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Voicing-Conditioned Vowel Duration in Southern Serbian*

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Abstract

This study presents results of an acoustic analysis of a sample of controlled speech in Southern Serbian. Durations of vowels before voiced and before voiceless obstruents were examined in word-final and word-medial position in two experimental conditions: in isolation and in a sentence frame. The duration of the vowels before voiced obstruents tends to be longer than that before voiceless obstruents. The overall average of ratios is 0.82, which is similar to findings in other languages. The effect is greater in words read in isolation. In word-final position this effect is slightly greater before fricatives than before stops. In the second part of the study, these results are compared with the results for Standard Serbian, which has both phonemic vowel length contrast and voicing-conditioned differences in vowel duration, unlike Southern Serbian, which does not have phonemic length contrast. A hypothesis that voicing-conditioned durational differences in vowels would be bigger in Southern Serbian than in Standard Serbian was not confirmed by the results of the study. In both Southern Serbian and Standard Serbian these differences are of the same magnitude with the overall ratios of 0.82 and 0.84 respectively.

1. Introduction

Previous research on the voicing contrast in obstruents has shown that in word-final and syllable-final position vowels before voiced obstruents tend to be longer than vowels before voiceless obstruents, e.g. in English word pairs *bid-bit* or *bag-back*. A common way of quantifying this difference is a ratio which represents the duration of the vowel before voiceless obstruents divided by the duration of the vowel before voiced obstruents, for example 2:3 or 0.67.

This effect has been documented for a number of languages, but English is the best researched language in this respect (House & Fairbanks 1953, Peterson & Lehiste 1960, House 1961, Sharf 1962, Chen 1970, Cochrane 1970, Klatt 1973, Hogan & Rozsypal 1980, Luce & Charles-Luce 1985). Mean differences in vowel durations before voiced and voiceless obstruents in English vary from 55 ms (Luce & Charles-Luce 1985) to 140 ms (House 1961), and the corresponding ratios from 0.55 (House 1961) to 0.74 (Hogan & Rozsypal 1980), but the majority of studies found this ratio to be for English about 2:3, or around 0.67 (House & Fairbanks 1953, Peterson & Lehiste 1960, Sharf 1962, Luce & Charles-Luce 1985).

Voicing-conditioned vowel duration exists in a number of other languages as well, such as French (Chen 1970, Mack 1982, Laeuffer 1992), Russian (Kozhevnikov & Chistovich 1966, Chen 1970), Korean (Chen 1970), German (Chen 1970), Norwegian (Chen 1970), Spanish (Zimmerman & Sapon 1958), and Dutch (Slis & Cohen 1969). Differences in these languages are smaller than in English, and vary from 18 ms for

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Spanish (Zimmerman & Sapon 1958) to 55 ms for Norwegian (Chen 1970). The ratios are higher than in English, between 0.74 for French (Mack 1982) and 0.90 for German (Chen 1970).

However, there are some languages without voicing-conditioned vowel duration, such as Czech and Polish (Keating 1985) and Saudi Arabian Arabic (Flege & Port 1981). In these three languages observed differences in vowel duration are negligible and all below 10 ms, (with high ratios, close to 1: 0.95 for Czech, 0.97 for Arabic, and 0.99 for Polish).

Voicing-conditioned vowel duration is regarded as a nearly universal phenomenon. However, its extent is language-specific with English forming a class of its own, and other languages clustering together (Chen 1970).

It is important to note that large effects were observed mainly in isolated words and in phrase-final position. The effect was smaller in spontaneous speech than in words read from lists (Klatt 1976, Crystal & House 1988), and it was smaller at a fast speaking rate than at a slow speaking rate (Port 1981). Some studies have found that this effect is larger in the context of fricatives than in the context of stops (House & Fairbanks 1953, Peterson & Lehiste 1960, House 1961, Hogan & Rozsypal 1980, Laeuffer 1992).

2. Aims of the study

There is very little research on voicing-conditioned vowel duration in Serbian, apart from some unpublished work, which deals with Standard Serbian (Sokolović-Perović 2008, Sokolović-Perović, unpublished data). The aim of the present study is to examine this phenomenon in Southern Serbian: 1) to establish whether voicing-conditioned vowel duration exists in Southern Serbian, and if it does, 2) to examine its extent and its characteristics (whether there are differences in isolation vs. sentence frame and whether there is any difference in the effect before stops and before fricatives).

Further motivation for this study comes from Keating's (1985) study on Czech. Namely, Czech has no voicing-conditioned durational differences in vowels, but has a phonemic vowel length contrast. Keating proposed that in Czech vowel duration difference is preserved for the phonemic length contrast and that is why it does not differentiate vowel duration as a function of obstruent voicing. The question that arises is: What happens if a language has both durational difference due to the following obstruent voicing and phonemic vowel length contrast? And further, if a language has voicing-conditioned vowel duration difference and a variety with phonemic vowel length contrast and a variety without it, it could be hypothesised that the effect of obstruent voicing on the preceding vowel duration would be greater for the variety without phonemic vowel length contrast, since there is no need for durational difference to be preserved for phonemic vowel length contrast.

This hypothesis can be tested on the data from the Serbian Language. Standard Serbian has both phonemic vowel length contrast and voicing-conditioned vowel duration (Sokolović-Perović 2008, Sokolović-Perović, unpublished data), while Southern Serbian has only short vowels and no phonemic vowel length difference. Southern Serbian belongs to the Prizrensko-Timočki Dialect situated in Southern and South-Eastern Serbia. It is a non-standard dialect. For the purpose of this study, the most important facts are that it has only one type of accent and only short vowels (Ivić 1985). The main material for this study is from Southern Serbian. Standard Serbian, on

the other hand, has four word accents, and most importantly for this study, it has phonemically short and long vowels (Ivić 1985). In the present paper it provides material for comparison.

3. Experiment

3.1. Linguistic material and subjects

A set of 25 minimal or near minimal pairs, differing in one or two features (Kristal 1987) was used for this study (the full list is given in Appendix A). These were monosyllabic and disyllabic words with the following structure: CVC/CCVC/CCVC or CVCV/CCVCV. In Southern Serbian all vowels are short¹. Obstruents under investigation were either in word-final position (monosyllabic words such as *snob-snop*) or word-medial position (disyllabic words such as *Nada-Nata*). Seven obstruent pairs were included in the material (/b-p/, /d-t/, /g-k/, /z-s/, /ʒ-ʃ/, /dʒ-tʃ/, /dʒ-tʃ/).

Four subjects, one male and three female, all speakers of Southern Serbian (from the town of Leskovac, which belongs to Prizrenko-Timočki Dialect) participated in the study. They were between 30 and 40 years old (mean age 35, median age 35) and reported no known speech and hearing disorders.

Material for comparison comes from an unpublished study (Sokolović-Perović, unpublished data). Four subjects were used for this study as well, one male and three female. They were all from Northern and North-Western Serbia. Linguistically, this area belongs to Šumadijsko-Vojvođanski and Istočnohercegovački dialects, which are considered to be the base of Standard Serbian (Ivić 1985). Their age was between 30 and 62 years (mean 39.5, median 33 years), and they also reported no known speech or hearing problems.

3.2. Recording and analysis

For the first group of subjects words from the list were randomized and mixed with other words (fillers) and presented to the subjects to read. There were two conditions: isolation and a sentence frame. Each subject read the list once in isolation and once in the sentence frame: *Reci ... osam puta* 'Say ... eight times'.

Subjects were advised to read the tokens at a habitual, natural rate. Recordings were made in a quiet room. The utterances were recorded onto a Toshiba laptop via an M-Audio MobilePre USB audio box and a Sony ECM-MS907 electret condenser microphone. The sampling rate was 44.1 kHz. Material was presented on the laptop screen using Prompt and Record software (ProRec 1.0)². This software presents timed text prompts on the computer screen and simultaneously records speech to the hard disc. For material recorded in isolation, tokens were displayed every 3 seconds, and for the sentence material every 5 seconds. This timing was judged by the author as providing a comfortable and habitual rate of speech.

¹ In Standard Serbian some of these vowels are short and some of them are long. Since it was difficult to find enough minimal or near-minimal pairs with the appropriate word structure and a short vowel, both words with long and short vowels in Standard Serbian were included. For Standard Serbian they were analysed separately and only results for words with short vowels were used for comparison with Southern Serbian. In Southern Serbian, however, the same words are pronounced with short vowels only, and all results are included in the comparison.

² Available online from <http://www.phon.ucl.ac.uk/resource/prorec/>

Acoustic analysis was performed using PRAAT (v. 4.5.14)³. The duration of each vowel was determined from waveform displays and wideband spectrograms of recorded speech tokens. Measurements were made using an existing PRAAT script for durational measurements (Remijsen 2004), and rounded to the nearest millisecond.

Segmentation criteria in this study were based on the segmentation principles proposed by Turk et al. (2006), with one exception. Namely, what is proposed as a vowel duration by Turk et al. in a CVC sequence includes formant transitions, bursts and possible aspiration after the release (in case of aspirated voiceless stops). A difficulty is that previous studies on voicing-conditioned vowel duration have adopted different approaches. In a minority of studies, the duration of the vowel included possible aspiration (Zimmerman & Sapon 1958, Peterson & Lehiste 1960). In some studies it was not specified which approach was used (Sharf 1962, Edwards 1981, Davis & Van Summers 1989), but in the majority of the studies, especially more recent ones, it was the duration without the aspiration that was measured (Chen 1970, Cochrane 1970, Mack 1982, Wardrip-Fruin 1982, Laeufer 1992, Kessinger & Blumstein 1998), so that cross-linguistic comparisons would not be affected by differences in VOT. In the present study vowel duration was defined in the same way, that is, it did not include the aspiration of the preceding stop (if there was any aspiration).

Statistical analysis was performed using SPSS 15.0 for Windows. The following procedure was used for all data sets. Normality of the data was assessed using a normal probability plot and tested for normality using a Shapiro-Wilk normality test (Stevens 1996, Field 2000). If the distribution was normal, a 2-sample t-test was performed. If the distribution was non-normal, a Mann-Whitney non-parametric test was used.

Speakers in the second group read the same word list, but here word tokens were mixed with a different set of words, intended for research on another topic. Words were randomized and presented to the subjects in the same way and in the same two conditions as above (isolation and the sentence frame). Obstruents under investigation were in word-final and word-medial position, as above, but this sample of speech contained both short and long vowels. In the present study only results for words with short vowels will be used for comparison. For this sample of speech the same method for recording and analysis was used, as above, and the same statistical procedures.

4. Results

4.1. Voicing-conditioned vowel duration in Southern Serbian

Table 1 shows results for voicing-conditioned vowel duration in Southern Serbian in word-final and word-medial position. Results are pooled across subjects. For each condition (isolation and the sentence frame) and for each position (word-final and word-medial), mean vowel duration (in ms), number of tokens, and standard deviations are given before voiced obstruents and before voiceless obstruents. In the two columns on the right are presented an absolute difference in ms (rounded to the nearest millisecond), and the ratio, defined as duration of the vowel before voiceless obstruents/duration of the vowel before voiced obstruents (rounded to two decimal places). Statistically significant differences in vowel duration were annotated in the following way: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ (and this notation is used in all tables in the paper).

³ Available online from <http://www.praat.org>

As can be seen from the pooled data in Table 1, voicing-conditioned vowel duration does exist in Southern Serbian. It is present in both word-final and word-medial position, and both in isolated words and words read in the sentence frame. Differences between means vary from 22 ms to 32 ms and ratios are between 0.79 and 0.84.

There is a tendency for these differences to be smaller in the sentence condition compared to isolation: 20 ms vs. 25 ms in word-final position and 22 ms vs. 32 ms in word-medial position, or, represented in ratios 0.84 vs. 0.81 and 0.84 vs. 0.79 for word-final and word-medial position respectively. All observed differences were statistically significant at the 0.001 level.

Table 2 shows results in pooled data for Southern Serbian, but for each obstruent class separately, in word-final position and in both conditions (isolation and the sentence frame). The table is organized in the same way as Table 1. Out of the three obstruent classes in Serbian, only stops and fricatives are represented, because no appropriate words with affricates in word-final position were found.

Table 1. Mean vowel duration (ms), number of tokens, standard deviation, difference in vowel duration (ms) and ratio in the pooled data for word-final and word-medial position in Southern Serbian.

	Mean vowel duration (ms), N and StDev		Difference (ms)	Ratio
	Before voiced obstruents	Before voiceless obstruents		
<i>Word-final position</i>				
Isolation	132.30 (43; 24.39)	107.16 (43; 22.42)	25 ***	0.81
Sentence	124.47 (43; 24.7)	104.82 (44; 21.9)	20 ***	0.84
<i>Word-medial position</i>				
Isolation	153.18 (49; 22.72)	121.09 (53; 20.79)	32 ***	0.79
Sentence	138.60 (43; 21.45)	116.25 (48; 20.38)	22 ***	0.84

In word-final position, in both conditions, differences in vowel duration before voiced and voiceless obstruents are present when stops and fricatives are considered separately, and all differences are statistically significant at the 0.01 level. What is more, vowels before fricatives tend to be longer than vowels before stops, all else being equal. However, when expressed as a ratio, it seems that the effect of obstruent voicing

on preceding vowel duration is bigger in the context of fricatives only in isolation, but not in the sentence frame, and even then the difference is fairly small (0.80 for fricatives vs. 0.81 for stops, or 6 ms).

Results for word-medial position are given in Table 3. For this word position all three classes of Serbian obstruents were represented in the material.

In word-medial position, the same tendencies of vowels being longer before voiced obstruents than before voiceless obstruents are preserved for all three obstruent classes: stops, fricatives and affricates. These differences were also statistically significant without exception.

The tendency of vowels being longer before fricatives than before stops is present in word-medial position as well, but the actual effect of obstruent voicing on preceding vowel duration is smaller in the context of fricatives in both isolation and the sentence frame (ratios of 0.88 for fricatives vs. 0.75 for stops, and 0.87 for fricatives vs. 0.85 for stops, respectively).

As far as affricates are concerned, they do not exhibit a consistent behaviour. In isolation the magnitude of the effect on the preceding vowel duration is between the values for stops and fricatives (0.83), but in the sentence frame they introduced the biggest differences in the preceding vowel durations of all obstruent classes (0.79).

Table 2. Mean vowel duration (ms), number of tokens, standard deviation, difference in vowel duration (ms) and ratio in the pooled data before stops and fricatives in word-final position in Southern Serbian.

		Mean vowel duration (ms), N and StDev		Difference (ms)	Ratio
		Before voiced obstruents	Before voiceless obstruents		
<i>Word-final position</i>					
Isolation	Stops	127.06 (35; 21.38)	103.20 (35; 22.01)	24 **	0.81
	Fricatives	155.25 (8; 24.66)	124.5 (8; 15.15)	31 **	0.80
Sentence	Stops	119.11 (35; 22.87)	100.00 (36; 20.56)	19 **	0.84
	Fricatives	147.88 (8; 18.72)	125.50 (8; 15.24)	22 **	0.85

Table 3. Mean vowel duration (ms), number of tokens, standard deviation, difference in vowel duration (ms) and ratio in the pooled data before stops, fricatives and affricates in word-medial position in Southern Serbian.

		Mean vowel duration (ms), N and StDev		Difference (ms)	Ratio
		Before voiced obstruents	Before voiceless obstruents		
<i>Word-medial position</i>					
Isolation	Stops	154.19 (27; 21.64)	115.00 (31; 17.25)	39 ***	0.75
	Fricatives	163.83 (12; 18.26)	144.55 (11; 17.98)	19 *	0.88
	Affricates	137.70 (10; 23.9)	114.82 (11; 16.38)	23 *	0.83
Sentence	Stops	136.13 (24; 20.98)	115.32 (28; 17.09)	21 ***	0.85
	Fricatives	149.60 (10; 20.8)	130.10 (10; 18.44)	20 *	0.87
	Affricates	133.00 (9; 21.41)	105.00 (10; 24.41)	28 *	0.79

4.2. Voicing-conditioned vowel duration in Standard Serbian

Table 4 shows results for short vowels in Standard Serbian (from Sokolović-Perović, unpublished data). The table is organized in the same way as before, and the results are pooled across subjects.

In Standard Serbian, vowels before voiced obstruents are longer than vowels before voiceless obstruents. All of these differences are statistically significant at the 0.01 level. Word-medially the effect is smaller in the sentence condition (0.86) than in isolation (0.81), but in word-final position the difference is negligible (22 ms vs. 23 ms, and the same ratio of 0.83).

Table 4. Mean vowel duration (ms), number of tokens, standard deviation, difference in vowel duration (ms) and ratio in the pooled data for word-final and word-medial position in Standard Serbian.

	Mean vowel duration (ms), N and StDev		Difference (ms)	Ratio
	Before voiced obstruents	Before voiceless obstruents		
<i>Word-final position</i>				
Isolation	137.63 (19; 26.52)	114.14 (18; 29.314)	23 **	0.83
Sentence	132.21 (19; 18.64)	109.79 (19; 22.21)	22 **	0.83
<i>Word-medial position</i>				
Isolation	141.57 (23; 30.62)	114.00 (21; 26.754)	28 **	0.81
Sentence	139.55 (22; 19.058)	120.22 (23; 21.326)	19 **	0.86

4.3. Voicing-conditioned vowel duration in Southern Serbian in comparison to Standard Serbian

The second aim of the present study was to compare results for Southern Serbian with the corresponding results for Standard Serbian. Table 5 summarizes findings for both Southern and Standard Serbian. For Standard Serbian only results for short vowels are included in the comparison.

Results in Table 5 indicate that the same tendencies exist in both Southern Serbian and Standard Serbian. In both cases voicing-conditioned differences in vowel durations are present for both conditions and both word positions under investigation. These differences are all statistically significant (for Southern Serbian at the 0.001 level and for Standard Serbian at the 0.01 level). Relationships between corresponding ratios are similar in both Southern and Standard Serbian, e.g. ratios in the sentence condition are higher (or durational differences smaller) than in isolation, with the exception of word-final position in Standard Serbian, where ratios are the same.

Table 5. Mean difference (ms) and ratio for both word positions (initial and medial) and both conditions (isolation, sentence frame) for Southern and Standard Serbian in the pooled data.

	Southern Serbian	Southern Serbian	Standard Serbian	Standard Serbian
	Difference (ms)	Ratio	Difference (ms)	Ratio
<i>Word-final position</i>				
Isolation	25 ***	0.81	23 **	0.83
Sentence	20 ***	0.84	22 **	0.83
<i>Word-medial position</i>				
Isolation	32 ***	0.79	28 **	0.81
Sentence	22 ***	0.84	19 **	0.86

5. Discussion and conclusions

Findings of the present study confirm that voicing-conditioned vowel duration exists in Southern Serbian. There have been no previous reports on Southern Serbian. The observed mean differences are in the range between 19 ms (before final stops in the sentence frame, and before word-medial fricatives in isolation) and 39 ms (before stops in word-medial position in isolation). All differences are statistically significant, for all three obstruent classes and for both conditions and both word positions under investigation. Observed ratios vary from 0.75 for word-medial stops in isolation to 0.88 for fricatives in the same position in isolation.

The average of ratios for Southern Serbian is 0.82, which is in line with the findings for other languages, such as Russian and Norwegian (Chen 1970).

The effect of obstruent voicing on the preceding vowel duration is greater in isolation. This is similar to findings from English, where the biggest effect was also found in isolated words read from a list (Klatt 1976, Crystal & House 1988).

The effect of fricatives, however, does not exceed that of stops, as was found in some other studies for English (House & Fairbanks 1953, Peterson & Lehiste 1960, House 1961, Hogan & Rozsypal 1980) and for French (Laeufer 1992). Only in word-final position in isolation, this effect was greater in the context of fricatives, and even then the difference was small (0.80 for fricatives vs. 0.81 for stops).

As far as differences between Southern Serbian and Standard Serbian are concerned, they tend to be small. The overall average of ratios for Southern Serbian is 0.82 and for Standard Serbian 0.84 (for short vowels). The hypothesis that voicing-conditioned difference in vowel duration would be greater in Southern Serbian was not confirmed. Irrespective of whether a variety has phonemic vowel length contrast or not, voicing-conditioned durational differences are within the same range, here 0.82 and 0.84. In Serbian, effect of obstruent voicing on the preceding vowel duration is the same

in both varieties, irrespective of whether phonemic vowel length contrast is present or not. It can be concluded that voicing-conditioned differences in vowel duration are similar across different varieties of Serbian. Although there is a potential in Southern Serbian for greater differences in vowel durations as a function of the following obstruent voicing, it is not utilized, and voicing-conditioned vowel duration differences seem to be uniform in different varieties of Serbian.

Appendix A

List of words used in the experiment.

Minimal or near minimal pairs with final obstruents:

štab	štap
kub	tup
snob	snop
led	let
sprud	prut
nad	mat
lug	luk
breg	prek
smog	cmok
staž	šaš
svež	veš

Minimal or near-minimal pairs with medial obstruents:

snoba	snopa
tuba	tupa
ploda	plota
Nada	Nata
kada	Kata
nega	neka
nego	neko
boga	Boka
koza	kosa
Vasa	vaza
Sneža	Neša
gedža	Beča
siđi	sići
leđa	leća

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