The "Fortis-Lenis" Distinction in Bulgarian and German

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Abstract

The present study investigates the voicing contrast in Bulgarian and German. Analyses of two production experiments are reported. In the first experiment logatoms were constructed containing /p, t, k/ and /b, d, g/ in intervocalic position. In the second experiment one Bulgarian and one German sentence were elicited in different focus conditions resulting in different accentuation levels. Based on the obtained data we analyze the phonetic implementation of the phonological categories voiced vs. voiceless and the influence of focus condition and accentuation. It is shown, that: First, the two languages differ in the phonetic realization of /p, t, k/ but not /b, d, g/ in intervocalic position in terms of voice onset time (short lag in Bulgarian and long lag in German). Second, accentuation levels are realised in different ways in the two languages.

Keywords: voicing contrast, voice onset time, accentuation, information structure, Bulgarian, German.

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1. Introduction

Voicing contrast in plosives has been a major topic in phonology and phonetics over the last few decades (see the comprehensive discussion in [1]). The phonetic realization of the voicing contrast varies across languages. German belongs to the group of *aspirating languages* and contrasts zero to short lag voice onset time (VOT) plosives with their long lag VOT counterparts [2]. *Voicing languages* (Romance and Slavonic languages) on the other hand contrast prevoiced plosives (including in word-initial position and after another obstruent) with zero to short lag VOT plosives. Bulgarian is a South Slavonic Language and, to the best of our knowledge, has not been widely investigated with regard to the voice-voiceless distinction. Traditional phonetic descriptions of Bulgarian consonants assume that /b, d, g/ are always realized with complete vocal fold vibration and there is no aspiration in /p, t, k/ [3]. Pronunciation difficulties experienced by Bulgarians while learning German (lack of aspiration) seem to suggest that Bulgarian belongs to the *voicing languages* [4].

This paper investigates the phonetic properties of voiced and voiceless (fortis and lenis or tense and lax) plosives, with a descriptive focus on Bulgarian and German. The following hypotheses are investigated: 1) The phonetic implementation of the two phonemic classes, voiced and voiceless, is different in Bulgarian and German; 2) The two languages to differ in the phonetic implementation of the voicing contrast depending on accentuation levels in different focus conditions.

2. Data

2.1. Corpus 1 (logatomes)

The subjects for the first experiment were six native speakers of Sofia Bulgarian and six native speakers of Standard German (aged 25-51 years). Logatomes with six plosives of interest in intervocalic strong (accented) position (paˈpapa, paˈtapa, paˈkapa, paˈbapa, paˈdapa, paˈgapa) were produced five times from a PowerPoint Presentation in a random order in a sound treated studio at the Institute of Phonetics (Saarland University). In total, 180 plosive tokens per language were collected (6 plosives x 6 speakers x 5 repetitions). Due to approximant realizations five productions were removed from the data set.

2.2. Corpus 2 (question-answer pairs)

Six speakers of Sofia Bulgarian and six speakers of Standard German from the Saarland (3 female and 3 male per language, aged 22-47 years) produced 6 repetitions of one Bulgarian and one German sentence (displayed via a PPT presentation) as responses to pre-recorded questions, eliciting different focus conditions resulting in 3 different degrees of accentuation: de-accented, pre-nuclear accented and nuclear accented. These sentences are a subset of a larger data set.

The sentences contained two "critical words" (CW1 and CW2), one early (but not initial) and one late (but not final) and are part of a larger dataset. The early CWs were /ˈpesen/ and /ˈpeːter/, the late CWs were /bɛt/ and /ˈbaba/ for Bg and G respectively. The bilabial plosives under investigation /b/ vs. /p/ occurred in word initial position.

For each sentence, a number of questions were devised to elicit a *broad-focus* response with pre-nuclear accented CW1 and nuclear accented CW2, a response with a *non-contrastive or contrastive narrow-focus* on CW1 or CW2. The CW not in focus was expected to be de-accented, while the CW in focus carried the nuclear accent.

An example set of the Bg test sentence plus five different context questions is given below; focus constituents are indicated by square brackets; the nuclear accented syllable is underlined.

Izpjax	pesen	za	baba	mi
sing [1.Sg,Past]	*song*	*for*	*granny*	*my*

'I sang a song for my granny.'

(a) *broad focus* (broad)
A. What did you do?
B. [Izpjax pesen za baba mi.]

(b) *early narrow non-contrastive focus* (n-contr early)
A. What did you sing for your granny?
B. Izpjax [pesen] za baba mi.

(c) *late narrow non-contrastive focus* (n-contr late)
A: For whom did you sing a song?
B: Izpjax pesen za [baba mi].

(d) *early narrow contrastive focus* (contr early)
A: Did you sing a book for your granny?
B: Izpjax [pesen] za baba mi.

(e) *late narrow non-contrastive focus* (n-contr late)
A: Did you sing the song for your older sister?
B: Izpjax pesen za [baba mi].

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In total, 360 plosive tokens per language were collected (2 plosives x 5 focus conditions x 6 speakers x 6 repetitions).

Recordings were made in a sound-treated studio on a Tascam DA-P 1 DAT recorder using an AKG C420IIIPP headset.

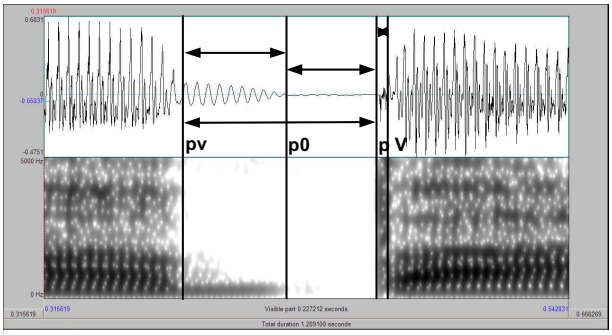


Figure 1: *Example of the segmental labelling. The sample material is* /pa'papa/. *<pv> - beginning of the voiced portion of /p/, <p0> - beginning of the voiceless portion of /p/, <p> - beginning of burst and <V> - beginning of the following vowel.*

3. Acoustic measurements of voicing

The recordings were digitized at a sampling frequency of 16 kHz and with an amplitude resolution of 12 bits, using the Advanced Speech Signal Processing Tool (xassp) [5]. All data were manually labeled on the basis of the synchronized microphone signal and spectrogram. Since we want to investigate the differences in the realization of voiced and voiceless plosives, /p, t, k/ and /b, d, g/ were labeled in great detail; particularly the closure phase, which was divided into voiced and voiceless portions (see Figure 1).

Because in this work we are focussing on the "amount" of voicing in plosives, rather than overall variance along various acoustic correlates of voice implementation, in both studies reported further in this paper we used the same two relative measures:

the time interval between the plosive release and the voice onset of F2 in the following vowel, more specifically, the duration of release onset to vowel onset interval normalised by the duration of the plosive; we will refer to this measure as *release ratio*, and

voiced portion of the closure measured as the proportion of the voiced parts of the given plosive closure normalised by the closure duration; we will refer to this measure as *voice ratio*.

4. Analysis and results

To analyse the differences in the phonetic realisation of the voicing contrast in Bulgarian and German multivariate analyses of variance were carried out. The confidence level was set at α=0.05.

4.1. The effect of plosive type and language

The first study investigates variance in voicing (as measured by release and voice ratios) between voiced and voiceless plosives (/b/, /d/, /g/, /p/, /t/, /k/) in Bulgarian and German.

We first compared differences between voiced and voiceless plosive groups in the two languages. For both languages repeated measures MANOVAs were conducted with release ratio and voice ratio as dependent variables and voicing (voiced/voiceless) as a within-subjects factor. Both in Bulgarian and German, there was a significant main effect of voicing on the linear combination of voice ratio and release ratio. In German the effect of voicing both on release ratio and voice ratio was significant ($F(1,17)=248{,}141$ $p<.000$ and $F(1,17)=913{,}155$, $p<.000$ respectively) while in Bulgarian only a significant effect on voice ratio was found ($F(1,17)=348{,}539$ $p<.000$). This suggests that unlike in German, where aside from voicing within the closure also aspiration is an important factor to distinguish between the two plosive categories, in Bulgarian aspiration is not relevant.

In order to investigate differences in the realization of the individual plosive categories, mixed between-within MANOVA was performed with plosive category as within- and language as between-subjects factors.

Table 1: *Means and standard deviations per plosive category /p, t, k, b, d, g/ and language (Bulgarian: Bg and German: G)*

Group		*n*	Release ratio		Voice ratio	
			M	*SD*	*M*	*SD*
Bg	/p/	6	8.02	3.65	16.59	7.44
	/t/	6	10.38	3.84	15.78	9.13
	/k/	6	26.94	7.13	9.38	7.30
	/b/	6	7.00	1.60	83.85	18.22
	/d/	6	10.76	3.00	88.89	18.15
	/g/	6	18.67	2.68	89.25	13.51
G	/p/	6	33.64	6.76	22.24	8.97
	/t/	6	43.33	7.97	22.92	5.84
	/k/	6	45.88	3.73	18.38	9.31
	/b/	6	10.91	1.63	94.44	7.40
	/d/	6	22.59	3.39	96.92	4.88
	/g/	6	24.98	3.48	87.98	15.45

Table 2: *Effects of plosive category and language on release ratio and voice ratio*

Source	Variable	*df*	F	part. η^2	*p*
Language	Release ratio	1	107.380	.915	.000
	Voice ratio	1	2.420	.195	.151
Error	Release ratio	10			
	Voice ratio	10			
Plosive category	Release ratio	2,165	66.891	.870	.000
	Voice ratio	5	207.255	.954	.000
Language x Plosive cat.	Release ratio	2,165	24.969	.714	.000
	Voice ratio	5	.565	.054	.726
Error	Release ratio	21.647			
	Voice ratio	50			

Table 1 shows the means and standard deviations of release ratio and voice ratio measurements for all levels of the independent variables. Most important for the research questions addressed in this paper is the highly significant interaction between the plosive category and language for release ratio, but not for voice ratio. For voice ratio there was a significant effect of plosive category, but not of language, suggesting that the two languages behave the same way in terms of voicing. For release ratio highly significant main effects of plosive category and language were found. Table 2 summarizes the effects.

Posthoc comparisons per language using repeated measures MANOVA with Bonferroni correction did not yield clear homogeneous groups with respect to release ratio. We therefore also present profile plots (see Figure 2) in order to indicate the general trends. While in German release ratio is

associated both with place of articulation (POA) and voicing, in Bulgarian it is associated only with POA and increases from front (labial) to back (velar) plosives with the only greater difference between voiced and voiceless in the velar POA. Mean release ratio of /p, t, k/ vs. /b, d, g/ is 15.11 and 12.14 in Bulgarian and 40.95 and 19.45 in German. The voiceless plosives in Bulgarian are realized with short lag VOT, whereas in German with long lag VOT. The voiced plosives in this intervocalic strong position are almost prevoiced.

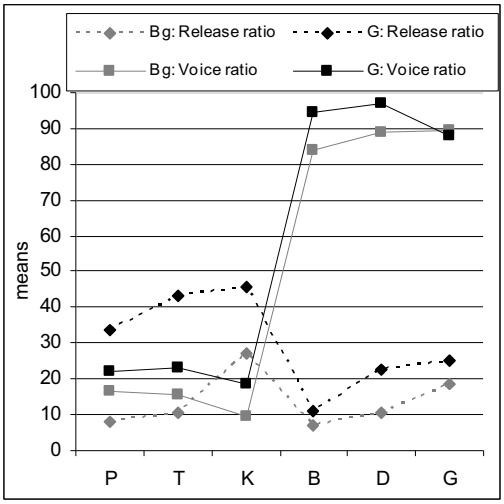


Figure 2. *Profile plots of voice ratio (solid lines) and release ratio (dashed lines) for all the plosives*

4.2. The effect of focus/accentuation level

In order to investigate the effect of accentuation level, we compared Bulgarian and German realizations of /p/ and /b/ in different focus conditions outlined above along the same two acoustic measurements as in the first study.

Mixed between-within MANOVA was performed with a linear combination of release ratio and voice ratio as dependent variables, plosive category (two levels) and focus condition (five levels) as within-subjects factors and language as a between-subjects factor. Both the homogeneity of variances and the sphericity assumption were violated. We report univariate tests with the Greenhouse-Geisser estimates of F. These were verified with the multivariate Pillai's trace statistic; cells were equal in sizes.

Table 3 shows the means and standard deviations of release ratio and voice ratio measurements for all levels of independent variables. The first point to note is that there was a highly significant main effect of language and focus condition on both acoustic measures and their linear combinations for both plosives. For /b/, a significant interaction was found between language and focus condition for both release and voice ratio (release ratio: F(1.837, 18.371)=4.499, part. η^2=.672; voice ratio: F(2.063, 18.371)=17.267, p<.001, part. η^2=.999), while for /p/ a significant interaction was found only for voice ratio (voice ratio: F(2,135, 21.346)=8.784, p=.001, η^2=.955; release ratio: F(2.454, 24.542)=.591, p=.594, part. η^2=.145) (see Figure 3).

In both languages there is a tendency for release ratio to decrease with increasing accentuation level (from deaccented nuclear accented trough pre-nuclear accented to nuclear accented) independently of voicing: In other words the stronger the accentuation the shorter the release ratio and the longer the closure phase of the plosive. In Bulgarian there is less variance in release ratio between /p/ and /b/ than in German, which is consistent with our findings from Section 4.1. With respect to voice ratio voicing is observed for /p/ in German but not in Bulgarian. The Bulgarian /p/ is characterized by considerably more voiced portions in the closure. In German less voicing is observed for both /p/ and /b/ in narrow focus conditions.

Table 3: *Means and standard deviations per language, plosive category, and focus condition*

Group			*n*	Release ratio		Voice ratio	
				M	*SD*	*M*	*SD*
Bg	/p/	contr early	6	11.22	3.21	.44	1.09
		n-contr early	6	11.33	2.59	.00	.00
		broad	6	15.94	5.28	.00	.00
		n-contr late	6	16.83	6.29	.00	.00
		contr late	6	15.28	3.54	.00	.00
	/b/	contr early	6	16.80	6.85	81.03	20.39
		n-contr early	6	15.58	4.50	79.42	20.69
		broad	6	12.83	3.20	91.80	11.19
		n-contr late	6	10.53	1.23	85.08	19.53
		contr late	6	9.50	1.02	86.92	19.28
G	/p/	contr early	6	35.39	4.91	8.53	9.65
		n-contr early	6	35.61	5.90	9.67	10.98
		broad	6	37.25	3.38	17.42	9.60
		n-contr late	6	38.17	2.78	21.97	11.07
		contr late	6	38.67	5.36	12.00	9.26
	/b/	contr early	6	26.50	5.39	61.28	37.52
		n-contr early	6	24.86	5.80	77.64	21.91
		broad	6	17.75	4.66	76.61	14.00
		n-contr late	6	13.14	4.09	41.25	18.26
		contr late	6	13.22	5.13	17.22	15.07

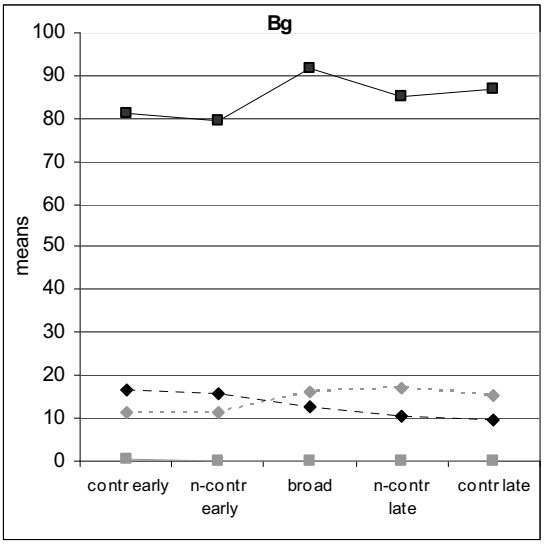
Pair-wise t-tests with Bonferroni correction showed that in Bulgarian, the only statistical differences across focus conditions are in the release ratio for /p/, with a clear-cut difference only between early focus conditions (nuclear accented) and the contrastive late focus (deaccented). In German both voice ratio and release ratio contribute to focus realization for /b/, while for /p/ only voice ratio is relevant (see Table 4).

Between-language posthoc comparisons using independent samples t-test for each focus condition revealed that in the early focus conditions (/p/ - nuclear accented, /b/ - deaccented) for both plosives there was no significant difference between the languages in terms of voice ratio, but the difference was significant in the release ratio (Bg < G). In the broad focus condition (/p/ - pre-nuclear accented, /b/ - nuclear accented) the languages differ on both variables for the voiceless plosive (Bg < G), but behave the same way for the voiced plosive. In the late focus conditions (/p/ - deaccented, /b/ - nuclear accented) the languages differ on both variables for the voiceless plosive (Bg < G), while for the voiced plosive they differ in terms of voice ratio (Bg > G), but not in terms of release ratio. The differences are summarized in Table 5.

5. Discussion

The present study was based on two hypotheses:

1. In Bulgarian, based on literature survey, we expect voicing to coincide with or to occur shortly after the release of the articulators for voiceless plosives, and to begin well before the release of the articulators for voiced plosives. By contrast, in



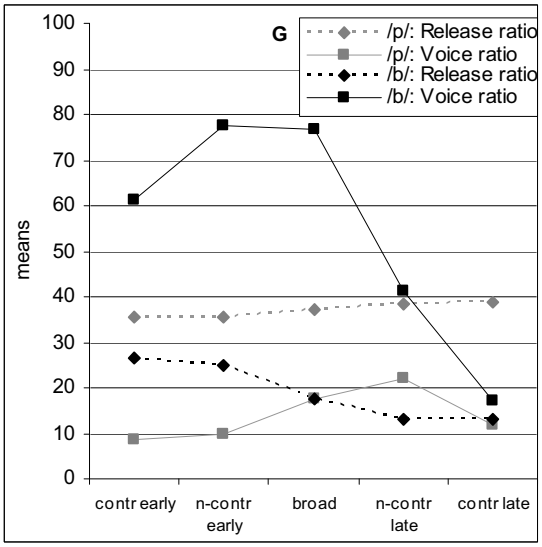


Figure 3**.** *Profile plots of voice ratio (solid lines) and release ratio (dashed lines) for /p/ and /b/ in Bulgarian (left) and German (right) in different focus conditions*

Table 4: *Plosive category grouping in Bulgarian and German (p<.000)*

Lang		Measure	Grouping
Bg	/p/	Release ratio	{contr early, n-contr early} ≤ {broad, n-contr late} ≤ {contr late}
		Voice ratio	/
	/b/	Release ratio	/
		Voice ratio	/
G	/p/	Release ratio	/
		Voice ratio	{contr early} ≤ {n-contr early, contr late, broad} ≤{n-contr late}
	/b/	Release ratio	{ contr late, n-contr late, broad}< { n-contr early , contr early}
		Voice ratio	{n-contr early, broad} ≤ {contr early} ≤ {n-contr late, contr late}

Table 5: *Differences between languages across focus conditions; * p<0.05, ** p<0.01, *** p<0.001, = no significant difference*

	/p/		/b/	
	Release ratio	Voice ratio	Release ratio	Voice ratio
contr early	nuclear accented		deaccented	
	Bg<G***	=	Bg<G *	=
n-contr early	nuclear accented		deaccented	
	Bg<G***	=	Bg<G *	=
broad	pre-nuclear accented		nuclear accented	
	Bg<G***	Bg<G **	=	=
n-contr late	deaccented		nuclear accented	
	Bg<G***	Bg<G **	=	Bg>G **
contr late	deaccented		nuclear accented	
	Bg<G***	Bg<G *	=	Bg>G ***

German, voicing begins long after the release of the articulators for voiceless plosives, and coincides with or occurs shortly after the release of the articulators voiced plosives. However this is not true for voiced plosives in intervocalic position, where "passive" voicing results from a voiced context [1].

2. Given the differences in the phonetic basis underlying the voicing distinction, we expect the two languages to differ in the phonetic implementation of the voicing contrast depending on accentuation levels in different focus conditions.

Both hypotheses are confirmed. Concerning the first hypothesis we found that in intervocalic strong position Bulgarian contrasts short lag voice onset time /p, t, k/ with their prevoiced counterparts /b, d, g/, while German contrasts a long lag /p, t, k/ with their prevoiced counterparts /b, d, g/. Our results suggest that in intervocalic position there are cross-linguistic differences in the prosodic modulation of plosive realisation. What is interesting is that the accentuation levels are realised in different ways in the two languages: For the Bulgarian voiceless /p/ accentuation is associated with differences in release ratio, while in German with differences in voice ratio. For /b/ there are no significant differences across accentuation levels in Bulgarian, unlike in German.

6. Acknowledgements

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