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TONGUE PELLET MOVEMENT FOR THE JAPANESE CV SYLLABLES — OBSERVATIONS USING THE X-RAY MICROBEAM SYSTEM —

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The method of tracking tongue pellet movement by use of an x-ray microbeam [1), 2)] has been established for collecting a wide range of articulatory data. Basic sets of data are presently being analyzed for the CV syllables, for words consisting of a vowel sequence, for various types of VCV's in Japanese, etc. Movements of the velum during speech are also being studied.[3), 4), 5)] Preliminary data for English and Swedish have also been collected.

Fairly good sound recording conditions have been attained by isolating noise sources such as the rotary vacuum pumping units and the oscillator unit in the high voltage power supply, and also by special treatment of the cooling fans in the x-ray system. The feasibility of simultaneous recording of EMG has been confirmed through the pilot experiment.

This paper presents data on tongue pellet movement for the basic set of CV syllables in Japanese. This data represents an initial step in articulatory studies by the present x-ray system and will serve as reference data for further studies. The list of the test utterances is given below:

1) i e a o u ja ju jo wa

2) pa ta ka sa ba da ga za

3) pi ci ki si bi zi gi zi

4) pu cu ku su bu zu gu zu

5) pe te ke se be de ge ze

6) po to ko so bo do go zo

7) sja sju sjo cja cju cjo zja zju zjo

They were uttered as meaningless syllable sequences monotonously at a constant rate.

Pellet locations on the tongue and teeth are shown in Figure 1(a). Five pellets were attached to the tongue and one to the lower incisor. Figure 1(b) shows the pellet trajectories for the vowel sequence /ieaou/. The six pellets were tracked simultaneously at a rate of 140 frames per second. Time duration of pellet tracking was approximately 5.5 sec. for each recording, containing a total of 800 time samples. In each recording, one of the above test utterances was repeated nearly twice. At the beginning of the tracking, the subject maintained the tongue gesture of /i/ until the pellets were detected, then started the utterance.

Figure 2 shows pellet movement trajectories for the articulations of selected voiceless consonants combined with the five Japanese vowels. The pellet positions at the maximal consonantal tongue gesture are depicted by drawing straight lines connecting one position to another. The pellet positions for the vowels (at the beginning and the end of the rapid movements for the consonants) are also connected by straight lines. These then approximate the tongue gestures for the vowel portions, although the pellet

positions during the vowels are not completely stationary.

Figure 3 shows the time functions of the x- and y-coordinates of each pellet. Data for the voiced consonants and a vowel sequence is also included in this figure. Local peaks in the curves correspond to the articulations of the consonants.

Articulations of /ta/, /ka/, and /sa/ are shown in Figure 2(a). For /t/, the pellets on the posterior part of the tongue move forward horizontally, and the pellets on the tongue blade move forward and upward. For /k/, the tongue body moves upward, pellet 2 showing the largest displacement. In this example, all pellets show approximately straight back and forth displacements. The looped trajectories noted by Houde are observed for /ke/. For /s/, movement of the tongue blade is similar to that for /t/, but the forward movemnnt of the posterior pellets is less than that for /t/, indicating more stretched tongue surface for /s/. Time functions of the coordinates show that, in general, /t/- articulations are more sharply peaked than /s/-articulations. (See Fig. 3. (b), (e) and (f).)

For the combinations of the dental consonants and the vowel /u/, articulations of the dental consonants leave significant after-effects on the following vowels. It is seen that there are considerable differences between the tongue shapes for the vowels preceding and following the consonants.

Examination of the time functions in Figure 3 reveals that there are certain differences in the articulations of the voiced and voiceless stop cognates. For dental consonants, the position of the tongue blade is higher for /t/ than for /d/ in the context of vowel /a/ and /o/ as reflected in the positions of pellet 4. It is also seen that for /k/, the posteriormost pellet generally shows higher positions than for /g/.

It is noted that for /ba/ and /bo/, there are slight movements of the pellets, although there are no accompanying movements of the jaw. This may be interpreted as the release of the after-effect of /s/ in the preceding syllable with the production of the new syllable.

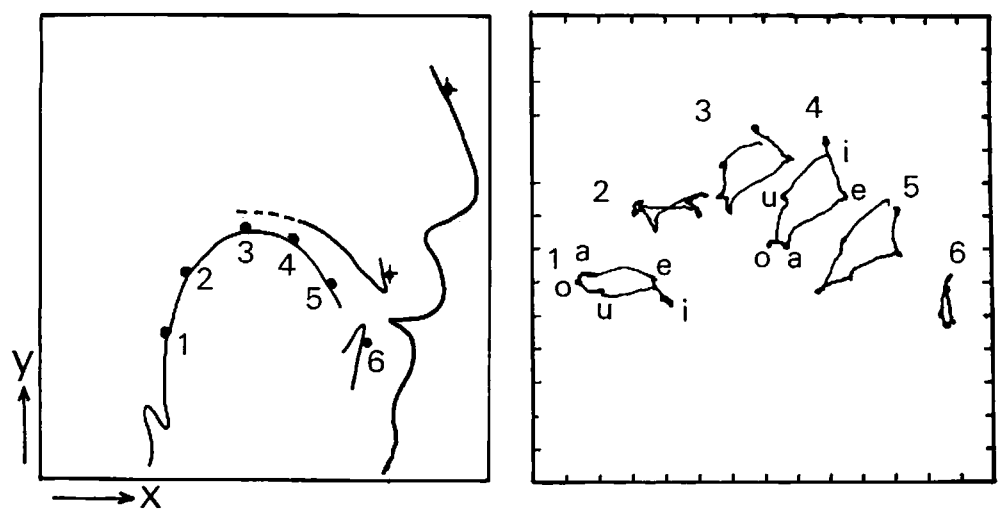


Fig. 1. (a) Pellet locations; (b) Pellet trajectories in the utterance of vowel sequence /ieaou/.

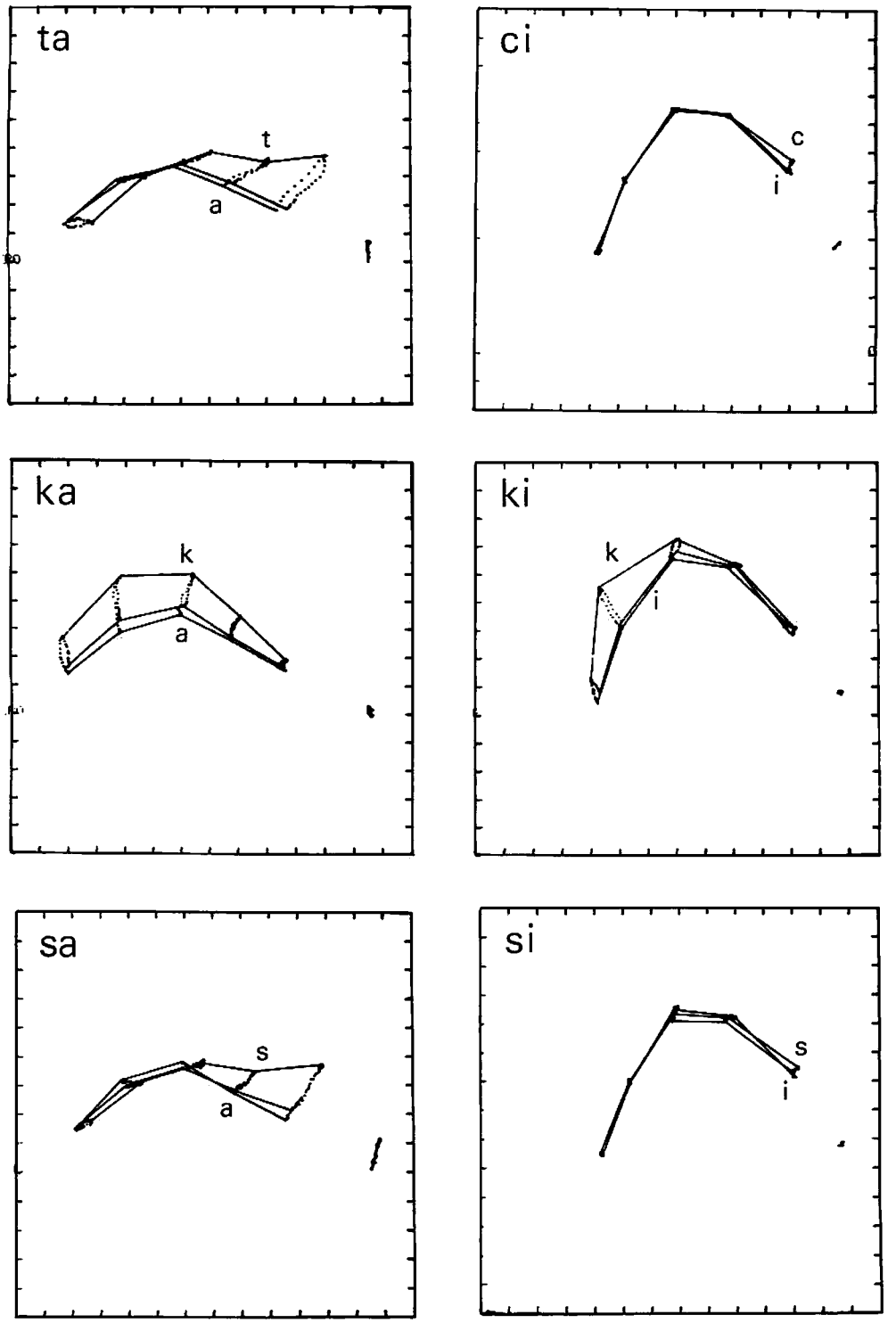
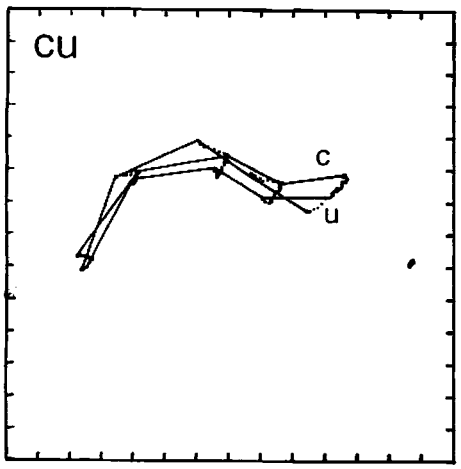
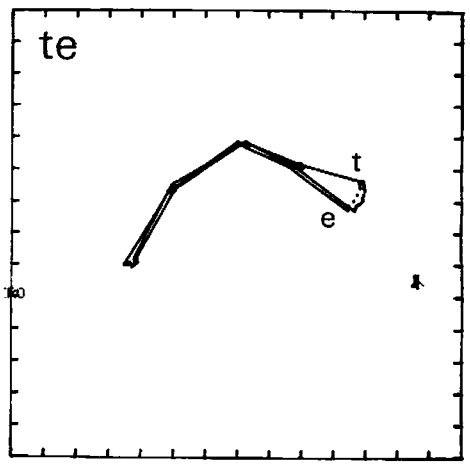


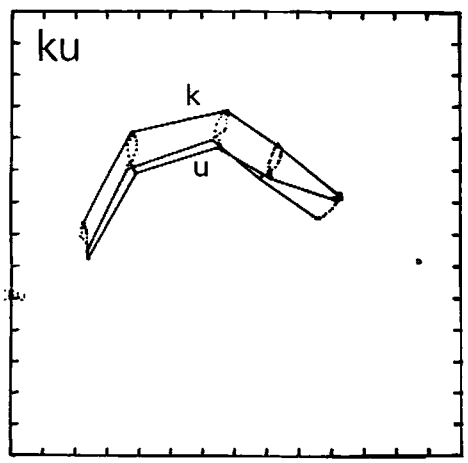
Fig. 2 (a)

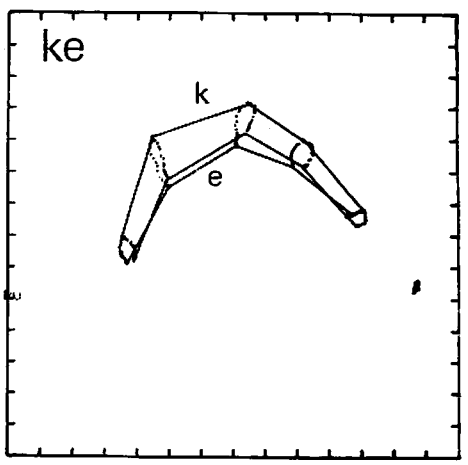
Fig. 2 (b)

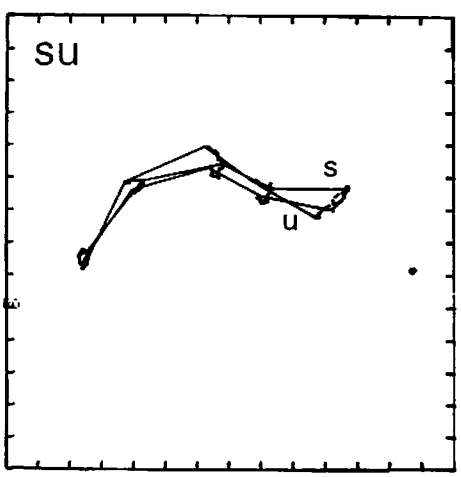
Fig. 2. Pellet trajectories for a set of CV syllables. 7.5 mm/division











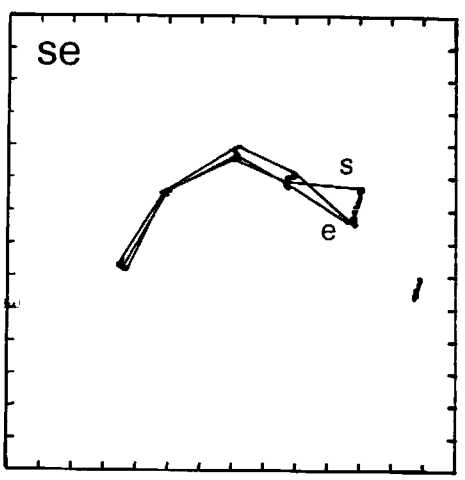
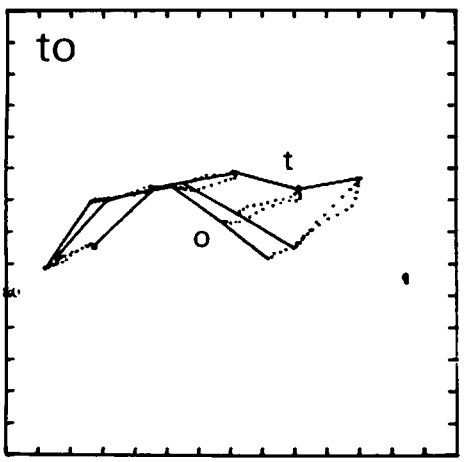
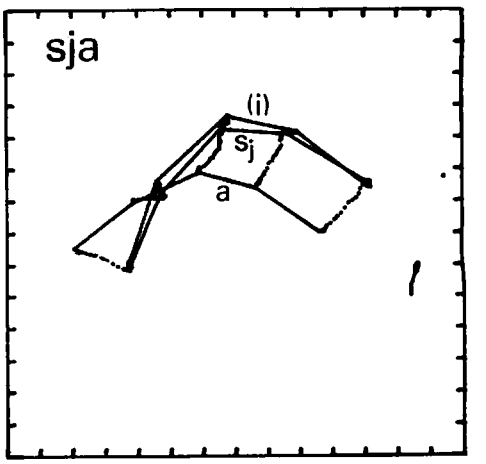
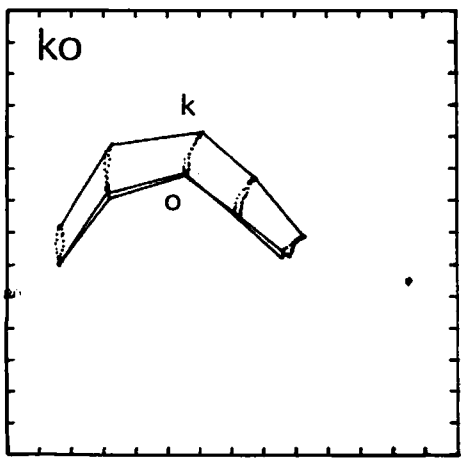


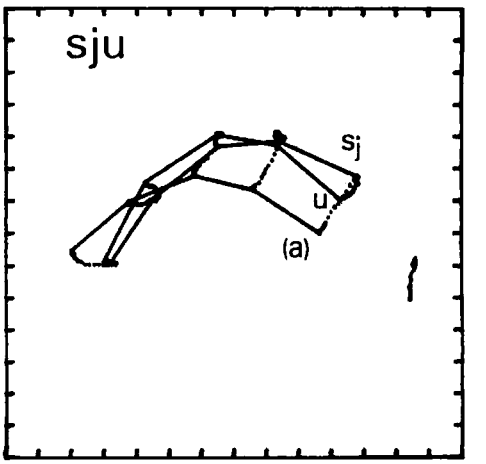
Fig. 2 (c)

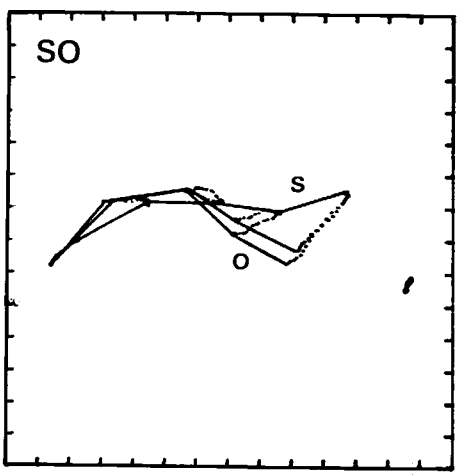
Fig. 2 (d)











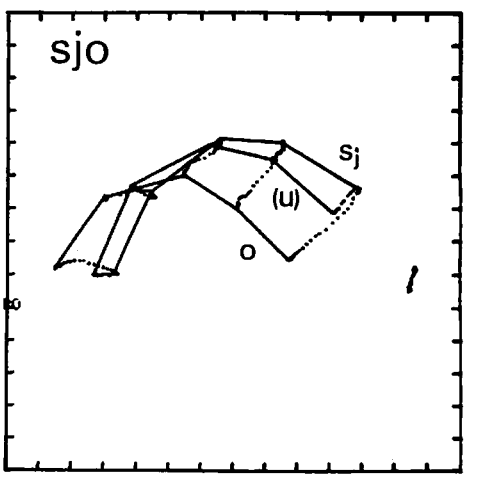


Fig. 2 (e)

Fig. 2 (f)

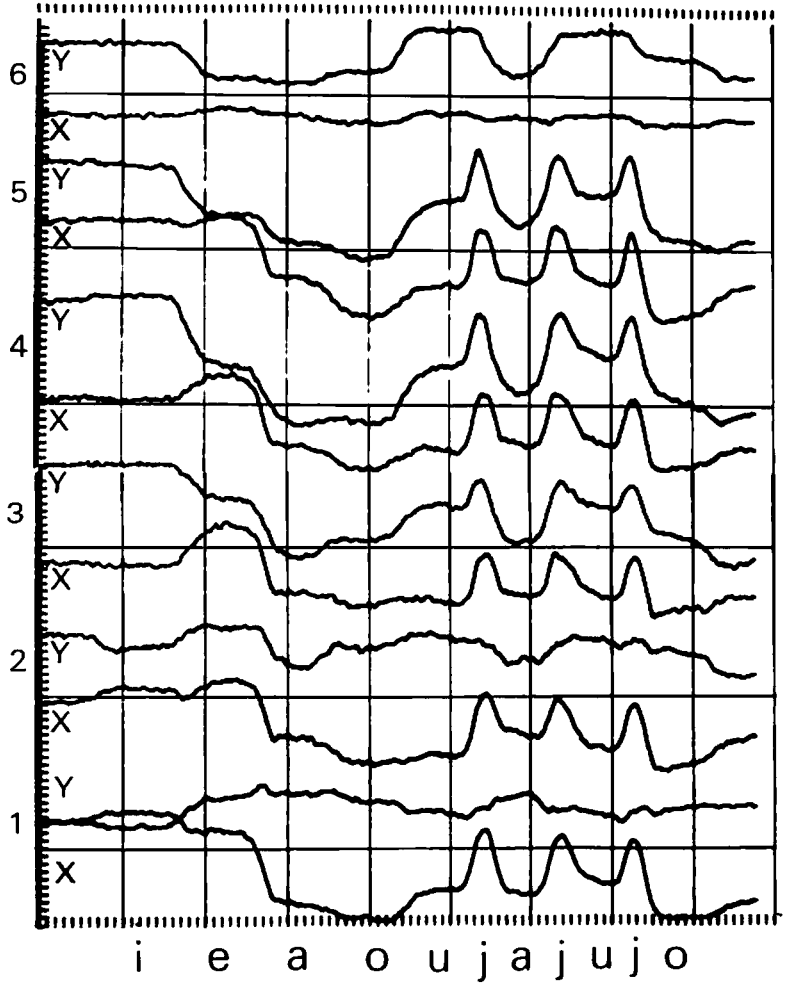


Fig. 3 (a)

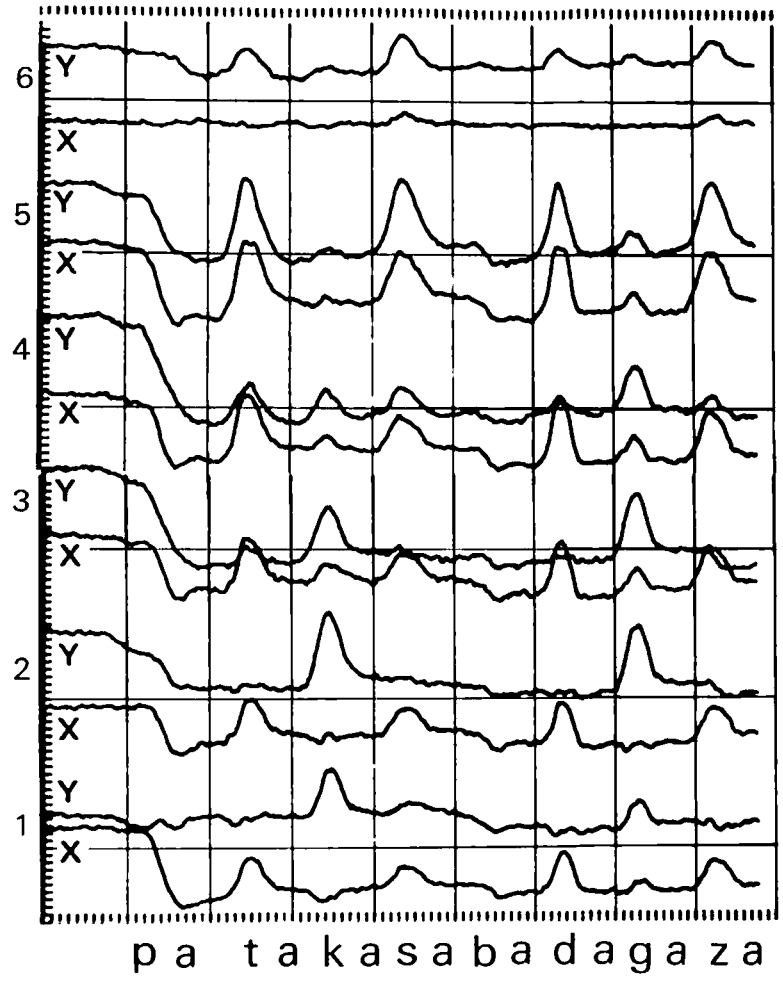


Fig. 3 (b)

Fig. 3. Time functions of the x- and y-coordinates of each pellet. Ordinate, 5 frames/division; Abscissa, 1.5 mm/division.

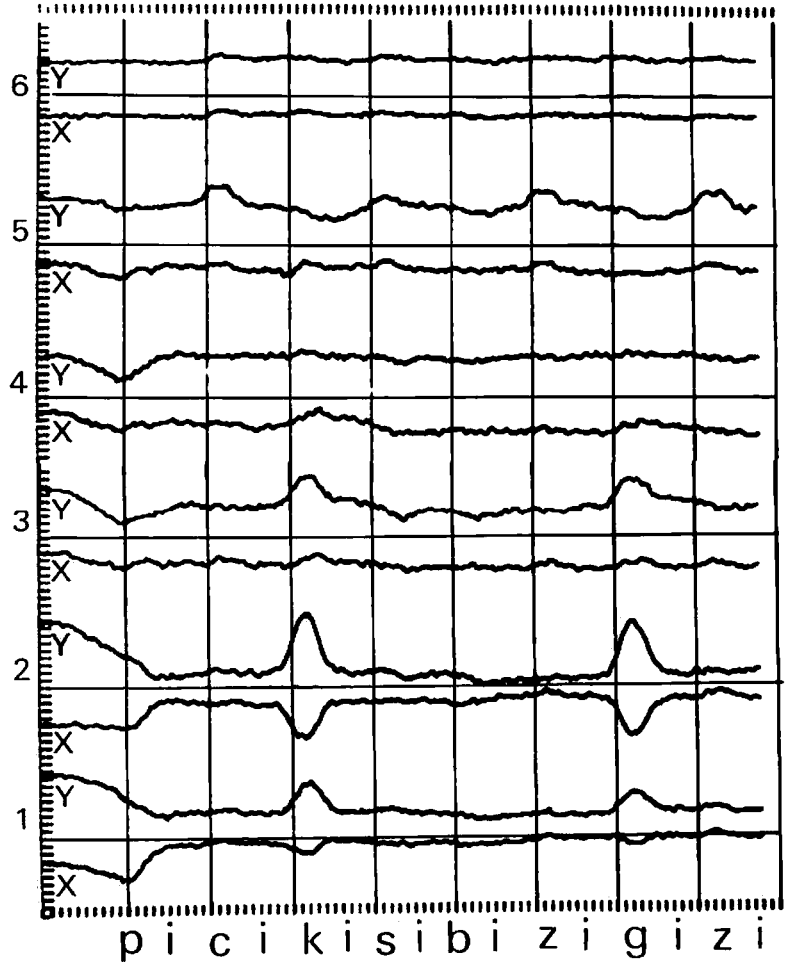

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Fig. 3 (c)

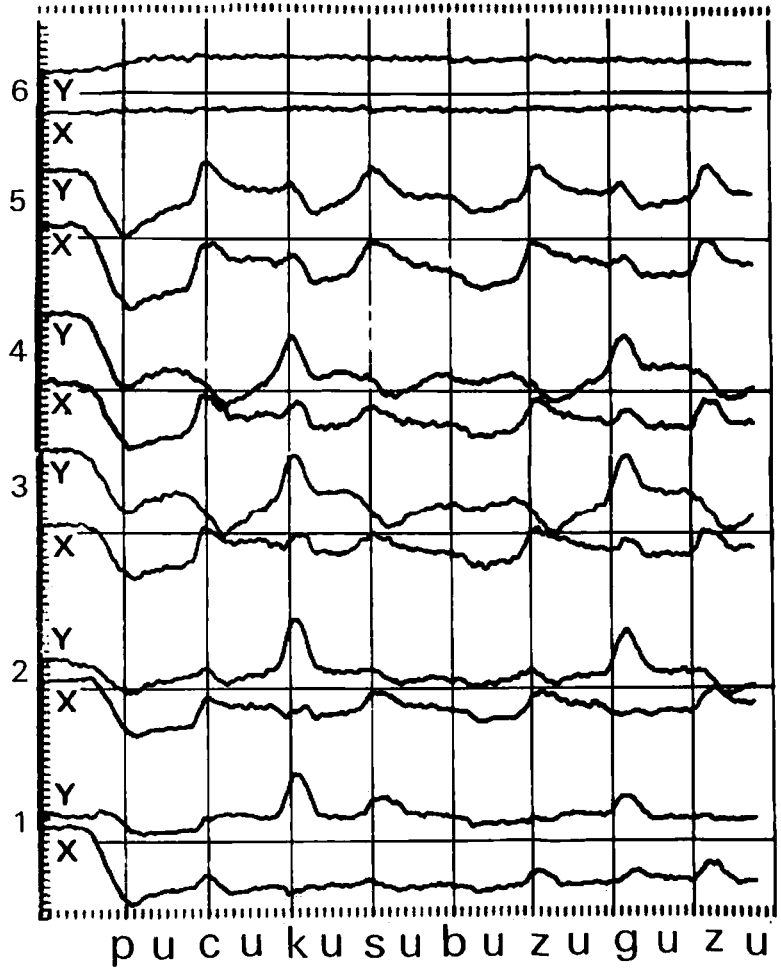
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Fig. 3 (d)

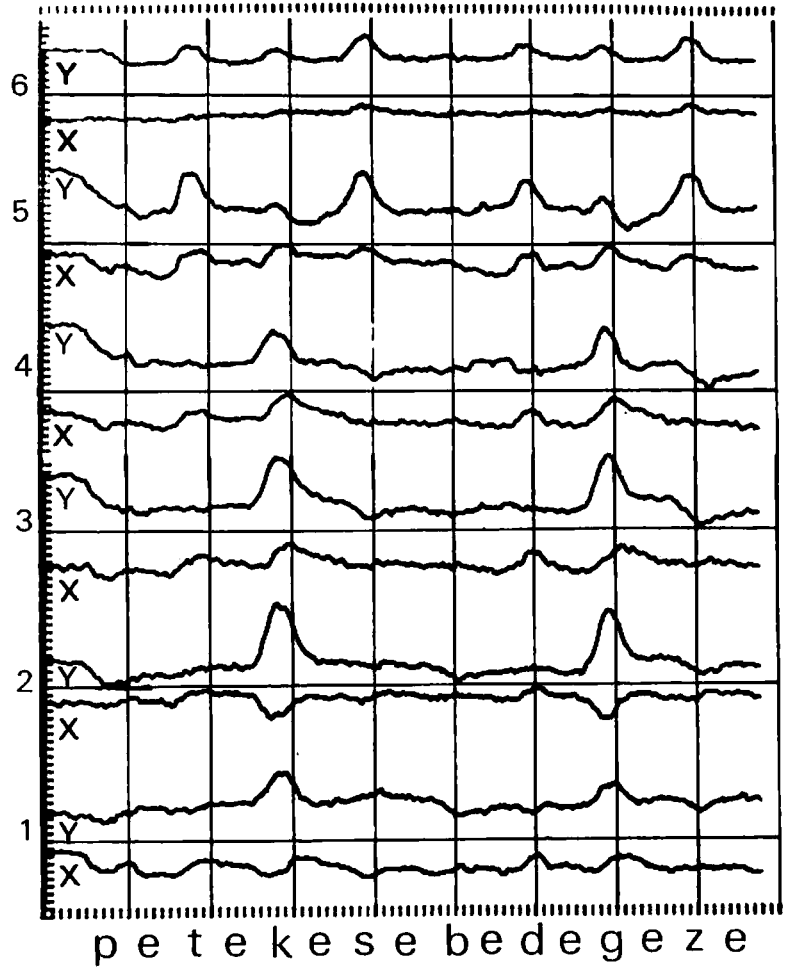
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Fig. 3 (e)

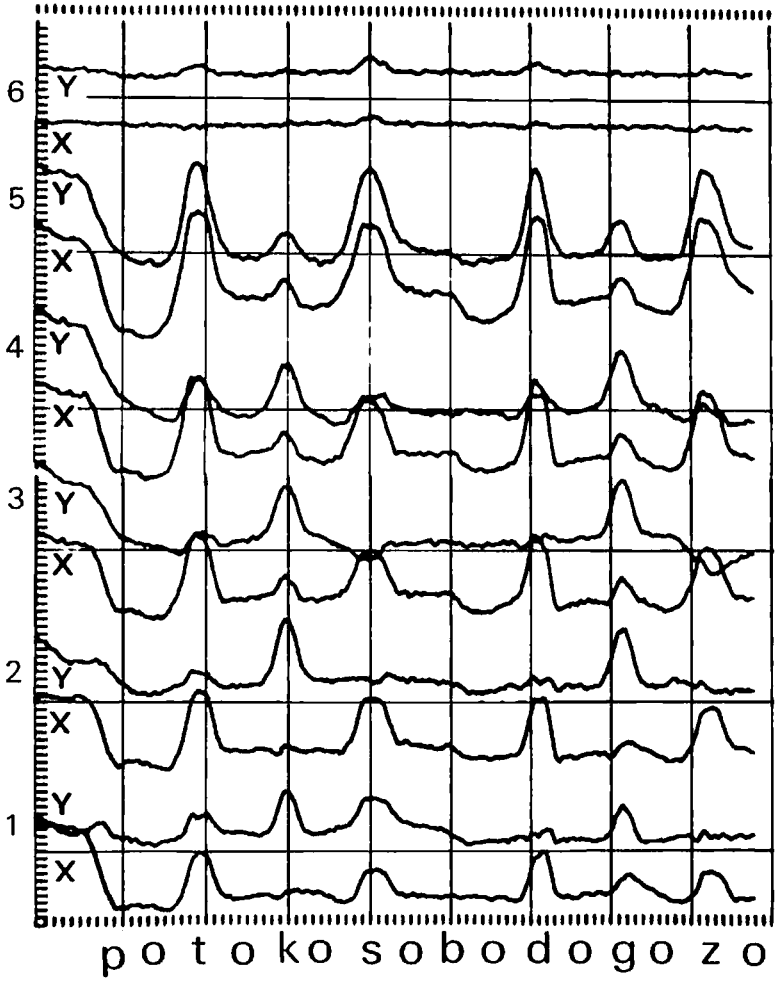
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Fig. 3 (f)

Refernces

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2. Kiritani, S., K. Itoh, H. Imagawa, H. Fujisaki and M. Sawashima (1975). "Tongue Pellet Tracking and Other Radiographic Observations by a Computer-Controlled X-ray Microbeam System," Annual Bulletin, Research Institute of Logopedics and Phoniatrics, University of Tokyo, No. 9, 1-13.
3. Kiritani, S., K. Itoh, H. Imagawa, H. Fujisaki, and M. Sawashima (1975), "Observations of the Articulatory Movements of the Tongue in Japanese by Use of a Computer-Controlled X-ray Microbeam System," Transactions of the Committee on the Speech Research, Acoustical Society of Japan, No. S75-55.
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