


Figure 1. Results of acoustic analyses.

The ellipses represent a 50 percent confidence region on the data values assuming a Gaussian distribution for the data. The straight lines are discriminant functions.

Table 2 is that Japanese subjects identify some instances of Russian /s'/ as /s/. The reason for this type of error is not clear at present and further acoustic analysis of these sounds is necessary.

SUMMARY

As the results of the acoustic analyses show, Japanese /s/ and /sj/ were distinguished mainly by both NF and F2O, while Russian /s/ and /s'/ were distinguished mainly by NF only and F2O only respectively.

In the perception test by Russian subjects, some of /sj/ were identified as /s/, while, by Japanese subjects, they confused some of /s'/ with /s/. These results may explain the effects of native boundaries. But they are not conclusive at present and further experiments are necessary.

Table 1. Confusion matrix of Japanese fricatives by Russian subjects.

following vowel /a/		
answer stimuli	s	sj
s	98	2
sj	6	94

following vowel /o/		
answer stimuli	s	sj
s	99	1
sj	24	76

following vowel /u/		
answer stimuli	s	sj
s	96	4
sj	3	97

Table 2. Confusion matrix of Russian fricatives by Japanese subjects.

following vowel /a/			
answer stimuli	s	s'	ʃ
s	99	1	0
s'	12	69	19
ʃ	1	26	73

following vowel /o/			
answer stimuli	s	s'	ʃ
s	96	4	0
s'	19	51	30
ʃ	2	24	74

following vowel /u/			
answer stimuli	s	s'	ʃ
s	92	6	2
s'	28	29	43
ʃ	3	22	75