THE INFLUENCE OF THE PLACEMENT OF WORD-BOUNDARY ON THE ACOUSTIC INVARIANCE OF THE SYLLABLE

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ABSTRACT

The influence of the higher language processing levels, namely the placement of the word-boundary (V1C#V2 or V1#CV2, e.g.tat#ući - ta#tući), on the syllabification patterns in Croatian is assessed. The consonants were /p/, /t/, /k/. Fifteen frame utterances were read by 10 subjects, recorded, and then digitised and treated to measure the following acoustic variables: the duration of V1, C, V2, and possible pause between C and V2, and the intensity of V1, V2 and consonant burst. The univariate analysis of variance and regression analyses show that C-closure duration , V2 and pause can predict the placement of the word-boundary.

INTRODUCTION

Discussing the phenomenon of production of smaller speech units some authors emphasize the importance of the phonetic level [1, 2, 3], the others insist on the conceptual and language level [4, 5, 6], while the third group suggest that the answer to the question should be "one and the other" and not "one or another" [7, 8]. Boucher [9] and Quené [10] found that the syllable acoustic parametars are influenced by the placement of the word boundary. Browman and Goldstein [11] proved the C-center can be the measurable parametar of the consonant belonging to the preceeding or following vowel. In the present paper the relationship between conceptual-language and phonetic levels of speech is examined by investigating the influence of the word boundary on the acoustic syllable structure in Croatian. Identical VCV segments which differ only in the placement of word boundary (V#CV or VC#V) are measured in frame utterances pronounced at a normal tempo and short enough not to require a syntactic pause within the VCV segment.

PROCEDURES

Fifteen pairs of sentences, 5 for each of the consonants /p, t, k/ were constructed. In the paired sentences the consonants were in the identical vowel context but the placement of the word boundary was either before or after the consonant. The sentences were matched according to the stress of observed vowels, number of syllables and rhytmic structure. For example:

Možda će ta tući. - a#tu
Možda će tat ući. - at#u

Ten female students of the Faculty of Philosophy in Zagreb, of normal speech and hearing status, read 30 randomized sentences. The sentences were recorded and then analysed by means of the computer speech program AGOS [12]. The investigated VCV syllables were described by measuring 8 acoustic variables: 5 variables of duration (first vowel - DV1, consonant closure - DCC, consonant burst - DCB, second vowel - DV2 and duration of the possible pause between consonant burst and second vowel - DPA), and 3 variables of maximal intensity (first vowel - IV1, consonant burst - ICB and second vowel - IV2).

The differences between V#CV and VC#V segments for each variable were tested by means of univariate analysis of variance. By means of multiple regression analysis the predictive strength of the variables to distinguish word boudary placement were determined.

RESULTS AND DISCUSSION

The results of the univariate analysis of variance are given in Table 1 and Figure 1.

The variables DCC, DV2 and DPA statistically significantly differentiate the two segments.

The consonant closure (DCC) is 16 ms (23%) longer if the consonant is placed after the word boundary (V#CV) than when it is before the boundary (VC#V). This result corresponds to that of Quene [10], who found that the consonant durations vary between 49 ms for intended CVC#VC, and 71 ms for intended CV#CVC, and post-boundary vowel rise time varies between 19 ms and 13 ms, respectively.

*Table 1. Means ($\bar{X}$) and standard deviations (s) of variables in ms in segments V#CV and VC#V. Statistically significant differences (p=.01) are marked by *.*

	V#CV		VC#V	
	$\bar{X}$	s	$\bar{X}$	s
DV1	68.6	28.9	68.5	28.1
DCC	85.3	19.4	69.5	16.5 *
DCB	23.8	15.6	26.0	16.9
DV2	115.1	26.0	124.3	24.8 *
DPA	0.5	6.0	36.9	33.6 *
IV1	62.5	2.6	62.3	3.1
ICB	49.8	5.3	49.3	4.8
IV2	62.5	2.8	62.5	2.7

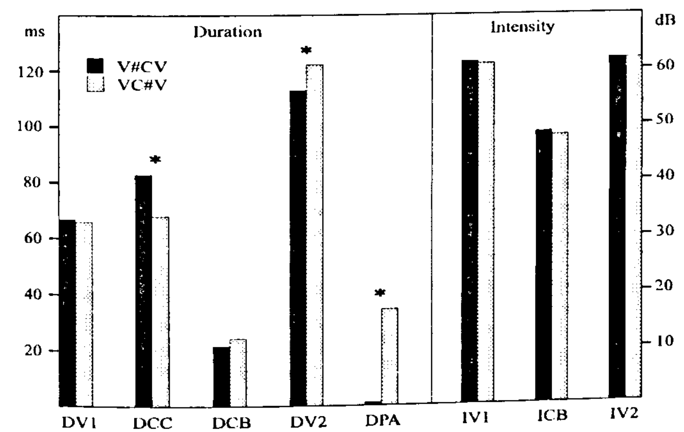

Figure 1. Means of measured variables in segments V#CV (black column) and VC#V (gray column).

It must be mentioned that closure in segment V#CV enables the speaker to produce a syntactic pause after the word boundary which cannot be separated from closure if the consonants are voiceless stops as in our experiment. Škarić [13] states that the average duration of syntactic delimitation pause equals approximately syllable duration, or about 100 ms. Our results show that the duration of consonant closure is shorter than that, so it could not include the syntactic delimitation pause. But it can be considered a kind of syllable delimitation or syllabic pause.

The duration of the second vowel in the segment VCV (DV2) is shortened in the position V1#CV2 by about 9 ms (9%) compared to the V1C#V2 position. This shortening can be explained by faster articulation of the vowel when it is triggered by the consonant (V#CV) than when it is triggered by the intercostal muscles (VC#V).

Pauses between the consonant burst and the second vowel in the explored sample were found only in the V1C#V2 word boundary position. Of the 150 possible pauses in VC#V segments 96 (64%) were realised. Average duration of all the possible pauses was 40 ms; average duration of the realised pauses was 54 ms. As that is less than the duration of syntactic delimitation pauses, this kind of pause can be considered to indicate the syllabic structure.

Table 2. Multiple correlation (R), determination (R^2), regression coefficients (Beta) and correlations with the criterion (r).

	Beta	r	
DV1	.02	-.01	R = .67627
DCC	-.28 *	-.41	R^2 =.45734
DCB	.01	.07	
DV2	.15 *	.18	
DPA	.52 *	.60	
IV1	.01	-.04	
ICB	-.04	-.05	
IV2	-.12	-.00	

Regression analysis (Table 2) proved the results obtained by univariate analysis of variance. The chosen variables account for 46% of the variability of the whole system. The V1#CV2 and V1C#V2 were best positively predicted by the duration of the possible pause (DPA), duration of consonant closure (DCC) and negatively by the duration of second vowel (DV2). Such structure of the regression function shows that the segments V#CV and VC#V are best differentiated by the simultaneuos prolongation of the pause and V2, and shortening of the consonant closure, and vice versa. In other words, when in the VC#V segment the pause is realised at the word boundary the consonant closure is shortened. On the other hand, in the V#CV segment the zero pause is realised and the consonant closure is prolonged. These results prove the stability of the articulatory program and the possibilities of compensatory mechanisms at the level of sound articulation [8].

CONCLUSIONS

The investigation proved the influence of the placement of word boundary on some acoustic parametars of segments V1#CV2 and V1C#V2. The discrimination of the segments is mostly based on the duration of the syllabic delimitation pause and on the duration of the consonant closure, in which, potentially, the delimitation pause can be hidden. The duration of the second vowel was found to be less important element of discrimination. These variables are indicators of syllabic structure and the position of the word boundary. Intensity parameters did not prove to play a significant role in revealing the syllabic structure.

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