Phonatory Demarcations of Intonation Phrases in Bulgarian

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ABSTRACT

Vowel devoicing at phrase boundaries is shown to depend on sentence mode (statement, question) and information structure (non-contrastive vs. contrastive and broad vs. narrow focus), which affect the type of nuclear accent and boundary tone. In *li*-questions, considerably less devoicing of the vowels before the phrase boundary is found than in other conditions, because the rising boundary contour prevents devoicing. In all other conditions, mode and information structure only affect the realisation of the vowel in the two syllables before the phrase boundary if the nuclear accent is realised on the last content word of the phrase, just before the boundary. In these position, the differences in observed vowel devoicing can also be related to the intonational properties of the utterance, namely to the accent type. In particular, the peak alignment of the accent explains the presence or absence of voicing, or better the amount of devoicing, since it is clearly a gradient phenomenon. In general, the earlier the peak, the greater the tendency towards devoicing.

1. INTRODUCTION

In the phonetic typology of Slavic languages Bulgarian is said to be a language with accommodative pronunciation, which is characterised by a large number of contextually conditioned allophones of vowels and consonants, motivated either by the direct segmental context or by their position in the syllable/word or by their distance from the accented syllable. Bulgarian has strong qualitative vowel reduction, depending on accent (Level 2 in the first pre-tonic and in all post-tonic syllables, Level 1 elsewhere) [1]. To our knowledge, no vowel devoicing has been reported in the literature.

Vowel devoicing is a well-known phenomenon in a large number of languages [2] and depends on the quality and duration of the vowel, its segmental context, speech rate, level of stress, pitch and morpho-phonological boundaries. It is sometimes also employed for phrase boundary demarcation in addition to boundary tones and F0 resets, final lengthening and voice quality in general [3]. In a recent exploratory analysis of segmental deviation from the canonical phonetic form, intonation-dependent elision and reduction of phrase-final unstressed vowels was observed in a falling, but not in a rising tonal contour in the spontaneous (Map Task) and read speech recordings of Sofia Bulgarian and of Moscow Russian [4]. In addition, as we report here, phrase endings can also be marked by vowel devoicing under the same condition. A similar effect of tonal contour on phrase-final (partial) devoicing has also been observed for French [5].

The following considerations were taken as a point of departure for an explanation of the initial observations:

a) Intonation phrases (for declarative utterances) show not only F0 declination but also intensity reduction.
b) Word endings (and syllable codas) are generally less well defined than onsets.
c) A rising final contour counteracts F0 and intensity declination patterns, requiring both increased sub-glottal pressure and a different glottal adjustment compared to the final falling contour.

The present study, which focuses on Bulgarian, investigates whether vowel devoicing in falling intonation contours occurs only in the speech of certain individuals, i.e., is an extreme case of a gradient phonetic phenomenon, or is a conventionalised pattern, i.e., a phonetically explainable phenomenon that has "strengthened" to possible communicative status.

The following hypotheses are investigated:

- Phrase-final vowel devoicing depends on mode and information structure (focus and contrast).
- Phrase-final vowel devoicing is more likely if the nuclear accent occurs earlier in the phrase.
- Phrase-final vowel devoicing depends on accent type.

2. MATERIAL AND METHOD

The subjects for the experiment were five persons from Sofia (4 female and 1 male, aged 25-45 years). The following 4 test sentences (with the material relevant to phrasal demarcation underlined) were recorded several times in random order in a sound-treated studio. These sentences are a subset of a larger data set.

1. *ˈvčera ˈmama ni poˈmaga po graˈmatika.*
   yesterday mama us helped in grammar
   'Yesterday mum helped us in grammar.'
2. *ˈvčera ˈmareto poˈmaga po graˈmatika?*
   yesterday Mareto helped in grammar
   'Yesterday Mareto helped in grammar?'
3a. *ˈvčera ˈmama li vi poˈmaga po graˈmatika?*
   yesterday mama Q[1] you helped in grammar
   'Is it mum who helped you in grammar yesterday?'

[1] Q = interrogative particle *li*

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3b. ˈ*včera* ˈ*mama vi* *poˈmaga po* *graˈmatika li?*
yesterday mama you helped in grammar Q
'Is it grammar that mum helped you with yesterday?'
'Yesterday mum helped you in grammar, didn't she?'

The statements in the material (sentence 1) were embedded in dialogue sequences as replies to *wh*-queries uttered by the instructor and were produced three times with broad focus or with contrastive and non-contrastive narrow focus on the first or last content word (*'mama'* or *'gramatika'*).

The material contains both confirmation-seeking yes-no questions (checks) marked only by intonation (sentence 2) and information-seeking yes-no questions with the interrogative particle *'li'* [2] (sentences 3a and b) produced with narrow focus on the same content words as in the statements. Sentence 2 was produced three times as a reaction to a described situational context, which was constructed to induce focus on the first or the last content word in the sentence. Sentences 3a and 3b were read four times in a random list.

	broad	narrow non-final	narrow final
statements [-contrast]	x	x	x
statements [+contrast]		x	x
checks [-contrast]		x	x
li-questions [-contrast]	x[2]	x	x[2]

Table 1. Realised focus conditions for four sentence modes (black areas indicate unfeasible focus positions)

The recordings were digitised at a sampling frequency of 16 kHz and with an amplitude resolution of 12 bits, using the Advanced Speech Signal Processing Tool (xassp) [6]. All data were manually labelled on the basis of the synchronised microphone signal and spectrogram. Since we want to investigate non-modal voicing as a cue for phrase demarcation, the material *'-tika(li)'* after the last lexically stressed vowel in the utterance was labelled in great detail, particularly the vowels, which were divided into devoiced, non-modally (breathy-voiced or creaky) and modally voiced portions. The aspiration phase after the closure and release of the syllable-initial plosive was analysed as part of the following vowel. There are two reasons for this: first, although the aspiration phase is usually considered to be part of the plosive, it cannot be distinguished from a devoiced realisation of the vowel; second, we observed that the aspiration phase is longer in weakening context such as unaccented syllables, so that it is more appropriate to analyse it as part of the vowel than as part of the consonant (the latter would imply that the consonant is strengthened in unaccented positions). For each of the vowels, the duration of the devoiced signal was divided by the total vowel duration *(relative devoiced vowel portions)*. Analogously, the total duration of devoiced + non-modally voiced portions were divided by the total vowel duration to compute the *relative non-modally voiced vowel portions*.

In addition to the segmental labelling the pitch accents, phrase accents and boundary tones were also labelled, using ToBI [7], with the peak alignment of the H(igh) tones explicitly specified.

3. RESULTS

To analyse the effects on phonatory demarcation, we carried out multivariate analyses of variance, with Scheffé post-hoc tests if appropriate. Significant effects at the 5%-level are reported for the relative devoiced portions of [i] and [a]. We shall also report the number of *complete* devoicings, which we did not analyse statistically[3].

3.1. The effect of sentence mode and focus position

To see if there are any phrase-final devoicing effects of mode and focus position, we first compare non-contrastive statements with checks. These have identical morpho-syntactic structures and differ only in the nuclear pitch movement (in impressionistic terms, rise-fall and fall, respectively), analysed as L*+H L-L% for the checks and as H* L-L% for the statements [8].

When narrow focus is on the last content word (final), no complete vowel devoicings occur for checks, while in non-contrastive statements 53% of the /i/'s and 47% of the /a/'s are completely devoiced. On average, /i/ and /a/ have significantly shorter relative devoiced portions in checks (31% for [i] and 35% for [a]) than in non-contrastive statements (72% and 71%, respectively). The vowels in non-contrastive statements never contain modal voicing, while this is only true for /a/ in checks. A large portion of /i/ is modally voiced in checks (69%).

When narrow focus is on the first content word (non-final), both vowels are completely devoiced, except /a/ in non-contrastive statements, of which 80% are completely devoiced, so that the above results cannot be entirely explained by sentence mode per se. It is the distance of the nuclear accent from the intonation phrase boundary which also affects the degree of vowel devoicing: the greater the distance from the phrase boundary, the greater the relative devoiced portion of the vowels in the last two syllables of the phrase.

[2] Typically *li* belongs to the focal segment. When it occurs in sentence-final position an ambiguous focus interpretation arises (broad or narrow in final position).

[3] Wilcoxon tests on the averaged data per subject are possible, but decided against this because of the small dataset (5 observations per cell).

3.2. The effect of peak alignment

As expected, differences are only found when narrow focus is on the last content word in the phrase. This shows that the vowel realisation in the ultimate and penultimate (post-nuclear) syllables is not dependent on mode per se, but is a consequence of the realisation of the nuclear pitch accent and its position in the utterance. To test this, we shall compare accent types with early and late peak alignment in final and non-final positions, namely L*+H with late peak alignment in the post-accentual syllable(s), H* with late peak alignment (at the end of the accented syllable) and H* with early peak alignment (early in the accented or in the pre-accent syllable). In the non-final conditions there was no significant effect on the devoiced portions in /i/ and /a/. Both vowels showed a strong tendency to devoice, caused by the decrease of sub-glottal pressure and the resulting low volume velocity airflow, which in turns inhibits devoicing [2, p. 100]. In the following sections we shall therefore report the results for focus *in final position only.*

3.2.1. Non-contrastive statements and checks

In checks, the pitch accent is always realised as L*+H. In non-contrastive statements, the subjects differ in their realisation of the pitch accent (11 H* with early and 4 H* with late peaks).

If we re-analyse the utterances with final narrow focus with respect to accent type, we find that the relative devoiced portion of the [i] and [a] is dependent on the pitch accent. The relative devoiced portion of /i/ is significantly larger in H* (early) than in H* (late) than in L*+H conditions. Therefore, the earlier the peak, the stronger the tendency to devoice the vowel. For /a/ a significant difference was only found between the H* (early) than for the two other conditions. This is probably because the earlier the peak is aligned, the sooner a low pitch is reached and the vowel is devoiced.

3.2.2. Statements with broad and narrow focus

Broad focus in non-contrastive statements is *always* realised with a H* pitch accent with an early peak on the last content word in the utterance [cf. 8]. The pitch accent signals a complex focus domain in the case of focus projection. This type of accent was also used in the majority of the narrow foci in the same position (cf. section 3.2.1) and has exactly the same effect on vowel devoicing. Besides an increase in pitch range or emphasis, the speakers sometimes use a late peak alignment in the case of narrow focus in an attempt to resolve the ambiguity caused by the realisation of the focus exponent of both focus types on the last content word in the utterance. As expected, the difference in peak alignment causes a significant difference between the devoiced vowel portion of broad focus realisations and narrow focus on the last content word, with shorter devoiced portions in the latter case.

3.2.3. Contrastive and non-contrastive statements

So far, we have neglected the contrastive statements. Like non-contrastive statements, these also have falling nuclear pitch accents (H*, cf. [8]), but the tendency towards realising late peaks is stronger for contrastive statements (2 early[4] and 13 late peaks, cf. non-contrastive statements in 3.2.1). As expected on the basis of the identical peak alignment, no significant differences in the relative devoiced portions of [i] and [a] are found between contrastive and non-contrastive statements with a *late* peak. If we compare contrastive utterances with non-contrastive utterances with an *early* peak, we do find a significant difference in the relative devoiced portions of /i/ and /a/, which is also expected.

3.2.4. Contrastive statements and checks

The differences between contrastive statements and checks exactly parallel those between non-contrastive statements with a late peak and checks (see section 3.2.1). The pooled results for the data discussed in section 3.2 are shown in Fig. 1.

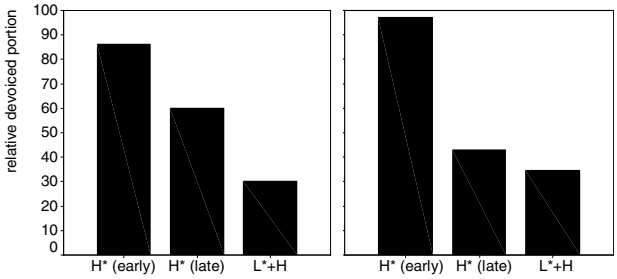

Figure 1: Mean relative devoiced portion for /i/ (left graph) and /a/ (right graphs) for all H* (early), H* (late) and L*+H accents on the last content word, excluding *li*-questions

3.3. The effect of accent type and boundary tones

3.3.1. Accent type

The data analysis so far has shown that vowel devoicing depends on focus position. In the final focus condition, the peak alignment exerts a strong influence, since early peaks tend to allow for a stronger vowel devoicing than late peaks, but does not *entirely* determine it. The significant difference observed in section 3.2.3 between contrastive statements (H*) and checks (L*+H), both with late peak alignment, indicates that accent type influences vowel devoicing, too. We shall return to this point in the discussion (section 4).

3.3.2. Boundary tones

We shall now consider *li*-questions. These are not directly comparable to the other sentence modes. First, when focus is on the last content word in the utterance, this word is followed by the particle '*li*'. Therefore, the /a/ context is different from that in all other conditions, since it is

[4] Given their small number, the early peaks will be ignored in the rest of the analysis.

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followed by /l/ instead of a phrase boundary. This is expected to reduce the tendency towards devoicing. Furthermore, a comparison of the penultimate and antepenultimate syllables in li-questions with the final /ka/ and penultimate /ti/ in the other conditions is not warranted. We observe that neither /i/ nor /a/ is ever completely devoiced in li-questions with narrow focus on the last content word (final), although we do sometimes find a short relative devoiced portion (36% for /i/, 28% for /a/). Besides checks with final focus positions (section 3.1), the li-questions in this condition were the only utterances with modal voicing in /i/ and /a/ (53% and 72%, respectively).

When the focus is on the first content word, vowel devoicing in *li*-questions (77% for [i] and 43%[a]) is different from that in all other sentence modes.

Devoicing in *li*-questions differs from that in checks and statements. This is possibly caused by the fact that the boundary tones in *li*-questions were realised as L-H% instead of L-L%, which is typical of spontaneous speech. This may be because we are dealing with read speech in the case of *li*-questions, or because of a list effect (since only the *li*-questions were read in a list).

4. DISCUSSION

Analogously to the observations for vowel loss and reductions [4], we never observe complete vowel devoicing with final rising intonation contours (*li*-questions), while it is quite frequent in falling intonation contours (statements and checks). This is also reflected in the shorter relatively devoiced portions in *li*-questions as compared to statements and checks.

For the final falling intonation contours (L-L%), the position of the nuclear accent with respect to the intonation phrase boundary is one of the main determinants of phonatory demarcation in the form of vowel devoicing: the further the pitch accent is away from the phrase boundary, the larger the relative devoiced portion of the vowels in the last two syllables in the phrase becomes.

When the nuclear accent is realised on the last content word in the phrase, we found that sentence mode (statement vs. question) and focus type (broad vs. narrow; contrastive vs. non-contrastive) sometimes affect the duration of the relative devoiced vowel portions. But the (lack of) differences could mostly be explained by corresponding (lack of) differences in the phonetic realisation (peak alignment) of phonological categories (accent type).

The focus-associated accent in statements was analysed in [8] as a H*, with late peak alignment for contrastive and early peak alignment for non-contrastive utterances. In fact, comparing contrastive and non-contrastive statements with different peak alignments with checks (which also have a late peak alignment) we observe significant differences in vowel devoicing for /i/ and /a/ between statements with early and late peaks, as expected. In the comparison with checks (L*+H), we find that /a/ behaves the same as statements with late peaks, but /i/ does not (less devoicing, as shown by the relative devoiced portions below):

/i/:	H* (early) >	H* (late) >	L*+H
	86	60	31
/a/:	H* (early) >	H* (late),	L*+H
	97	43	35

Inspection of the speech signals and the corresponding F0 tracks shows that in non-final position the H* with a late peak is followed by a fall, so that it may be more appropriate to reanalyse the pitch accent as a bitonal H*+L accent. The reanalysis implies a sharp drop in F0, which enhances devoicing of the following /i/ in 'gramatika'. The L*+H accent in checks not only differs in the steep rise towards the peak, it also has a slower fall, which prevents devoicing of the /i/ (since F0 remains high longer). This does not explain why the relative devoiced portion in /a/ is not also longer in statements with late peaks than in checks. We tentatively hypothesise that the need to audibly signal the fall forbids a strong devoicing of /a/.

In summary, vowel devoicing is a phonatory phrase demarcation phenomenon which depends on the phonetic realisation of nuclear pitch contours.

REFERENCES

[1] D. Tilkov, T. Bojadžiev, E. Georgieva, J. Penčev, V. Stankov, *Gramatika na sâvremennija bâlgarski knižoven ezik (vol. 1): Fonetika,* Sofia: Bâlgarska akademija na naukite, 1982.

[2] M. Gordon, "The phonetics and phonology of non-modal vowels: a cross-linguistic perspective," *Berkeley Linguistics Society*, vol. 24, 93-105, 1998.

[3] R. Dauer, "The reduction of unstressed high vowels in Modern Greek," *Journal of the International Phonetics Association*. vol. 10.17-27, 1980.

[4] W. J. Barry and B. Andreeva, "Cross-language similarities and differences in spontaneous speech patterns," *Journal of the International Phonetic Association,* vol. 31/1, pp. 51-66, 2001.

[5] C. Smith, "Marking the boundary: utterance-final prosody in French questions and statements." *Proc. of the XIVth Int'l Congress of Phonetic Sciences*, San Francisco, pages 1181-1184, 1999.

[6] http://www.ipds.uni-kiel.de/forschung/xassp.de.html

[7] M. Beckman, M. and G. A. Elam, "Guidelines for ToBI labeling," version 3. Linguistics Department, Ohio State University, 1997

[8] B. Andreeva, T. Avgustinova and W.J. Barry, "Link-associated and focus-associated accent patterns in Bulgarian," in: *Current Issues in Formal Slavic Linguistics*, G. Zybatow, U. Junghanns, G. Mehlhorn and L. Szucsish, Eds., Frankfurt: Peter Lang, pp. 353-364, 2001.

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