



# L1 and L2 Serbian Accents: Analysis of Pitch Parameters

*Ekaterina Panova*

Saint-Tikhon's Orthodox University, Russia

panovaekal@gmail.com

## Abstract

This paper examines realization of Serbian falling (FA) and rising (RA) pitch accents by Serbian and Russian speakers. The study is based on the analysis of disyllable words in initial and medial position of the statements. For each syllable of the disyllable word the set of pitch parameters was calculated, as well as F0 inter-syllable interval. The main statistical differences between realizations of FA and RA by L1 speakers are found with respect to the pitch parameters of the second (post-tonic) syllable and F0 inter-syllable interval. In the accented (first) syllable some L1 speakers don't provide any FA/RA opposition regarding analyzed pitch parameters. This fact requires more evidence, because it raises a question about disyllabic realization of FA/RA.

The statistical analysis of the L2 speakers' results shows that L2 speakers regardless their level of language skills don't make any systematic difference in realization of FA and RA. In particular, in initial and medial position L2 speakers realize a "type of accent" that is similar to Serbian RA.

**Index Terms:** pitch parameters, pitch accent, Serbian, Russian

## 1. Introduction

Traditionally, standard Serbian has been described as a pitch-accent language [1], which has four accents: long rising (LR), long falling (LF), short rising (SR) and short falling (SF), i.e. these accents differ in pitch (rising or falling) and duration (short or long).

Serbian prosody has been investigated experimentally since the beginning of twentieth century. Numerous studies have been devoted to the analysis of acoustic parameters that contribute most to the realization of Serbian pitch accents (the history of these studies are well described in [2]). P. Ivic and I. Lehiste [2] come to a conclusion, that the most relevant parameters in distinction of falling and rising accents (FA and RA) are the range of F0 between accented and post-tonic syllable and location of the F0 peak. FA has negative intervals between accented and post-tonic syllable and early F0 peak locations, while RA has positive intervals and late F0 peak locations. However, some researchers as A. Peco and P. Pravica [3] believed that Serbian accents were realized only within accented syllable. Later research conducted by [4, 5] show that realization of Serbian accents depends on regional varieties: in the dialects of Belgrade and Vojvodina the opposition between FA and RA is realized on the sequence of accented and post-accented syllables, but for west Serbian dialects the realization of FA and RA within accented syllable is more typical.

The different definitions of meaning "F0 peak locations" (within accented and post-accented syllable of the word or within whole word) were discussed in the studies conducted by [6, 7]. Smiljanic [1] described FA and RA as early and late

tonal peak alignment within a pitch contour of the word. The results of our previous study [8] confirm this definition and show that timing of F0 maximum calculated on the contour of the whole word is considered to be an effective indicator of FA/RA distinction. Our study also shows that another relevant parameter for FA/RA distinction is F0 start value, which was previously investigated by [9]. Higher F0 start values are typical for FA and lower for RA.

Experimental investigations of Russian showed that Russian stress is mostly characterized by duration and vowel quality, while pitch is considered to be the main parameter of phrasal level [10, 11].

Both Serbian and Russian belong to the languages with strong influence of intonation on word prosody. For example, in Serbian in neutral (medial) position of the phrase the tonal differences between FA and RA appear the most clearly, while in final position there is a tendency in neutralization of FA and RA [2].

The work presented here aims to study the realizations of Serbian accents by L1 and L2 speakers regarding pitch parameters. For this task we have determined relevant pitch parameters that describe FA/RA opposition for L1 speakers and then tested them on L2 speakers.

## 2. Method

In the present study we take into account only tonal distinction of Serbian accents, so we will analyze only two types: FA and RA.

As far as in standard Serbian pitch accents have specified distribution: FA can only be on the initial syllable of a word and RA can occur on any syllable except on the last one, the tone opposition is possible only in polysyllabic words with stress on the first syllable [12]. Thus, for the present investigation 45 target words of disyllables (23 FA + 22 RA) with stress on the first syllable and with different vowel inventory were selected from available dictionaries. For minimizing segmental influences words or at least accented syllables only with unvoiced consonants were selected.

Each target word was embedded in frame sentences so as to occur two times: in initial and medial position (total 90 sentences). All the sentences were statements. These sentences were then checked carefully by Serbian linguists. The sentences were randomized and put into a Power Point presentation which was later read by the speakers.

Next, the L1 and L2 speakers, aged from 21 to 35, were selected. Three L1 speakers were Serbians: two females, S1, originally from west region and S2, linguists from Belgrade and one male, S3, a student of linguistics, from Novi Sad. That's why in this experiment three varieties of standard Serbian (Belgrade, Novi Sad and west region) were presented.

Five L2 speakers were Russians: one male R3 and four females R1, R2, R4, and R5. The speakers R1, R2 were

students and R3, R4, R5 were post-graduated, professors of Serbian. The knowledge of Serbian varied among the L2 speakers, from intermediate (R1, R2) to advance (R3, R4, R5).

All the speakers were instructed to read the sentences as naturally as possible and to repeat any misread sentence.

The recordings of L1 and L2 samples took place in several locations: in sound recording studios or in quiet rooms using professional digital equipment. All the samples were converted to 16 kHz sampling rate at a 16 bit rate.

For both L1 and L2 samples the contour of F0 was calculated. Then the visual and auditory analyses were conducted to eliminate misreadings and errors in F0 contour extraction.

For the analysis of F0 contours of the first (accented) and second (post-accented) syllable of the target words we used the set of pitch parameters, adopted from [13]:

- F0 start value – the initial F0 value of the first and second syllable in Hz.
- F0 end value – the final F0 value of the first and second syllable in Hz.
- F0 maximum – the maximum F0 value within the first and second syllable in Hz.
- F0 minimum – the minimum F0 value within the first and second syllable in Hz.
- F0 mean value – the arithmetic mean of F0 values within the first and second syllable in Hz.
- F0 range – the interval between F0 minimum and F0 maximum values within the first and second syllable in semitones (ST).
- F0 inter-syllable interval – the difference between F0 start value of the second syllable and F0 end value of the first syllable in Hz.
- Timing of F0 maximum – time point of F0 maximum measured in % of the total first and second syllable duration.

The extracted pitch parameters then were processed with the STATISTICA software program. For the statistical analysis an ANOVA repeated measures with within-subject factor as L1 SPEAKERS and L2 SPEAKERS was performed for L1 and L2 speakers separately. For the first six pitch parameters we investigated effects between independent variables ACCENT (FA vs. RA) and SYLLABLE (1 vs. 2). For the F0 inter-syllable interval we investigated only ACCENT (FA vs. RA). For more detail statistical analysis of each L1 and L2 speaker post hoc Tukey HSD tests were used.

For the analysis of timing of F0 maximum we used Survival Analysis with ACCENT (FA vs. RA) as a grouping variable.

### 3. Results

#### 3.1. F0 start value

For L1 speakers the main effect of ACCENT was significant ( $p < 0.01$ ). There was also significant main effect of SYLLABLE ( $p < 0.0001$ ) and interaction between ACCENT and SYLLABLE ( $p < 0.0001$ ). The results of F0 start value (see Figure 1) of the first syllable for FA have higher values than for RA for all the L1 speakers, but only for one L1 speaker this difference is highly significant (S1  $p = 0.05$ , S2  $p < 0.0001$ , S3  $p = 0.52$ ). The results of F0 start value of the second syllable

for FA have significantly lower values than RA for all L1 speakers (S1, S2, S3  $p < 0.01$ ).

For all L2 speakers the main effect of ACCENT was not significant ( $p = 0.29$ ), although the results for L2 speakers demonstrate some similar tendencies. There was significant main effect of SYLLABLE ( $p < 0.0001$ ) and interaction between ACCENT and SYLLABLE ( $p < 0.01$ ).

It can be observed that L1 speakers have higher F0 start values of RA in the second syllable comparing to the first syllable. L2 speakers demonstrate the same tendency in greater extent.

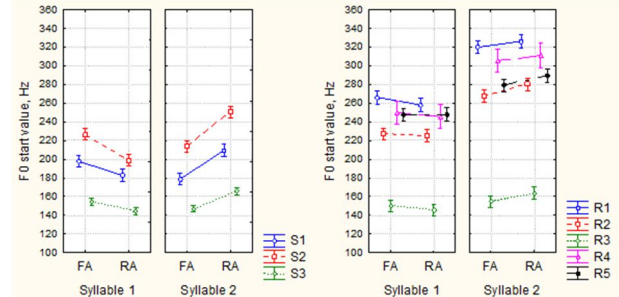


Figure 1: F0 start value scores of the first and second syllables of the words with FA and RA for L1 (S1-S3) and L2 (R1-R5) speakers.

#### 3.2. F0 end value

For L1 speakers the main effect of ACCENT was significant ( $p < 0.0001$ ) as well as SYLLABLE ( $p < 0.0001$ ) and interaction between ACCENT and SYLLABLE ( $p < 0.0001$ ). The results of F0 end values (see Figure 2) for the first syllable show that only for one L1 speaker FA have significantly higher values than RA (S2  $p < 0.001$ ). For other L1 speakers different tendencies were observed, but they were not statistically significant (S1  $p = 0.99$ , S3  $p = 0.33$ ). The results of F0 end value of the second syllable for FA have significantly lower values than RA for all L1 speakers (S1, S2  $p < 0.001$ , S3  $p = 0.048$ ).

For all L2 speakers the main effect of ACCENT was not significant ( $p = 0.09$ ), although there was significant main effect of SYLLABLE ( $p < 0.0001$ ) and interaction between ACCENT and SYLLABLE ( $p < 0.01$ ).

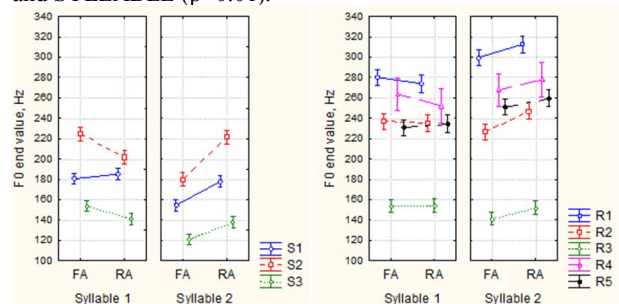


Figure 2: F0 end value scores of the first and second syllables of the words with FA and RA for L1(S1-S3) and L2 (R1-R5) speakers.

#### 3.3. F0 maximum and timing of F0 maximum

For L1 speakers the main effect of ACCENT was significant ( $p < 0.01$ ). There was also significant interaction between ACCENT and SYLLABLE ( $p < 0.0001$ ). The analysis of F0

maximum (Figure 3) for the first syllable shows that only for one L1 speaker FA have significantly higher values than RA (S2  $p<0.0001$ ). For other L1 speakers similar tendencies are observed, but they are not statistically significant (S1  $p=0.99$ , S3  $p=0.08$ ). Regarding F0 maximum of the second syllable FA have significantly lower values than RA for all L1 speakers (S1, S2  $p<0.05$ ).

For all L2 speakers the main effect of ACCENT was not significant ( $p=0.29$ ), although there was significant main effect of SYLLABLE ( $p<0.0001$ ) and interaction between ACCENT and SYLLABLE ( $p<0.05$ ).

It can be observed that L1 speakers have higher F0 start values of RA in the second syllable comparing to the first syllable. L2 speakers demonstrate the same tendency in greater extent.

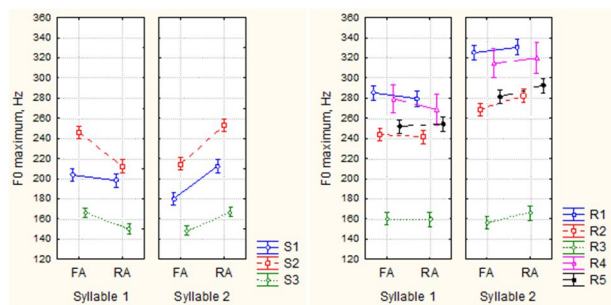


Figure 3: F0 maximum scores of the first and second syllables of the words with FA and RA for L1 (S1-S3) and L2 (R1-R5) speakers.

The analysis of timing of F0 maximum showed that only one L1 speaker, S1 ( $p<0.001$ ), had significant opposition between FA and RA in the first syllable (see Figure 4): FA has earlier locations of F0 maximum (up to 75% of the duration of the first syllable) than RA. It should be noted that S1 came from west region, where FA/RA opposition can be realized within accented syllable. Nevertheless in this case FA/RA opposition is not as clear as in [11], where we compared values of timing of F0 maximum on the contours of the whole words. For other L1 and L2 speakers there is not any significant FA/RA opposition both in first and in second syllable.

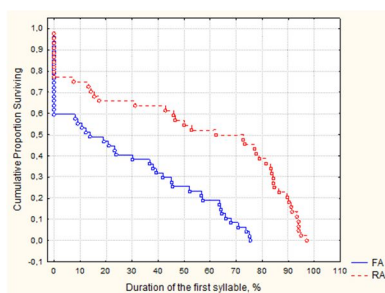


Figure 4: Timing of the F0 maximum scores of the first syllable of the words with FA and RA for S1.

### 3.4. F0 minimum

For L1 speakers the main effect of ACCENT was significant ( $p<0.01$ ) as well as SYLLABLE ( $p<0.001$ ) and interaction between ACCENT and SYLLABLE ( $p<0.0001$ ). The analysis of F0 minimum (see Figure 5) for the first syllable shows that only for one L1 speaker FA have significantly higher values

than RA (S2  $p<0.0001$ ). For other L1 speakers the same tendencies were observed, but they were not statistically significant (S1  $p=0.94$ , S3  $p=0.28$ ). Regarding F0 minimum of the second syllable FA have significantly lower values than RA for all L1 speakers (S1, S2, S3  $p<0.05$ ).

For all L2 speakers the main effect of ACCENT was marginally significant ( $p=0.43$ ), nevertheless only one L1 speaker, R3, has tendencies, which is similar to L1 speakers. There was also significant main effect of SYLLABLE ( $p<0.0001$ ) and interaction between ACCENT and SYLLABLE ( $p<0.01$ ).

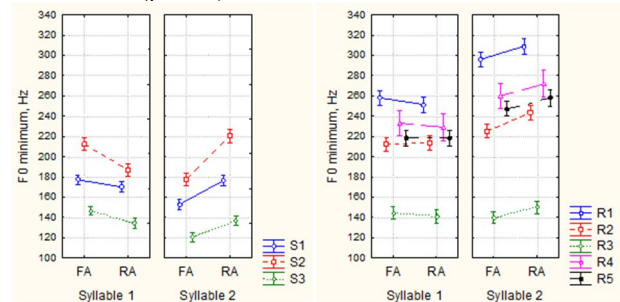


Figure 5: F0 minimum scores of the first and second syllables of the words with FA and RA for L1 (S1-S3) and L2 (R1-R5) speakers.

### 3.5. F0 mean value

For L1 speakers the main effect of ACCENT was significant ( $p<0.01$ ) as well as interaction between ACCENT and SYLLABLE ( $p<0.0001$ ). The analysis of F0 mean value (see Figure 6) for the first syllable show that for two L1 speakers FA have significantly higher values than RA (S2, S3  $p=0.05$ ). For one L1 speaker the same tendencies are observed, but they are not statistically significant (S1  $p=0.76$ ). Regarding F0 mean value of the second syllable FA have significantly lower values than RA for all L1 speakers (S1, S2, S3  $p<0.01$ ).

For all L2 speakers the main effect of ACCENT was not significant ( $p=0.14$ ), although there was significant main effect of SYLLABLE ( $p<0.0001$ ) and interaction between ACCENT and SYLLABLE ( $p<0.01$ ). As in the previous pitch parameters we can observe that all the results for L2 speakers demonstrate the same tendencies as results of RA for L1 speakers, but in greater extent.

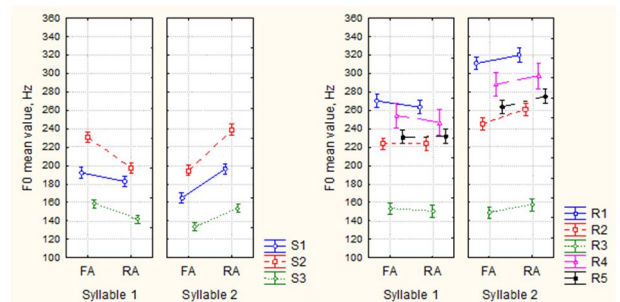


Figure 6: F0 mean value scores of the first and second syllables of the words with FA and RA for L1 (S1-S3) and L2 (R1-R5) speakers.

### 3.6. F0 range

For all L1 and L2 speakers the main effect of ACCENT was not significant (L1  $p=0.2$ , L2  $p=0.07$ ), although there was

significant main effect of SYLLABLE ( $p < 0.0001$ ) for L1. All L1 speakers have larger F0 ranges in the second syllable than in first syllable for FA and RA, comparing to L2 speakers, who demonstrate more various results (see Figure 7).

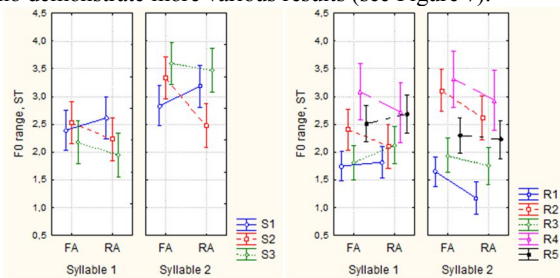


Figure 7: F0 range scores of the first and second syllables of the words with FA and RA for L1 (S1-S3) and L2 (R1-R5) speakers.

### 3.7. F0 inter-syllable interval

For L1 speakers the main effect of ACCENT was significant ( $p < 0.0001$ ). The analysis of F0 inter-syllable intervals (see Figure 8) show that for all L1 speakers RA have significantly higher values than FA (S1, S2, S3  $p \leq 0.001$ ). As the results showed L1 speakers have larger and positive intervals for RA and negative and smaller intervals for FA.

For L2 speakers the main effect of ACCENT was significant ( $p < 0.01$ ). Although L2 speakers have the same tendencies as L1 speakers, all L2 results of F0 inter-syllable intervals are similar to the results of L1 speakers for RA, i.e. L2 speakers have larger and positive intervals between the first and second syllable, except for R3 speaker, who has the most similar tendency to L1 speakers in the opposition of FA and RA.

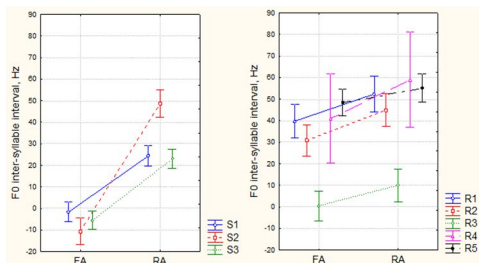


Figure 8: F0 inter-syllable interval scores of the words with FA and RA for L1 (S1-S3) and L2 (R1-R5) speakers.

### 3.8. L2 Serbian accents

The results of the present analysis can be summed up as follows: there is not any statistically significant difference in the realization of FA and RA by all L2 speakers regarding pitch parameters. Moreover, the tendencies that are observed comparing of L1 and L2 results show some similarity between L1 RA and “type of accent” realized by L2 speakers. This observation can be proved by many visual cues, that we made working with L2 samples. In Figure 9 we give an example of production of two words “pitam” (LF) and “koka” (LR) in the initial position of the statement. The upper contours uttered by S2 demonstrate difference between F0 of accented (first) and post-accented (second) syllable, i.e. F0 fall for LF and F0 rise for LR, while the bottom contours uttered by R5 don’t demonstrate F0 fall in LF.

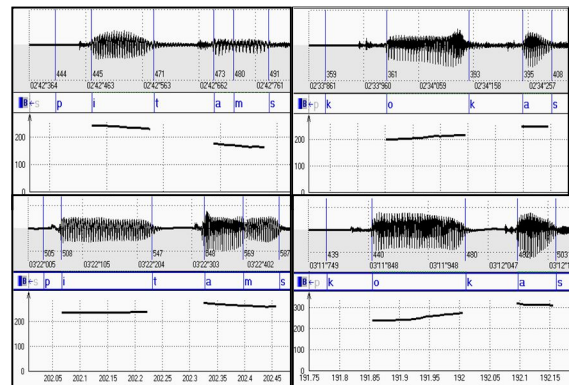


Figure 9: Pitch contours of the target words “pitam” (LF) and “koka” (LR): the upper contours belong to S2 and the bottom contours belong to R5.

## 4. Discussion and Conclusions

The results of the present study show that the analyzed pitch parameters allow providing the systematic distinction between Serbian FA and RA pronounced by L1 speakers and can serve as indicators of L2 deviations in FA/RA production. Nevertheless, such pitch parameters as F0 range and timing of F0 maximum within accented and post-accented syllable don’t demonstrate any significant ability in FA/RA distinction. This fact is in line with the observation in [13] that so-called linguistic parameters as timing and F0 range calculated within monosyllabic structure have “too little space for feature variation”. On the contrary, physical parameters as F0 start value, F0 end value, F0 max and etc. calculated within monosyllabic structure show the best results that is confirmed in [13] and in recent study. At the same time the results of [8] show that timing of F0 maximum calculated on the contour of a whole word provide FA/RA distinction, while physical parameters calculated on the contour of the whole word, except F0 start value, don’t demonstrate any significant distinction between FA/RA. Thus, the distinctive ability of the same pitch parameters differs depending on the analyzed segments (word, syllable etc.). The results of F0 range neither within the contour of the whole word nor within accented or post-accented syllable show any significant difference between FA and RA.

The present study also shows that in Serbian disyllable word the post-tonic (second) syllable demonstrates more reliable distinctive ability than the accented (first) syllable. This fact requires more experimental evidence, because it raises a question about disyllabic realization of FA/RA in Serbian.

This study confirms the results of our previous research [8] that Russian speakers regardless their level of language skills can’t provide any systematic tonal opposition between FA/RA in initial and medial position of the statements. The “type of accent” that Russian speakers realize is similar to Serbian RA. These observations correspond to the results of study [11] of Russian which claims that in non-final position of the statements the first accented syllable of disyllabic word usually has lower F0 or the same F0 as post-accented syllable. Although in Russian pitch doesn’t contribute to the realization of word stress, nevertheless pitch contour of the word has certain constraints even in non-focus positions.

## 5. References

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