A STUDY OF DYNAMIC PALATOGRAPHY

Sadao Shibata*

A new experimental method has been devised for the observation of dynamic changes in the contact between the tongue and the palate during articulatory processes. Similar attempts have been reported by several authors,[1-4] but the present method is unique and practical both for implanting very many electrodes into a thin and undisturbing artificial palate and for recording and displaying the result.

Procedures

Sixty-four pairs of small silver electrodes (1-mm in diameter) are implanted into a thin plastic artificial palate, the thickness of which is approximately 1-mm (Fig. 1). One of each pair is connected to a Wien-bridge oscillator for a sinusoidal source signal of an assigned frequency, the other to a busline for a common output.

Sixty-four oscillators equally spaced in frequency covering a range from 5000- to 15650-Hz with a 150-Hz step are used to generate the source signals. The palatal output signals are recorded in one track of magnetic tape, and the speech signal is recorded in the other track. A block diagram is shown in Fig. 2.

The tape is played back in the half speed, and the two signals are mixed through filters and fed into a sound spectrograph. For the lower frequency range of the spectrogram, the speech signal is displayed by use of a wide-band filter. The palatal signals from different points are displayed as horizontal lines in the upper part (between 2500-Hz - 7800-Hz) of the same spectrographic display, indicating the lingual contact by blackness of each line.

Special care is taken for the best arrangement of the palatal signals on the recording paper, viz. the connection of the oscillators to the palatal electrodes,

---

* Visiting Research Assistant from the Department of Otorhinolaryngology, Faculty of Medicine, University of Tokyo.

Fig. 1 - Photographs of the artificial palates for three different male subjects.

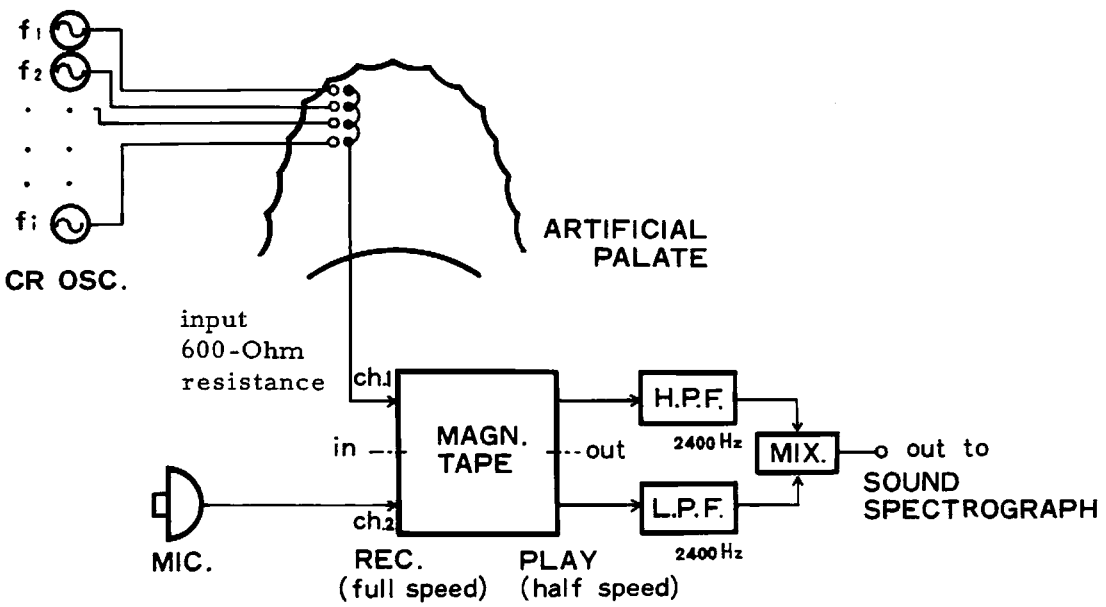

Fig. 2 - A block diagram of the experimental setup.

in accordance with the specific point of interest of the study. In one case, for example, sixty-four points are divided into four groups, in each of which a progressively higher frequency is assigned to every point in the order of increasing distance from the last molar teeth of the right side to that of the left (Fig. 3).

In the preliminary experiment reported in the following, the subject is instructed to utter meaningless bi-syllabic (VCV) Japanese words.

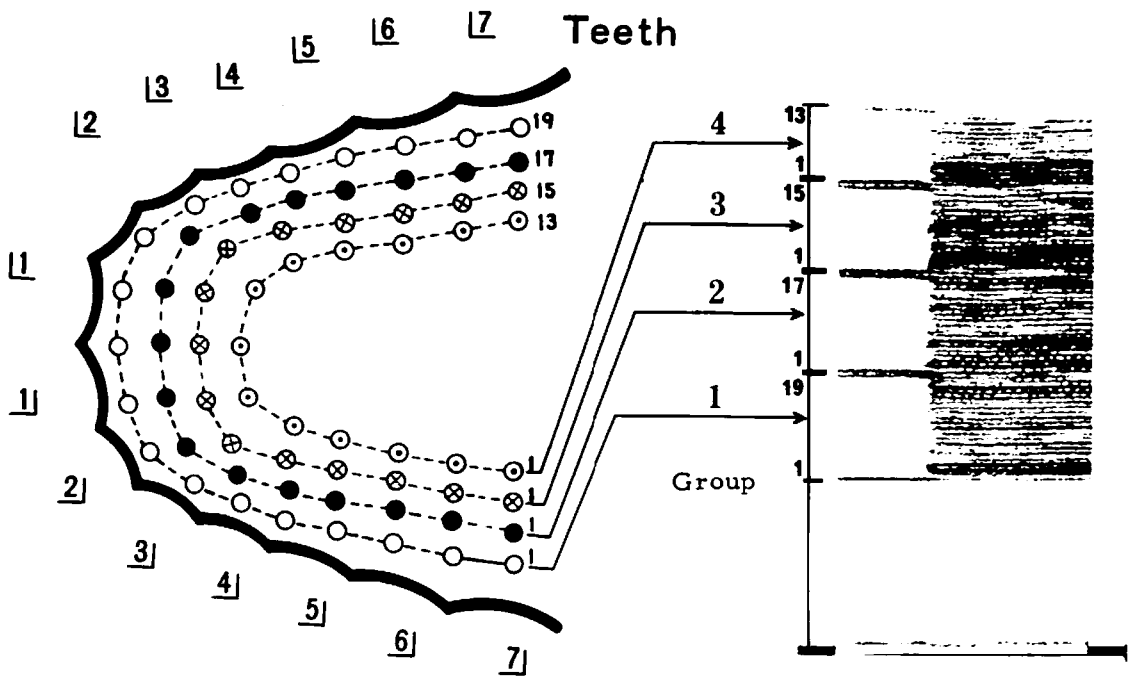

Fig. 3 - Selection of electrodes and arrangement of the palatal signals on the recording paper.

Results

The patterns illustrated in Fig. 4 show details of the manner of contact in selected Japanese consonants.

[t]: A complete closure is observed in both Group 1 and Group 2 for a considerable length of time. Only a partial contact at the level of Group 3 is seen and no contact for Group 4. In the initial phase of closure, the contact

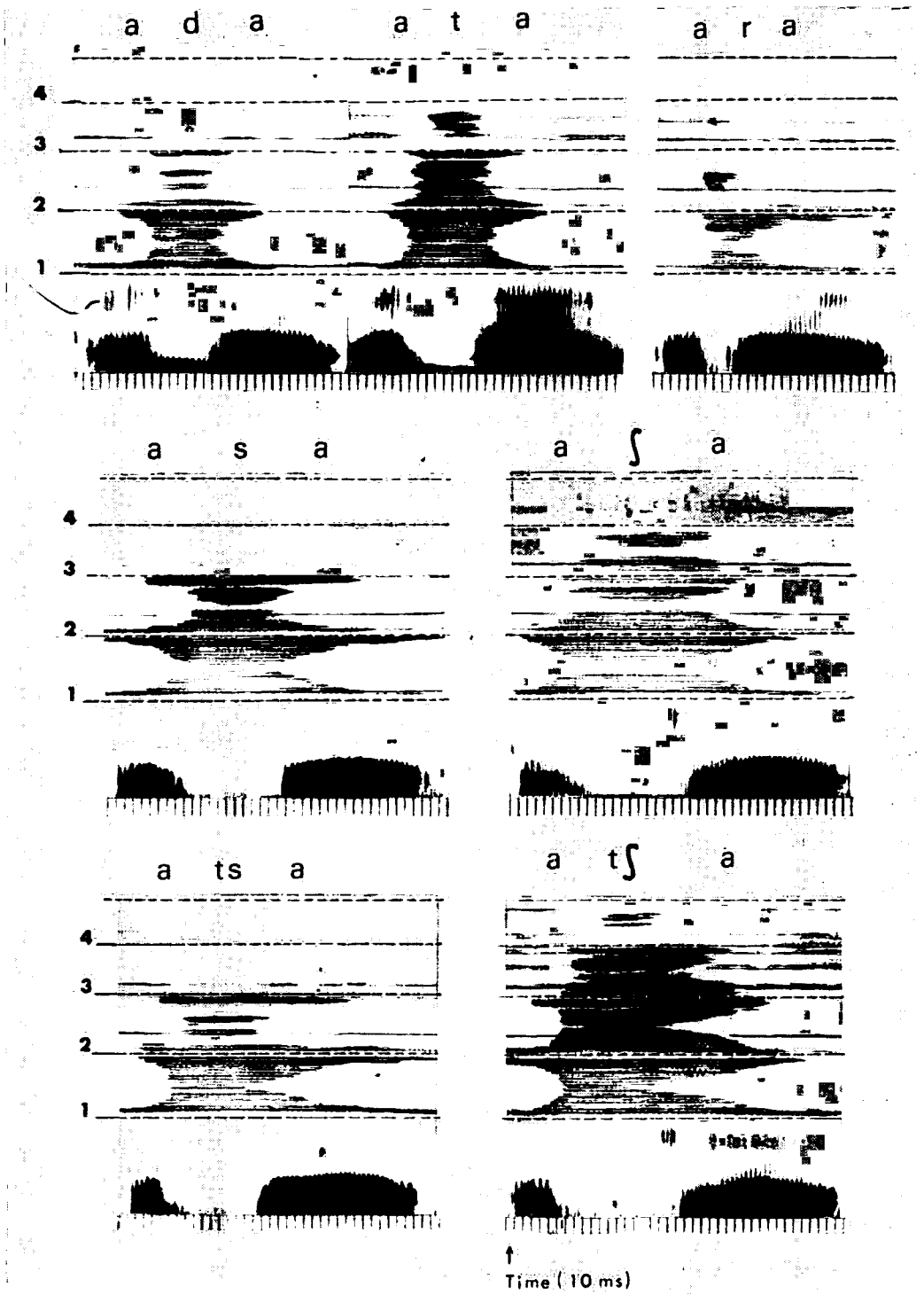

Fig. 4 - Examples of the dynamic palatograms (palato-spectrograms). The upper parts show contacts at the palatal electrodes, the lower parts sound spectrograms.

in each group (cf. Fig. 3) begins at the distal region (near the molar teeth) and successively proceeds toward the medial region (near the incisor teeth). The lower points on the palate show earlier contacts than the higher ones (Compare Group 2 to Group 1 in Fig. 4). In contrast, the release proceeds from the medial to the distal and from the higher to the lower. The acoustic release approximately coincides with the release of the contact in the central portion of the palate where the air passage breaks through.

[d]: The contact pattern appears to be similar to that of [t], except that the contact is here lighter: both the area and the duration of the contact are significantly smaller in [d] than in [t]. In this sense, it is shown that the articulation of the Japanese [d] is lax compared to that of [t].

[r]: The pattern is entirely different from that of all other consonants and it reveals characteristics of a flapping articulation. In [ara], for example, the tip of the tongue at first touches the medial portion of the palate at the higher levels (Group 2 and 3) and then incompletely at the lowest level (the middle portion of Group 1). A momentary closure appears in the course of this swift shift (see infra).

[s]: There is no contact in the central electrodes of any group. This shows that a narrow central groove remains open. The contact in the distal portions appears and disappears slowly. These features characterizes the lingual fricatives against stops.

[ʃ]: Compared with the pattern of [s], a wider space in the central portion remains free from contact, while the contacts are seen also in the higher palatal positions.

[ts], [tʃ]: In the initial phase of the articulatory movement, the manner of contact is similar to that for [t]. The temporal pattern of release, on the other hand, seems similar to that of [s] and [ʃ], respectively.

For visualizing the articulatory movement of the tongue, a motion-picture type display can be produced based on the palatograms that are obtained in the manner described above. The lingual contact in the course of utterance is examined at crucial time moments where a change of configuration takes place, and the continuous change is depicted as a series of palatal patterns as shown in Figs. 5b and 6b. The black points represent electrodes which revealed the

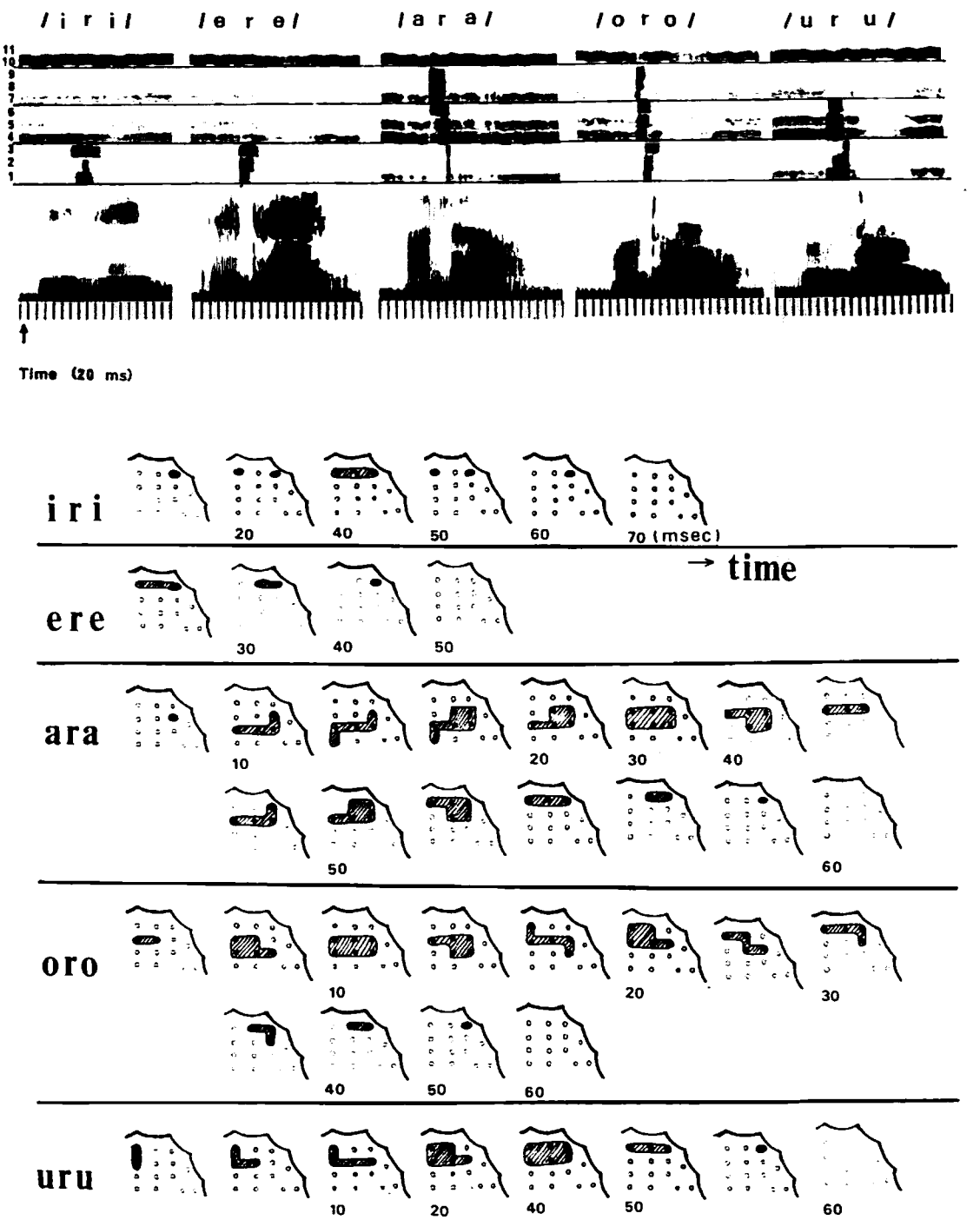

Fig. 5a (upper portion) - The palato-spectrograms

Fig. 5b (lower portion) - The changes of patterns of the lingual contact depicted as motion-picture type displays. The flapped [r] in different vowel contexts.

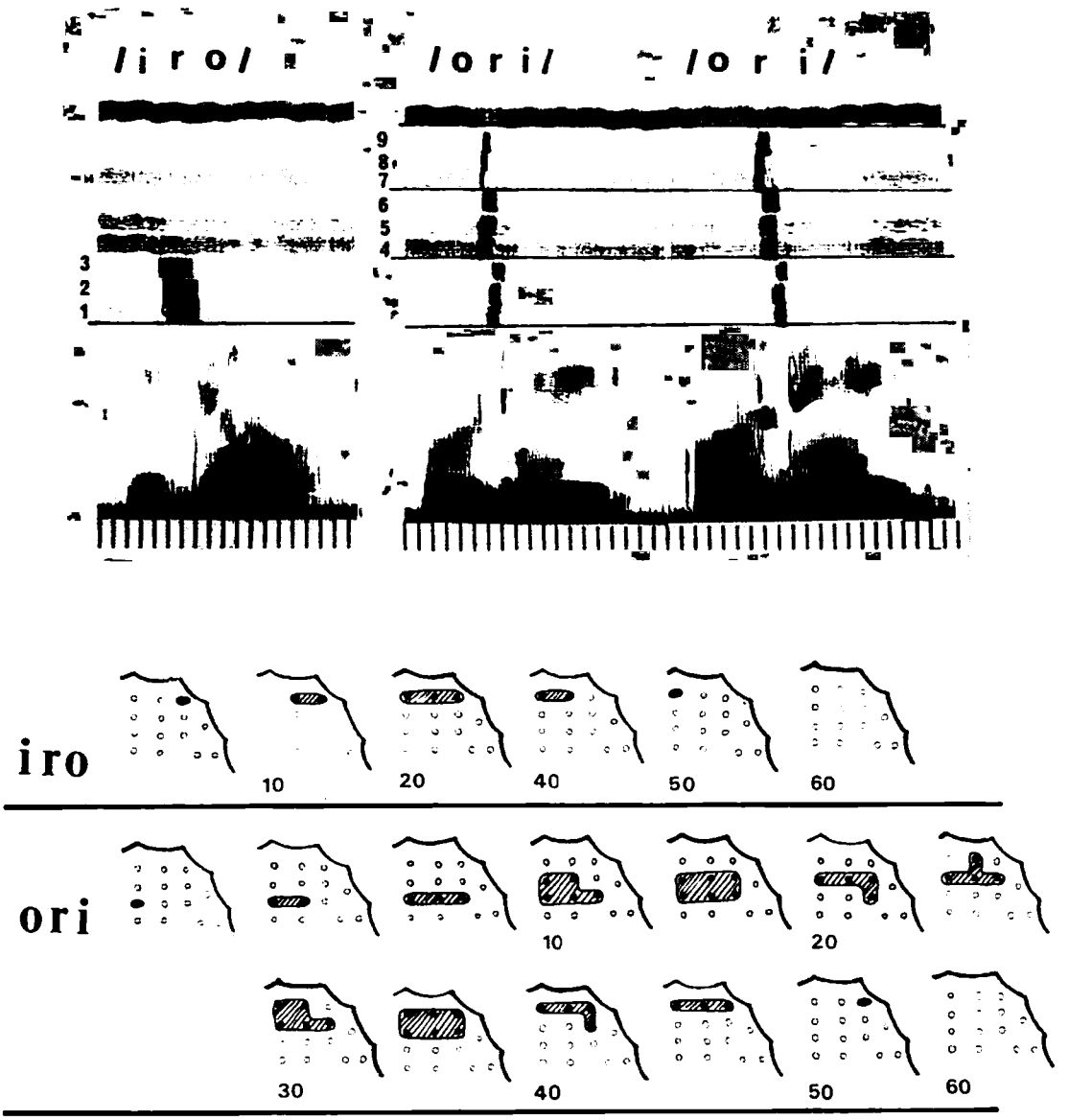

Fig. 6 - Similar to Fig. 5. Comparison of [iro] vs. [ori].

tongue contact at the time moment.

In Figs. 5 and 6, the various manners of contact for the Japanese /r/ in VCV contexts are illustrated for different vowels used as V. For this purpose, only the pertinent portion of the palate was used for the palatographic recordings (Fig. 7).

When either [i] or [e] is used for both the preceding and the succeeding vowels, the contact is seen only at the most peripheral points on the palate with a relatively simple pattern of change. In the case where a non-front vowel such as [a], [o], and [u] is used as the context, the contact proceeds from the higher points to the lower points in general (Fig. 5).

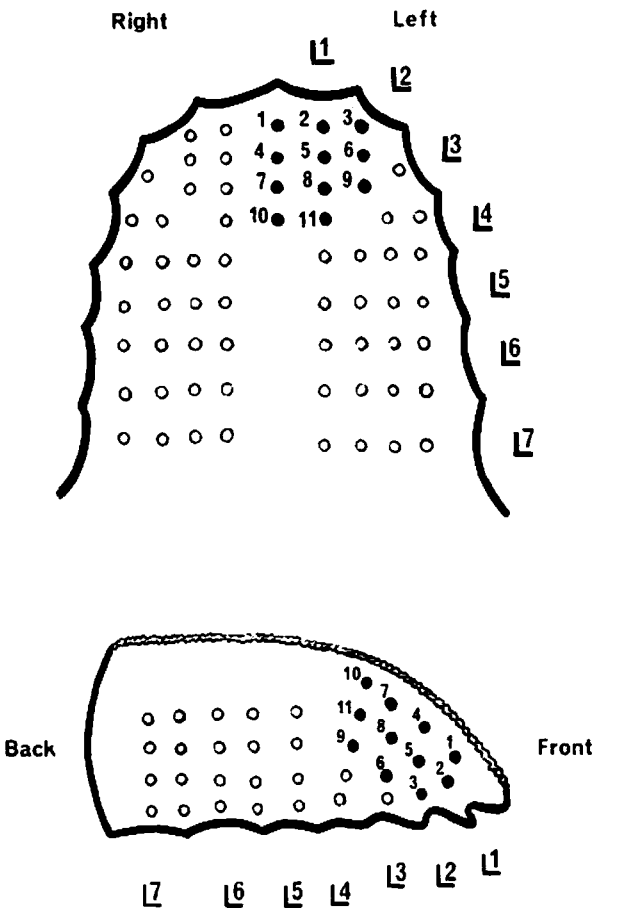

Fig. 7 - Selection of electrodes for examples shown in Fig. 5, 6.

It is of interest whether the initial or the final vowel has the dominant influence on the pattern of contact (flapping) of the tip of the tongue.

A comparison of [ori] and [iro] is shown in Fig. 7. When the initial vowel is [o] and the final is [i], the contact is similar to that of [oro], whereas for the word [iro], the contact is quite similar to that of [iri]. The articulatory movement for this kind of flapping /r/ is thus found to be typically determined by the preceding vowel.

References

1) Kozhevnikov, V. A. and Chistovich, L. A.: "Rech: Artikulyatsiya i Vospriyatiye (English translation: "Speech: Articulation and Perception"), Chapter II, Moscow-Leningrad, (1965).

2) Kuzmin, Y. I.: "Mobile Palatography as a Tool for Acoustic Study of Speech Sounds," Proc. Fourth International Congress on Acoustics, Paper G 35, Copenhagen (1962).

3) Kydd, W. L. and Belt, D. A.: "Continuous Palatography," J. Speech Hearing Disorders 29, 489-492 (1964).

4) Rome, J. A.: "An Artificial Palate for Continuous Analysis of Speech," Quarterly Progress Report, Research Laboratory of Electronics, Massachusetts Institute of Technology, No. 74, 190-191 (1964).