# Intensity and Duration Analysis of Hungarian Secondary Stress

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It is generally agreed that in Hungarian, primary stress always falls on the first syllable of a word. Fónagy (1966) found no consistent acoustic correlate to this stress, but did find a correspondence between the activity of the internal intercostal muscles and stress. However, Magdics' study (1969) seems to indicate that stressed vowels are generally more intense, longer, and higher in pitch than their unstressed counterparts.

The status of secondary stress--both its placement and rhythmic function--has been much disputed (Rákos, 1966). There are two main proposals regarding the placement of secondary stress: position and syllable-length theories.[1] Kerek (in press) attempts to resolve the issue by offering an alternative which accounts for secondary stress placement in terms of context, that is, "on the basis of the speaker's (subconscious) anticipation of the stress conditions in the immediately following context." Closely connected with this theory are certain constraints related to syllable length and unstressed syllable sequences. Despite the general interest in Hungarian secondary stress, there exists, to our knowledge, no experimental research into either its acoustic or physiological basis. It was the purpose of this study to determine to what degree intensity and duration function as acoustic correlates of this secondary stress.

It was assumed that the appearance of secondary stress on a vowel in terms of intensity and duration would manifest itself as an increase of these parameters over the vowel's unstressed counterpart, and not necessarily as absolute intensity or duration prominences over adjacent syllables. This is consistent with the view that stress is correlated with effort of production, i.e., that both stress production and perception involve a knowledge of the intrinsic physical parameters of a syllable and the consequent adjustment of effort needed to mark the presence of stress. Also important in stress analysis is the magnitude of the increase, for it is doubtful that a non-perceivable increment can have any functional significance. It was decided that the general perceptual threshold of ±1 dB for intensity and 10-40 msec. for duration (Lehiste, 1970) would serve as a fair indicator of the potential perceptual significance of intensity and duration increases.

The following set of sentences was chosen for the experiment (´ = primary stress; ˆ = secondary stress):

1. A. [fé∫tɛt:e:k pétit] "They painted Pete."
   B. [fé∫tɛt:ê:k pétit] "They painted Pete."
2. A. [fé∫tɛt:ê:tɛk pétit] "You (pl.) painted Pete."
   B. [fé∫tɛt:ê:tɛk pétit] "You (pl.) painted Pete."

2. C. [fé∫tɛt:e:t̂ê̂tit] "You (pl.) painted Pete."
3. A. [fé∫tɛgɛt:ê:tɛk pétit] "You (pl.) kept painting Pete."
   B. [fé∫tɛgɛt:ê:tɛk pétit] "You (pl.) kept painting Pete."
   C. [fé∫tɛgê̂t:e:t̂ê̂k pétit] "You (pl.) kept painting Pete."
4. A. [fé∫tɛgê̂thɛt:ê:tɛk pétit] "You (pl.) may have kept painting Pete."
   B. [fé∫tɛgê̂thɛt:ê:tɛk pétit] "You (pl.) may have kept painting Pete."
5. A. [fé∫tɛgê̂thɛt:ê:tɛk i∫ pétit] "You (pl.) may have also kept painting Pete."
   B. [fé∫tɛgê̂thɛt:ê:tɛk i∫ pétit] "You (pl.) may have also kept painting Pete."

These sentences were chosen for the following reasons: (1) the numerous voiceless fricatives and plosives would facilitate segmentation; (2) for the most part, the vowel qualities could be kept constant throughout the expanding sequences; and (3) a variety of secondary stress placements could be employed.

The subject (AK), a trained linguist, is a native of Budapest, Hungary, who has lived in the United States since 1957. He constructed the test sentences, which exhibited possible secondary stress patterns in his dialect. He was presented with a randomized list consisting of ten occurrences of each of the sentence patterns (except 2.C. and 3.C.) and was asked to produce the sentences at his normal rate of speech. He was then instructed to produce 2.C. and 3.C. (the alternate secondary stress assignments for 2.B. and 3.B. respectively) ten times each. This procedure was followed since a randomization of 2.C. and 3.C. within the first list might have introduced an uncontrolled variable into the experiment, that is, the subject could have inadvertently substituted 2.C. for 2.B. and 3.C. for 3.B. or vice versa. He then repeated the first list and the alternate patterns. Two additional similar sessions followed at intervals of about a week, at the end of which about 60 productions of each pattern or approximately 720 utterances for the total set had been recorded.

The recorded utterances were processed by a Frøkjaer-Jensen intensity meter and pitch meter, the output of which was converted by an Elema-Schönander Mingograph (100 mm/sec) into a three-channel display: (1) oscillogram, (2) intensity curve, and (3) fundamental frequency pattern. The duration of the vowels was measured to the nearest 1/2 millimeter (i.e., 5 milliseconds). The intensity of the vowels was measured in terms of peak sound pressure level in dB relative to an arbitrary level.

Table I presents the intensity results. There were no differences between the vowels with secondary stress and their unstressed counterparts. Note that there was a 1 dB difference between the unstressed [ɛ]'s of -[tɛt]- of 2.A-C and between the unstressed [ɛ]'s of -[tɛt]- of 4.A-B. However, these differences did not occur between similar unstressed vowels within the other sentences.

TABLE I
AVERAGE INTENSITY OF VOWELS IN UTTERANCES OF VARIOUS LENGTHS (in dB)
(Secondary stressed vowels underlined)

| Sentence Type | Syllable Type | | | | | |
|---|---|---|---|---|---|---|
| | tɛ(t) | gɛt | hɛt | tɐ:(k) | tɐk | ij |
| 1A | 43 | | | 41 | | |
| 1B | 43 | | | 41 | | |
| 2A | 43 | | | 41 | 42 | |
| 2B | 44 | | | 41 | 42 | |
| 2C | 43 | | | 41 | 42 | |
| 3A | 43 | 43 | | 41 | 41 | |
| 3B | 43 | 43 | | 41 | 41 | |
| 3C | 43 | 43 | | 41 | 41 | |
| 4A | 43 | 43 | 42 | 41 | 41 | |
| 4B | 43 | 43 | 42 | 41 | 42 | |
| 5A | 43 | 43 | 42 | 41 | 41 | 38 |
| 5B | 43 | 43 | 42 | 41 | 41 | 38 |

Table II presents the duration results. There was a 1-7 msec. difference between unstressed vowels of the same syllable sequence with the A-B-C comparisons and also between the secondary stressed vowels of the same syllable sequences in the A-B-C comparisons. In six of the seven unstressed versus secondary stressed comparisons, the unstressed vowel was longer than its secondary stressed counterpart; the range of these differences was 6-12 msec. In only one comparison (1A-b) was the secondary stressed vowel longer; the difference was 14 msec.

TABLE II
AVERAGE DURATION OF VOWELS IN UTTERANCES OF VARIOUS LENGTHS (in msec.)
(Secondary stressed vowels underlined)

| Sentence Type | Syllable Type | | | | | |
|---|---|---|---|---|---|---|
| | tɛ(t) | gɛt | hɛt | tɛ·(k) | tɛk | ij |
| 1A | 72 | | | 74 | | |
| 1B | 67 | | | 88 | | |
| 2A | 71 | | | 88 | 70 | |
| 2B | 72 | | | 83 | 66 | |
| 2C | 66 | | | 76 | 56 | |
| 3A | 58 | 74 | | 87 | 69 | |
| 3B | 58 | 74 | | 80 | 64 | |
| 3C | 51 | 67 | | 68 | 55 | |
| 4A | 56 | 80 | 59 | 89 | 70 | |
| 4A | 56 | 79 | 55 | 83 | 64 | |
| 5A | 55 | 81 | 54 | 86 | 68 | 57 |
| 5B | 56 | 80 | 54 | 84 | 65 | 51 |

Since the average differences fall below the just noticeable differences, intensity and duration cannot be considered as acoustic correlates of secondary stress. However, since the fundamental frequency of the vowel comparisons had not been analyzed, this parameter could not be ruled out as a possible correlate. To determine if this was a promising direction for a future study, a perceptual test was given to the subject to see if indeed he could perceive the stress patterns that he had produced. The subject was presented with a tape of twenty randomized productions of the sentences:

2. B. [fé]tɛt:ê:tɛk pètIt] "You (pl.) painted Pete."
   C. [fé]tɛt:ə:tɛ̂k pétIt] "You (pl.) painted Pete."

and twenty randomized productions of the sentences:

3. B. [fé]tɛgɛt:ê:tɛk pétIt] "You (pl.) kept painting Pete."
   C. [fé]tɛgɛt:ə:tɛ̂k pétIt] "You (pl.) kept painting Pete."

These were the two sets of sentences in which alternate secondary stress assignments occurred. The subject was asked to assign secondary stress to each sequence. He correctly identified 6 out of 20 sequences in the 2.B-C set, and 10 out of 20 sequences in the 3.B-C set. Hence,

his judgments were random. We conclude that an explanation of Hungarian secondary stress in terms of acoustic and perceptual correlates does not seem promising.

## Footnote

[1]Most linguists who have commented on Hungarian stress hold that secondary stress occurs on the third and every subsequent odd-numbered syllable of a word, i.e. according to numerical syllable position. Some linguists, notably Szinnyei and Lotz, point out that a short third (and any odd-numbered) syllable causes the stress to shift to the following even-numbered syllable; hence, in this view, the relevant condition is the length value of a syllable. For references, see Kerek (in press).

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