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ELECTRO-PALATOGRAPHIC PATTERNS OF JAPANESE /d/ AND /r/ IN INTERVOCALIC POSITION

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Introduction

Systematic studies on the tongue-palate contact patterns of Japanese intervocalic /d/ and /r/ have been conducted. Our previous reports[1), 2)] in this area can be summarized as follows:

1) In the articulation of /d/, the contact regularly proceeds posterio-anteriorly along the alveolar ridge until a complete closure is achieved at the anterior end of the palate. For /r/, in contrast, a complete closure is not necessarily seen. Also, some /r/ samples show the contact occurring at the anterior portion in advance of that proceeding posterio-anteriorly along the alveolar ridge.

2) Comparing the maximum contact patterns, /d/ shows a wider contact area than /r/. The inter-utterance variability in the contact area at the anterior half of the palate is greater for /r/ than /d/.

These results are based on limited utterance samples with a symmetric vowel context in which the proceeding vowel is the same as the following one. In the present paper, the contact patterns for all of the vowel contexts examined to date are summarized.

Experimental Procedures

Utterance samples and subjects were the same as in our previous report.[2)] Three native Japanese speakers of the Tokyo dialect served as subjects. None of the subjects reported any speaking disabilities. Test words were meaningless sequences of the form /$V_1CV_2V_1CV_2$/ (V_1=i, e, a, o, u; V_2=e, a, o; C=d, r). The test words were embedded in the carrier sentence /Sorewa ____ desu/ (It is ____). Each of the test sentences was repeated ten times, with a flat accent for the test word, at a comfortable speaking rate for the subject. Thus, 20 utterance samples were recorded for a given /V_1CV_2/ sequence.

The data correcting system was the same as in our previous reports[1), 2)] as shown in Fig. 1. Contact signals from the electrodes in the artificial palate were stored in a computer connected to a portable electro-palatograph unit at a rate of 64 frames/sec. When the subject read a test sentence and pushed the control button after each utterance, the data for a duration of one-second were stored in the computer. The speech signals were also sampled by the computer at a rate of 64 frames/sec after rectification and integration over a 16 msec time window. The stored data were reproduced and observed in slow motion on an oscilloscope. The plotting of the necessary contact patterns was

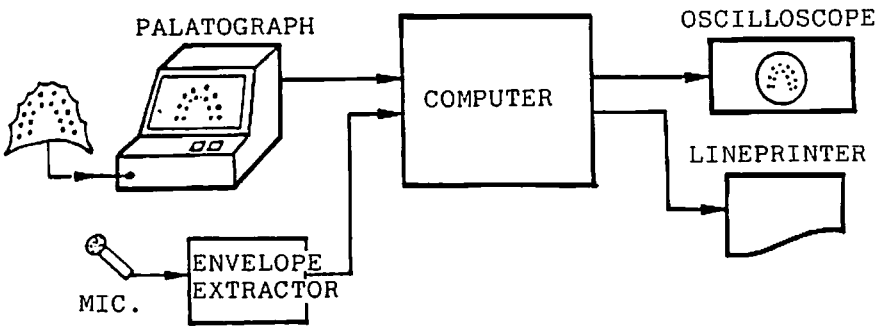

Fig. 1 Data correcting system using an electro-palatograph unit.

printed out by a high-speed line printer.

Results and Comments

1. Maximum contact patterns

For each test word of each subject, we constructed a contact pattern which consisted of the electrodes showing contact in more than 10 (50%) of the 20 repetitions. This pattern was considered to be the average contact pattern for each test word in a given subject. The results are shown in Fig. 2. In the figure, the patterns for /d/ and /r/ in the same vowel context are superimposed on the scheme of the artificial palate. The area demarcated by the thick line indicates the contact area for /d/, while the shaded area indicates that for /r/.

It is apparent that, for /d/ there is a complete stop closure at the anterior margin of the palate for all of the vowel contexts in all three subjects. Also, there is little variation in the contact pattern among the different vowel contexts at the anterior part of the palate within each subject, while there is some context-dependent variability at the posterior part.

The maximum contact pattern for /r/ generally shows a smaller contact area than that for /d/. At the anterior part of the palate, there are many /r/ patterns which do not show complete closure. The characteristic feature for Subj. 1 is that the contact at the anterior part shifts backward for /r/ as compared to /d/. This appears to occur only in the context of the back vowels for Subj. 2, while no such shift in the place of contact is observable for Subj. 3. Thus, there is some individual variation in the contact patterns for /r/.

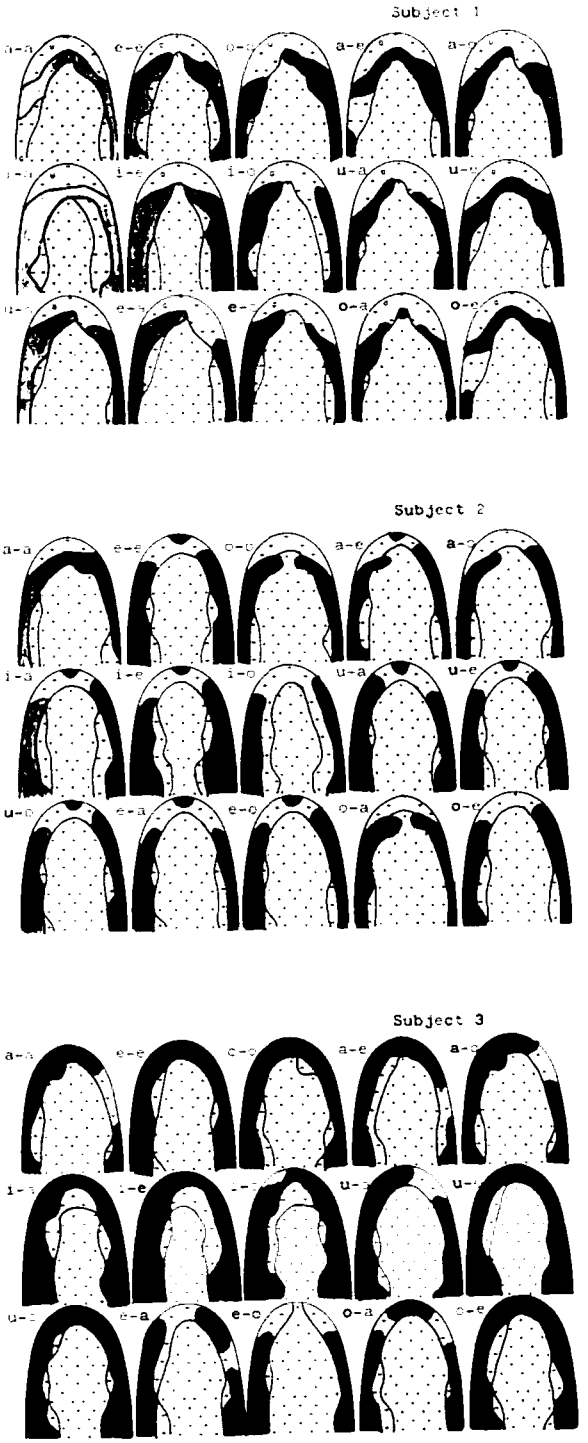

Fig. 2 Maximum contact patterns for /d/ and /r/. The area is demarcated by the solid line for /d/; the shaded area for /r/.

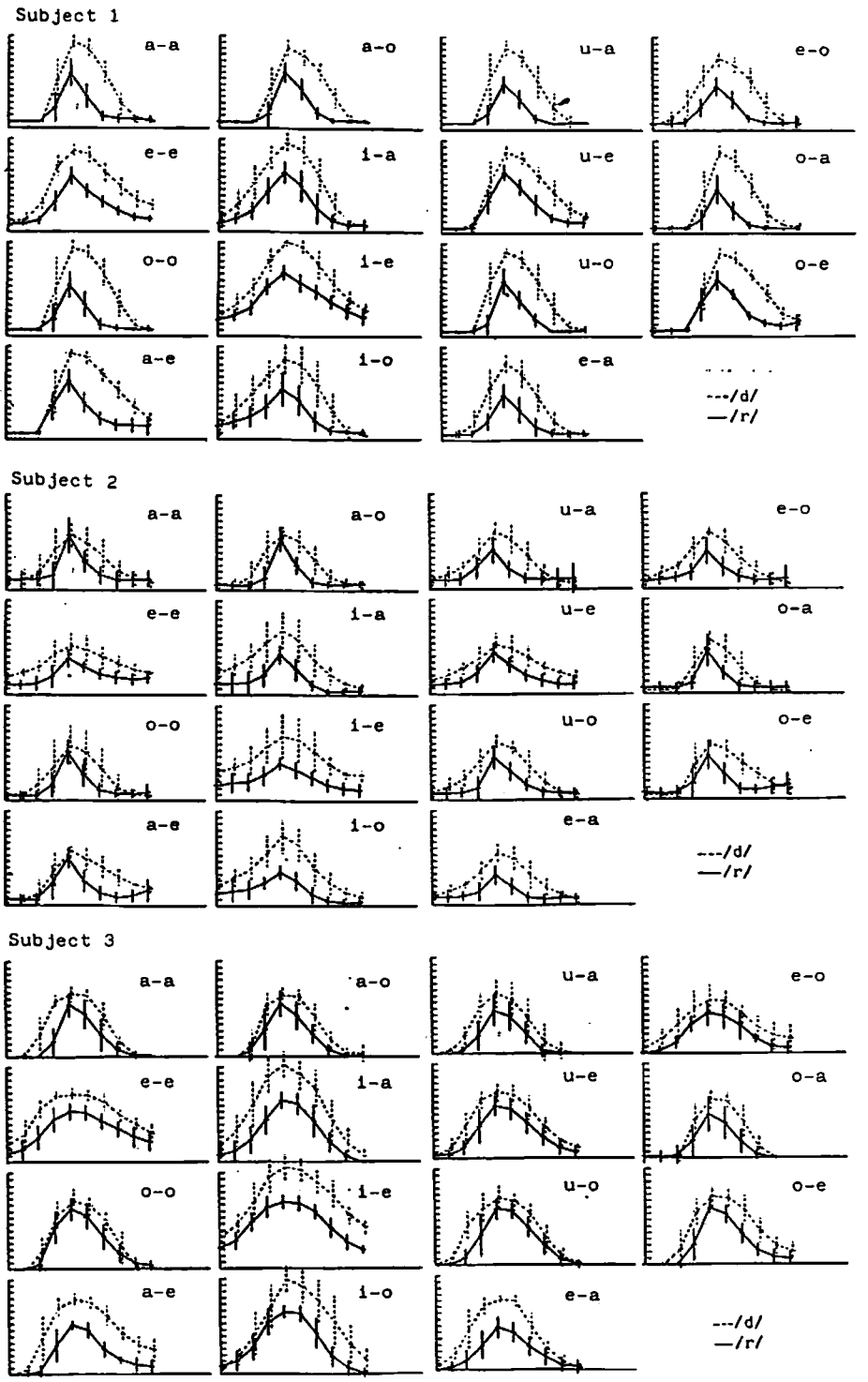

Fig. 3 Time curves of the area of contact at the anterior palate for /d/ and /r/. The vertical bars indicate mean values and standard deviations. Dashed line for /d/; solid line for /r/.

Another feature of /r/ is that some of the /r/-patterns show contact at the anterior part separate from the contact at the lateral part of the palate. Whether this represents a specific tongue gesture for /r/ or not is an open question at this moment.

2. Time course of the tongue-palate contact

As described above, there was a complete stop closure at the anterior part of the palate which occurred regularly for /d/. The duration of the complete closure ranged from 2 to 4 frames out of 64 frames/sec. Some of the /r/ patterns also showed this stop closure. The duration of the closure in these cases ranged from 1 to 2 frames. This indicates that there is a difference in the time pattern, as well as the spatial pattern, of the tongue-palate contact between /d/ and /r/.

We then determined the average number of on-electrodes at the anterior part of the palate for 20 repetitions along the time course of each /V_1CV_2/ sequence, as shown in Fig. 3. In the figure, the ordinate of each graph indicates the number of on-electrodes and the abscissa the time axis. The time curve is demarcated by each frame of the palatogram, and the vertical line on the curve indicates the standard deviation. The dashed line indicates the contact for /d/ and the solid line that for /r/.

It should be noted that the area of the contact, i.e., the number of on-electrodes, is larger for /d/ than for /r/ throughout the time curse for all of the subjects and for all of the test samples. Also, it is apparent that /d/ shows a longer time span than /r/ both in peak contact and in the transition of the contact area. Thus, the /d/ and /r/ curves of Subj. 1 are clearly separated from each other for all of the vowel contexts. Some of the curves of Subj. 2 show that the peak values of contact for /d/ and /r/ are comparable to each other. In these cases, however, the /r/ curves show a much steeper slope before and after the peaks than the /d/ curves, indicating a faster transition to and from the peak contact for /r/. The time curves of /r/ for Subj. 3 present rather similar contours to those for /d/, the contacts for /r/ showing smaller values than those for /d/. Thus, the distinction between /d/ and /r/ appears to be less evident in Subj. 3 than in Subjs. 1 and 2, as far as the tongue-palate contact pattern is concerned.

Acknowledgement

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References

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2. M.M. Sudo, S. Kiritani and M. Sawashima: The articulation of Japanese intervocalic /d/ and /r/: An electro-palatographic study. Ann. Bull. RILP, No. 17, 55-59, 1983.