VOICING CONTRAST OF INTERVOCALIC PLOSIVES IN HUNGARIAN

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ABSTRACT

The conflict of articulatory targets may result in neutralization of phonological oppositions, for instance in languages, where prevoiced and non-aspirated voiceless plosives constitute voicing contrast, voicing may be ceased leading to partial or entire devoiced plosives. The question has been arisen by several studies, whether the neutralization is entire regarding the phonetic voicing (type, ratio, duration etc.), and whether and how "additional" features (like vowel duration, consonant duration, vowel voicing etc.) may hold at least partially the contrast of the counterparts. The present study aims to serve some further information on these questions for intervocalic plosives on the basis of Hungarian. Results show that devoicing of [+voice] plosives is not frequent, as expected due to the intervocalic position, however, [-voice] plosives may get partially voiced, therefore partially neutralizing the contrast.

Keywords: voicing contrast, plosives, Hungarian, laboratory speech

1. INTRODUCTION

Voicing distinctions among plosives have been addressed by a large number of studies, either in terms of conflicts of the articulatory targets of voicing and closure, with active and passive compensatory possibilities e.g. [17, 22], or with respect to the variability of the number of voicing categories and their phonetic realizations across languages e.g. [12].

In two-way voicing contrast languages, the opposition is mostly between prevoiced and voiceless unaspirated or between voiceless unaspirated and voiceless aspirated plosives e.g. [12, 13]. However, the conflict of closure and the voicing gesture may lead to the cessation of prevoicing during closure, since oro-pharyngeal pressure build-up during the constricted phase may lead to the loss of the transglottal pressure drop needed for phonation e.g. [17, 22]. In principle, prevoicing should cease after 10-15 ms, thus the possibility of prevoicing can be explained by compensatory gestures, which may be active like pharynx enlargement or passive like oral cavity enlargement due to oral pressure build-up [22]. Both types of gestures are dependent on the phonetic (articulatory) context, thus prevoicing is proved to be place of articulation e.g. [17], speaker e.g. [1], and utterance position e.g. [24], vowel context [18, 20] dependent among other features.

The Hungarian stop inventory exhibits a two-way voicing distinction of prevoiced vs. voiceless unaspirated counterparts e.g. [6, 7]. However, some studies have reported fully/partially devoiced realizations of [+voice] stops in both spontaneous and laboratory speech [7, 8]. Both studies analyzed the VOT of /b, d, ɡ, p, t, k/, and [8] examined the manner of articulation of the realized sounds. No analysis so far has been conducted regarding not assimilation caused voicing neutralization, as far as we know, to (i) reveal data on other features of the voicing contrast in Hungarian plosives to consider whether and how features other than VOT (like vowel duration, consonant duration) participate in cueing the voicing contrast, and to (ii) investigate the two palatal stops of Hungarian. Palatals share common features both with plosives and affricates, therefore their categorization in Hungarian is author dependent [summary: 12]. The present analysis considers them as plosives based on [11, 23], following the presumption based on their phonetic behavior, that palatals are plosives phonologically and in several cases phonetically, while in other cases—as sounds—they sometimes are realized more similar to affricates due to the larger obstruction resulted by the specialty of their place of articulation.

The present study considers some features of the intervocalic voicing contrast of plosives, and some of the universal secondary features of the voicing contrast in Hungarian.

2. METHOD

The eight plosives of Hungarian /b, p, d, t, ɟ, c, ɡ, k/ were recorded in intervocalic

position in nonsense words with the structure *laCal* /lɔCɔl/ and embedded in the carrier sentence *A képernyőn a laCal alak látható.* ('The word laCal can be seen on the screen.') The sentences were displayed in a random order by SpeechRecorder [4] for 12 native speakers of (standard) Hungarian (6 males, 6 females; 21-29 years). Four repetitions were recorded for each sentence. No speech disorder or hearing loss was reported. The recordings were carried out with an Audio-Technika AT 4040 microphone at 44.1 kHz, 32 bit in a sound treated room.

Data labeling and acoustic analysis were carried out manually by the author by means of Praat 5.1 [3]. The following data were collected: (i) target consonant; realized manner of articulation; duration of the entire sound; duration of voicing of the consonant; duration of closure (in cases of plosive realizations with at least one detectable burst); and VOT (or restart of voicing in cases of less than fully voiced sounds); (ii) preceding vowel: duration; duration of devoicing.

The onset of the vowel was determined as the mid-point of the formant transition of the [lɔ] sequence (intensity and formant trajectory). The end of the vowel was either set at the end of the detectable F_2; or (in case of approximant realization of the consonant) at the mid-point of formant transition (intensity and formant trajectory). Voice off- and onset times were labeled on the basis of the last/first detectable quasi-periodic signal on the waveform and the spectrogram (including breathy voicing, i.e. proper VOT was analyzed). The end of the consonant was set at the end of the release, or in fricative realizations at the end of the friction characteristic of the fricative of the given place of articulation; or in approximant realizations at the mid-point of the formant transition. The release of the closure was defined at the most intense burst on the basis of [5]. Four realizations (1 /b/, 2 /ɟ/, 1 /k/) had to be discarded due to misreading by the speaker or additional noise during the target word.

Multivariate ANOVA (at the 95% confidence level) and Mann-Whitney U-test statistics were run by means of SPSS 15.0.

3. RESULTS AND DISCUSSION

93.6% of the plosives were realized as stops. Voiceless plosives appeared as stops more frequently (93.8-100%) than the voiced phonemes did (81.5-97.9%). These results are similar in tendency to previous spontaneous speech results [8], but show lower percentages presumably due to the different speech styles. Among voiced plosives /ɟ/ and /g/ more often appeared as non-stops than the anterior phonemes. The non-stop realizations were either fricatives or approximants. Combination of sonorant and obstruent manners of articulation were detected only in one or two cases of each analyzed voiced consonant. No burst appeared in 0-12.5% and several bursts appeared in 4.3-42.6% of all stop realizations. The highest number of no-burst cases was detected among palatal plosives. As expected, the number of several-burst cases increased with the backness of place of articulation. No difference could be found regarding the voicing of the plosive.

Figure 1 shows the distribution of the voiced part of the consonants in ms. The differences of voicing duration between members of each pair significantly decrease as a function of place of articulation from front to back [Mann-Whitney U-test: $p < 0.001$ (Z = -8.546, -8.620, -8.099, -8.007]. However, the alveolar and palatal counterparts share relatively long voiced part duration intervals (Table 1). One entirely voiced /p/-realization resulted in 100% overlap of bilabial counterparts realizations, while ignoring this single case (which may have been caused by passive voicing due to intervocalic position) the bilabial pair showed the lowest overlapping ratios.

Figure 1: Duration of voiced part of the entire C (ms).

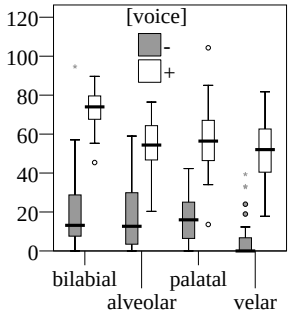


Table 1: Ratio of occurrence (% of all cases) in the common interval of the voiced part duration of the consonant. (The results in brackets for bilabials indicate the results without the single entirely voiced /p/-realization.)

[voice]	bilabial	alveolar	palatal	velar
+	4.3 (100)	64.6	17.4	18.8
-	4.2 (6.3)	61.7	60.4	10.5

The average duration of the unvoiced plosives was 14-30% longer than that of their voiced counterparts (Table 2). However, these results follow the universal tendencies of the shorter duration of voiced plosives compared to the

unvoiced e.g. [15] [Multivariate ANOVA: $F(1, 380) = 174.699$, $p < 0.001$; $r = 0.320$], as the value of partial eta indicates, the duration of the voiced plosives almost entirely overlaps with the lowest region of that of their counterparts. Considering these overlapping regions, only 0-13% of the realizations of voiced plosives can be distinguished from their counterparts on the basis of their duration.

Table 2: Duration of the plosive and the preceding vowel (ms) (mean and SD).

[voice]		/b, p/	/d, t/	/ɟ, c/	/g, k/
+	C	74.2 (8.9)	84.3 (13.9)	93.8 (16.8)	73.7 (17.4)
-	C	91.7 (15.3)	59.1 (10.1)	68.2 (15.1)	63.1 (11.2)
+	V	80.5 (16.2)	87.2 (12.2)	89.2 (16.2)	89.2 (11.0)
-	V	76.7 (12.1)	83.5 (10.9)	86.2 (13.1)	95.2 (11.0)

The universal tendency of longer vowel duration before voiced consonants compared to their unvoiced counterparts e.g. [15] does not hold for the present results at all (Table 2) [Multivariate ANOVA: $F(1, 380) = 0.733$, $p = 0.393$]. Former studies have also reported inconsistency regarding this feature see e.g. [9, 10, 16, 19].

Vowel devoicing appeared in approximately 6% of /p/, /t/, /c/ realizations and in 40.4% of /k/ realizations, while (as expected) no preaspiration occurred in the case of voiced plosives. The mean duration of the devoiced part of the vowel was 10.7 ±7.2 ms. The duration of the preaspirated part of the vowel was 3.4-36.1% of the vowel duration.

In the following analyses, we shall only consider realizations that appeared as plosives and with at least one detectable burst.

The duration of voicing into the closure in most realizations approximates to the duration of the voicing of the entire consonant due to the shortness of the release. However, the occurrence of several bursts or long friction may lead even to a difference of 40 ms of the two calculations. Considering the ratio of the voiced part of the closure on the basis of previous suggestions [14, 21], realizations where this ratio exceeded 50% were categorized as voiced; those where it was below 30% were categorized as devoiced. In cases where this ratio was between 30 and 50%, the sound was considered as partially voiced. Applying this categorization to the present data gives the following results. 98.2% of the [+voice] stop realizations appeared as voiced sounds. 2 partially voiced and 1 unvoiced realization occurred. However, only 68.3% of the [–voice] plosives were actually unvoiced; 18.3% of them occurred as partially voiced, and 13.3% as a voiced sound. The frequency of non-unvoiced realizations of [–voice] plosives is shown in Table 4. The results vary with the place of articulation. Over 90.0% of velar stops were realized unvoiced, while plosives of other places of articulation appeared in 20-25% as partially voiced, and /t/ and /c/ in 16.7% and 23.8% of the cases was voiced. This phenomenon may be due to the effect of intervocalic position as hypothesized above, a position that may lead to passive voicing. For the palatal consonant, some other reasons may also be hypothesized. Since its place of articulation results in a broader surface in the occlusion than other places of articulation do, this broader surface may also lead to longer release and shorter closure, as already mentioned. Therefore, the ratios of the closure and release phases of this consonant are also different from plosives at other places of articulation for Hungarian see e.g. [12]. Figure 2 introduces an example of /c/ where over 70% of the closure is voiced, while it makes up less than 45% of the entire consonant.

In the case of bilabial plosives where not the entire closure was voiced, VOT and closure voicing duration clearly separate the voicing categories (except for two /p/ realizations), whereas for the other three pairs some overlap appears: 33.3% of /t/ realizations overlap with 17.8% of /d/, 19.4 of /c/ with 38.1% of /ɟ/, and 11.6% of /k/ with 12.5% of /g/ realizations. (In the case of the palatals, one extremely long closure voicing duration causes high overlap ratio. Not considering that only one realization, /c/ overlaps in 3.6% of the cases with 16.7% of the /ɟ/ realizations.)

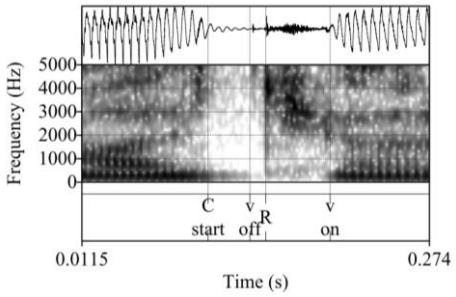
Table 3: Closure voicing duration and ratio, and VOT (%).

	Voicing into the closure ms		Voicing into the closure %		VOT ms	
	Mean	SD	Mean	SD	Mean	SD
/b/	18.5	17.8	21.7	20.8	15.2	18.3
/p/	69.4	8.1	99.0	3.6	-57.1	31.2
/d/	18.0	15.8	25.1	21.2	24.4	8.8
/t/	50.0	10.0	96.2	10.6	-29.8	34.2
/ɟ/	14.4	13.3	29.8	26.9	48.7	10.6
/c/	42.9	12.4	94.6	15.2	-10.5	38.3
/g/	5.4	9.5	8.9	14.9	39.5	10.4
/k/	46.5	11.2	90.0	13.2	-4.8	38.9

Table 4: Voicing categorization of the realizations of [–voice] plosives (%).

	bilabial	alveolar	palatal	velar
voiced	8.5	16.7	23.8	4.7
partially voiced	21.3	25.0	21.4	4.7
unvoiced	70.2	58.3	54.8	90.6

Figure 2: A /c/-realization with voicing over 70% of its closure duration. (C.start: beginning of closure, v.off: voicing offset, R: release, v.on: voice onset).



4. CONCLUSIONS

The aim of the present study was to reveal data on the intervocalic voicing opposition of plosives in Hungarian. Though only one vowel quality was used as context, the results may suffice to raise further questions. Our data follow the universal tendencies of consonant voicing durations of both the closure and the entire consonant, while they are inconsistent with the universal tendencies of vowel duration. A possible reason for the latter result may be the ease of voicing in intervocalic position as compared to utterance final positions, where devoicing may be more pronounced see e.g. [24], for Hungarian [7]. This hypothesis is also to be considered on the basis of fricative voicing studies for Hungarian, which reported more pronounced vowel duration differences, and consonant devoicing for utterance final fricative counterparts than for their utterance medial realizations [2]. Voicing of the [–voice] consonants also shows diverse results, as some of them appeared with considerable prevoicing. Our hypothesis is that this phenomenon is caused by intervocalic passive voicing. Therefore a more comprehensive analysis of these values, phonation type and their perceptual consequences are needed.

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