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Mimicking and perception of synthetic vowels, part II

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I. SPEECH PERCEPTION

A. MIMICKING AND PERCEPTION OF SYNTHETIC VOWELS, part II

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The following report pertains to a continuation of the work reported in the Speech Transmission Laboratory, QPSR No. 2/1966. Two sets of experiments have been made. The aim of the first experiment was to check the categorical nature of mimicking. In the second experiment an attempt was made to gain some insight in the decision rules used by subjects in vowel identification. The stimulus vowels were produced with the new miniaturized version of the manually controlled vowel synthesizer, OVE Ib, constructed by Johan Liljencrants (see Fig. I-A-1). A noise generator was used as an excitation source instead of the standard pulse generator for voiced sounds. The choice of a noise source was motivated by the desire to avoid interaction between responses to the formant pattern and to a harmonic pattern.

Experiment I

The function generator for deriving the F_1 F_2 signals was equipped with a mechanical linkage for selecting a prescribed path of variation, a "trajectory", in the F_1 - F_2 plane. The subject was instructed to move the control in small steps along a trajectory and to mimick the vowels produced by the synthesizer. The subject's response vowels were recorded on magnetic tape and afterwards presented to a group of two listeners.

These evaluated each of the mimicked vowels with respect to identity with the previous vowel. By this method the number of different vowels mimicked by the subject in response to vowels sampled along a given trajectory was determined.

Each of the nine subjects fulfilled the mimicking experiment along fourteen selected trajectories. In 120 out of the 126 trajectory tracings the number of responses labelled different was less than the number of mimicked vowels. These results suggest that the separate members of a certain class of vowels evoked one and the same reaction within the mimicking subject.

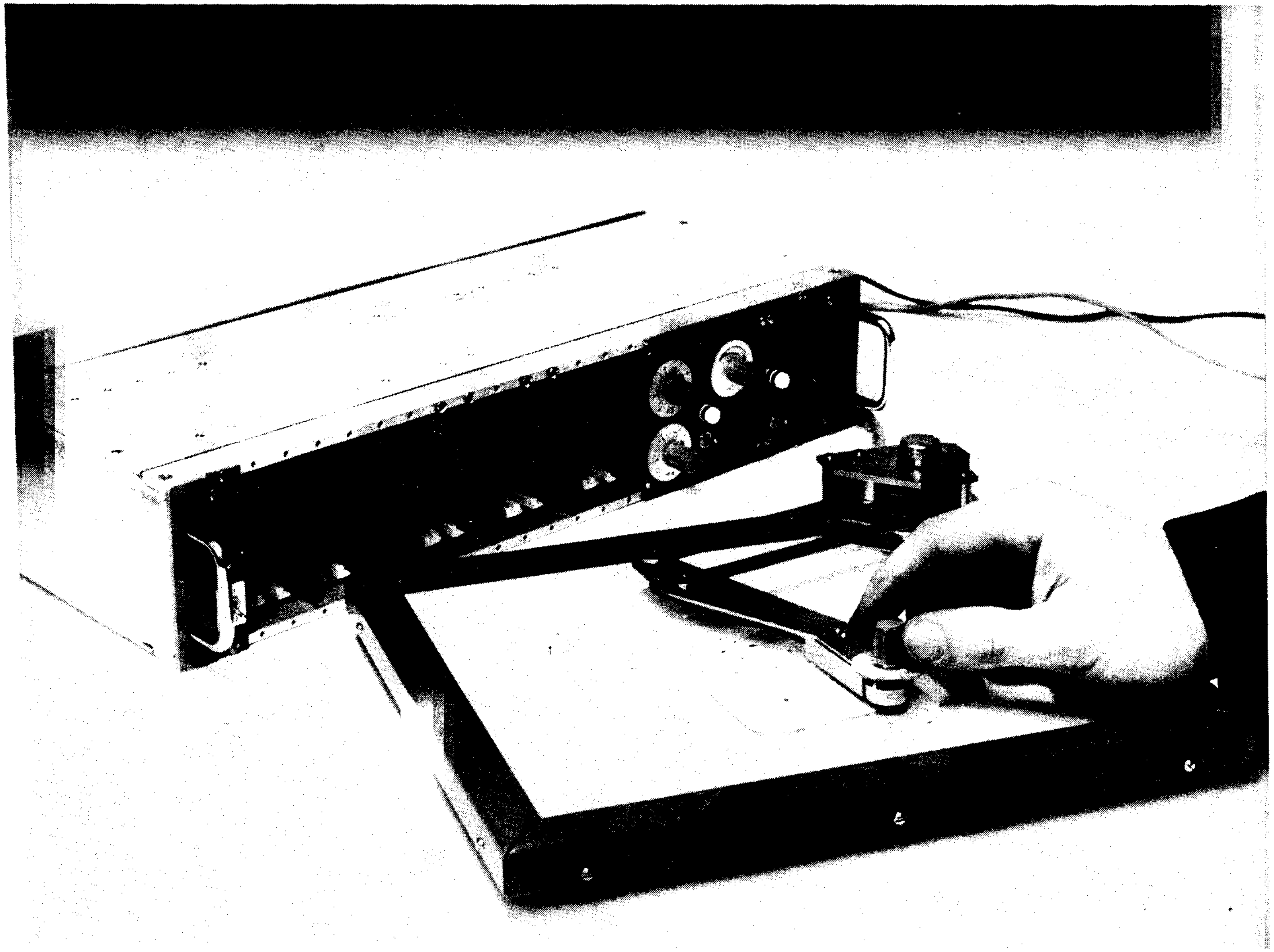

Fig. I-A-1. The new portable OVE Ib with electronics unit (including power supply, formant circuits, voice source, output amplifier) and function generator for control of F_1, F_2, F_0 and voice on/off.

The results of spectral analysis of F_1 and F_2 of the response vowels support this conclusion, as seen in Fig. I-A-2, A, B, and C, where the trajectories are shown together with the measured F_1 F_2 response data. The listener group categorization of the response data is indicated by the parentheses in the figure heads. It is apparent that the responses are not distributed evenly along the stimulus trajectories. A number of steps along the trajectories seems to be accompanied only by small and random changes in response parameters followed by occasional large jumps to new areas of rather limited variation.

Experiment 2

Another set of experiments was concerned with the boundaries between two adjacent vowel allophones in the F_1 F_2 function generator field. A number of trajectories passing through adjacent allophone areas was selected and the subject was instructed to generate sequences of sounds along these pathways and to find points corresponding to a perceived shift from one vowel to the other within a pair. The manual control of F_1 and F_2 was arranged so that the subject could not observe the particular position of the mechanical F_1 F_2 linkage. Only after a decision was made the subject could turn his attention to the setting and was asked to make a mark at the particular F_1 F_2 point. After 10-20 different pathways through the vowel pair had been investigated the subject was asked to draw a line through the boundary points. This boundary line was then calibrated by spectrographic measurements of vowels generated with the control unit moved through the line.

The corrected data were redrawn together with the subject's other boundaries on a F_1 F_2 diagram. In all 102 boundaries from four subjects were determined in this way. Data on subject JM (Hungarian born Swedish citizen) are shown in Fig. I-A-3. It is seen that most of the boundaries are ordered in constant F_1 or constant F_2 and that one and the same line often serves to differentiate two or three different vowel pairs.

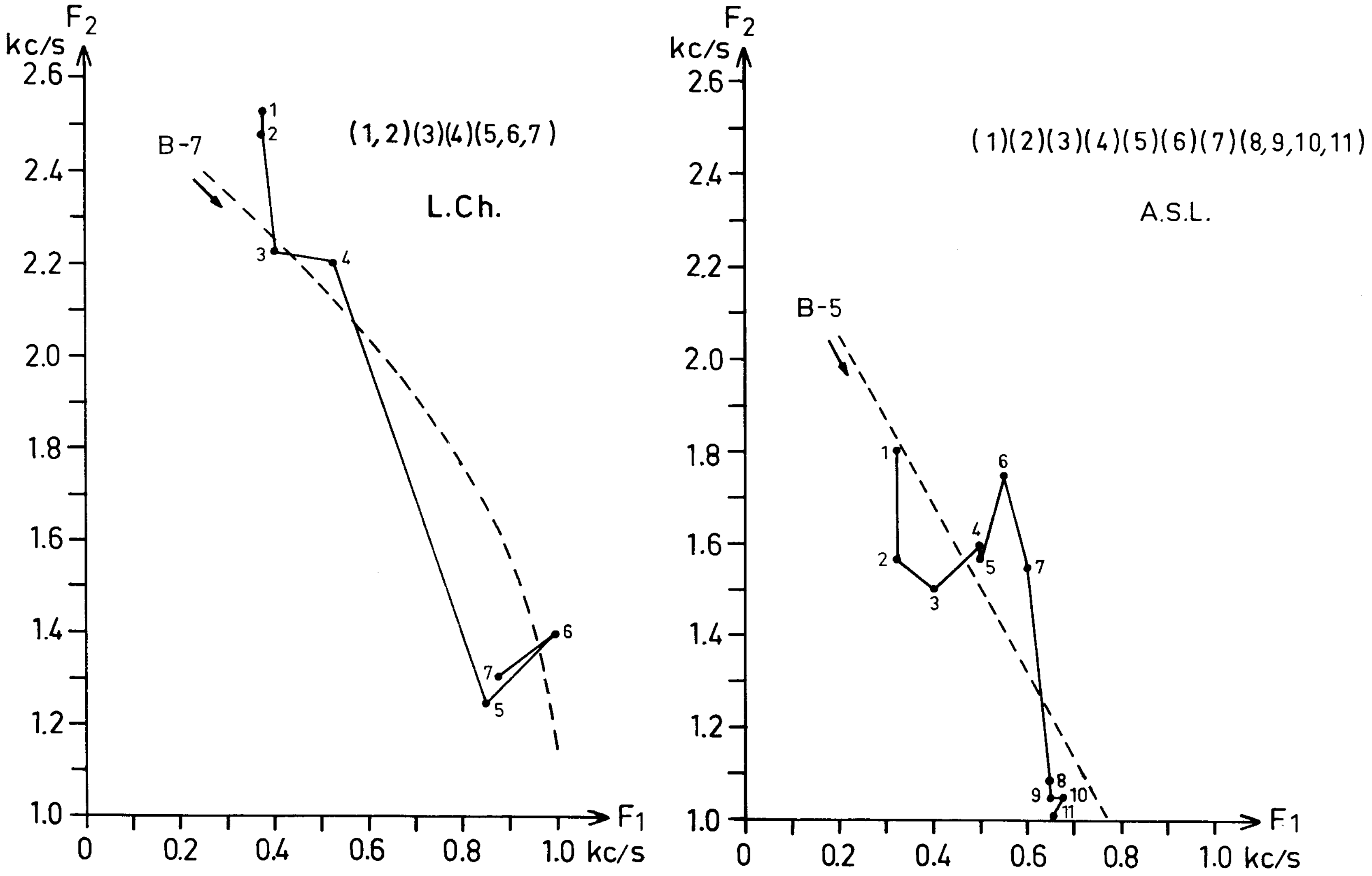

Fig. I-A-2. a. F_1 F_2 extent of stimulus trajectories (broken lines) and spectrographic measurements of $F1$ and $F2$ of the subject's mimicking response (solid points). The parentheses at the top of each diagram enclose mimicking responses judged to belong to the same category (phonetic identity being the criteria). Noise source excitation.

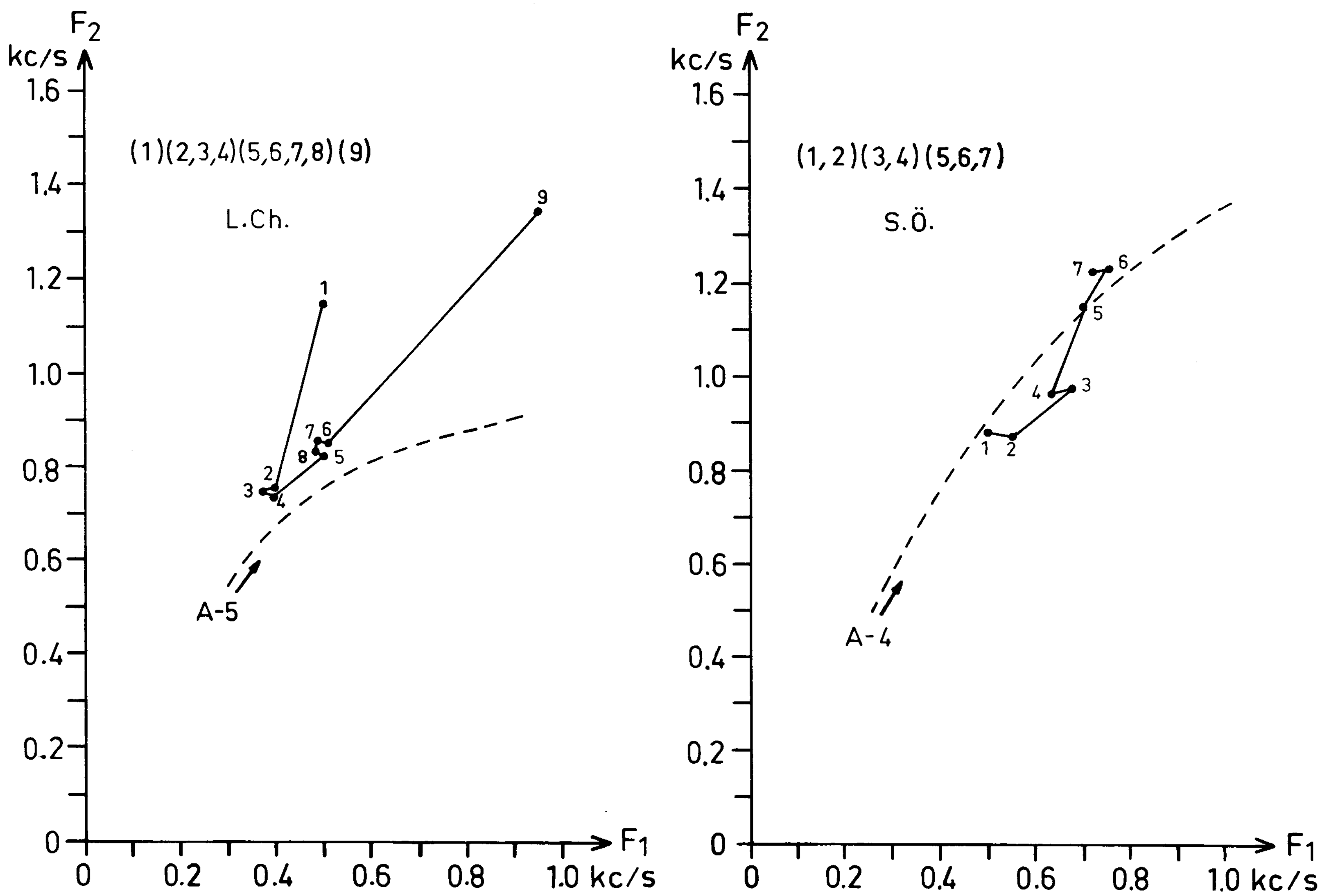

Fig. I-A-2. b. See legend, Fig. I-A-2.a.

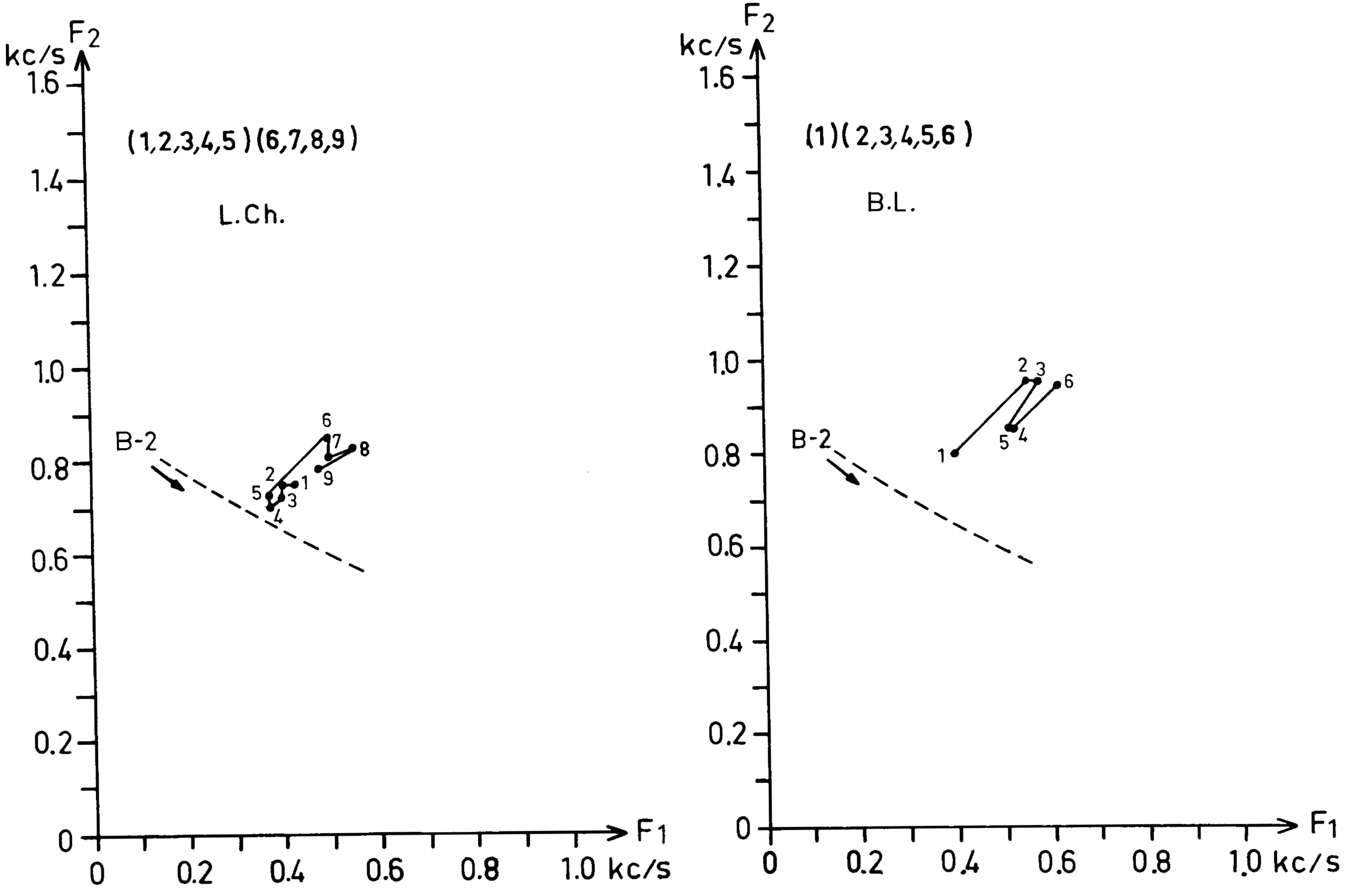

Fig. I-A-2. c. See legend, Fig. I-A-2.a

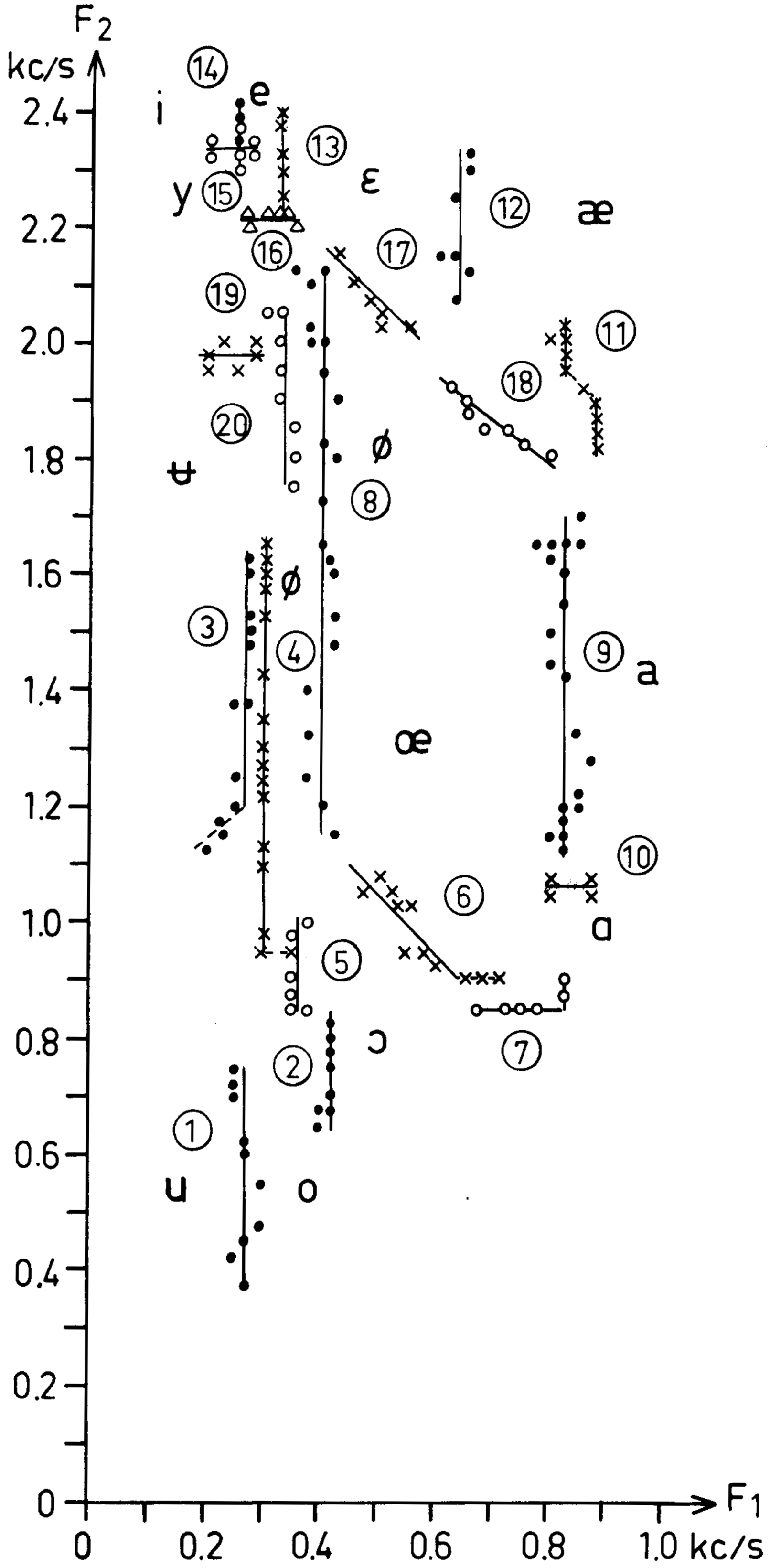

Fig. I-A-3. Perceptual boundaries in the F_1 F_2 plane of synthetic vowels, subject J. M. The two parallel boundaries F_1 = 300 c/s pertain to the same subject on two different occasions. This difference can be an instrumental artefact. Observe the tendency of boundaries ordered in constant F_1 or F_2 or constant $F_1 + F_2$.

Of the whole material of 102 boundaries 80 could be approximated by lines of constant F_1 or F_2. This suggests that extremely simple rules employing critical boundary values of formant frequencies operate in vowel perception. Such a principle conforms with the general idea of one and the same distinctive feature operating in several vowel pairs. Our limited data suggest that some of these critical boundaries are not much different in different languages.

The pilot character of this study must be stressed. The material is limited and the results should be considered as preliminary only. The technique of data extraction could be speeded up if the mechanical control unit had a greater stability so that the spectrographic calibration would be unnecessary. The stability requirement will be fulfilled in the new version of the OVE Ib function generator. Our OVE II type computer controlled synthesizer which is under construction will allow an even more flexible and reliable tool for generation and recording of stimuli data including not only F_1 and F_2 but also other synthesis parameters that need to be varied in an experiment.