

THE ACOUSTIC DIFFERENTIATION OF SERBO-CROATIAN WORD-TONES IN STATEMENT ENVIRONMENTS

EDWARD T. PURCELL

The present paper describes some of the findings of an acoustic investigation into the interaction of word-tone and sentence intonation in contemporary standard Serbo-Croatian. A traditional description of Serbo-Croatian might state that rising and falling tones are linked with vowel length or its absence to form a four-way system of short rising, short falling, long rising, and long falling accents. The basic question is this: how are the four word-tones differentiated from each other within sentences? Here we will limit discussion to the patterning of certain acoustic parameters within statements, although similar results have been obtained for questions.

1. METHOD

Five randomly chosen male informants from Bosnia-Herzegovina, representing various age and education groups, tape-recorded a carefully constructed reading text, which provided a suitable context for the production of fifty test words in three statement environments: statement start, statement mid, and statement end. The fifty test words contained five examples each of the possible combinations of monosyllabic, disyllabic, or trisyllabic words bearing short falling, short rising, long falling, and long rising accent. The resulting 750 examples of the fifty test words in the three statement environments were acoustically analyzed. A maximum of twenty measurements of fundamental frequency, duration, and intensity were made for each occurrence of the fifty test words. Fundamental frequency and duration measurements were averaged; intensity measurements were compiled. These calculations yielded mean fundamental frequency and duration values for each word type (e.g., a disyllabic word bearing a short falling accent) in each of the three statement environments for the five speakers. Comparisons between various word types in various statement environments are based on these averages. The results of the investigation clearly indicate that within the three statement environments there is a regular pattern of sizeable differences in the acoustic parameters investigated, which seems to correspond to the traditional distinctions between the four accents of Serbo-Croatian.

2. DURATION DIFFERENCES

By comparing the occurrences of short falling with long falling and of short rising with long rising accents, in the three statement environments, it was learned that there are regular differences in the duration of the accented vowel corresponding to the traditional distinction between 'short' and 'long' accents. (For all test words, the first syllable was the 'accented' syllable, i.e., the syllable above which one of the four accent marks is traditionally written). Table 1 displays the average duration of accented vowels for corresponding short vs. long accents. The average duration of the accented vowel bearing a short falling accent is 60% of that for a long falling accent. Similarly, the average duration of the accented vowel for a short rising accent is 66% of that for a long rising accent. Thus, it seems that durational differences in a word's accented vowel signal the presence of a long or a short accent.

TABLE 1

Average duration in centiseconds of accented vowels for disyllabic and trisyllabic test words in three statement environments, based on average data for all five speakers.

environments	TEST WORDS								
	disyllabic				trisyllabic				
	falling		rising		falling		rising		
	short	long	short	long	short	long	short	long	
statement									
start	8.5	14.7	11.6	14.8	8.7	12.7	8.0	12.5	
mid	7.4	14.9	11.2	15.5	7.5	11.3	7.9	12.9	
end	7.9	14.9	10.2	17.5	7.6	11.3	7.4	11.7	
mean	7.9	14.8	11.0	15.9	7.9	11.8	7.8	12.4	
average duration of the accented vowel for:									
short falling accent =	7.9 cs								
long falling accent =	13.3 cs								
short rising accent =	9.4 cs								
long rising accent =	14.1 cs								
duration of short falling is 60% of duration of long falling									
duration of short rising is 66% of duration of long rising									

Similar to findings previously reported by Lehiste and Ivić, data for the present investigation indicate that the duration of a short post-accentual vowel is much less than for an accented vowel, either short or long. Thus, it seems that duration may be an important cue for the differentiation of accented vs. unaccented vowels.

Durational differences also appear in the data for post-accentual vowels. Vowels in syllables following a rising accent regularly have greater duration than vowels following a falling accent. Within a word, a vowel in a syllable following a rising

accent is, on the average, 30% longer than a vowel in a syllable following a falling accent.

3. FUNDAMENTAL FREQUENCY DIFFERENCES

A consistent pattern of fundamental frequency differences was found between the average realizations of corresponding rising and falling accents in any of the three statement environments. By comparing the average fundamental frequency values for short falling vs. short rising accents, and by comparing the average values for long falling vs. long rising accents in the three statement environments, it was possible to formulate the following pattern of fundamental frequency differences between corresponding 'rising' and 'falling' accents: (see Figures 1 and 2).

(1) within the accented vowel,

(a) the fundamental frequency at the start of the accented vowel is higher for a falling accent than for a corresponding rising accent (one exception, see below)

(b) the fundamental frequency at the end of the accented vowel is lower for a falling accent than for a corresponding rising accent;

(2) within the first post-accentual vowel,

the value of the fundamental frequency at (a) the start, (b) the middle, and (c) the end of the vowel is lower for a falling accent than for a corresponding rising accent.

Thus, within the accented vowel, the average realization of a falling accent in any of the three statement environments starts higher and ends lower than does the average realization of a corresponding rising accent in the same statement environment. Within the first post-accentual vowel, the average realization of a falling accent starts, 'mids', and ends lower than for a corresponding rising accent.

There is one consistent deviation from the above pattern. For trisyllabic words bearing long accents, the average value of the fundamental frequency at the start of the accented vowel is not as stated above; instead, the fundamental frequency at the start of the accented vowel is lower for a long falling than for a long rising accent.

4. PEAK LOCATION DIFFERENCES

It was found that within the vowel of the accented syllable, the peak of the fundamental frequency always occurs closer to the start of the vowel for a falling accent than for a corresponding rising accent within the same statement environment. In other words, a falling accent peaks earlier than does a corresponding rising accent (see Figures 1 and 2).

The preceding description of differences in fundamental frequency and peak location holds true for 100% of the average realizations of short falling vs. short rising and of long falling vs. long rising accents in the three statement environments.

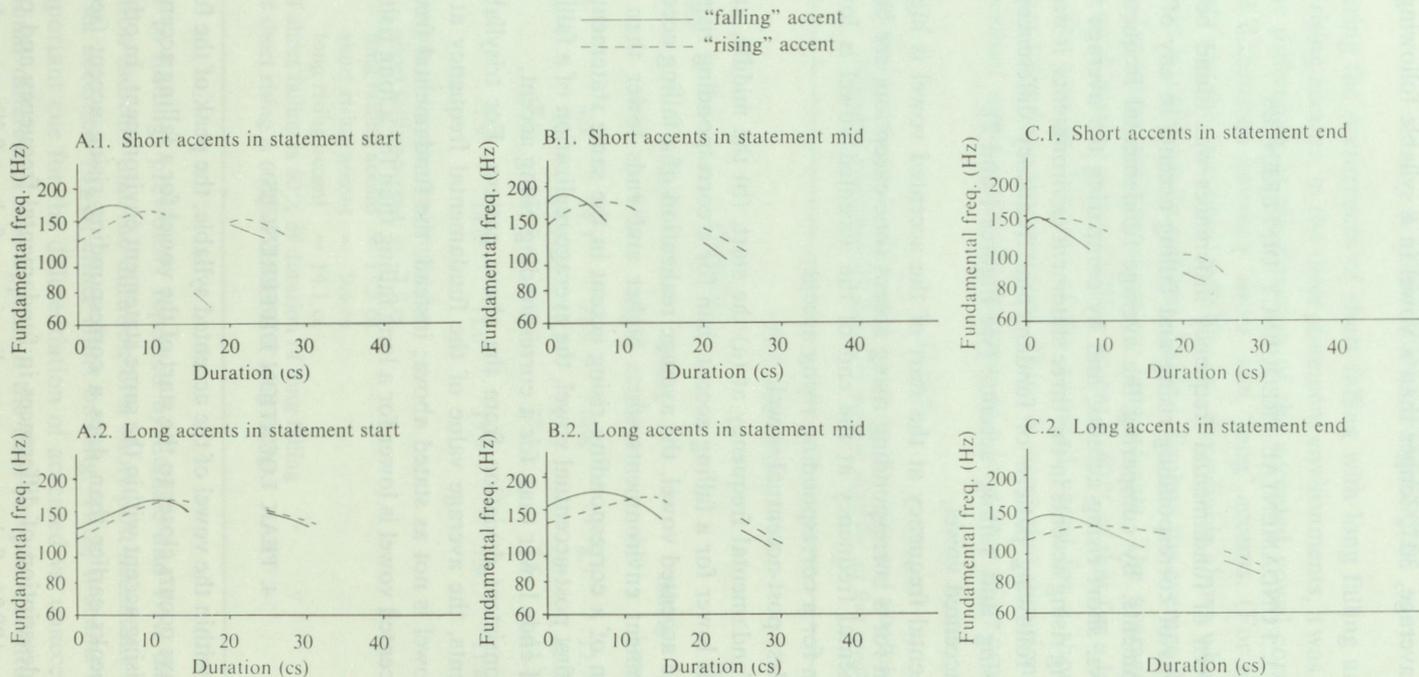


Fig. 1. Fundamental frequency and duration of vowels for disyllabic test words in three statement environments: statement start, statement mid, and statement end; based on average data for all five speakers collectively.

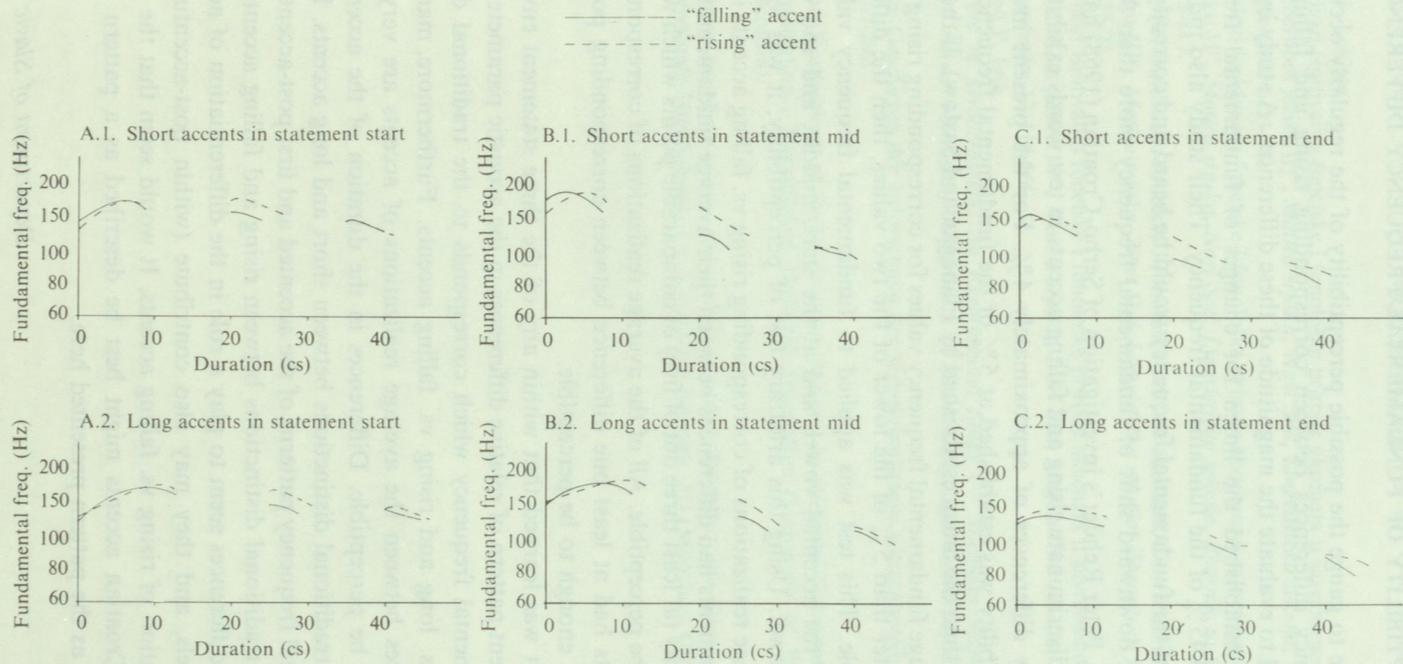


Fig. 2. Fundamental frequency and duration of vowels for trisyllabic test words in three statement environments: statement start, statement mid, and statement end; based on average data for all five speakers collectively.

5. PERCEPTIBILITY OF FUNDAMENTAL FREQUENCY DIFFERENCES

Based on a desire to gauge the possible perceptibility of the regularly occurring fundamental frequency differences between corresponding rising and falling accents, a test was devised to evaluate the magnitude of these differences. A study by Flanagan and Saslow has established the limen for changes of fundamental frequency as $\pm 0.23\%$ to $\pm 0.45\%$ of the fundamental frequency. Their study also indicated that a change of 1% of the fundamental frequency would be heard and correctly identified as an upward or downward shift of fundamental frequency more than 90% of the time. In addition, Peter Rehder's investigation of Serbo-Croatian (1968) has indicated that natives can discriminate rising and falling accents in test words exhibiting fundamental frequency differences of approximately 4%. For the present investigation, a test of perceptibility was established at 5% of the fundamental frequency (roughly ten times greater than the limen established by Flanagan and Saslow). If the difference between the average fundamental frequency values for corresponding rising and falling accents was greater than 5% of the lower of the two values, then the difference was judged perceptible. This test was applied to fundamental frequency values at the start and end of the accented vowel, and at the start, middle, and end of the first post-accentual vowel. Using this arbitrary test of perceptibility, it was learned that 83% of the average realizations of corresponding rising vs. falling accents in the three statement environments had differences between their average fundamental frequency values at a majority (at least three out of five) of comparable points which were judged great enough to be perceptible. All of the average realizations of corresponding rising vs. falling accents had at least one difference between corresponding points which was judged great enough to be perceptible.

In summary, it was learned that within any of the three statement environments there is a consistent pattern of relative differences in the acoustic parameters of duration and fundamental frequency which corresponds to the traditional distinctions between short vs. long and rising vs. falling accents. Furthermore, many of these relative differences between the average realizations of accents are very probably great enough to be perceptible. Differences in the duration of the accented vowel regularly match traditional distinctions between short and long accents. Differences in the fundamental frequency patterns of the accented and first post-accentual vowels regularly match traditional distinctions between rising and falling accents. In addition, durational differences seem to play a role in the differentiation of accented vs. unaccented vowels, and they may also contribute (within post-accentual vowels) to the differentiation of rising vs. falling accents. It would seem that the differences between Serbo-Croatian accents might best be described as a pattern of relative differences, such as the pattern presented here.

*Department of Slavic Languages
University of Southern California
Los Angeles*

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