A Distinctive Feature Based System for the Evaluation of Segmental Transcription in Dutch

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1. Introduction

However extensive the literature on transcription systems may be, it remains astonishing to see that data on inter- and intrasubject reliability are almost completely lacking. One of the major problems in the assessment of reliability is that it requires a system with which differences between transcription symbols can be assigned numbers corresponding to the distances between the transcription symbols, or rather corresponding to the distances between the segments that the transcription symbols stand for. Preferably, these distances should be defined articulatorily rather than auditorily, since the training in the use of transcription symbols is largely articulatorily based as well.

For the construction of a system in which the distances between the Dutch vowels are numerically expressed, enough experimental data may be found in the literature (e.g. Nooteboom, 1971, 1972; Rietveld, 1979). The available data with respect to the Dutch consonants appear to us less satisfactory. Spa (1970) describes the Dutch consonants by means of 16 distinctive features. One of our main objections against Spa's system is that the front-back dimension - a dimension which is crucial for the classification and the adequate use of transcription symbols - is only implicitly represented by the features [cor], [ant], [high], [low], and [back]. Moreover, the validity of Spa's system was not experimentally tested. We therefore decided to develop a new consonant system for Dutch with a heavier emphasis on articulation. The validity of this system was assessed by means of an experiment in which subjects were asked to make dissimilarity judgments on consonant pairs.

2. The vowel system

From the data in the literature (Eijkman, 1955; Moulton, 1962; Nooteboom 1971, 1972; Rietveld, 1979; Booij, 1981; Schouten, 1981) - data which to a great extent have been tested experimentally - the following characteristics of the Dutch vowels may be established:

The 15 vowel allophones [i, y, e, ø, ɛ, a, ɑ, ɔ, o, u, Y, I, ə, œ, U] can be subdivided into long, halflong, and short. Before [r, R] [i:, y:, e:, ø:, a:, o:, u:] are long; in foreign words [ɛ:, œ:, ɔ:] are long. The remaining vowels are short

in these positions. When not before [r, R], [e., ø., a., o.] are halflong, the rest is short. In our system long = 1, halflong = 2, short = 3.

From Rietveld (1979), it appears that 'the proprioceptive articulatory dissimilarities can be predicted quite satisfactorily by using a traditional vowel scheme and giving extra weight to differences on the front/back dimension' (1979: 88). This statement only pertains to the nine vowels examined by Rietveld, namely [i, e, ɛ, y, ø, u, o, ɔ, ɑ]. We assume that this finding applies to all Dutch vowels. Thus, for the front/back dimension we have used a weight factor of 2, resulting in front = 2, central = 4, and back = 6.

Finally, by adding two values for rounded/unrounded (rounded = 1, unrounded = 0) and four values for the high/low dimension (high = 4, high/mid = 3, mid/low = 2, low = 1) all Dutch vowels may be distinguished.

Following Moulton, diphthongs are considered as vowel + vowel sequences, the second vowel being non-syllabic allophonically.

Table I (upper half) shows the dissimilarity matrix which results from assigning the above values on the dimensions distinguished to all Dutch vowels. The distances thus established can be used to express differences in the choice of transcription notations for vowels numerically. Examples of maximal differences (numbers 9 and 10) are [ɑ-ø:, ɑ-i:, ɛ-u: ɑ-y:]; examples of minimal differences (numbers 1 and 2) are [i-y, e:-ø, ɛ-i].

Table I. Dissimilarity matrix for all Dutch vowels (upper half) and for all Dutch consonants (lower half). * = Consonants used in the experiment.

	a:	e:	o:	ø:	i:	y:	u:	œ:	ɛ:	ɔ:	a·	e·	o·	ø·	ɑ	ɛ	ɔ	U	I	Y	œ	ə	i	y	u							
*p	–	4	5	5	5	6	6	2	3	4	1	5	6	6	4	5	6	7	6	6	4	4	7	8	8	a:						
*b	1	–	5	1	1	2	6	4	1	6	5	1	6	2	8	3	8	7	2	6	6	4	3	4	8	e:						
*t	2	3	–	4	6	5	1	3	6	1	6	6	1	5	5	8	3	2	7	5	5	5	8	7	3	o:						
*d	3	2	1	–	2	1	5	3	2	5	6	2	5	1	9	4	7	6	3	5	5	5	4	3	7	ø:						
c	3	4	3	4	–	1	5	5	2	7	6	2	7	3	9	4	9	8	3	5	7	5	2	3	7	i:						
*k	5	6	3	4	2	–	4	4	3	6	7	3	6	2	10	5	8	7	4	4	6	6	3	2	6	y:						
g	6	5	4	3	3	1	–	4	7	2	7	7	2	6	6	9	4	3	8	4	6	6	7	6	2	u:						
*f	3	4	3	4	6	6	7	–	3	2	3	5	4	4	6	5	4	5	6	4	2	2	7	6	6	œ:						
*v	4	3	4	4	7	7	6	1	–	5	4	2	7	3	7	2	7	8	3	7	5	5	4	5	9	ɛ:						
*s	4	4	2	3	5	5	6	1	2	–	5	7	2	6	4	7	2	3	8	6	4	6	9	8	4	ɔ:						
*z	5	4	3	2	6	6	5	2	1	1	–	4	5	5	3	4	5	6	5	5	3	3	6	7	7	a·						
ʃ	4	4	4	5	3	5	6	3	4	2	3	–	5	1	7	2	7	6	1	5	5	3	2	3	7	e·						
ʒ	5	4	5	4	4	6	6	4	3	3	2	1	–	4	4	7	2	1	6	4	4	4	7	6	2	o·						
*x	7	8	5	6	4	2	3	4	5	3	4	3	4	–	8	3	6	5	2	4	4	4	3	2	6	ø·						
ɣ	8	7	6	5	5	3	2	5	4	4	3	4	3	1	–	5	2	3	6	6	4	4	7	8	4	ɑ						
χ	6	7	4	5	5	3	4	3	4	2	3	4	5	1	2	–	5	6	1	5	3	3	2	3	7	ɛ						
ʁ	7	7	5	4	6	4	3	4	3	3	2	5	4	2	1	1	–	1	6	4	2	4	7	6	2	ɔ						
*m	3	2	5	3	6	8	7	4	3	5	4	5	4	8	7	7	6	–	5	3	3	3	6	5	1	U						
ɱ	4	3	4	4	7	7	6	3	2	4	3	6	5	7	6	6	5	1	–	4	4	2	1	2	6	I						
*n	5	4	3	2	6	6	5	4	3	3	2	5	4	6	5	5	4	2	1	–	2	2	3	2	2	Y						
ɲ	6	5	6	6	3	5	4	7	6	6	5	4	3	5	4	6	5	3	4	3	–	2	5	4	4	œ						
*ŋ	8	7	6	5	5	3	2	7	6	6	5	6	5	3	2	4	3	4	4	3	2	–	3	4	4	ə						
*l	5	4	3	2	6	6	4	4	3	3	2	5	4	6	5	5	4	4	2	3	4	5	–	1	5	i						
ɫ	7	6	5	4	6	4	3	6	5	5	4	7	6	4	3	3	2	6	5	4	3	3	2	–	4	y						
r	4	3	2	1	5	5	4	3	2	2	1	4	3	5	4	4	3	3	2	1	4	4	1	3	–	u						
ɾ	5	4	3	2	6	6	5	4	3	3	2	5	4	6	5	5	4	4	3	2	5	5	2	4	1	–						
*R	6	5	4	3	5	3	2	5	4	4	3	6	5	3	2	2	1	5	4	3	4	2	3	1	2	3	–					
*w	4	3	4	3	7	7	6	3	2	4	3	6	5	7	6	6	5	3	2	3	6	6	3	5	2	3	4	–				
ʋ	3	2	5	4	6	8	7	4	3	5	4	5	4	8	7	7	6	2	3	4	5	7	4	6	3	4	5	1	–			
*j	7	6	5	4	4	4	3	6	5	5	4	5	4	4	3	5	4	6	5	4	3	3	4	4	3	4	3	3	3	–		
*h	7	8	5	6	6	4	5	4	5	3	4	5	6	2	3	1	2	8	7	6	7	5	6	4	5	6	3	6	8	6	–	
ʔ	6	5	4	3	5	3	2	7	6	6	5	8	7	5	4	4	3	7	6	5	6	4	5	3	4	5	2	6	7	6	3	–
	p	b	t	d	c	k	g	f	v	s	z	ʃ	ʒ	x	ɣ	χ	ʁ	m	ɱ	n	ɲ	ŋ	l	ɫ	r	ɾ	R	w	ʋ	j	h	ʔ

3. The consonant system

From the literature the following data with respect to Dutch consonants may be established:

On the basis of the results of a multidimensional scaling analysis Van den Broecke (1976: 120) states that 'there is some evidence to believe that there are a number of different inner speech dimensions, at least 4, possibly 5, employed in similarity evaluations on inner speech stimuli'. The dimensions which Van den Broecke found allow for current phonetic interpretations in terms of place and manner of articulation features. Several systems developed for English consonants also make use of features of place and manner of articulation (Singh, 1976). Therefore, we decided to make use of these features too. As for place of articulation, our system differs from the system proposed by Spa, since there this feature was ony implicitly represented.

On the basis of the above considerations we selected the following distinctive features to distinguish the 32 Dutch consonants which may appear in a narrow transcription: the feature of place of articulation (bilabial = 1, labiodental = 2, dental/alveolar = 3, palato-alveolar = 4, palatal = 5, velar = 6, uvular = 7, glottal = 8) and seven binary features, i.e. voicing, nasality, continuity, glide, laterality, fricative, and flap.

3.1. The experiment

3.1.1. Method

In order to allow comparison with the results of the first experiment conducted by Van den Broecke (1976), and also in order to restrict the number of stimuli, from the 32 consonants given in Table I, lower half, a subset of 18 consonants was selected for use in the experiment namely [p b, t, d, k, f, v, s, z, x, j, l, r(R), h, m, n, ŋ, w]. These consonants are indicated with an asterisk in Table I. Twenty-five first year speech therapy students were presented with these consonants pairwise in medial word position (cf. Van den Broecke: in isolation); they were asked to rate each pair on articulatory dissimilarity (cf. Van den Broecke: on dissimilarity represented perceptually by means of 'inner speech') on a 10-point scale (10 = maximal dissimilarity, 1 = minimal dissimilarity). The stimulus material consisted of $(18^2 - 18)/2 = 153$ word pairs which differed as little as possible, containing the same number of syllables, and exhibiting, with a few exceptions, the same stress pattern. The stimuli were offered in random order on paper. After the experiment was over, the subjects were asked to indicate which /r/-realizations they used because in Dutch /r/ may be realized both as [r] and [R]. In the instructions it was emphasized that during the rating the whole articulatory apparatus should be taken into consideration. As the subjects had just started their training as speech therapists, they had acquired no more than a negligible amount of phonetic knowledge.

3.1.2. Results and discussion

In order to gain insight into the dimensions underlying the dissimilarity judgments of the subjects, multidimensional scaling was carried out. Input to the program (ALSCAL, W. Young, Y. Takane, R.J. Lewyckyl, 1977) were the means of the dissimilarity scores. In Table II the stress values, the random stress values, and the correlations between the ultrametric distances and the dissimilarities are given for 1, 2, 3, 4, 5, and 6 dimensions (Euclidean metric).

Table II. Values of three statistics as a function of the number retained dimensions in an MSCAL (Euclidean metric).

Dimension	1	2	3	4	5	6
stress	38.6	26.4	18.1	11.2	7.7	5.1
stress random	47.3	27.9	18.5	13.0	9.6	-
correlation	.80	.81	.85	.91	.95	.97

As may be expected, the stress and correlation coefficients are most favorable in the six-dimensional solution. However, since the sixth dimension was not phonetically interpretable, we opted for the five-dimensional solution for which the stress and correlation coefficient are also satisfactory.

The positions of the 18 consonants in the five-dimensional solution are graphically presented in Figures 1a, 1b, and 1c. As may be seen, the first dimension clearly represents the front-central-back continuum: at the one end we find labials dentals, and alveolars, in the center the palatal [j], and at the other end the velars, uvulars, and glottals. The second dimension is less easy to name. Globally, if it were not for the position of [l], it looks like a +cont/-cont dimension. More specifically, the classes of fricatives, plosives, and nasals + laterals may be distinguished along it. Ignoring the position of [ŋ], and taking into account the overlapping area in which labials and the [h]

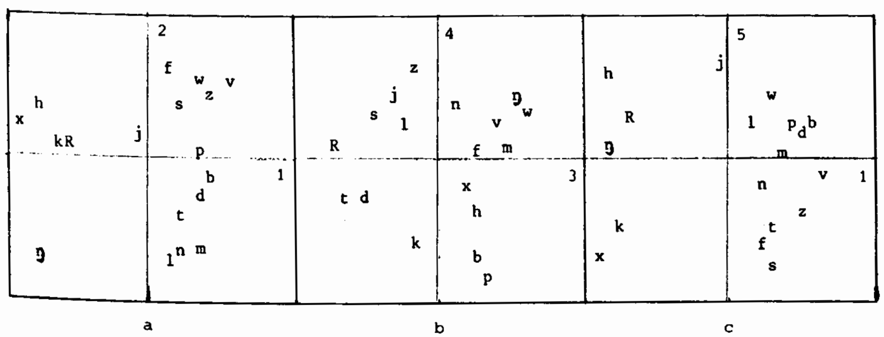

Figure 1. (a, b, c) Positions of 18 Dutch consonants in a five-dimensional solution.

are positioned the third dimension may be interpreted as a +lab/-lab dimension. With the exception of the positions of [z] and [s], the fourth dimension may be labeled +son/-son. Finally with the exception of the position of [h]and [p], the fifth dimension may be interpreted as a voiced/unvoiced dimension.

The correlation between the mean dissimilarity scores yielded by the experiment and the distances as defined in our consonant system is not very high ($r = .61$). Moreover, the positions of the consonants in the five-dimensional solution as depicted in Figures 1a, 1b, and 1c suggest that in the consonant system the feature of place of articulation should be split up in less than eight categories, and that the manner of articulation features should be changed. Therefore, our consonant system was revised in three different ways. In the first revised version the eight categories of place of articulation were maintained whereas the manner of articulation features were changed (deletion of the features +nas/-nas, +glide/-glide, and +fric/-fric); in the second version the place of articulation features were reduced to three categories, and the manner of articulation features were changed in a different way than in the first version (deletion of +cont/-cont and introduction of a dimension with at the one extreme plosive/fricative and at the other nas/lat), in the third version the place of articulation feature was reduced to five categories, and the manner of articulation features was changed in the same way as in the second version.

Of the three revised versions of the consonant system, the third one - the dissimilarities of which are given in Table I, lower half, - correlated most highly with the dissimilarities obtained in the experiment ($r = .75$, $r = .64$, and $r = .58$ for the third, second, and first revised version, respectively). The third version of our consonant system (SysV) was further evaluated by also relating it to the first experiment conducted by Van den Broecke (ExpB)and the consonant system developed by Spa (SysS).

The correlation between ExpV and ExpB was found to be fairly high ($r = .80$). From this it may be deduced that partly similar and partly differing criteria have been used by the subjects to judge the stimuli, the differing criteria probably having to do with the differences in experimental set-up. (Recall that in ExpB the stimuli were offered in isolation whereas in ExpV they were offered in medial word position. Recall also that in ExpB the subjects were asked to judge the stimuli auditorily whereas in ExpV they were asked to judge the stimuli articulatorily).

The correlation between SysV and SysS was considerably lower ($R = .57$). This may be the result of the fact that, as was said before, the features of SysV were more phonetically oriented than the ones in SysS. It furthermore appeared that the correlation of SysV with ExpV was significantly higher than the correlation of SysV with ExpB ($r = .75$ and $r = .55$ respectively; $t = 5.19$, $p < .01$, $df = 16$), and that the correlation of SysS with ExpB was higher (but not significantly so) than the correlation of SysS with ExpV ($r = .65$ and $r = .61$, respectively; $t = 0.914$, $p > .10$, $df = 116$). These differences could very

tentatively be interpreted in terms of differences in experimental set-up and structure between the two consonant systems: SysS is a better predictor of the auditorily based dissimilarity judgments of Van den Broecke, and SysV is more successful in predicting our articulatory based dissimilarity judgments. The choice of either of the two systems will therefore depend on the purpose it has to serve.

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