Disentangling metrical prominence from segmental and word-boundary effects

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This paper reports on the results of an acoustic study of the correlates of primary and secondary stress in Ukrainian. The experiment has been designed to control for the intrinsic differences in segmental length and influence of word boundaries, which can potentially constitute confounding factors in the studies of metrical prominence (e.g., [1], [2], [3]). Ukrainian has free lexical stress and predictable rhythmic stress ([4], [5], [6]). Lexical stress can appear on any syllable in the word and rhythmic stress can be located at both word edges, provided that at least one unstressed syllable intervenes between the rhythmic and lexical stress. This is illustrated in (1) with minimal pairs of quadrisyllabic words with lexical stress placed on the second and the third syllable.

In the present study, we performed pairwise comparisons of consonants and vowels in segmentally identical pairs of quadrisyllabic words differing in the position of stress, such as the minimal pairs exemplified in (1). The words contained only canonical CV syllables. Four metrical configurations were examined: pretonic - secondary (1st syllable), tonic - pretonic (2nd syllable), unstressed - tonic (3rd syllable), secondary – unstressed (4th syllable). (We adopt the terminology widely used in the literature on Slavic prosody, e.g. [7], where 'tonic' refers to primary lexical stress, while 'pretonic' points to positions immediately preceding main stress.) The stimuli consisted of 7 minimal pairs, uttered in 3 repetitions, and filler items, which were embedded in a frame. The data were collected from 8 monolingual native speakers in Western Ukraine. Segmentation was done manually, and eight duration measurements were taken for each token. Annotation and automated measurements were conducted in Praat [8]. A potential problem in extrinsic comparisons is variable tempo of speech. To control for this, duration of each vowel was expressed in proportion to the average duration of vowel segments in a word. In sum, measurements from 2688 segments (1344 consonants and 1344 vowels) were entered into statistical analyses (done in SPSS, v. 25). Linear mixed effects models were built for each position separately to test the effect of stress on vowel duration. Intercepts and slopes for speaker and item were included in the random structure. For vowels, significant results were obtained for all positions (see Fig. 1): 1st syllable (pretonic *vs.* secondary stress: $\beta = 0.1$, $SE = 0.02$, $t = 4.61$, $p < 0.01$), 2nd syllable (tonic *vs.* pretonic: $\beta = 0.79$, $SE = 0.05$, $t = 16.75$, $p < 0.001$), 3rd syllable (unstressed *vs.* tonic: $\beta = -0.96$, SE = 0.05, $t = -19.65$ $p < 0.001$), 4th syllable (secondary stress *vs.* unstressed: $\beta = 0.08$, $SE = 0.03$, $t = 2.36$, $p = 0.045$). For consonants, the effect of stress was significant only for the second and third position (tonic *vs.* pretonic and unstressed, respectively).

In sum, the results indicate that lexical stress is expressed by the increased duration of both the consonant and the vowel. The comparison of the initial syllables points to the presence of pretonic lengthening, which, contrary to what one might expect, is stronger than the lengthening induced by the presence of rhythmic stress. However, pretonic lengthening has also been reported in previous acoustic studies on Ukrainian stress [5], [9], which looked at words containing more than four syllables. The presence of the same effect in quadrisyllabic words reported here corroborates the intuition expressed in these studies that pretonic lengthening occurs consistently in pretonic position independently of the number of syllables between the lexical position and the edge of the word, and hence of the rhythmic structure of words. A significant difference in duration was observed in word-final position: the final vowel was longer in [σˈσσˌσ] than in [ˌσσˈσσ]. This result demonstrates that the acoustic prominence of the word-final vowel reported earlier ([4], [6]) is not conditioned by the presence of a word boundary, but is a realisation of secondary stress.

(1) **σˈσ σ˛ σ** [pɔˈʋɔdɨ˛tɨ] ‘to behave’ [dɔˈbʲiɦa˛tɨ] ‘to run, perf.’
˛σ σ ˈσ σ [˛pɔʋɔˈdɨtɨ] ‘to lead, perf.’ [˛dɔbʲiˈɦatɨ] ‘to run, imperf.’

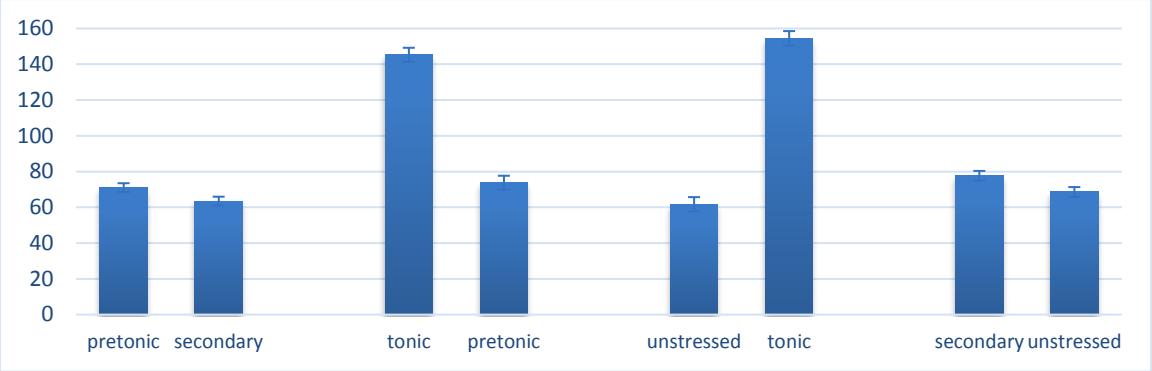

Figure 1. Mean vowel duration (ms) depending on position and stress. (Error bars: 95% confidence intervals adjusted for paired comparisons.)

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