A SCALING TECHNIQUE IN AN EXPERIMENT WITH VOWEL-LIKE SOUNDS

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In the investigation I am going to describe to you, a group of 30 listeners were asked to determine, whether they thought that the second of a group of three artificial vowels was more like the first or more like the third vowel presented to them. 140 groups of three artificial vowels were presented to the listeners, the first and the third artificial vowel being fixed and the second being variable. The fixed points originated from the vowel triangle, as it can be drawn for the Dutch vowels (see fig.1),

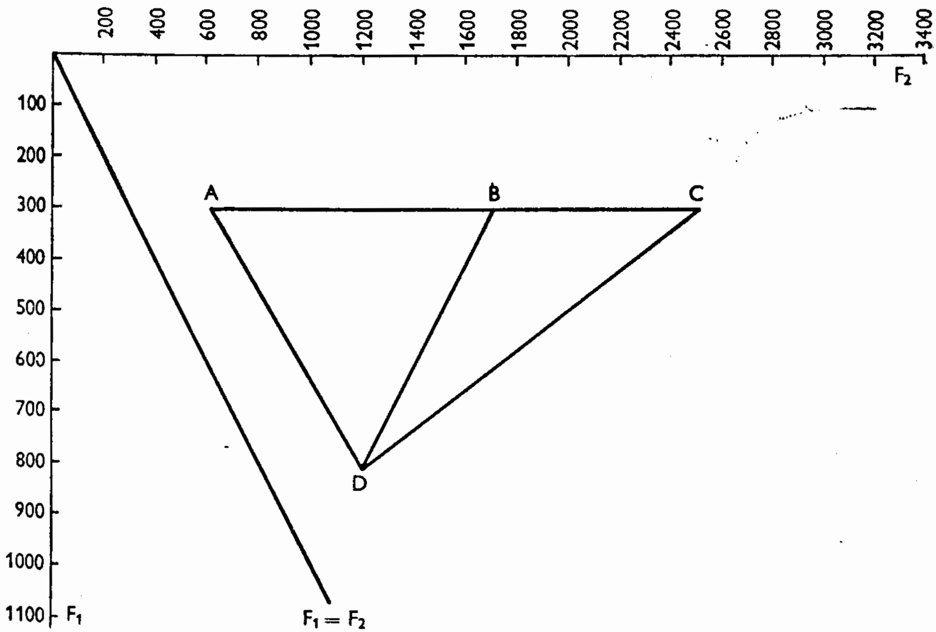

Fig. 1.

thus furnishing us with four scales: AD, BD, CD and AC. 33 points equally divided along each of these scales were taken as the variable vowellike sound. The stimuli were presented in such a way that the first variable in a scale had the fixed vowel-like

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sounds—for example in the scale AD—in a sequence AD, the second next variable in a sequence DA, the third variable had again AD and so on. Every variable had a reversed position of the surrounding fixed points as compared with the pair preceding and the pair following. This applies to any of the scales mentioned. The pairs of three vowel-like sounds coming from the four different scales were presented in random order. The listeners were asked to score their opinion in a linear scale (see fig. 2). The first vowel-like sound—a fixed point in the formant scale—has its position at the extreme left of the scale, the third vowel-like sound, being also a fixed point in the formant scale, at the extreme right of the same scale. The subjects were instructed that also the position within one of the seven parts of the scale was of importance. The listeners were not told that they were going to hear artificial vowels. The instruction mentioned only three sounds. The subjects were recruited from a department in which no information about vowels, vowel-systems and the vowel triangle was given.

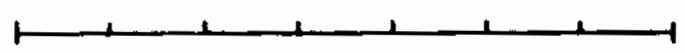

Fig. 2.

When listening to an unfamiliar vowel one is inclined to relate this vowel to a known vowel class. We wanted to gain some insight into the grounds on which subjective judgments as to vowel difference or vowel resemblance are made. Therefore we took as our starting point the problem, to what degree vowel-like sounds, the formants of which are quite near one another, might be judged to be different. The backbone of this problem is the question whether a distance, that could be expressed in formant frequencies, could be scaled and related to these frequency distances. In other words: are physical distances correlated with perceptual distances?

In order to produce the vowel-like sounds mentioned above, we used a vowel generator, consisting in a pulse generator and two LCR-chains. The damped oscillations produced were summated and controlled as to damping coefficient, the amplitudes of the two formants produced and as to the respective frequencies of F 1 and F 2. The pulse generator, simulating the pulses given by the vocal cords, was adjusted at a frequency of 160 c/s. Pulse shape, damping coefficient and amplitude were set in such a way as to bear optimal resemblance to these parameters as they occur in actual Dutch vowels. The artificial vowels were recorded on tape at a same level and at electronically controlled distances in time. Every group of three vowel-like sounds was recorded twice at the same fixed distance in time and separated from the preceding and following groups by another pause of longer duration, which was also electronically controlled.

The subjects were isolated in boxes. The subjects were given printed, carefully worded instructions, allowing control by the experimenter.

Nevertheless some of them did not succeed in responding in the correct way. The

responses of the subjects were made on preprinted forms, allowing a quick coding for processing on an electronic computer.

As a first step we tested the hypothesis that scaling is possible and that the subject's responses rise monotonously with the stimuli.

We therefore applied Kendall's rank correlation test.

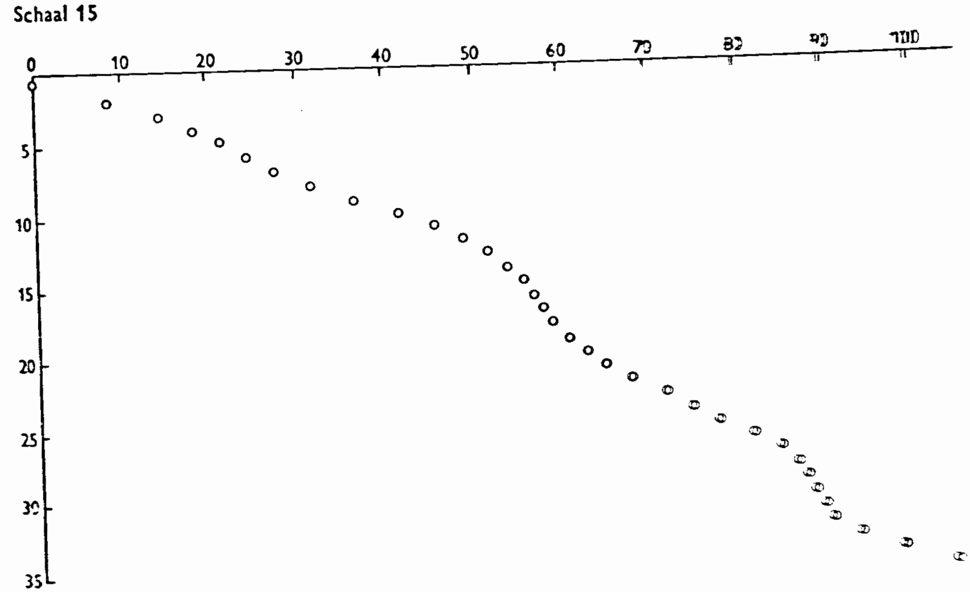

Fig. 3. Smoothed curve scale 1 (AD).

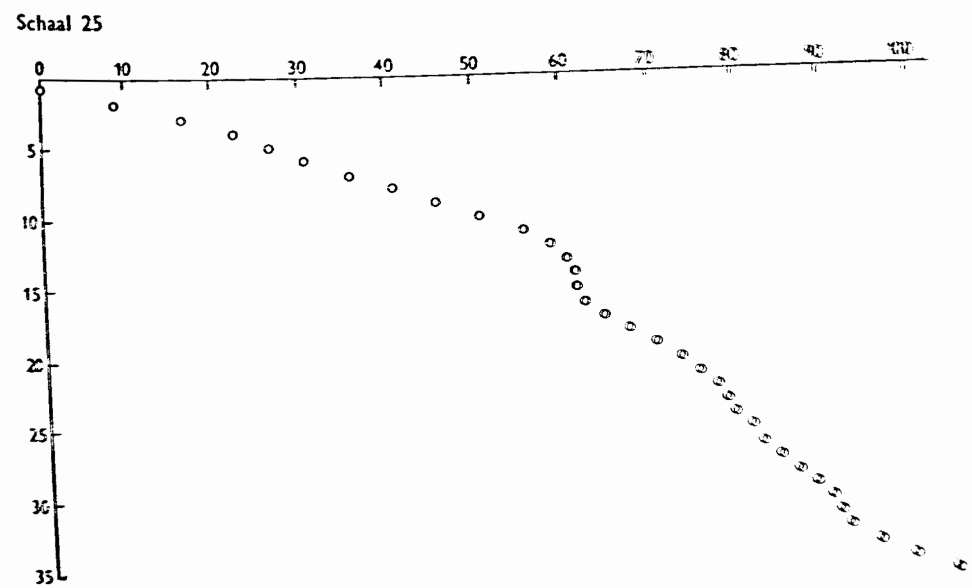

Fig. 4. Smoothed curve scale 2 (BD).

Out of 30 subjects 25 produced rank correlation coefficients sufficiently high to conclude to positive ranking within a 99.5 percent reliability.

5 subjects had very low or even slightly negative rank correlation coefficients. So that in their case we could not conclude significant ranking. The responses of these 5 subjects were therefore discarded.

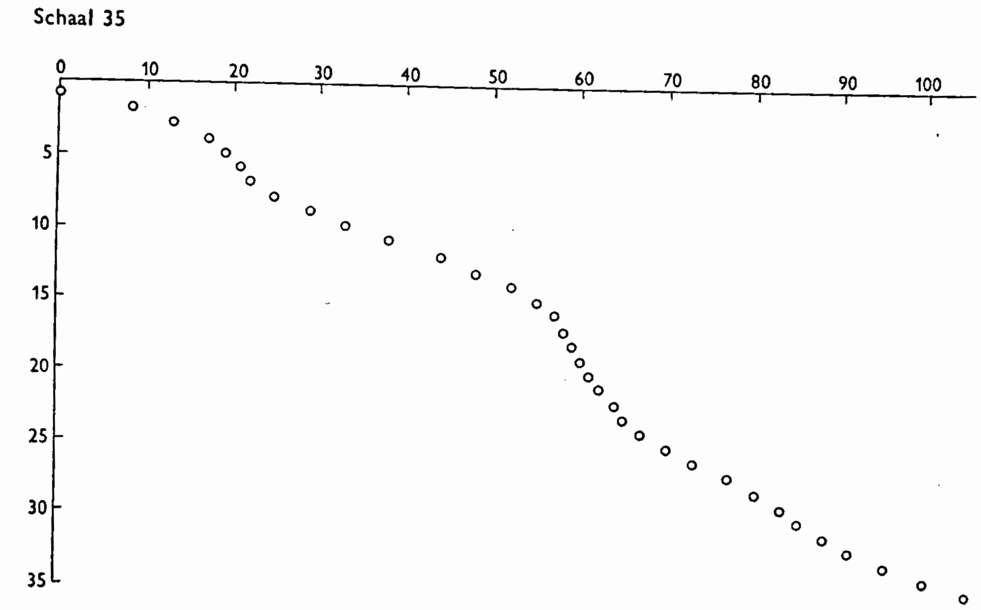

Fig. 5. Smoothed curve scale 3 (CD).

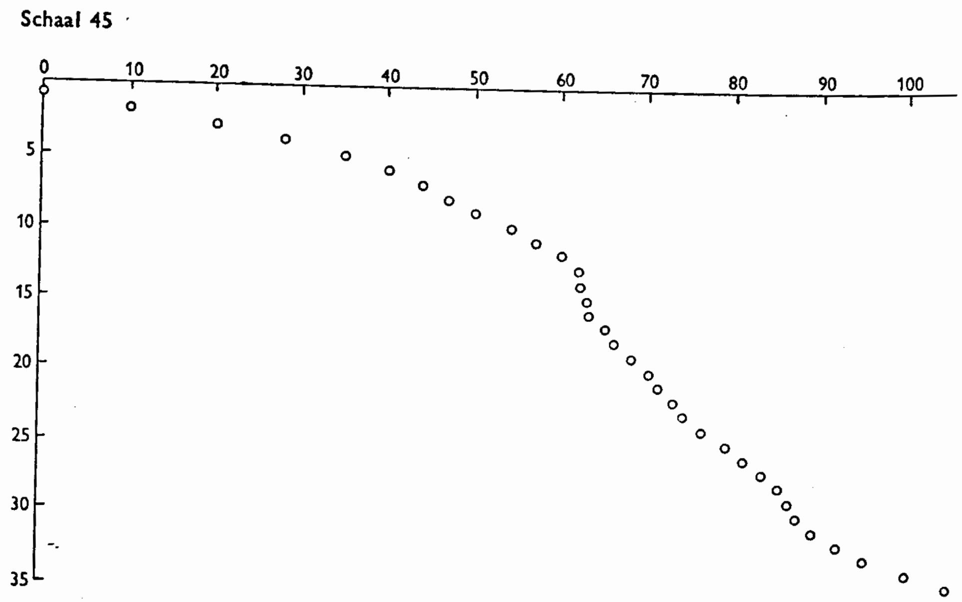

Fig. 6. Smoothed curve scale 4 (AC).

The accuracy of the scaling is expressed by the fact that the standard deviation for the response positions is about one seventh of the length of the whole scale. This applies to all scales and all stimuli.

Although the sequences in the perceptual and the physical scale were strikingly correlated, there was no tendency towards a linear relation. In our experiment—just as in so many other scaling experiments—our subjects showed a reluctancy to score in the extremes of the scales.

Furthermore our subjects showed a tendancy to score high in relation to a linear scale. Thus in the scale AD subjects responded more in the direction of D than is justified by the position of those stimuli in the physical scale.

On the raw data a process of digital filtering was performed in order to obtain smooth curves. (Fig. 3, 4, 5, 6.)

It is justified to speak about a perceptive vowel triangle.

If we map the physical vowel triangle on the perceptive triangle we notice that some areas are preferred, while others are avoided. The distribution of these areas seems to be related to the distribution of the Dutch vowels in the perceptual triangle.

Whether a native vowel system plays a role in the evaluation of perceptual distance between vowellike sounds can only be established by repeating our experiment with subjects with different mother tongues.

Further investigation in this field is in progress.

DISCUSSION

Scully:

Please clarify the relationship between your results from two-formant stimuli and a chart of the first and second formant frequency in Dutch' which does not include all the parameters needed to specify vowel qualities acoustically.

Meinsma:

ad Scully: Principally this experiment was designed to investigate whether there *is* a relationship between the perception of two-formant *stimuli* and a chart of the first and second formant frequency in (Dutch) *vowels*.

Whether two or more formants are needed to specify vowel qualities acoustically was not the question. We may however refer to Phonetica, 15, 1966, p. 65—85 (J. G. Blom and J. Z. Uys; Some notes on the existence of a 'universal concept' of vowels) from which article it appears that in Dutch vowel-contrasts are sufficiently well described in two formants.