

Experimental Phonetics. — *Contributions to an experimental investigation of the Dutch language. II. oo, eu and ee followed by r or not*¹⁾.
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(Communicated at the meeting of February 25, 1928).

Among vowels *oo* (*o*), *eu* (*ø*), and *ee* (*e*) take a peculiar position. This appears e.g. when we arrange the vowels in a so-called vowel-triangle: *aa* (*a*), *oe* (*u*), and *ie* (*i*) take the angles, *oo*, *eu* and *ee* being far away from them. The first mentioned are the so-called fundamental vowels, common to all primitive languages, the others are sounds that have only developed later. To pronounce *oo*, *eu* and *ee* the speech organs must assume a position that answers very definite requirements. To pronounce the so-called fundamental vowels, this is only the case to a less degree. In this connection it is worthwhile to compare the transition of *oo*, *eu* and *ee*, into the diphthongs *au* (*ou*), *ui* (*uy*) and *ei* (*ei*) in the careless pronunciation of the larger towns of Holland on the one hand as against the fact that in animal and instrumental sounds we may recognise *aa*, *oe* and *ie* often enough, but very seldom *oo*, *eu* and *ee*.

The influence of a following *r*-sound suffices to make these latter vowels lose their clearness. In Dutch in this case peculiar sounds are formed, which usually are compared or even identified with the short vowels: *o*, *u* and *i*. The vowels in *boor*, *beur* and *beer* are very different from those in *boot*, *beuk* and *beet*, and bear much resemblance to those in *bot*, *put* and *bit*, differing from these mainly or exclusively by their greater duration.

It is obvious that the way in which *r* itself is pronounced influences the phenomenon. To me it seems, that the altered vowels are most characteristic and constant before a lingual *r* (*r*), but that also with people who use a uvular *r* (*R*), this pronunciation is usual. Sometimes however, the vowels in that case are very much like the wide vowels *o* (*ɔ*), *u* (*œ*) and *e* (*ɛ*).

Concerning the articulation of *r* ZWAARDEMAKER²⁾ stated, that in the pronunciation of *r* the muscles only fulfil the task of loosely raising the tongue, and that in the bottom of the mouth only then some tonus is noticeable, when a very strong relaxation has preceded. Hence after a vowel in which the bottom of the mouth is always tense, *r* must cause a relaxation. We may add that relaxation will take the more time and the more energy, as the vowel is pronounced with greater tension.

¹⁾ From investigations made at the Physiological Laboratory of the Amsterdam University.

²⁾ Nederl. Tijdschr. v. Geneesk. 1898. I. N^o. 24.

As the characteristic tone of voiceless *r* STUMPF 1) gives $a^2—a^3$ (870—1740 vibrations p.s.)

If we compare the accounts of different investigators concerning articulatory and acoustic qualities of *oo*, *eu* and *ee*, we find agreement on the following points. They are vowels pronounced with great tension in the speech organs, with a mid-position of the tongue (articulation for *oo* in the back-part of the mouth; for *eu* and *ee* in the front-part) and with a moderate opening of the jaws (varying little in the three sounds). The characteristic overtones are according to STUMPF 1) :

oo formant 388—517
eu underformant 388—517 ; formant 1550—2324 ;
ee underformant 388—517 ; formant 1954—2764.

The few dates at hand concerning Dutch vowels (BOEKE, TER KUILE, BENJAMINS) agree very well with the above.

Experimental part.

A cinematographical record demonstrated that the outwardly visible differences between *oo*, *eu* and *ee*, followed by *r* or not, are very slight. In *oo* the opening of the mouth seems to be larger, in *ee* smaller when *r* follows. In *eu* no distinct difference could be noted. From records obtained by means of the labiograph of VON WILCZEWSKI the vertical distance between the lips was seen to be greater in *oo* and *eu* when *r* followed.

By means of ZWAARDEMAKER's apparatus to register speech movements (made of aluminium) records were made to compare the two series of sounds. As may be seen in fig. 1 the opening of the jaws was generally diminished when *r* followed. In *oo* and *eu* the difference was considerable, in *ee* small as in other vowels. This agrees well with EYKMAN's 2) dates concerning the distance of the jaws.

Palatograms in which by means of E. A. MEYER's method also the profil of the tongue was investigated, showed a picture as in fig. 2.

In all three vowels the tongue moves in a straight way, when *r* follows. Only a very small part of the mouthhole remains free from the moving tongue. No *r* following, the tongue moves in a curved way, the so-called front resonance-chamber remaining free. This curved way is only possible with a strong tension in the tongue. The larger palatal surfaces touched by the tongue, observed when *r* is following, may be due in first place to the smaller distance between the jaws.

If we try to pronounce a pure *oo*, *eu* or *ee* before *r*, it appears to be impossible to make *r* follow the vowel immediately : between the two arises

1) C. STUMPF. *Die Sprachlaute*, 1926.

2) *Onderzoekingen Physiol. Lab. te Utrecht*. 5^e reeks, II. 1901.

an *aa*-sound (compare English *poor*, *beer*, etc.). In the records made from such trials by means of ZWAARDEMAKER's apparatus, a great distance

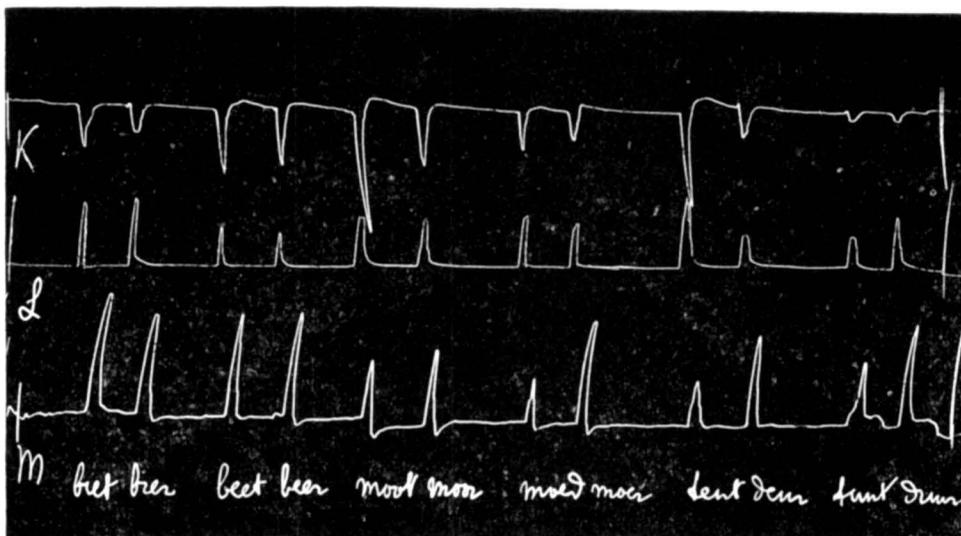


Fig. 1.

between the jaws and a strong relaxation of the bottom of the mouth before *r* were clearly perceptible.

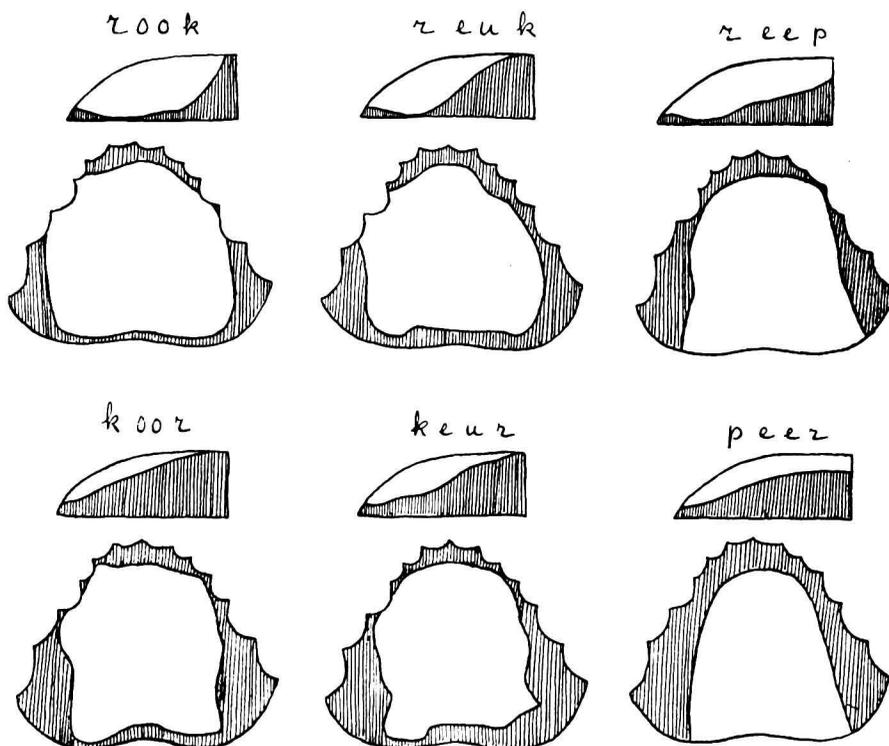


Fig. 2.

In deviating from the usual articulation it is possible, however, to pronounce a rather normal *oo*, *eu* or *ee* before *r*. To that effect the opening of the mouth must be actively or passively reduced in case of *oo*, and enlarged actively or passively in case of *eu* and *ee*.

A number of other influences make *oo*, *eu* and *ee* pass into the vowels that precede *r*. Raising the point of the tongue, putting a piece of wood or wax in the front part of the mouth have almost the same effect. The other vowels remain practically unchanged thereby, as they do when followed by *r*.

To compare the acoustical qualities of the sounds, in the first place phonographical records were made, a lioretgraphe transcribing them $\pm 150 \times$ enlarged on smoked paper. The greater part of these records were made from two subjects (B and K), both possessing a normal pronunciation with a lingual *r*. Fig. 3 shows some of these records. Accurate observing and simple measuring of these records showed the following: B spoke on a fundamental tone (pitch) of 170—190 p.s.; K on 200—225 p.s. The most important overtones were all within the limits indicated by STUMPF. For *oo* moreover a relatively strong tone of nearly 800 vibrations per second was found. This value agrees a.o. with that found by PAGET. In vowels not followed by *r* the second overtone was relatively strong especially in K, while in the vowels followed by *r* the importance of this overtone was of less importance, and became weak in B, while the amplitude of the third and to a less degree, that of the fourth overtone increased. The highest characteristic (formant) showed in *ee* a strong fall, under the influence of the following *r*, n.l. from 2300—2000.

For *eu*, where the highest characteristic was at 1600, a slight alteration in the same direction was noted. In *oo* the phenomenon was reversed, a feeble mounting of the overtone with frequency of 800 being noted. In all these cases, it was clearly visible that the highest characteristics towards the end of the vowel were transferred to a frequency of 1250, the formant of *r*. Records of the short vowels in *bot*, *dut* and *bit*, showed differences as well as striking similarity with both series. Determination of the first ten overtones by the method of HERMANN, which was applied in a few cases, affirmed the facts stated above.

The whispered vowels, too, were taken into account.

Also in whispering there is a marked difference between *oo*, *eu* and *ee* followed by *r* or not. Comparing also the sounds related to the investigated pairs of vowels with these latter, I came to the following series:

oe, *o* (*o*)¹⁾, *oo* (*r*), *o* (*o*), the higher characteristic rising and the lower being indistinct;

uu, *eu*, *eu* (*r*), *u*, *œ*, the higher characteristic falling and the lower rising;

ie, *ee*, *ee* (*r*), *i*, *e* (*ε*), the higher characteristic falling and the lower rising.

1) KAISER. *The short o*. These Proceedings, Vol. 26, p. 745.

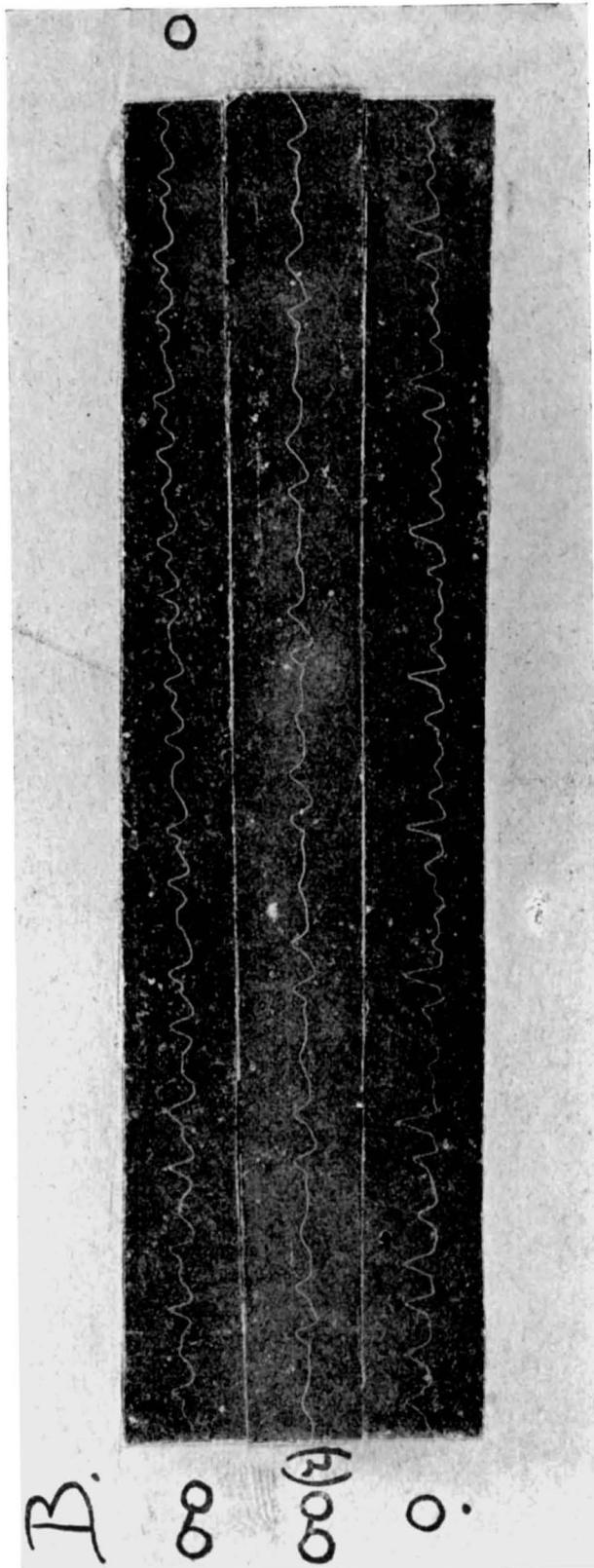


Fig. 3a.

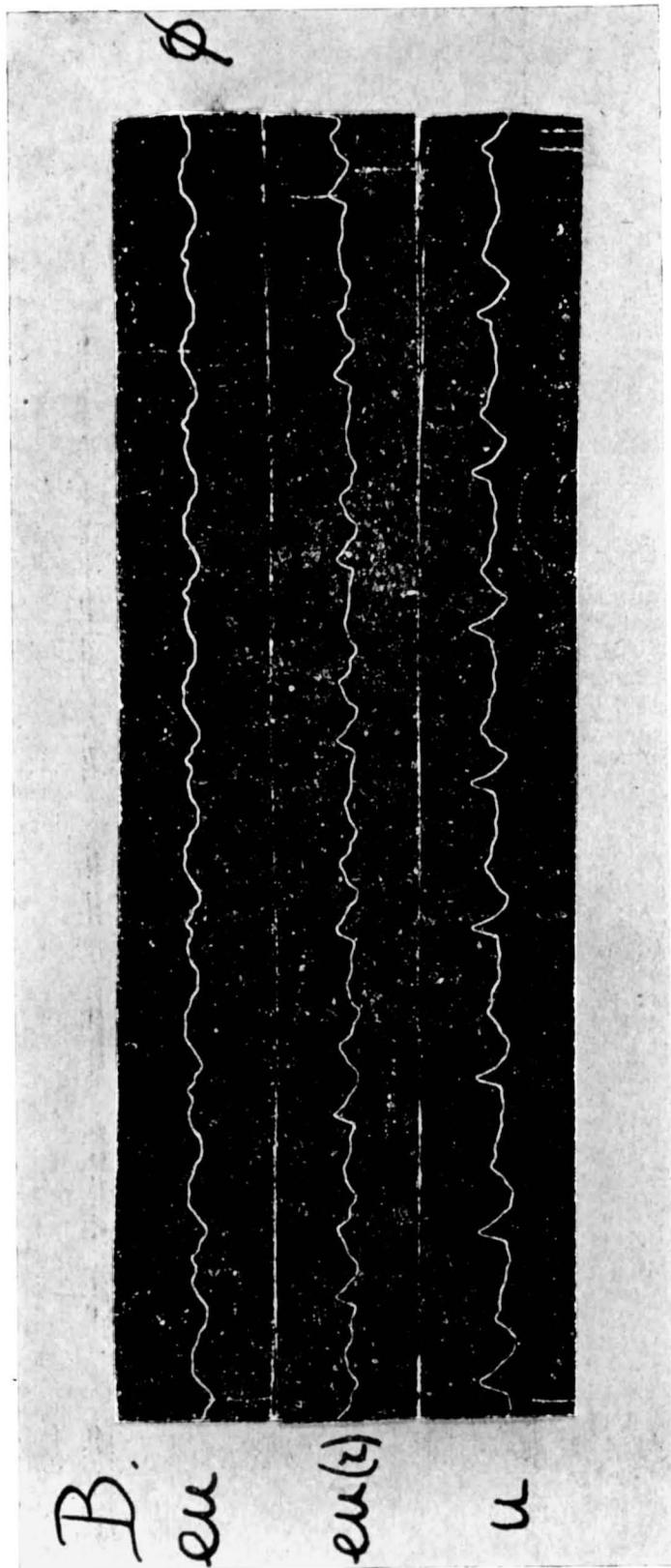


Fig. 3b.

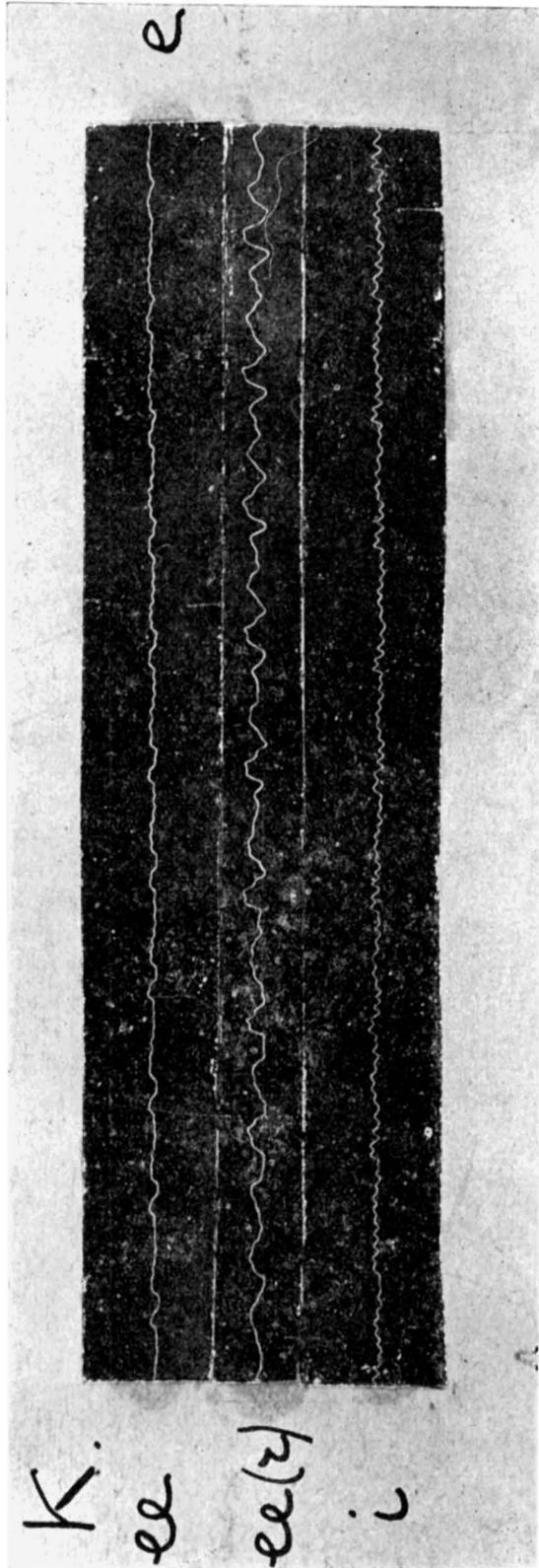


Fig. 3c.

However these results agree fairly well with those stated above, as a whole it did not appear quite satisfactory to me. Then BOUMAN 1) developed a method to determine the overtones of vowels by means of electric resonance. The results of his investigations made a new explanation of facts acceptable.

Synopsis of results.

The acoustical phenomena described above are corresponding in *eu* and *ee*, the reverse in *oo*. The cause of this can only be looked for in the place of articulation, which is the same for *eu* and *ee*, but different for *oo*. The consequence of this may be that in *oo* the narrowing of the opening of the mouth only reduces the space before the place of articulation, and in *eu* and *ee* especially the space behind it. This would imply that in *oo* the formant rises, in *eu* and *ee* the underformant rises, which is the case indeed.

The front resonance chamber in which the formant of *eu* and *ee*, is formed, becomes necessarily smaller with lessening of the distance between the jaws. The narrowing of the mouth opening attending it especially in *ee*, has a contrary effect and can be the stronger of the two influences at work, i.e. it can cause lowering of the formant : *eu* and *ee*. Widening of the mouth opening has in *oo* the same influence as reduction of the space : rising of the formant.

I cannot explain in details, at any rate not for *eu* and *ee*, how the moving point of the tongue and a small piece of wood or wax can have a similar effect. If BOUMAN's views are right, there is an explanation in them also for these phenomena.

Speaking generally we may say that *oo*, *eu* and *ee* are only pure under special circumstance and that everything which is anyhow detrimental to the pureness of these vowels, brings them in the class of the more or less imperfect vowels (BRÜCKE), where also the so-called short vowels have their place.

As *oo*, *eu* and *ee* are pre-eminently tense vowels and the pronunciation of *r* requires considerable laxity, it is comprehensible that they cannot be joined as they are.

In the Dutch language the joining of *r* to any other vowel is possible. To me this seems to prove that these latter vowels are not tense or at least far less so than *oo*, *eu* and *ee*.

1) Archives Néerlandaises de phonétique expérimentale, 2, 1928,