

# Laryngeal articulations of /x/ in Southern Polish

**Grzegorz Nawrocki**

*Higher Vocational School, Tarnów, Poland*

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The present paper offers a summary of the results of two earlier experiments (Nawrocki and Gonet 2004; Nawrocki 2004), in which acoustic properties of the voiceless velar fricative phoneme /x/ in Southern Polish were investigated.

As is found in both studies (Nawrocki and Gonet 2004; Nawrocki 2004), speakers of both genders favour glottal articulation, with partial or full voicing. Word final contexts are decisively in favour of [x]. The word initial, prevocalic positions seem to allow quite a number of allophonic variants of /x/. These are: [x], [ɦ], [ç] and, additionally, the voiceless glottal, the pharyngeal or the epiglottal [h]/[ħ]/[H]. Another factor taken into account is the coarticulation effect of the vocalic context on the choice of articulation. Based on the results of the experiments, a reformulated allophonic composition is proposed for Polish /x/. It makes room for previously unconsidered pharyngeal and glottal allophones.

In order to inspect the acoustic properties of the allophones of Polish /x/ further, their static and dynamic spectral features are compared to those of phonetically similar sounds in other languages where they have the status of independent phonemes. Special attention is paid to the distribution of spectral peaks and their intensity. The fact that in Polish there are no ‘back’ fricative phonemes that would contrast with /x/ creates a wide range of acceptable allophonic articulations that cannot be challenged from either articulatory or perceptual points of view.

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## 1 Introduction

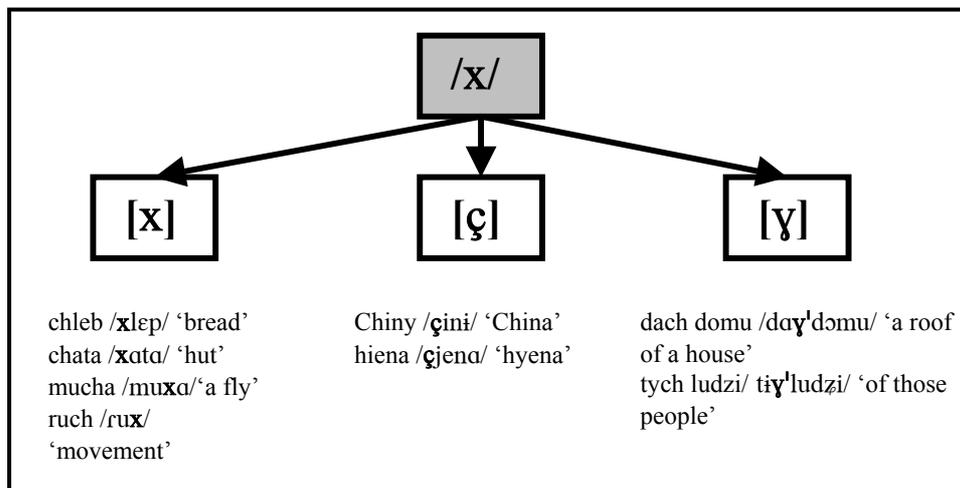
The studies by Nawrocki and Gonet (2004), and Nawrocki (2004) investigated the Polish phoneme /x/ only in the positions close to vowel sounds. Such contexts are known to bring about lenition in many languages.

In his presentation of one-strength hierarchy, Lass (1984:178) shows the direction of the change in manner and, ultimately, place of articulation from plosives to affricates, then fricatives, initially oral, where place of articulation is maintained, to more retracted, glottal. The final stage is the deletion of a segment. Green (2003), in his discussion of phonological lenition in Manx (Green 2003:52-53), includes an example of the process involving Manx /x/ in

word-internal V\_V contexts :  $x > y \sim h \sim \emptyset$  (e.g.  $le:x\grave{a}n \sim le:y\grave{a}n \sim le:h\grave{a}n \sim le:\grave{a}n$  'days'). The variants of Polish /x/ that prevail in word-internal intervocalic positions seem to follow the above principles. Lenited allophones of /x/ are more sonorous because of a wider articulatory channel (Lavoie 2002:44) in contrast to word-initial allophones which are likely to emerge as more salient sounds. The findings of Nawrocki and Gonet (2004) present a challenge to the descriptions of Polish /x/ that view it as a homogeneous element.

### 1.1 /x/ in Standard Polish

Polish phonetic and phonological literature provides descriptions of Polish /x/ as the voiceless velar fricative and from the prescriptivist point of view, such articulation is most desirable in native speakers and recommendable for foreign learners of Polish. The only major allophone of /x/ that occurs before /i/ and /j/ is the voiceless palatal fricative [ç] (Wiśniewski 1998:52), which Wróbel (1995:142) regards as an independent phonological entity. Both authors mention a less common voiced velar allophone [ɣ], in which voicing occurs due to regressive voicing assimilation, both at word boundaries and morpheme boundaries. Figure 1 presents the classic range of positional variants of Polish /x/.

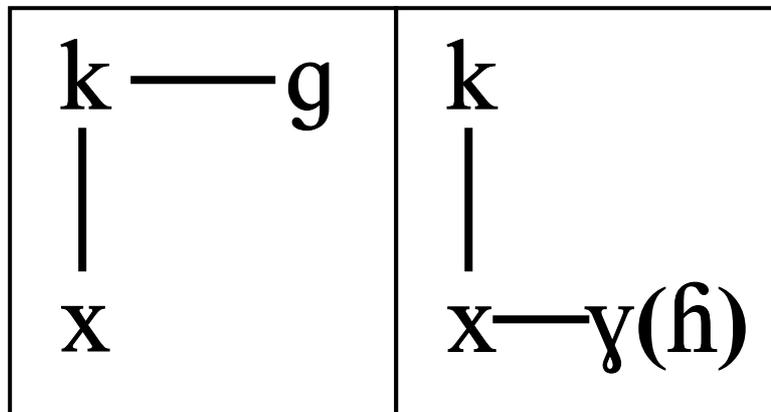


**Figure 1:** Composition of Polish /x/.

The use of the voiced velar [ɣ] is more widely commented on in earlier Polish dialectological literature (Nitsch 1994) together with minor, but more debatable pronunciations, chiefly in relation to {h}-spelling and pre-vocalic positions of /x/. Nitsch (1994:174), however, attributes the differentiation in the production of written {ch} and {h} only to the speech of inhabitants of eastern borderlands of Poland, mainly people of Ukrainian or Belo-Russian origin.

On the whole, {h} is considered by Nitsch as the spelling form confined mainly to loan words (e.g. from Ruthenian 'hałas' 'noise', from German 'hebel' 'plane'.) or onomatopoeic expressions (e.g. 'hm', 'hop',.) (1994:175). In terms of articulation, Ruthenian 'h' is classified as the voiced glottal fricative /ɦ/, whereas the German fricative consonant as the voiceless glottal /h/. Nitsch treats the glottal variants as rather unlikely in Polish, and argues against the instances of the glottal variants, reportedly attested in the region of the Tatra Mountains, defining the articulations as 'weak velar' ones.

The proposed 'weakness' of the Polish /x/ receives thorough attention in Stieber's account of Proto-Slavic /x/ (1974:104,105). Since, historically, /x/ had no contrastive correspondent phoneme in the velar region, spirantization of /g/ took place in order to fill the gap (see Figure 2).



**Figure 2:** Development of Proto-Slavic /x/ and the change of /g/ to /ɣ/(/ɦ/). The left box shows the situation in proto-Slavic and Modern Polish. The right box shows the change in Byelo-Russian, Ukrainian, Southern Russian, Czech, Slovak, Upper Sorbian dialects (Stieber: 1974:104).

In Polish, however, the change from /g/ to /ɣ/(/ɦ/) did not occur and /x/ remained uncontrasted, which led to its variable articulations. Stieber defines Polish /x/ as a weakly pronounced lenis velar consonant (1974:105). This 'weakness' of /x/, according to Stieber, applies to the whole of the Polish territory. Stieber comments on the fact, that Czechs and Slovaks automatically identify Polish /x/ 'rather with their own voiced laryngeal lenis *h* than with the Czech velar unvoiced and fortis *x*' (1974:105). Such an identification seems to support the findings of Gonet and Nawrocki (2004) and Nawrocki (2004).

Stieber goes on to mention the loss of word-initial pre-consonantal, word-medial intervocalic, and word-final /x/ in the most southern part of Poland (1974:105). An alternative possibility is mentioned, namely the substitution of /x/ with /f/, but only in word-initial and final position. /x/ may also be replaced with /k/ in word final position (Stieber; 1974:105). No examples of a

replacement of intervocalic word-internal /x/ with /f/ have been reported, however. I remember hearing pronunciations like ‘w Tychach [f'tɨfɨf]’ (‘in Tychy’), while visiting the area of Polish Spisz, or ‘pojechał do nich’ [p<sup>w</sup>ojɛ.ɔw 'dɔɲik] (‘he went to them’) which I have heard in broad local dialects outside Tarnów.

## 1.2 Acoustic features of the voiceless velar fricative [x]

The voiceless velar fricative sound [x] is defined as articulated with the back part of the tongue forming a narrow channel with the velum. The air pushed vigorously through the narrow dorso-velar channel produces sharp friction.

Cross linguistic studies (Gordon, Barthmeier, and Sands 2001) reveal close similarity of the spectral features of [x]. The data for Western Apache, Scots Gaelic, Western Aleut, Hupa show that the maximum energy is concentrated at or slightly below 2 kHz. Jassem (1972) points at the second formant of [x] as the dominant among all fricatives as regards its intensity. The second visible, but a less intense frequency peak is located at 4kHz for Western Apache, Scottish Gaelic, Western Aleut and at 5kHz for the Hupa, whereas the last observable energy maximum falls between 6 and 7 kHz (Gordon et al. 2001:8).

Very similar properties are mentioned by Lavoie (2002:48) to be typical of the Spanish [x], where the fricative noise is said to be concentrated at 2 and 4 kHz. Jassem additionally refers to the first formant of [x] at 0.5kHz about which the others remain silent, probably because its intensity is the weakest (1973:223) and therefore it may not be visible in the spectrogram. According to Jassem, formant level values for F<sub>1</sub>, F<sub>2</sub>, F<sub>3</sub>, F<sub>4</sub> of [x] are -12, 0, -10, and -17dB respectively (1973:225). Jassem does not, however, mention formants at values higher than 4 kHz and allocates the frequency level for F<sub>3</sub> at 2.5 kHz. Such a peak is omitted in the descriptions presented by Gordon et al. (2001).

What seems to transpire from the accounts presented above is a peculiar spectral image of [x]. Depending on the intensity of articulation, individual properties of a speaker’s articulators and on the quality of the recording one should see 1, 2, or at best 3 isolated bands in the spectrum of the voiceless velar fricative. They should be located at approximately 2, 4-5 and 6-7 kHz. Jassem’s study also includes noise range values for the spectrum of [x]. At -20 dB the span of visible frequencies’ extends from 0.3 – 7 kHz, and noise 30 dB weaker than the maximum peak is detectable in the range of frequencies from 0 – 12 kHz (1973:225).

As the two studies (Nawrocki and Gonet, 2004; Nawrocki, 2004) show, what speakers in Southern Poland articulate where [x] is expected is often radically different from the ideal pattern.

## **2 Results of the two studies of Southern Polish /x/**

### **2.1 Informants, method and equipment**

The study by Nawrocki and Gonet (2004) based its findings on audio material gathered from 16 informants, 8 female and 8 male speakers, aged between 20-40. All of them were students of English at the Higher Vocational School in Tarnów, Southern Poland. Most of the informants were inhabitants of the town and its vicinity at the distance of up to 20 km. Among the women, 3 were born and lived in towns quite considerably removed from Tarnów, namely Dębica, Rzeszów, and Przemyśl. The areas represented by these locations stretch to the east and, ultimately, the south-east of Tarnów in the direction of the Ukrainian border.

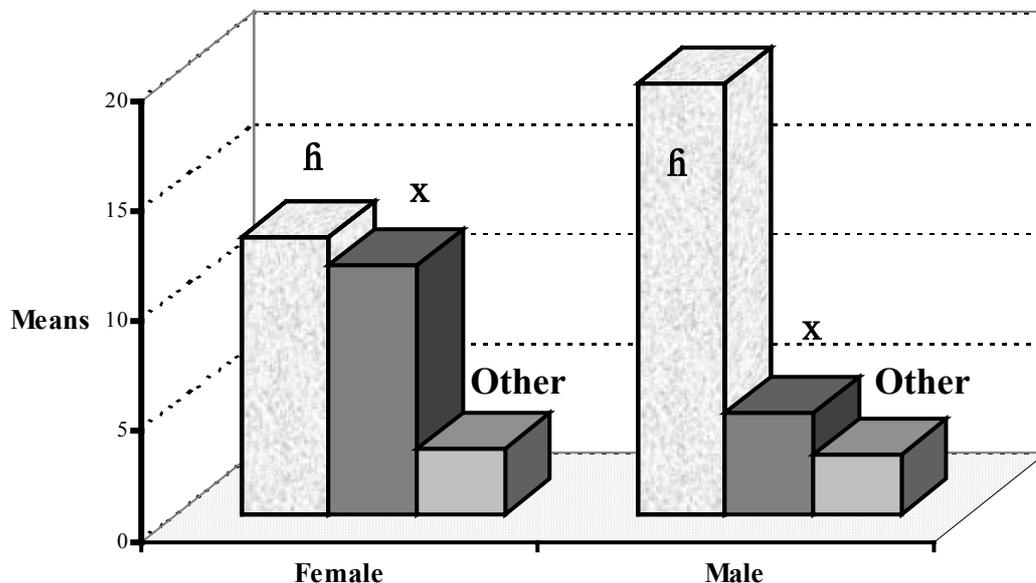
For the first study, the informants recorded 27 Polish words, all containing the phoneme /x/, spelt with {ch} in word-medial position between vowels. The items, placed in random order, were read by the informants and recorded in a small classroom setting using a dictaphone, at a sampling frequency of 20 kHz. The samples were later digitalized at 44 kHz in preparation for acoustic analysis, which was preliminarily carried out using SFS/Wasp 1.0 software. A more detailed spectrographic analysis was subsequently performed with the use of Speech Analyzer 1.5.

Due to the fact that the group of the female informants for the first experiment was not quite uniform as regards their whereabouts, the study by Nawrocki (2004) was focused only on female speakers. Furthermore, the impact of the vocalic environment was investigated. The group of women was this time made fairly homogeneous, representing the areas close to Tarnów, not more than 20km away from the place. The number of informants was increased to 11 in order to allow for more reliable statistical analyses. The reading list contained 69 words in which /x/ was found in all possible vowel contexts and desirable word positions (i.e. #\_V, V\_V, V\_#). There was a fairly representative list of words with word-initial {h} to check the influence of spelling on the choice of articulation. In order to enhance the quality of the tested material, a W-10 Olympus Digital Voice Recorder was used at the sampling frequency of 15.5 kHz. Preliminary auditory and visual identification of the fricative articulations was carried out using Speech Analyzer 1.5. The articulations for which less typical spectrograms were obtained had to be further looked into using Praat 4.2.05 software. Spectral slices were obtained for the central part of each fricative in order to measure the frequencies of spectral peaks.

## 2.2 Predominant pronunciations among male and female speakers

Both studies (Nawrocki and Gonet 2004; Nawrocki 2004) revealed an overwhelming preference for non-velar pronunciations in most positions in a word. The prevailing variant among these allophones appeared to be the glottal fricative [ɦ], either partially or fully voiced. Its spectra were relatively easy to identify because they are meant to mirror the formant structure of the neighbouring vowel sounds (Gimson 1989:180).

A two-way ANOVA test ('Sex' by 'Pronunciation type') showed highly significant variation for pronunciation types:  $F=37.63$   $F(2:42)=8.17$  at  $\alpha = 0.001$ . The interaction between sex and pronunciation type was also significant:  $F=9.97$   $F(2:42)= 8.17$  at  $\alpha = 0.001$ . Figure 3 illustrates means for each pronunciation type in both groups of speakers in the first study. Articulations that were not classified as either glottal or velar were labeled 'other'.

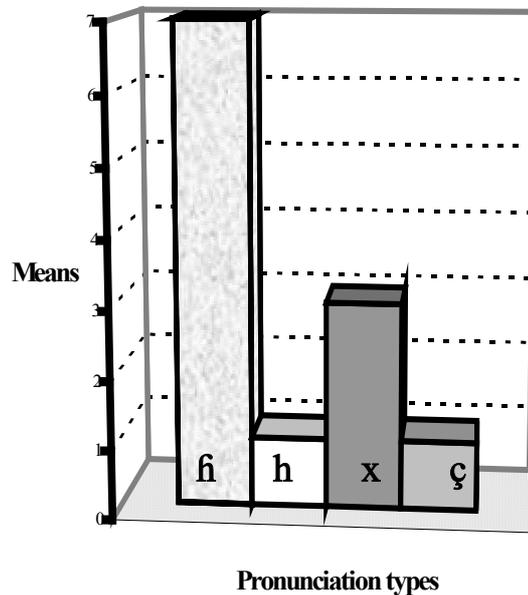


**Figure 3:** Means of the number of tokens for each fricative articulation in intervocalic contexts in the Interaction 'Sex' by 'Pronunciation Type' (Nawrocki & Gonet; 2004).

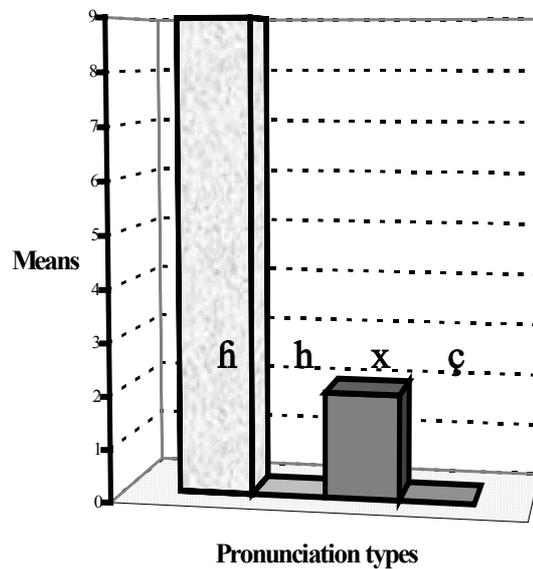
As can be seen in Figure 3 the glottal pronunciation appear to be characteristic of men, whose speaking habits have been observed before in various studies by Cruttenden (2001), Gonet and Gawrońska (2003), Gonet and Różańska (2003) as more innovative and less conservative than women's.

The results of the study by Nawrocki (2004) radically undermine the low occurrence of the glottal /ɦ/ in intervocalic position in female speakers obtained in the study by Nawrocki and Gonet (2004). Means for articulation types

(Figure 4) indicate clear dominance of the glottal allophone [ɦ] in female speakers.



**Figure 4:** Means of the number of tokens for each fricative articulation in all contexts in female informants (Nawrocki; 2004).



**Figure 5:** Means of the number of tokens for each fricative articulation in for V\_V contexts in female informants (Nawrocki; 2004).

In word-internal intervocalic contexts, the glottal variant towers over the remaining variants (Figure 5 ) to the degree that resembles the data for males from Nawrocki and Gonet (2004). It seems, after all, that both genders prefer the glottal articulation in V\_V contexts. There is a total lack of either fortis

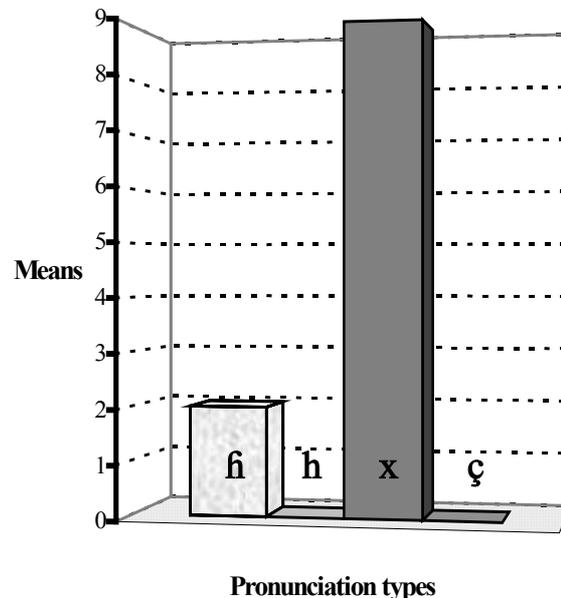
voiceless glottal /h/, or the palatal /ç/. A one factor ANOVA test has shown highly significant difference for pronunciation types:  $F=55.19$   $F(3:204)=5.62$  at  $\alpha=0.001$ .

Other articulations that were identified in both studies, especially the voiceless velar [x], the voiceless palatal [ç], and the voiceless fortis [h] were found more frequently in #\_V and V\_# contexts, the latter definitely favouring [x].

### 2.3 Minor articulation types and the influence of word and vocalic context

The identification of the velar fricative [x] from its spectrograms was fairly straightforward. It was based on the existence of an intense peak at around 2kHz, and occasionally an extra one at approximately 4kHz. The spacing of the peaks of [x] was not influenced by the vocalic context.

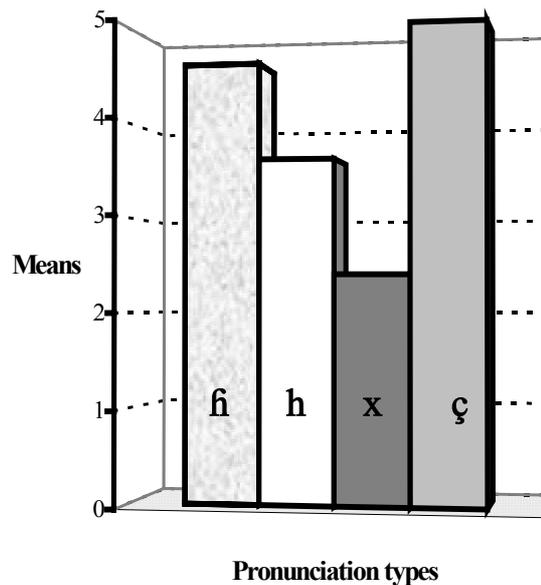
Although [x] occurred relatively rarely in V\_V contexts (cf. Figure 5), it was the most common variant in word-final position. Non-word-internal locations of /x/ were the subject of investigation in Nawrocki (2004). As may be seen in Figure 6, the mean for the velar variant is 9 as compared to 2 for the glottal one, with other articulations scoring zero. A one-factor ANOVA test shows highly significant differences for pronunciation types in word-final position:  $F=315.35$   $F(3:24)=7.55$  at  $\alpha=0.001$ .



**Figure 6:** Means of the number of tokens for each fricative articulation in word-final position in female speakers (Nawrocki; 2004).

The variation within individual speakers is not significant. As a matter of fact, 7 out of 11 speakers pronounced the final /x/ as invariably velar, and for 2 speakers there were single instances of the glottal fricative. Two remaining speakers pronounced mostly [ɦ] with more or less voicing.

The context that was the richest in allophones of /x/ was the word-initial pre-vocalic position. There were four major articulation types, namely [x], [ɦ], the voiceless palatal [ç] and also voiceless fortis glottal [h]. Figure 7 presents means for each articulation type.



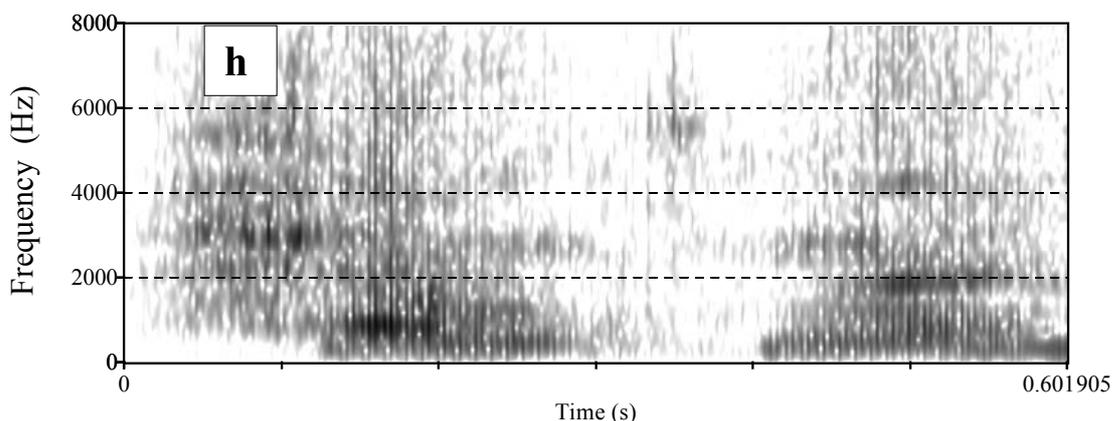
**Figure 7:** Means of the number of tokens for each fricative articulation in word-initial position in female speakers (Nawrocki; 2004).

A two-way ANOVA ('Speaker' by 'Word-initial articulation type') has proved significant variation for the initial {h}-spelling;  $F=4.91$   $F(3:30)=2.92$  at  $\alpha=0.05$ . The difference between the informants and within the {ch}-spelling was not significant. An additional one-factor ANOVA test proved that the overall impact of the two spelling forms on the choice of pronunciation was not significant (for {ch}  $F=0,21$   $F(3:15)=2.48$  at  $\alpha=0.1$  and for {h}  $F=0.78$   $F(3:24)=2.32$  at  $\alpha=0.1$ ).

A relatively high occurrence of [ç] in the initial position may be owing to quite a number of words with /j/ following initial {h}; 4 vocabulary items per 9 contained the palatal glide. This factor might have caused the significance in the differences in pronunciations with initial {h}, but not with {ch}, after which the sequences /ja/, /je/, /jo/ simply do not occur and hence the number of palatalizing contexts is limited. In the vocabulary list there were 4 items where /ç/ occurred invariably in all 11 speakers. These were: 'Chiny' ('China'),

‘hiacynt’(‘hyacinthus’), ‘hiena’(‘hyena’) and ‘Hiob’ (‘Job’). Before /i/ and /j/, [ç] appears regularly, and alternative pronunciations are hard to come across.

Yet another articulation type, common in all word positions, the voiceless fortis glottal fricative /h/, has so far been left unaccounted for. Judging by the difference in the spectrograms of the two ‘glottal’ allophones there would be no reason to treat them as identical pronunciation type. As can be noticed in Figure 8 the label ‘h’ seems to stand for two separate sounds.



**Figure 8:** Spectrogram of ‘chętny’(‘willing’) pronounced by a female speaker.

Both subvariants, still labeled as ‘h’ in the second study are characterized by strong noise frequencies and a complete lack of voicing, which completely distinguishes them from [ɦ]. They are clearly voiceless and fortis, but the fortition or intensity of friction is markedly stronger in the variant presented in bottom left part of Figure 8. What this might suggest is a slightly different place of articulation of the second ‘h’. While the first one has the noise bands that imitate the formant structure of the following vowel, the other one has much more densely concentrated noise peaks with a noticeably robust peak at around 3kHz. Compared with the acoustic properties of the voiceless pharyngeal fricative [ħ] given by Jassem (1973:225), the sound seems to be a fricative articulated with a considerable constriction of the pharynx, and hence it is classified as [ħ] in later part of the present paper.

### 3 Further analysis – Polish versus foreign ‘back’ fricatives

#### 3.1 Method

In order to have a closer insight into the spectral properties of the individual allophones of /x/, audio samples were selected from the material from Nawrocki (2004). For each allophone, three vowel contexts were chosen: mid-front /ɛ/, low /a/, and mid-low back /ɔ/. Each sample had an average duration

of 100 ms and represented the most stable part of the spectrum. The fricatives were isolated from words using Praat 4.2.05. Spectrograms were obtained using Wavesurfer 1.6.4 in Hamming window of around 60 points size. Grid frequency spacing was set at 1000 Hz for easier identification of noise peaks. Then FFT spectra were obtained from individual samples with the use of Praat for clearer recognition of spectral peaks' frequency values. Lower frequency peaks could easily be traced in logarithmic type of FFT spectra. Next, Center of Gravity values were calculated from FFT spectra. Additionally LPC smoothing was performed on individual FFT spectra with the number of peaks set at 5 in order to compare the spectral images of all samples in individual group. The samples representing fricative consonants from other languages were drawn from audio files that accompany 'Handbook of the IPA' (2002).

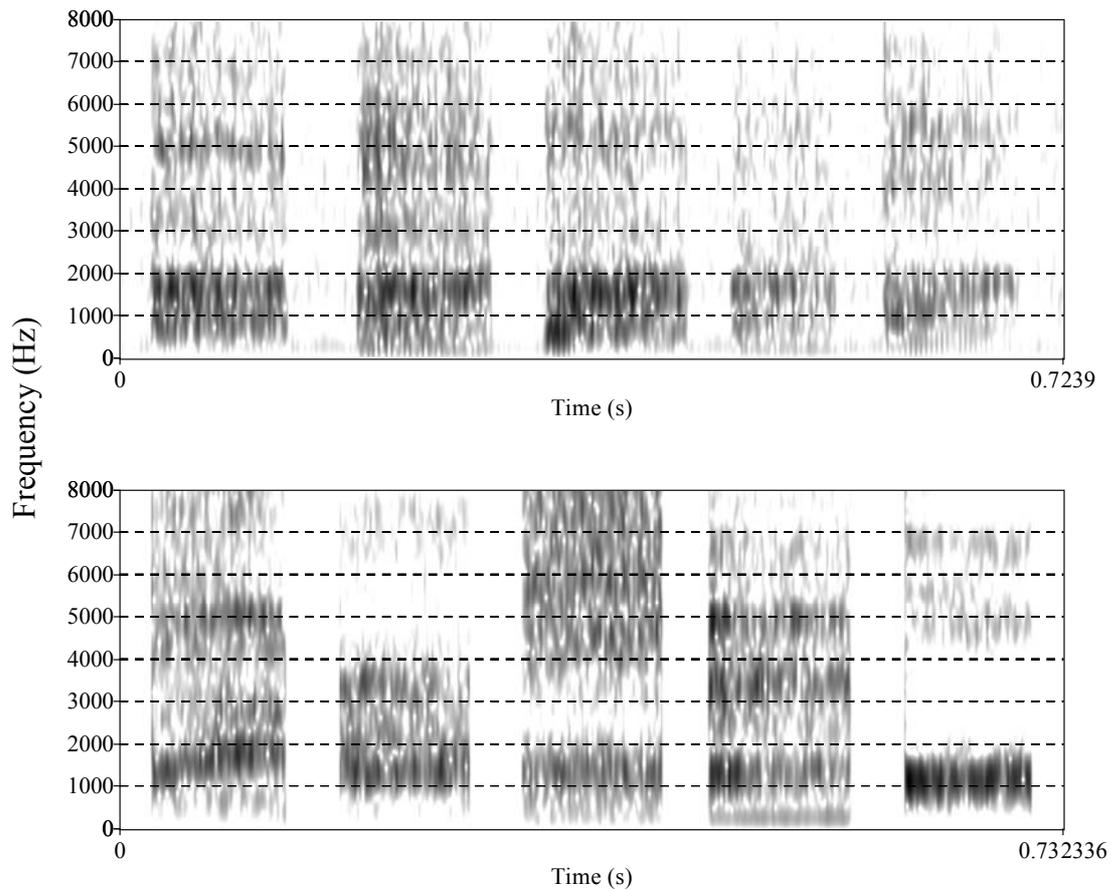
## **3.2 Spectrograms and LPC spectra**

### *3.2.1 Samples representing the velar variant [x]*

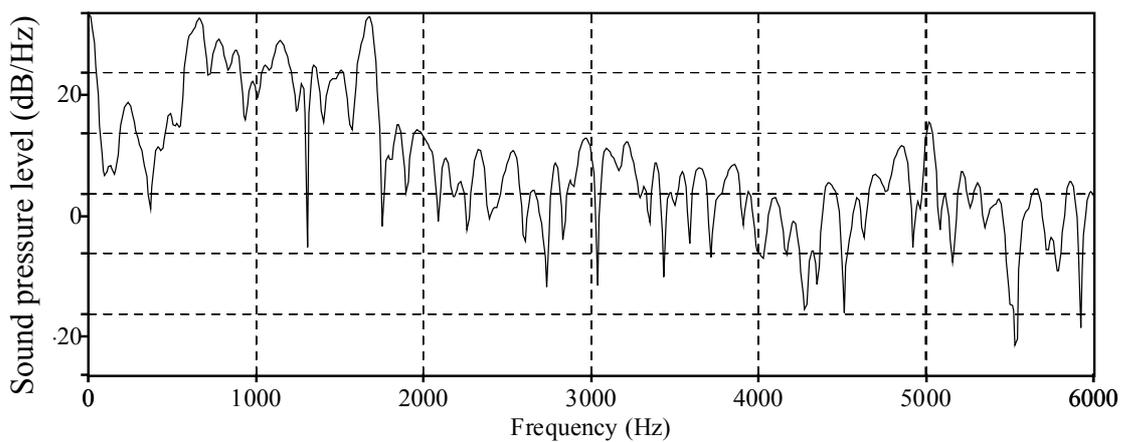
Samples representing the velar variant [x] were isolated from words where they appeared in the final position after /i/, /ε/ and /a/. The number of peaks that were clearly visible in spectrograms ranged from 1-2, at times 3. This complies with the number of frequency bands visible in the spectrograms representing phoneme /x/ in five randomly chosen languages (see Figure 9).

The FFT and LPC spectra of Polish [x] reveal the highest peaks located at 1.8-2 kHz and around 5 kHz. The lower noise peak has an average amplitude from -15 to -30 dB. The spectra of the foreign [x] differ only slightly from Polish. The first visible peak is found even at 1.5 kHz and there is also an additional peak at 3.5 kHz (German, Scottish Gaelic) or 4.5 kHz (Irish and Slovak). Logarithmic FFT spectra show yet another markedly noticeable spectral peak at 0.5 kHz ( $F_1$ ), mentioned by Jassem (1973:225). Its close proximity to  $F_2$  makes it hard to distinguish in normal spectra and spectrograms of [x].

Generally speaking, Polish [x] seems to share spectral cues with similar fricatives that exist in other languages. Its spectral parameters generally coincide with the cross-linguistic data presented in 1.2 above.



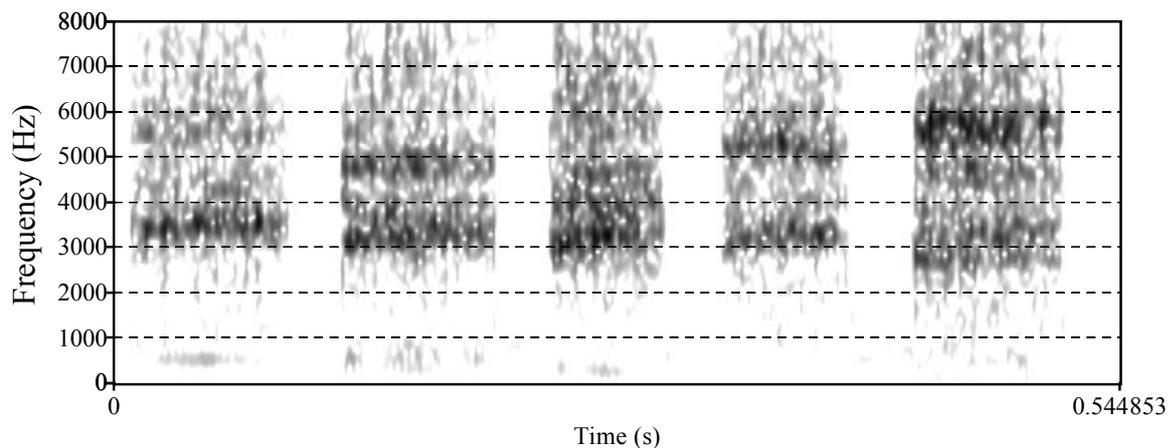
**Figure 9:** Spectrograms of Polish and foreign [x]. Top part: Polish [x] in the position after /a/ for five speakers. Bottom part: foreign [x] (Cz. ‘moucha’ ‘fly’, Ger. ‘Macht’ ‘power’, Ir. ‘chaol’ ‘thin(fem.)’, Sc.G. ‘biodach’ ‘tiny’ Sl. ‘dvoch’ ‘two(dat.)’).



**Figure 10:** FFT spectrum of Polish [x] after /a/.

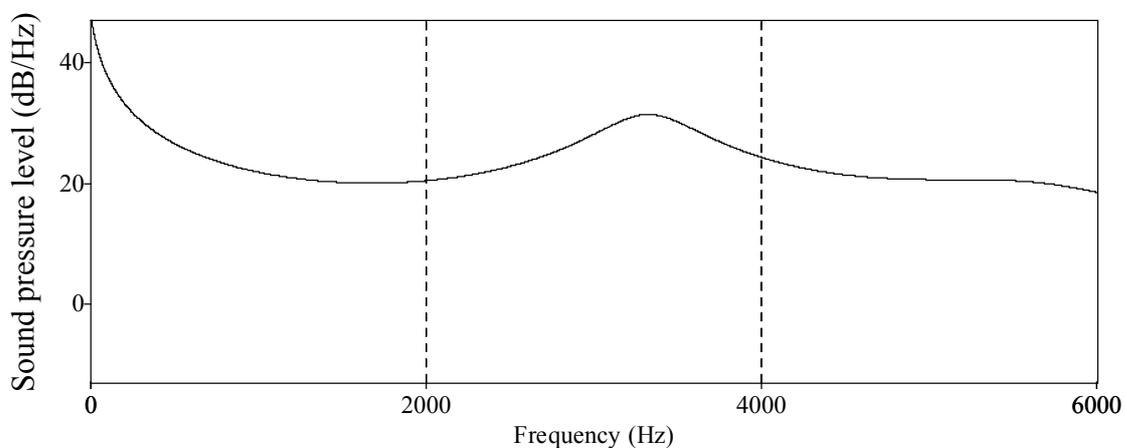
### 3.2.2 Samples representing the voiceless palatal fricative [ç]

The spectrograms of [ç] are radically different from those representing the velar variant (see Figure 11). There is barely any noise below 3 kHz and the friction range stretches from 3-6 kHz. The intensity of friction varies depending on the force of articulation of individuals. The faintest bands are at 20 dB, while the strongest ones reach even 80 dB.  $F_1$  does not exist, or is not detectable (cf. Jassem 1973:225). The number of visible peaks varies from 2-3.



**Figure 11:** Spectrograms of Polish [ç] in the position before /jo/.

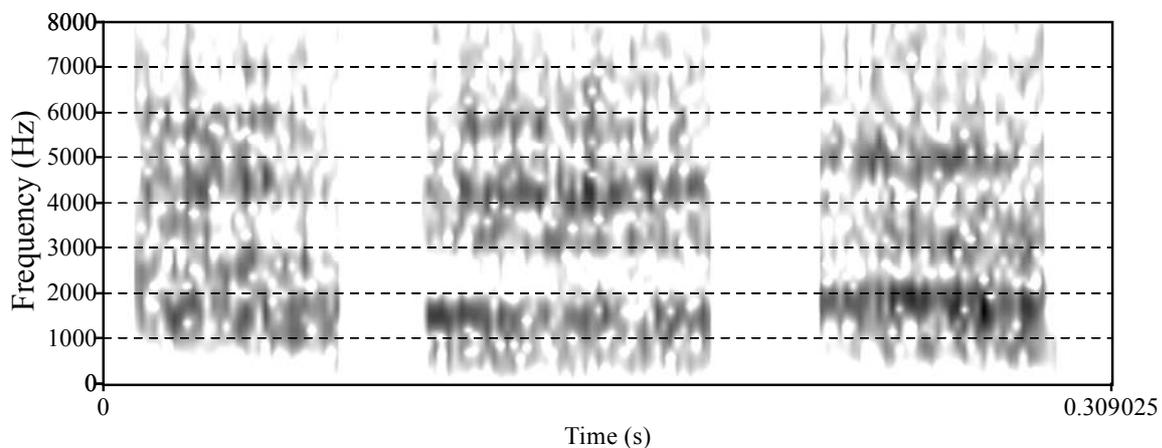
Smoothed LPC spectra of Polish [ç] display mostly two peaks located at 3-4 and 5-6 kHz (Figure 12). There is not too much difference in intensity between the frequency maxima and the distance between them is rather small.



**Figure 12:** Smoothed LPC spectrum of Polish [ç] in the position before /ja/.

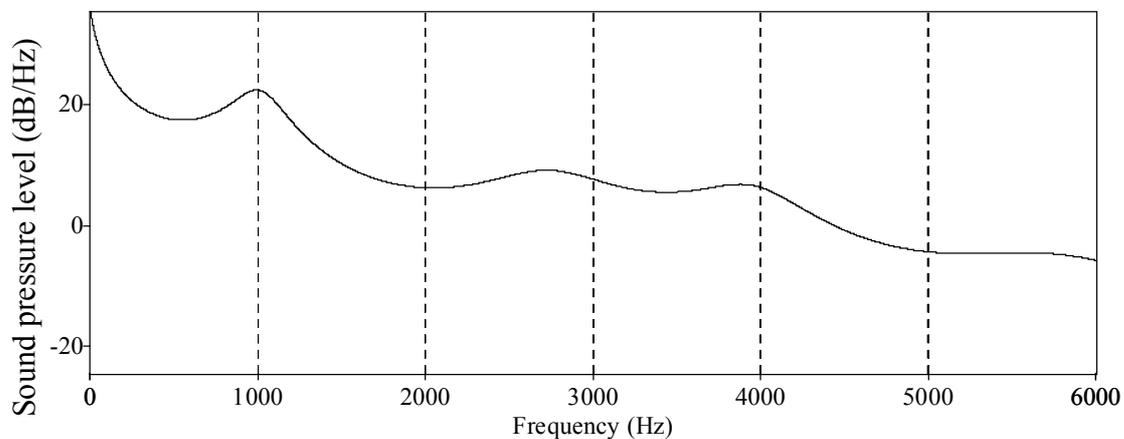
### 3.2.3 Samples representing the voiceless glottal fricative [h]

Polish voiceless glottal fricative [h] was identified only in word-initial, stressed position. The sound was analyzed only in the position before vowels /ε, a, ɔ/. As can be noticed in Figure 13, the pattern appears to be scattered and variable even before vowel of very similar quality. Such an irregular arrangement of spectral peaks and their relative robustness make this variant markedly different from the palatal and velar allophones of /x/ that are more stable in this respect. Strong noise and syllable-onset position of voiceless glottal /h/ may be dictated by high articulatory effort of the speakers who produce this variant.



**Figure 13:** Spectrograms of Polish [h] in word-initial position before /a/.

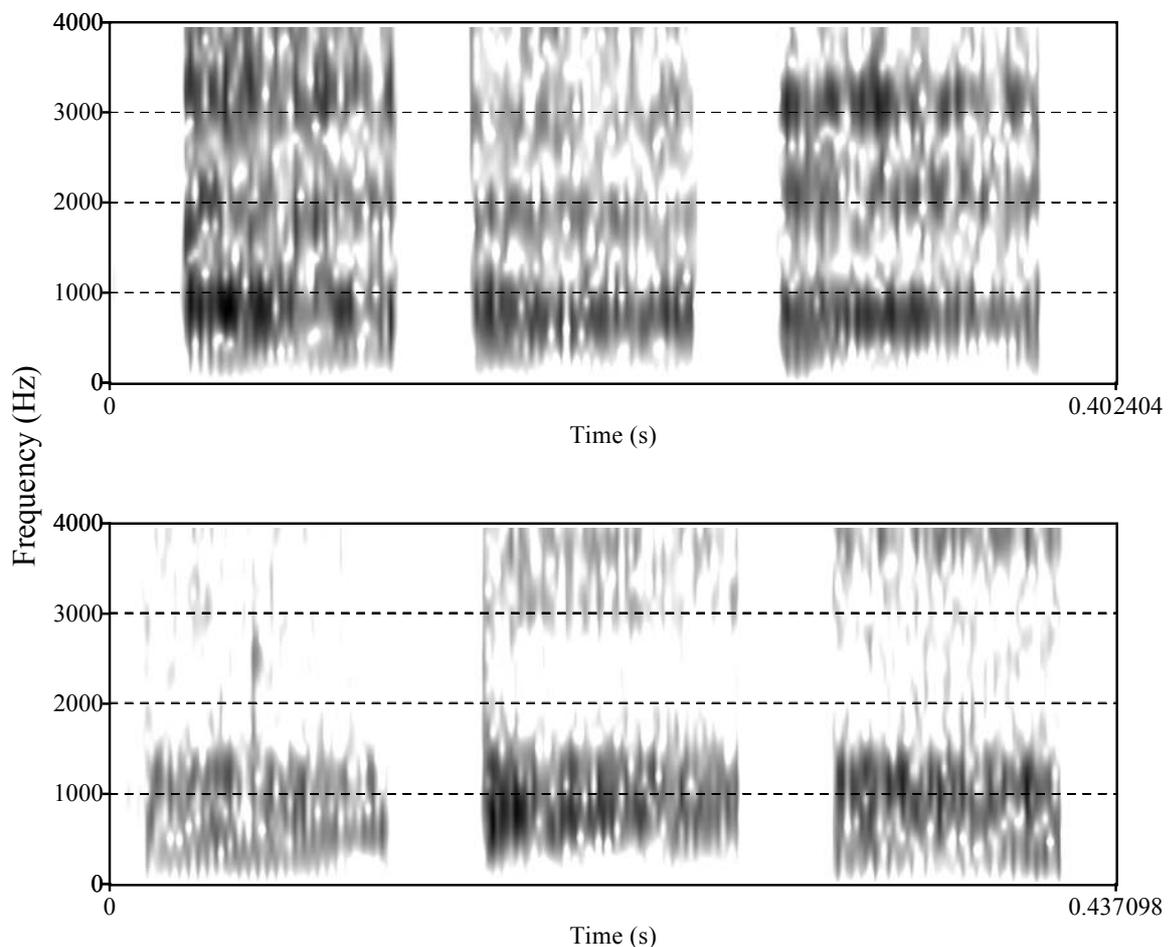
The smoothed LPC 10-peak spectra of Polish [h] indicate a peculiar spectral nature of the sound (see Figure 14). The sound appears in word-initial stressed position before a vowel. Therefore, a voiceless breathy onset of the following vowel sound seems to form strong articulatory grounds for the glottal voiceless [h] to figure as an allophone of /x/ in this context. Spectral features of [h] are quite outstanding in comparison to the variants that have been discussed so far.



**Figure 14:** Smoothed LPC spectrum of Polish [h] in the position before /ɔ/.

### 3.2.4 Samples representing the voiced glottal fricative [ɦ]

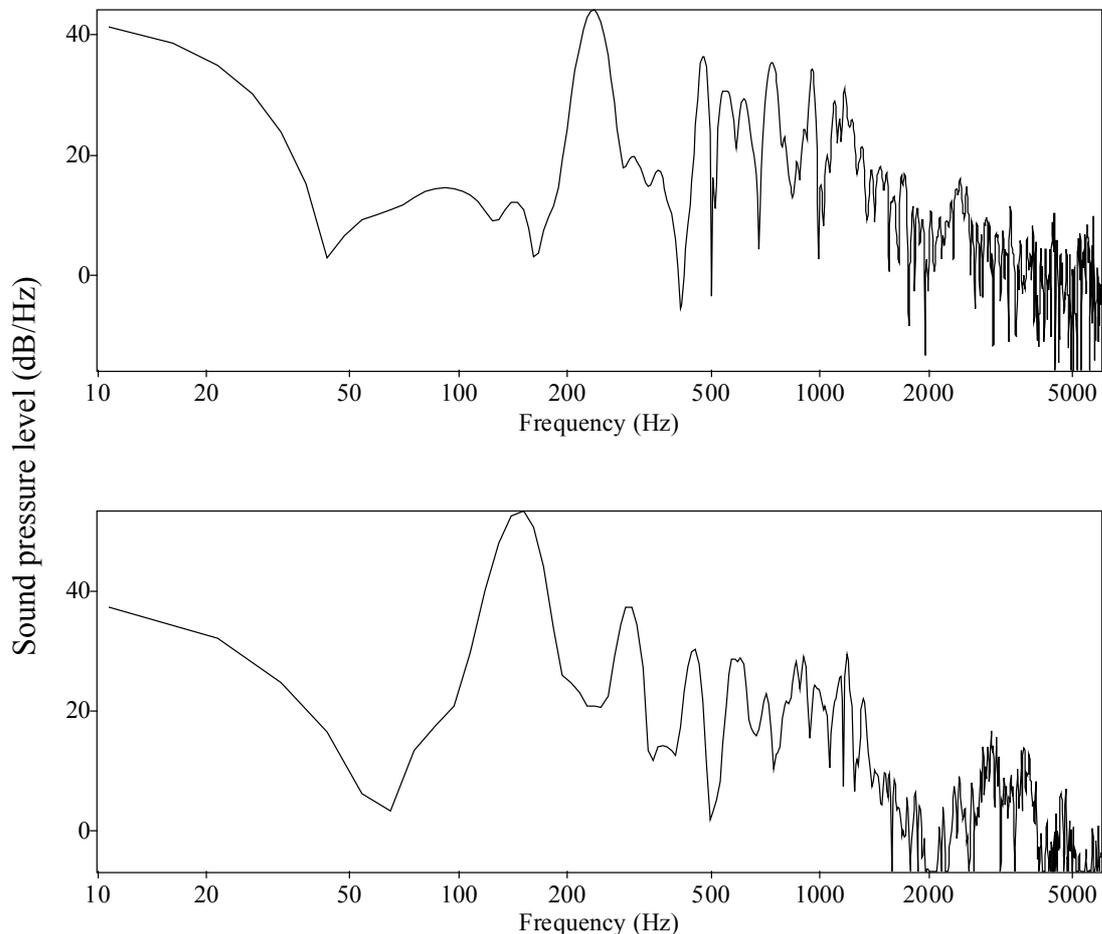
The samples for spectrograms presented in Figure 15 were isolated from the intervocalic position in the investigated material. The flanking vowels that were chosen were /ɛ/, /a/, and /ɔ/. As can be observed in both parts of Figure 15, friction in [ɦ] presents two different patterns. In the left-hand part the fricative stands in the  $\varepsilon\_ \varepsilon$  context and may be interpreted as a breathy voiced [ɛ̤]. The right-hand part of Figure 15 shows the formant structure of the fricative resembling the mid-low back vowel /ɔ/, which precedes and follows [ɦ]. Hence the fricative may be regarded as breathy voiced [ɔ̤].



**Figure 15:** Spectrograms of Polish [ɦ] in word-medial position in two different vocalic contexts. Top part : [ε\_ε], bottom part: [ɔ\_ɔ].

Unlike in the spectra of [h], the voicing in [ɦ] is present in the form of an additional peak at around 200 Hz. The top part of Figure 16 presents the logarithmic FFT spectrum of an example of Polish voiced glottal fricative in the  $\alpha\_ \alpha$  environment. The bottom part shows the spectrum of a similar sound taken from a recording of the Dutch word ‘hoed’ (‘hat’). The peak representing a glottal pulse in the Dutch fricative is situated at 100 Hz. The intensity of  $F_0$  is

very high, 50 dB, and dominates the remaining spectral peaks. The spectrum of the female voice pronouncing the Polish fricative has  $F_0$  located at 200 Hz, but of lower intensity. It manifests a higher fundamental frequency.



**Figure 16:** Logarithmic frequency FFT spectra of Polish (top) and Dutch (bottom) [fi].

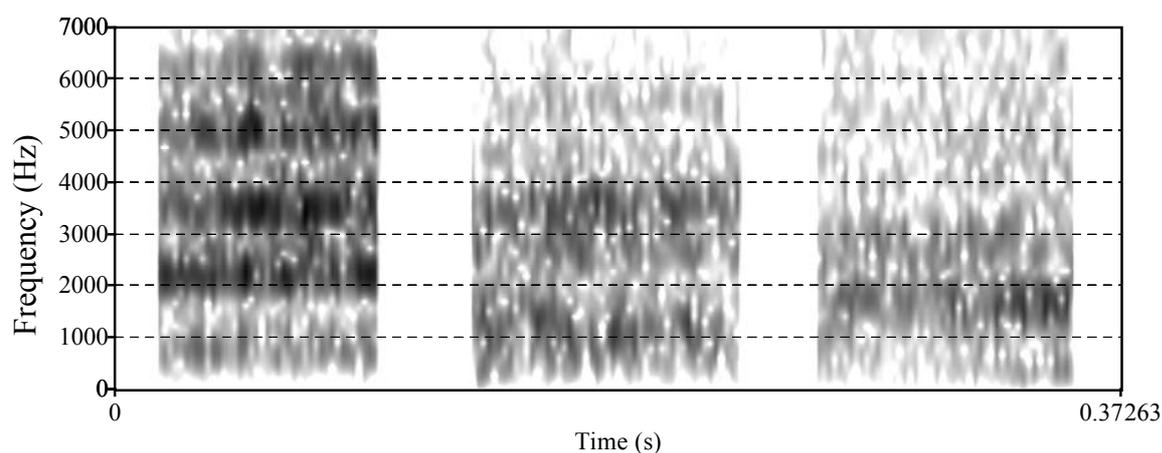
One might assume that, because of the fact that  $F_0$  is not the dominant peak in the example of the Polish [fi], voicing is not the distinctive feature in the pronunciation of the Polish sound

Similar maximum  $F_0$  was observed in the spectra of the remaining foreign voiced glottal fricatives, taken from Slovak, Czech, and Ukrainian. All have the status of a phoneme in those languages. Unlike in English, where [fi] is merely an intervocalic allophone of /h/, in the three languages (i.e. Slovak, Czech, and Ukrainian) /fi/ acts as an independent phoneme. The voiceless /h/ is, in fact, absent in phoneme inventories of the three languages. /fi/ originates here from proto-Slavic /g/, and is phonetically enhanced by contrast with /x/ (Stieber: 1974:104). That is why Czech, Slovak, or Ukrainian /fi/ may strike the ear as ‘more voiced’ than the Polish intervocalic allophone [fi].

Recapitulating, as regards Polish and foreign spectral images of [ɸ], the Polish variant differs from the latter only in voicing, fortition (or articulatory strength) being rather of secondary importance. In Polish, however, /ɸ/ was the most frequent variant in the inter-vocalic position, to which it owes its voiced character.

### *3.2.5 Samples representing the voiceless pharyngeal fricative [ħ]*

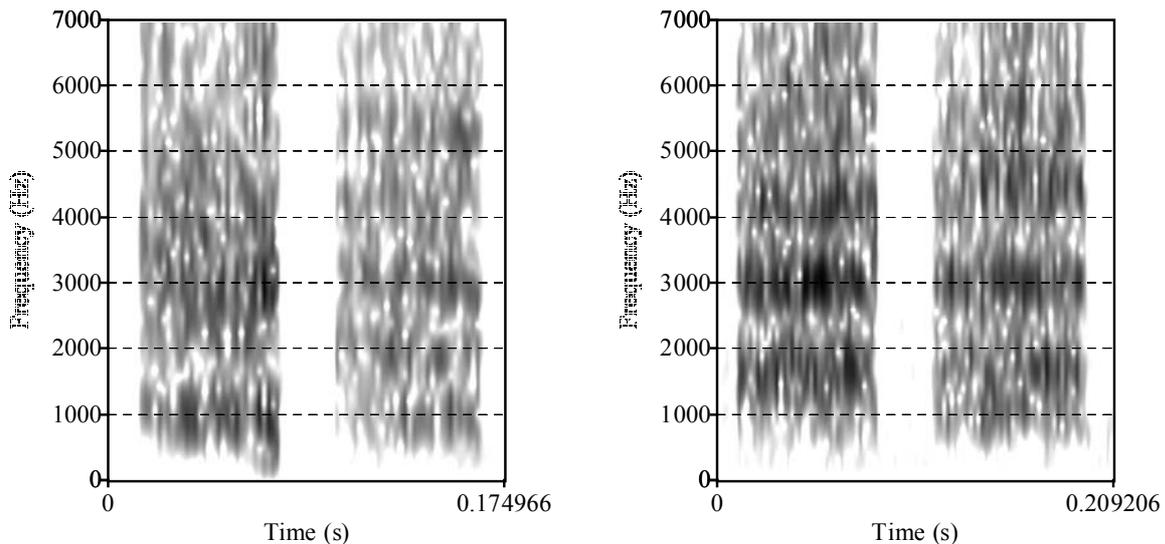
The voiceless pharyngeal fricative /ħ/ exists as a phoneme in only a few languages. Three such languages have been chosen for spectrographic illustration, namely Arabic, Hebrew and Agul (see Figure 17). The location of fricative noise agrees only roughly with the data from Jassem (1973:225), who locates the most intense peaks at 3.1 and 4.2 kHz with a weak one at 0.9 kHz. There seem to be other intense peaks in the spectrum of the Arabic consonant.



**Figure 17:** Spectrograms of foreign [ħ] (Ar. 'ħuruwb' 'wars', Heb. 'maħar' 'tomorrow', Ag. 'muħar' 'barns').

The study by Nawrocki (2004) attempted to label quite a large number of variants of [h] as 'epiglottal'. Yet, in view of the fact that hardly any language, apart from Agul, contrasts epiglottal and pharyngeal fricatives, the label has been discarded. Nevertheless, in word-initial pre-vocalic stressed positions, spectra of a fricative consonant of a more salient type than that of [h] were discovered. That is why, though not a very typical articulation in Polish speakers, [ħ] must not be ignored in the present study.

The sound was examined in the position before /ɛ, a, ɔ/. As seen in Figure 18 the fricative energy is thickly distributed all over the spectrum and most of the peaks are of high intensity.



**Figure 18:** Spectrograms of Polish [ħ] in the position before /ɛ/ (left) and /a/(right).

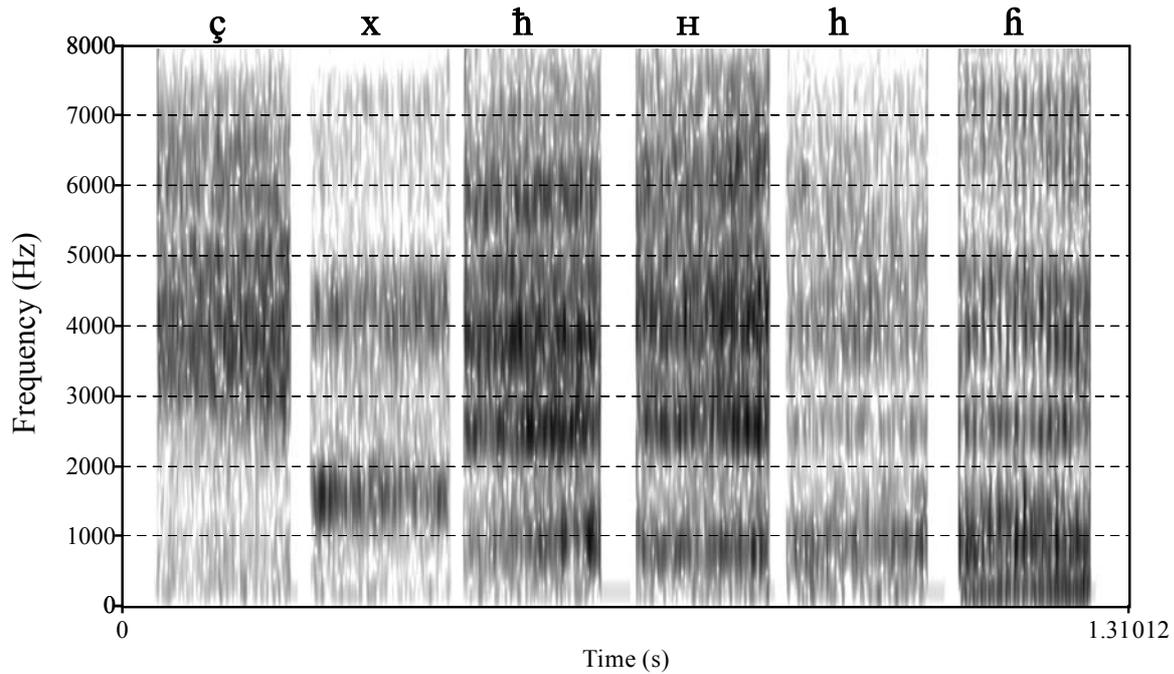
Maximum energy seems to be located at around 3kHz, which coincides with frequency values of  $F_3$  and  $F_4$  in Jassem's description of [ħ] (1973:225). Compared with the glottal [h] discussed earlier, [ħ] has a spectrum independent of the vowel context and the intensity of the noise is much higher, 40-50 dB. For [h], noise values were lower, 15-45 dB.

## 4 Conclusions

### 4.1 The proposed labeling of allophones of Polish /x/

Among the five allophones suggested for Polish /x/ in the present study, the voiceless palatal [ç] is invariably determined by the presence of the following high vocoid. As can be seen in Figure 19, the difference between the spectrograms of [ç] and [x] is quite radical. The movement of the tongue towards the palate in preparation for /i/ or /j/ appears to be a type of assimilation found in all speakers.

The relative difficulty of pronunciation of [x] makes it an unlikely candidate for all possible contexts. In fact, in both studies for male and female speakers (Nawrocki and Gonet 2004, Nawrocki 2004), [x] was the dominant type of articulation chiefly in the post-vocalic word-final position. In V\_V context, [x] was preferably replaced by the voiced glottal [ɦ].



**Figure 19:** Spectrograms of six model fricatives pronounced by the author in a\_a context.

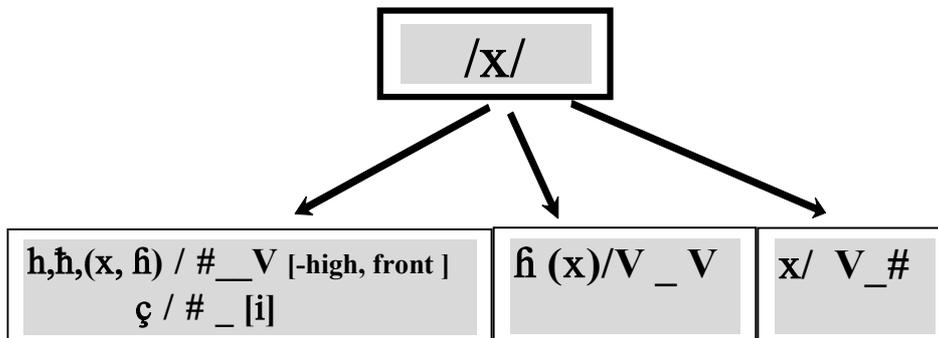
Word-initial positions require more salient allophones, and the strongest friction noise distributed over a relatively wide frequency range appears in the pharyngeal fricatives. Even the voiceless glottal [h] wins over [x] in this respect. Polish speakers opted for the glottal, at times pharyngeal, variant. One might assume that, in many cases this was a glottal friction, reinforced by a variable, and perhaps partial, pharyngeal constriction. The strength of the friction achieved in this manner, made the word-initial variant easily perceptible. Such an allophony might be expected from the reports of authors like Nitsch and Stieber, although they are not clear about the possibility of intervocalic laryngeal pronunciations of /x/. Yet, they report the loss of /x/ in such context, which might not possibly occur without an intermediate phase of laryngeal articulation (Lass 1984:178).

#### **4.2 Suggested composition of Southern Polish phoneme /x/ in vocalic contexts**

If we take into consideration only those contexts where /x/ appears close to vowel sounds, namely #\_V, V\_V, and V\_#, the distribution of allophones for Southern Polish /x/ might look as in Figure 20.

The frequency of occurrence is reflected in the sequence of allophonic symbols. Thus, the most likely variants stand first. The symbols in brackets represent possible, but relatively uncommon articulations. The distribution in #\_V has been slightly altered in relation to the data in 2. It gives priority to

fortis glottal and pharyngeal allophones and places the voiced glottal variant as the final alternative.



**Figure 20:** Phoneme /x/ in Southern Polish in the positions adjacent to vowel sounds.

It might be assumed, that Southern Polish /x/ should be underlyingly represented as /h/, in order to reflect the dominance of the ‘back’, or laryngeal sounds. In this way, the velar fricative [x] would become its allophone in word-final and pre-consonantal contexts. Of course, such reasoning would have to put aside all historical and most phonological evidence. If /x/ is a historically viable representation of the phoneme, the variants described above may constitute phonetic means of some ‘linguistic therapy’ to save the seriously weakened and unspecified phoneme (cf. Stieber 1974:107 for the discussion of the development of Upper Sorbian aspirated /k<sup>x</sup>/ in early 18<sup>th</sup> century). However, more research is necessary to find out to what extent [h] might represent /x/ in vocalic contexts in other parts of Poland.

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