ACOUSTIC CHARACTERISTICS OF STANDARD DUTCH /ɣ/

Sander van der Harst, Hans Van de Velde & Bert Schouten

UiL-OTS/CLS Nijmegen, UiL-OTS & Uil-OTS
Sander.vanderHarst@let.uu.nl, Hans.VandeVelde@let.uu.nl & Bert.Schouten@let.uu.nl

ABSTRACT

In this paper an acoustic analysis of Standard Dutch /ɣ/ is presented. 160 speakers, stratified for nationality, region, gender and age, performed a reading task in which (ɣ) was embedded in a carrier sentence. The analysis is based on measurements of the resonance frequencies, the intensity, the periodicity and the duration of the realizations of (ɣ). The results show that regional variation is high. Furthermore, the common representation of /ɣ/ as a voiced velar fricative will be questioned.

Keywords: Socio-phonetics, Dutch, regional variation, fricatives, voice.

1. INTRODUCTION

It is generally accepted that Dutch has two pronunciation standards: one for the Netherlands and one for Flanders [12]. However, the realization of the fricative /ɣ/, which has been widely discussed by both language users and linguists in the Dutch language area (cf. [7, 11]), does not completely fit this pattern. The distinction between 'hard' (uvular) and 'soft' (velar and palatal) realizations of /ɣ/, is often claimed to be one of the most important regional differences, with the 'big rivers' running east to west across the Netherlands – and not the national frontier between Flanders and the Netherlands – as its border, and has developed into a stereotype in the Netherlands. 'Hard g' speakers are claimed to live north of this border, 'soft g' speakers south of it (i.e. in Flanders and the southern provinces of Zeeland, Noord-Brabant and Limburg in the Netherlands).

Nonetheless, quantitative studies of the back fricative in Dutch are extremely rare. Acoustic studies of "Standard Dutch" /ɣ/ are more than 25 years old and are based on a limited set of speakers and tokens: Van den Broecke & Van Heuven [10] studied 4 male speakers from the Netherlands and 48 tokens, whereas Debrock's study [3] is based on 10 Flemish speakers and a total of 20 tokens.
All other studies are based on auditory transcriptions and reveal that (i) place of articulation is highly variable in dialects [4], (ii) uvular realizations of /ɣ/ have been gaining popularity in Standard Dutch as spoken in the Netherlands [11], (iii) Flemish speakers of Standard Dutch mainly use velars [11], (iv) /ɣ/ is mainly voiceless, sometimes partially voiced [11].

Until now, studies of standard Dutch have not focused on regional variation within the speech community of the Netherlands and the speech community of Flanders. Furthermore, acoustic analyses of consonantal variation are rare. Socio-phoneticians have so far mainly been studying vowels [5], with Foulkes & Docherty [6] as a rare exception. Apart from expanding our descriptive knowledge of Standard Dutch, we want to (i) show that the regional variability of /ɣ/ is not restricted to dialects, but also shows up in standard pronunciation, (ii) verify whether the regional claims based on unsystematic observations are confirmed by quantitative research and (iii) question the claim that /ɣ/ is a voiced fricative in Dutch.

2. MATERIALS

2.1. Speakers

The informants were 160 Dutch language teachers, stratified for speech community (the Netherlands - Flanders), region (nested under community), gender and age (22-40 and 45-60); see Table 1. The two core regions are N-R and F-B, i.e. the economic and cultural centers of their community. The intermediate zones are N-M and F-E respectively, the geographically peripheral regions are N-N, N-S, F-W and F-L. For further information about the selection of the informants, see Van Hout et al. [13].

2.2. Carrier sentences

As part of a large sociolinguistic interview, the informants had to perform a reading task, in which word initial consonants were preceded and followed by a neutral vowel. (ɣ) was embedded in the following carrier sentence, in the word *guize*:

<In de guize horen we g>

/In də ɣœyzə hɔrən ʊə ɣə/

[*In the guize we hear g*]

Each informant did the reading task twice, resulting in 320 tokens of (ɣ).

Table 1: The selected informants, sorted by speech community, region, gender and age.

	age	**22-40**		**45-60**	
	gender	**m**	**f**	**m**	**f**
Netherlands	Randstad	5	5	5	5
	Middle	5	5	5	5
	North	5	5	5	5
	South	5	5	5	5
Flanders	Brabant	5	5	5	5
	East-Flanders	5	5	5	5
	West-Flanders	5	5	5	5
	Limburg	5	5	5	5

2.3. Recordings

The informants were interviewed at home or at work. The speech was recorded on digital audiotape with a portable TASCAM DA-P1 recorder and an AKG C420 headset microphone. The recordings were digitalized on computer and down-sampled to 16 kHz (16 bits).

2.4. Acoustic measures

All segmentations and measurements were performed in Praat [1]. We will present statistical analyses for relative duration, main resonance frequency, relative intensity and periodicity. We also present absolute durations and intensities of (ɣ).

2.4.1. Relative duration (RT)

For the segmentation of (ɣ), the following criteria were used. From the onset of (ɣ), friction must be audible, while the preceding vowel is no longer audible. At the offset of the fricative, there must be at least some friction and the following vowel must not be audible. Sudden changes in the spectrogram and the waveform were used as indicators of boundaries.

Absolute duration (T_γ) was measured in milliseconds. To eliminate differences in speech rate, relative durations were calculated by dividing the absolute duration of (ɣ) by the duration of the syllable:

$$(1) \qquad RT = \frac{T_\gamma}{T_{syl}} \times 100$$

2.4.2. Resonance frequency (F)

The main resonance frequency was determined manually on the basis of the spectrum of a selected part of the fricative. This part was selected by means of the following steps. First, the first and the last 10 ms of segmented (ɣ) were cut off to reduce coarticulation. Second, from the remainder the most stable part containing the highest energy was selected. A spectrum was made of this selection by the Fast Fourier Transform method, and the most dominant peak between 800 and 4000 Hz was determined manually. The resonance frequency is the frequency value of this peak.

2.4.3. Relative intensity (RI)

For the measurement of intensity, the same method was used as in Kissine et al. [8]. From the beginning to the end of (ɣ) the intensity was calculated in 10 ms intervals (see (5)). The following equations were used, in which *I* stands for the intensity of the signal (6) and *H* for the harmonicity or degree of periodicity (7):

$$(2) \qquad \text{Intensity} = 10 \log_{10} [10^{I/10} / (1+10^{H/10})]$$

$$(3) \qquad I = 10 \log_{10} (\text{periodic energy} + \text{aperiodic energy})$$

$$(4) \qquad H = 10 \log_{10} (\text{periodic energy} / \text{aperiodic energy})$$

Then mean intensity (MI) was calculated for each token. After that, relative intensity was computed to compensate for differences in recording level. Relative intensity is the absolute value of the difference between the maximum intensity of the first third of the following vowel and the mean noise intensity.

$$(5) \qquad RI = |MI-(I_{max})|$$

2.4.4. Periodicity (P)

The presence of periodicity was measured every 10 ms from the beginning to the end of the fricative (see 2.4.1) by means of a Praat script. The lower boundary was set at 60 Hz. The upper boundary was set 50 Hz above the maximum F_0 of the first third of the following vowel. The number of samples with periodicity was then divided by the total number of samples and multiplied by 100, which resulted in an

index ranging from 0 (no periodicity at all) to 100 (periodicity present during the whole fricative).

All values generated by the script were checked manually. Frequencies lower than 94 Hz for males and 117 Hz for females were considered as not representing vocal cord vibration and were hence set to zero.

3. RESULTS

Tables 2 (the Netherlands) and 3 (Flanders) present the mean values for the acoustic measures per region. Table 4 shows the partial η^2-values for the significant effects in the ANOVAs, in which community, region (nested under community), gender and age were taken as independent variables, and the acoustic measures as dependent variables. In this paper, the main focus will be on geographical variation. Significant effects with a partial η^2 lower than .10 will not be discussed, as these effects are very weak and need further investigation.

Table 2: Mean values of resonance frequency (F; Hz), duration (T; ms), relative duration (RT; %), intensity (MI; dB), relative intensity (RI; dB) and periodicity (P; %), per region in the Netherlands (n=160).

	N-R	N-M	N-N	N-S	NL
F	1508	1641	1509	2041	1675
T	123.7	105.5	121.5	81.4	108.0
RT	35.7	31.0	34.7	24.4	31.5
MI	70.1	70.4	72.2	67.4	70.0
RI	12.9	13.6	11.6	17.4	13.9
P	10.8	22.4	11.9	31.6	19.2

Table 3: Mean values of resonance frequency (F; Hz), duration (T; ms), relative duration (RT; %), intensity (MI, dB), relative intensity (RI; dB) and periodicity (P; %), per region in Flanders (n=152).

	F-B	F-E	F-W	F-L	FL
F	2226	1885	1590	2124	1959
T	90.5	92.5	91.2	89.1	90.7
RT	27.3	27.7	29.1	26.3	27.6
MI	55.3	58.7	62.4	59.7	59.1
RI	21.5	20.9	17.1	21.5	20.2
P	13.0	12.9	14.9	21.3	15.6

Table 4: Partial η2 for the significant effects (<.05) in the ANOVAs on resonance frequency (F), relative intensity (RI), relative duration (RT), periodicity (P). η^2>.10 are bold.

	F	RT	RI	P
Community	**.336**	**.157**	**.630**	
Region (com)	**.580**	**.353**	**.401**	**.109**
Gender	**.292**	.060		.064
Age	.056			
Com x gender	.059			.045
Com x age	.072		.033	

3.1. Resonance frequency (F)

With respect to resonance frequency, significant main effects were found for community ($F_{1,125}$=63.346; p=.000), region within community ($F_{6,125}$=28.825; p=.000), gender ($F_{1,125}$=51.625; p=.000) and age ($F_{1,125}$=7.383; p=.008), as well as two very weak interaction effects for community x gender ($F_{1,125}$=7.805; p=.006) and community x age ($F_{1,125}$=9.712; p=.002).

In the Netherlands, a lower resonance frequency is found than in Flanders (1775 vs. 1959 Hz), which indicates a more backward place of articulation ([9]:140). This is in line with the fact that in the Netherlands uvular fricatives are the most frequent realizations of /ɣ/, whereas in Flanders velar fricatives are the most frequent ones [11, 14].

Tukey's B post hoc test revealed that in the regions N-R, N-N, N-M and F-W /ɣ/ is articulated in a more backward position than in the other regions, where F-E differs significantly from F-B.

The mean resonance frequency of /ɣ/ for men is 1685 Hz, for women 1942 Hz. This gender effect can be explained by the fact that women have a smaller vocal tract than men ([9]: 323). Women's smaller vocal tracts result in resonance frequencies being 5 to 15% higher than men's ([9]:131). The difference found here thus seems to be mainly physiological, which is supported by the finding of only weak gender effects for the other measures.

3.2. Relative duration (RT)

For relative duration, significant main effects were found for community ($F_{1,125}$=23.270; p=.000), region within community ($F_{6,125}$=11.387; p=.000) and gender ($F_{1,125}$=7.987; p=.005). In the Netherlands the ratio ɣ/syllable is higher than in Flanders. Post hoc tests revealed four subgroups: 1. N-S, Flanders; 2. Flanders, N-M; 3. N-M, N-N; 4. N-N, N-R. In N-S and Flanders durations are shorter. N-M is poised between the regions with short and long durations. A north-south distinction seems to be found here: the N-M speakers come from cities near or even between the 'big rivers' which divide the area in a northern and southern part, and therefore show intermediate behavior.

3.3. Relative intensity (RI)

For relative intensity, significant main effects were found for community ($F_{1,125}$=212.873; p=.000) and region within community ($F_{6,125}$=13.936; p=.000);

there was one weak interaction effect for community x age ($F_{1,125}$=4.296; p=.040).

Whereas for all other measures the regional effect was stronger than the effect for community, here the community effect was much stronger: in the Netherlands (ɣ) shows a higher intensity than in Flanders. For /v/ and /z/ similar patterns have been found [7]. Furthermore, within each community, the regions with more uvulars (N-R 100%, N-N 100%, N-M 70% and F-W 50%) show a higher intensity than the regions with a low number of uvulars (≤15%). A post hoc test resulted in three separate groups: in the three Dutch regions N-R, N-N and N-M the highest intensity was found, whereas F-B, F-L and F-E show the lowest intensity.

Furthermore, a significant correlation was found between intensity and resonance frequency (Pearson's r =-.653; p=.000).

3.4. Periodicity (P)

For periodicity, significant main effects were found for region within community ($F_{6,125}$=2.554; p=.023) and gender ($F_{1,125}$=8.512; p=.004), as well as a weak interaction effect for community x gender ($F_{1,125}$=5.945; p=.016). A post hoc comparison for region revealed no significant differences.

Overall, the extent of periodicity is extremely low. Kissine et al. [8] found comparable values for the voiceless fricatives /f/ and /s/. It can be concluded that (ɣ) is realized without vocal cord vibration in both the Netherlands and Flanders.

4. CONCLUSION

This paper describes the acoustics of Standard Dutch /ɣ/. First, it was shown that even in Standard Dutch considerable regional variation is found for resonance frequency, intensity and duration of /ɣ/.

Second, the observations of a north-south distinction in the realization of /ɣ/ were confirmed for intensity, as /ɣ/ shows less intensity south of the rivers. There might be a relationship between intensity and the soft-hard distinction, which is a perceptual and stereotypical distinction made by language users in the Netherlands. The north-south distinction was also confirmed for duration, where N-M is in an intermediate position, and partially for the resonance frequency of /ɣ/.

Third, the results for periodicity confirm that in contemporary Dutch /ɣ/ is voiceless (cf. [3, 10, 11]). The sound described in this paper is generally represented by the symbol /ɣ/ in the Dutch phonological literature (cf. [2]). Our study shows that there is no phonetic ground for this representation as a voiced velar fricative. First, in both the Netherlands and Flanders it is usually realized without vocal cord vibration. Second, the large variation in resonance frequencies reflects (regional) differences in place of articulation ranging from palato-velar to uvular, that are supported by auditory transcriptions (cf. [11, 14]). Uvulars are found most in the Netherlands, velars in Flanders.

5. REFERENCES

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