AN ATTEMPT TO REGISTER LIP PRESSURE AND LIP ROUNDING BY MEANS OF THE ELECTRO-GLOTTOGRAPH[1]

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From a phonetic point of view a simple, reliable method for registration of lip pressure and lip rounding would be of great interest. In order to investigate whether an electrical impedance measurement is a useful tool for this purpose, some preliminary experiments have been carried out.[2]

As an attempt to measure a variation of electrical impedance related to the lip pressure, two electrodes were placed at the middle of respectively the upper and the lower lip. These electrodes will be referred to as the A-electrodes. Two other electrodes, the B-electrodes, were placed in each corner of the mouth (at each conjunction of the lips). The B-electrodes were intended to give information about the roundness of the lips. Simultaneous recording of the two impedances was obtained by using two electro-glottographs.

In order to be able to interpret the output signals of the two electro-glottographs it is necessary to know how these output signals are related to changes in the impedance of the measuring object. This relationship is generally not simple. However, when the reactive part of the impedance is time-invariant, the level of the output signal

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1) The electro-glottograph was described in the Annual Report of the Institute of Phonetics, University of Copenhagen, Vol. 3 (1969), p. 1-8.

2) Børge Frøkjær-Jensen and Jørgen Rischel have participated in various phases of the present work.

depends linearly upon the change in impedance, i.e. the change in resistance. As the impedance between two electrodes placed on the lips is approximately resistive (Ohmic) at the frequency of 300 kcps, the output signal of the electro-glottographs is simply a measure of the resistance difference $R(t) - R_o$, where $R(t)$ is the momentary resistance between the electrodes, and R_o is the resistance corresponding to zero output level.

1. The resistance between two electrodes placed in the mid-sagittal plane on respect. the upper and the lower lip

The resistance between the A-electrodes depends primarily on whether the lips are separated or not. When the lips are pressed together and suddenly separated, the resistance between the electrodes changes discontinously. This feature may be of interest as it provides a method for registration of the exact moment of lip separation. However, this great change in the resistance may mask other relevant information and should therefore be avoided in registrations for other purposes. This can be done by introducing a strip of plast folio between the lips. The resistance between the electrodes is now mainly determined by the configuration of the lips. Thus, when the lips are separated, the resistance will mainly depend on the distance between the lips, and when the lips are closed, the lip pressure will be the main factor influencing the magnitude of the resistance. Furthermore, the distance between the corners of the mouth will influence the resistance slightly. This position of the electrodes seems to be useful when comparing degrees of pressure related to bilabial stops and nasals.

2. The resistance between two electrodes placed in each corner of the mouth

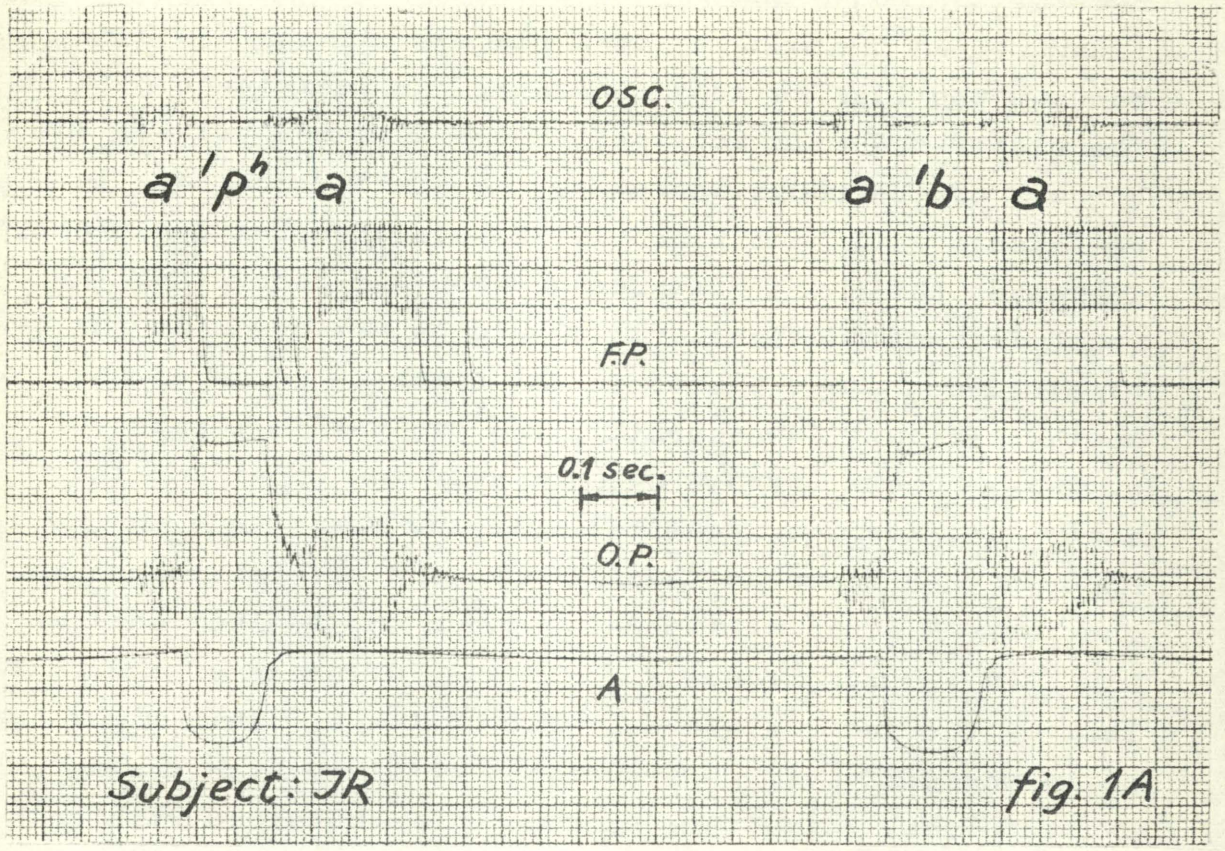
The resistance between the B-electrodes depends pri-

marily on two parameters: 1) The distance between the corners of the mouth and 2) the distance between the lips (measured in the mid-sagittal plane). If the distance between the lips is kept constant, the resistance between the electrodes will increase as the distance between the corners of the mouth increases. A similar increase in resistance will take place if the distance between the lips increases while the distance between the corners of the mouth is kept constant. It should be noticed that the B-electrodes are not placed in the symmetry plane of the mouth orifice. Consequently, the two possible paths of current, namely through respectively the upper and the lower lip, are not identical. If the resistance in the upper path of current is called R_U and the resistance in the lower R_L, the resistance between the B-electrodes is $R_U R_L / (R_U + R_L)$. If now $R_U \neq R_L$, the influence of the smallest of the two resistances will dominate. This might explain the different registrations obtained with the A- and B-electrodes. Simultaneous recordings obtained with both A- and B-electrodes will give information about the position of the lips from which the degree of rounding of the lips may be determined.

3. Recording of labiograms

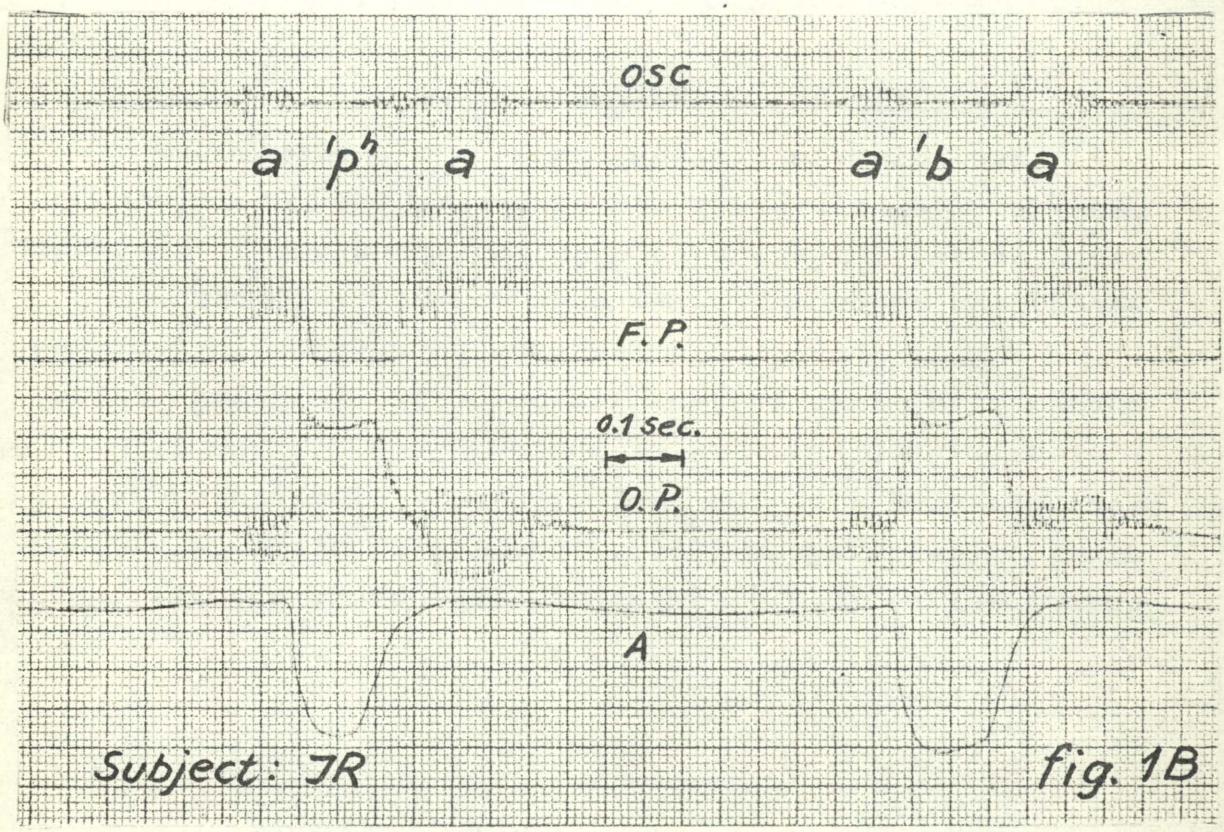
Recordings utilizing the A- and B-electrodes were made in order to verify and elaborate the considerations given above. Five subjects spoke a sequence of nonsense words, and recordings were made on the mingograph.

Fig. 1 shows the difference between labiograms recorded with (Fig. 1B) and without (Fig. 1A) plast folio placed between the lips of the subject (JR). The labiograms (A) were recorded with the A-electrodes. Simultaneous recordings of oscillogram (OSC), fundamental pitch (F.P.) and oral pressure (O.P.) are shown. The abrupt changes in the



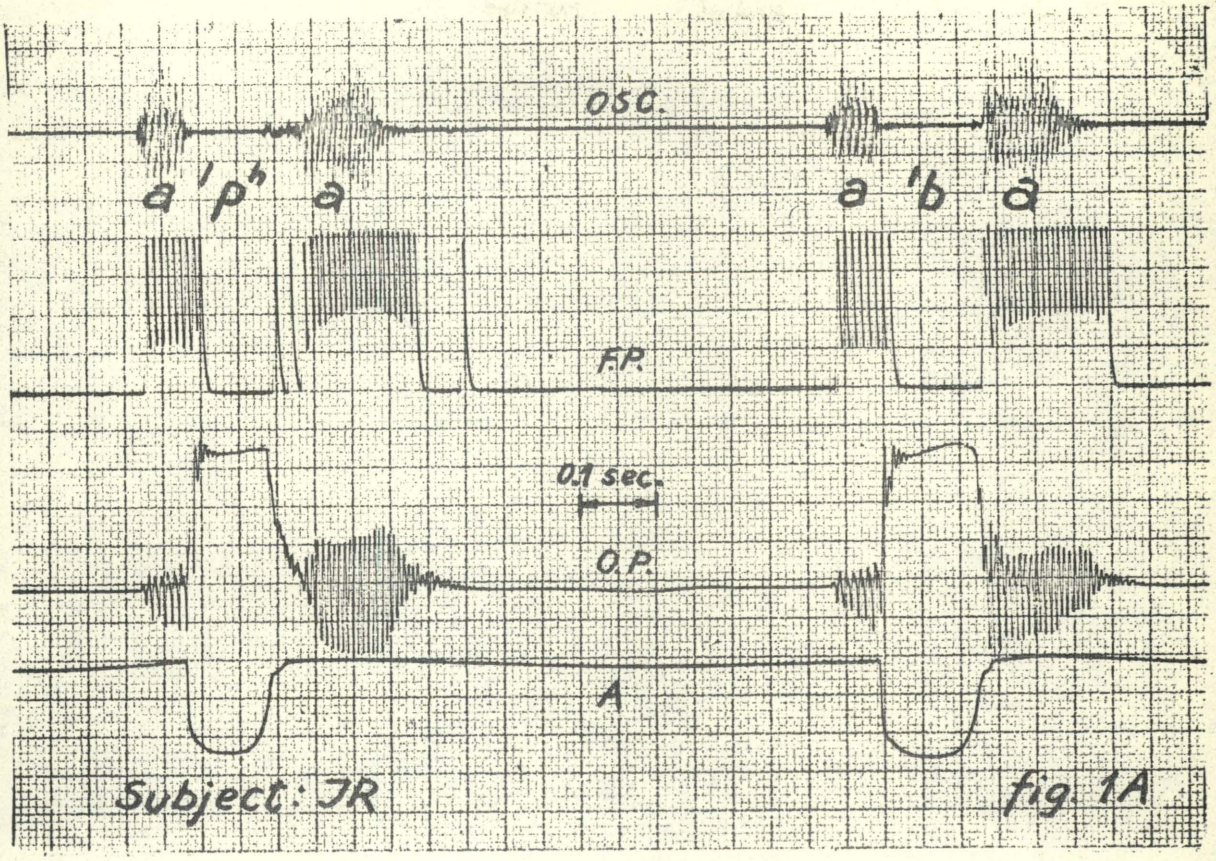
Subject: JR

fig. 1A



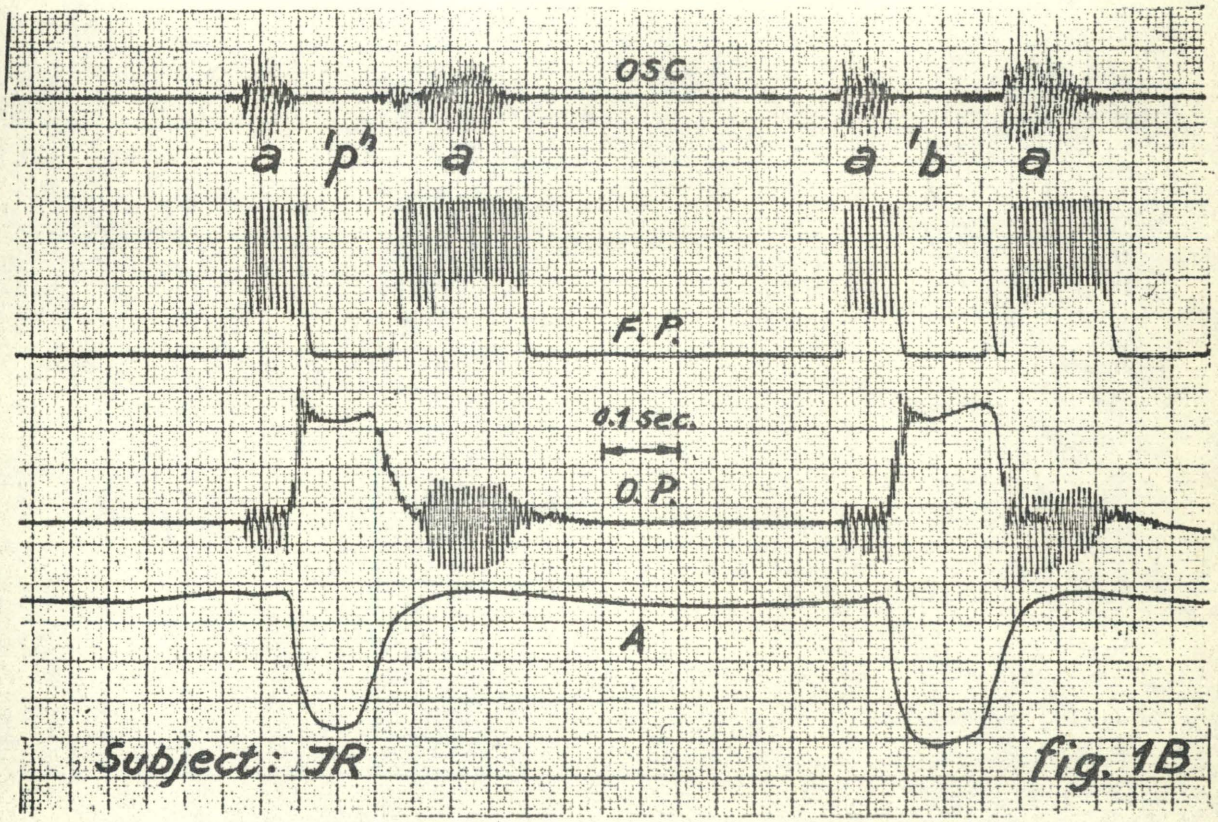
Subject: JR

fig. 1B



Subject: JR

fig. 1A



Subject: JR

fig. 1B

level of the labiogram Fig. 1A compared with Fig. 1B should be noticed. The moment of lip closure is well defined in Fig. 1A, while the labiogram in Fig. 1B seems to give more information about the position of the lips. Note that the labiogram scale has been changed from Fig. 1A to Fig. 1B. The labiograms shown in Fig. 2-4 were all recorded with plast folio inserted between the lips of the subject.

Fig. 2 shows A- and B-labiograms for two different subjects, (PT) and (CL). The two sets of labiograms are almost identical and indicate that the measuring method is reliable. It appears from the figures that the B-labiograms give more information about the identity of the vowels than do the A-labiograms, and that the level of the B-curve is correlated to the degree of rounding of the vowels.

Fig. 3 shows A- and B-labiograms of a bilabial stop consonant before stressed and unstressed vowels. It should be noticed that the electrical resistance related to the consonant is smaller before stressed than before unstressed vowels, indicating a greater lip pressure of the consonant before stressed than before unstressed vowels.

Fig. 4 shows labiograms of the two sequences of nonsense syllables bibybuba and titytuta. Fig. 4B shows that the influence of the position of the tongue is negligible. Thus the difference between the two labiograms is caused exclusively by the different distance between the lips. (It is supposed that the distance between the corners of the mouth varies identically in the two words.)

4. Final comments

As labiograms have to be recorded from the DC output jack of the glottograph, special attention must be paid to the possible drift of the zero-level. As one might expect, it turned out to be very difficult to fix the electrodes on the lips. Artifacts may be recorded if one or more of

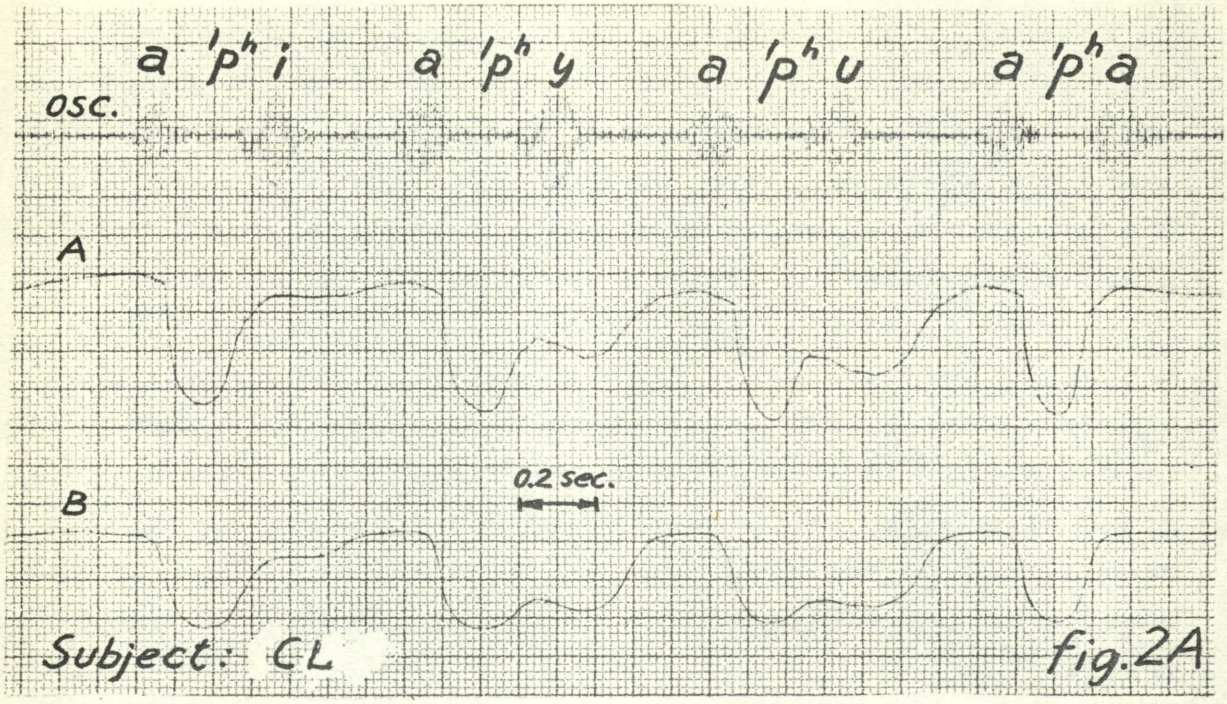
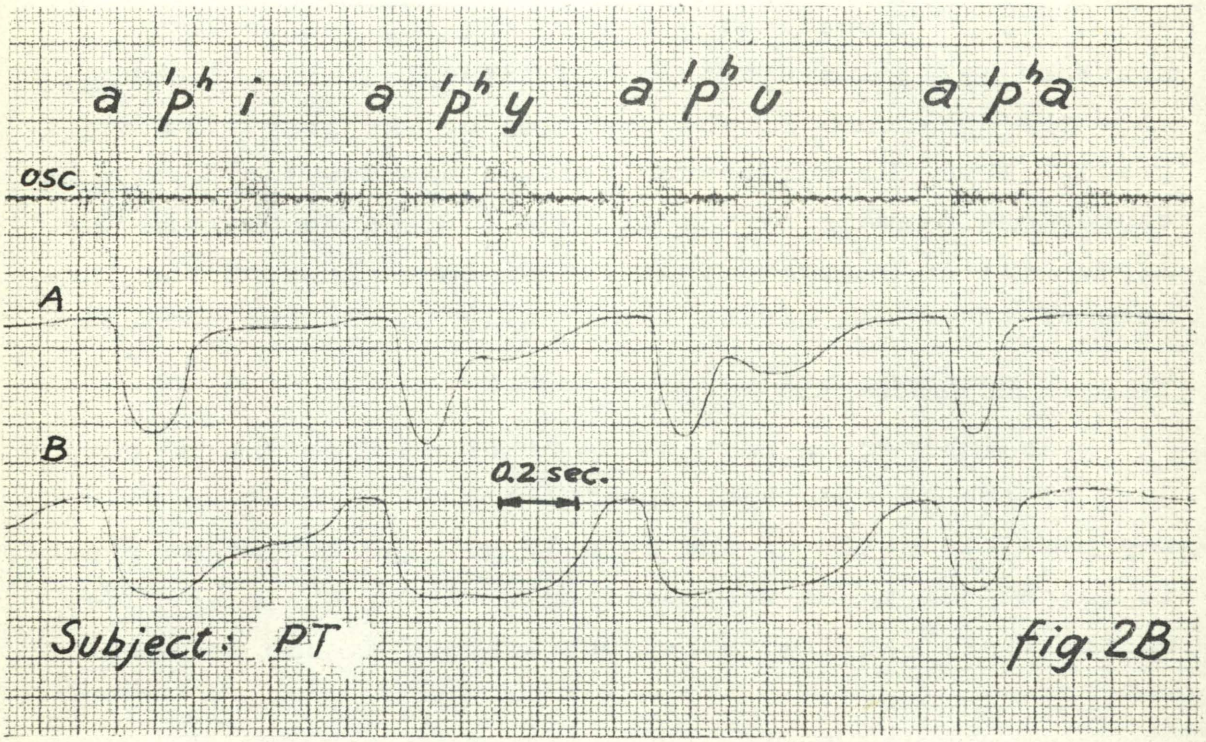

a 'pʰ i
a 'pʰ y
a 'pʰ u
a 'pʰ a
osc.
A
B
0.2 sec.
Subject: CL

fig. 2A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a 'pʰ u
a 'pʰ a
osc.
A
B
0.2 sec.
Subject: PT

fig. 2B

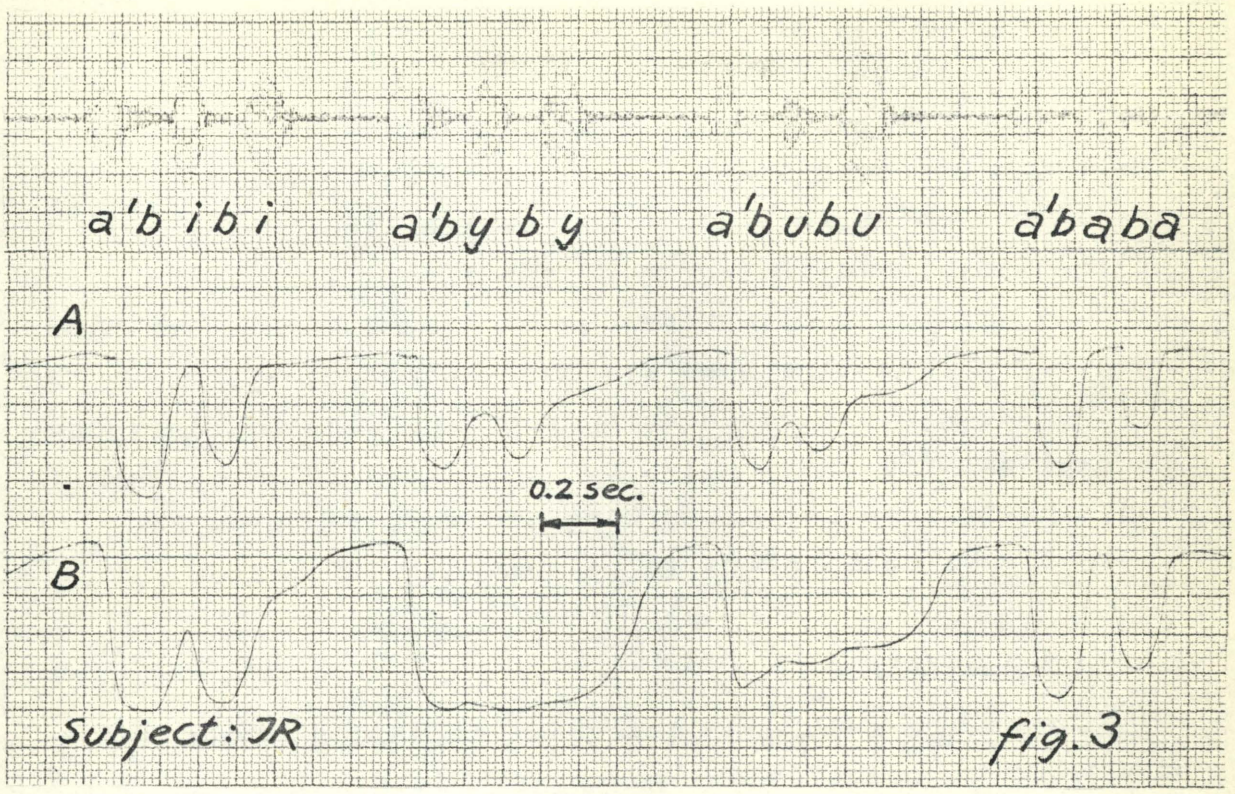

fig. 3

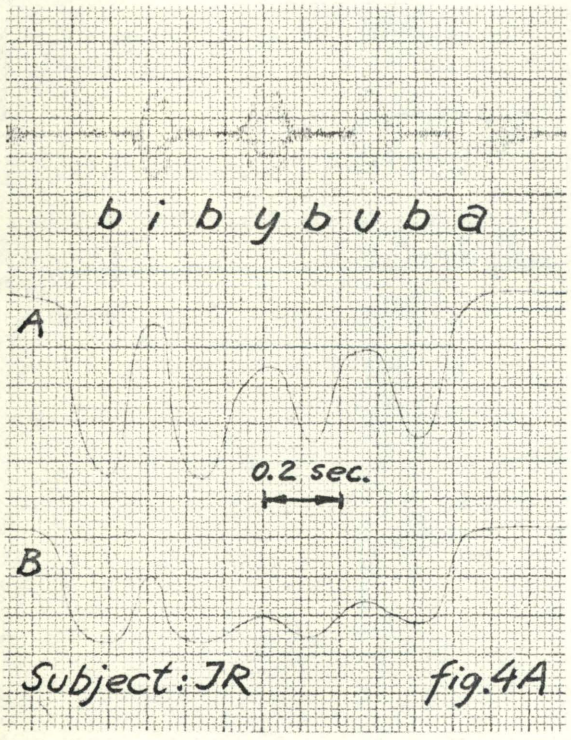

fig. 4A

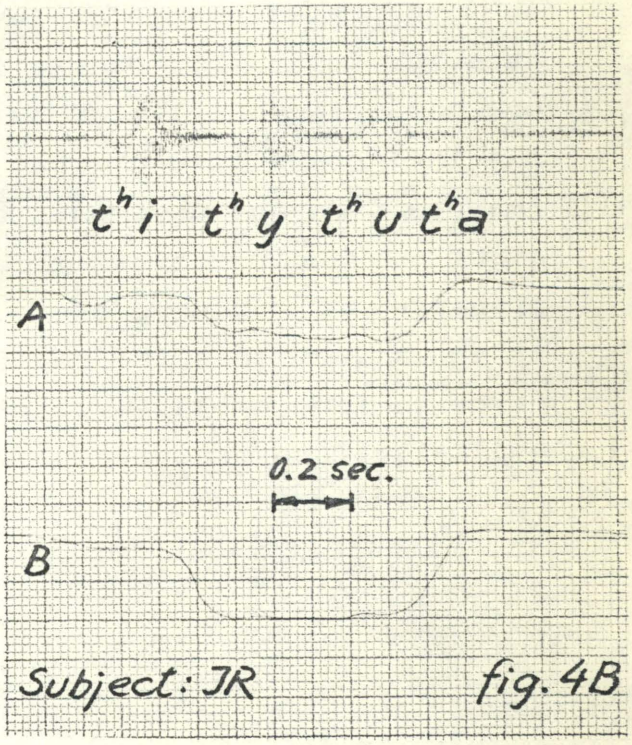

fig. 4B

the electrodes is not in proper contact with the lips. A special aspect of this problem is that the contact resistance between electrode and lip seems to depend on where the electrodes are placed. Thus the contact resistance seems to be somewhat smaller in the corners of the mouth than elsewhere on the lips. This might explain why the B-electrodes are more sensitive to the rounding of the lips than are the A-electrodes.

Fixing the electrodes on the lips does not influence the articulation seriously, but the plast folio between the lips is somewhat disturbing and may, for example, cause the bilabial stops to be somewhat affricated.

5. Conclusions

From the recorded labiograms as well as from the theoretical considerations given in this article, it is obvious that neither A- nor B-labiograms show the lip pressure or the rounding of the lips. The levels of the labiograms depend , as mentioned earlier, on several parameters; some of these may even be unknown. In order to interpret a change in level on a labiogram it is necessary that this change is caused by the variation of one parameter only, e.g. by lip pressure. However, the labiograms give a great deal of information concerning the position and movements of the lips. This information might be used to throw light on other features than lip pressure and rounding of the lips. Our main problem, then, is to extract this information from the labiograms or maybe to find a placement of the electrodes that especially emphasizes the features to examine.

The main purpose of this article is to introduce the method of measuring lip movements by means of the

electro-glottograph, and the investigations should be regarded as preliminary. A more extensive series of experiments is a necessary prerequisite to a more satisfactory interpretation of the labiograms.

Acknowledgements

Special thanks are due to Børge Frøkjær-Jensen, who generously placed an additional electro-glottograph at the disposal of the laboratory.