TEMPORAL INTERACTIONS OF STEMS, SUFFIXES, AND THE NUMBER OF SYLLABLES OF THE WORDS IN HUNGARIAN SPONTANEOUS SPEECH

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ABSTRACT

This paper focuses on the internal temporal structure of polysyllabic and polymorphemic Hungarian words produced in spontaneous speech. We assumed that the increasing number of syllables in the words would result in the shortening of stem durations. However, no such changes are expected concerning suffix durations. Results confirmed these assumptions: the stem durations showed systematic linear changes while suffix durations were kept stable. The findings can be explained primarily by the marked status of the suffixes in Hungarian, and might reflect speakers' intention to facilitate the processing of grammatical and syntactic agreement information for the listener.

Keywords: duration, last syllable suffixes, spontaneous speech, internal temporal organization.

1. INTRODUCTION

Spoken word production is preceded by a number of underlying processes including the speaker's selection of a syntactically and semantically appropriate word, the retrieval of the word's phonological properties, and preparations for the corresponding articulatory gestures [16]. This paper focuses on the temporal organization of suffixed words with various numbers of syllables occurring in spontaneous speech. Intrinsic durations of stem and suffix in a word might shed light on how the speakers of an agglutinating language handle the stems and suffixes depending on the number of the syllables of the stems.

Several factors are reported to influence the duration of a word and the variability therein [2, 7, 10, 3]. The robust frequency effect in word production is known from as early as 1929 [27]. Speakers are typically faster in articulating a high-frequency word than a low-frequency one; this was reported by various studies since [e.g., 24, 1, 8, 22]. It is assumed that accessing the phonological code, rather than lemma selection, is responsible for this effect [12].

Word durations were shown to be correlated with part-of-speech affiliation [13], particularly with the distinction between function words and content words. There is, however, no clear explanation of whether the word class differences or the effects of the different syntactic positions resulted in different durations. The term 'morphologically conditioned lengthening' might refer to vowels that are longer before morpheme boundaries than corresponding vowels in tautomorphemic environments [23], and to segments that are longer in polymorphemic than in corresponding monomorphemic sequences [19].

A stem and a suffix might follow slightly different duration rules depending on the effect of word and possibly suffix frequency, the local articulation tempo, word-final [2, 21, 14] and utterance-final lengthening, etc. [20, 18]. The phenomenon of utterance-final lengthening has also been confirmed for languages that exhibit vowel quantity opposition like Finnish and Hungarian [18, 20, 25].

About half a century ago, Lehiste claimed that morphological boundaries influence stem duration: the stem is shortened when we add suffixes to it in English [15]. However, the duration of the word containing the suffix was not very much longer than that of the stem on its own. In addition, the number of segments of the suffix did not have any systematic effect on the stem duration. The English past tense suffix (*-ed*) on low-frequency verbs was shown to result in longer duration than the addition of *-ed* to matched high-frequency verbs [17].

At the beginning of the last century, Gombocz and Meyer [9] observed that vowels are articulated shorter as the number of the syllables increases (their Hungarian examples were: ***tát*** 'open wide', verb; ***tátog*** 'gape', verb; ***tátogat*** 'gape' + frequentative suffix, verb; ***tátogatók*** 'gape' + frequentative suffix + agentive suffix + plural, noun; ***tátogatóknak*** 'gape' + frequentative suffix + agentive suffix + plural + dative, noun). Decades later, it was shown that vowels expand and compress more than consonants do, i.e., slow articulation primarily means vowel lengthening, and fast articulation primarily means vowel shortening (e.g., [5]).

The main question of this study is whether there is a morphologically conditioned shortening of stems and suffixes across the increasing number of stem syllables in Hungarian spontaneous speech. Due to the agglutinating character of Hungarian, there are several bound suffixes as functional morphemes that occur both with nouns and verbs. In Hungarian, the

words carry their stress on the first syllable without exception, that is, the first syllable of the words is normally stressed while the suffix is always unstressed.

The goal of this study was to show the effect of the increasing number of syllables of the stem on the durations of both the suffixes and the stems. Two hypotheses were stated: (i) the increasing number of syllables of the stems would influence the stem durations resulting in the shortening of the stems, and (ii) the word-final suffixes would not show durational changes irrespective of the number of the stem syllables. We assume that there might be a morphophonological code for each word that controls the inner temporal patterns of the stem and suffix morphemes that specifically interact in the suffixed words in spontaneous utterances.

2. METHODOLOGY

Spontaneous narratives and conversations of 23 Hungarian-speaking young subjects (14 females and 9 males, aged between 20 and 30; a more than 5-hour material in all) were randomly selected from the BEA Spontaneous Speech Database of Hungarian [11]. All nouns and verbs consisting of stems of 1, 2, 3, 4, 5 or 6 syllables and of one of the 6 selected suffixes (altogether 1,676 words) were used in the measurements (820 nouns, 856 verbs).

The suffixed words contained both closed and open syllables with various numbers of segments (see Table 1 for details). The temporal demands of spontaneously produced words are different from word list reading, and control over them cannot be guaranteed as systematically as in the case of word lists. However, we tried to control for as much as possible, following the same inclusion criteria and measurements of the words.

Table 1: The number of syllables and segments per word, and the number of the words in each category.

Number of syllables	Range / mean of segments	Number of words
2	4–7 / 5.2	437
3	5–10 / 7.8	682
4	5–12 / 9.3	350
5	6–16 / 13.1	105
6	8–18 / 12.6	48
7	12–18 / 15.5	54

All words occurred in the middle of a phrase (marked by bold in the example) in order to avoid the effect of phrase-final lengthening (e.g., *és ez azért elég nehéz egy* ***tanárnak*** *úgy megtervezni az órát hogy szórakoztató legyen* 'and it is relatively difficult **for a teacher** to plan a course to make it interesting'). Each stem was produced at least twice by the same speaker. Six monosyllabic suffixes of 2 (*-ba/-be* 'into', *-ta/-te* '3sg past') or 3 segments (*-ban/-ben* 'in', *-nak/-nek* 'for' and '3pl', *-tam/-tem* '1sg past') were used (number of relevant items: 266, 208, 245, 272, 408, respectively); three of them were verbal while the other three were nominal suffixes (considering the homophonous suffixes *-nak/-nek* separately). The verbal suffixes *-ta/-te* and *-tam/-tem* are bimorphemic. The suffix pairs containing front vs. back vowels are a matter of vowel harmony and will be disregarded here.

All of the suffixes formed the final syllable of the words and were preceded by the stem, so they always occurred in an unstressed position. For the purposes of this study only inflectional suffixes were selected, i.e., ones that are there solely to provide grammatical information or syntactic agreement. Examples: *házban* 'in the house', *teremben* 'in a room', *gimnáziumba* 'into high school', *körbe* 'into the circle', *vásárolta* 'he bought it', *kérte* 'she asked for it', *életszínvonalnak* 'for the standard of life', *sebességnek* 'for speed', *tanulnak* 'they learn', *verekednek* 'they quarrel', *dolgoztam* 'I worked', *féltem* 'I was afraid'. Words where the last consonant of the stem and the first consonant of the suffix were the same (e.g. *lát+ta* 'see + 3sg past' = 'saw') were excluded in order not to encounter segmentation problems. The suffixes occurred in similar ratios across stems consisting of various numbers of syllables.

All the words and the suffixes were manually annotated using Praat [4]. The word boundaries were identified in the waveform signal and spectrogram display via continuous listening to the words. Boundaries were marked between acoustically distinct regions in the signal. Markers were inserted at the closure and release of obstruents, and at the onset of voicing after the release in stops following standard acoustic-phonetic criteria [20].

Boundary location reliability was assessed at the time of segmentation using the labelers' confidence as a measure. Segmentation of the words was made by the first author while the second author checked each word (the agreement ratio was higher than 98%). Durations of both the stems and suffixes were taken by measuring the phase between the onsets and the offsets of the stems, the suffixes and the whole words. A specific script was written for obtaining the values automatically.

To test statistical significance, linear regression analysis, repeated measures ANOVA and Mann–Whitney test were used, as appropriate (using SPSS 19.0 version). The confidence level was set at the conventional 95%,

3. RESULTS

3.1. The effect of increasing number of syllables on word durations

The range of durations of all suffixed words was between 0.16 s and 1.71 s, while that of the stems was between 0.06 s and 1.40 s (see Table 2 for details).

Table 2: Durational properties of stems, suffixes and words (syl.=syllable; st+s=stem+suffix).

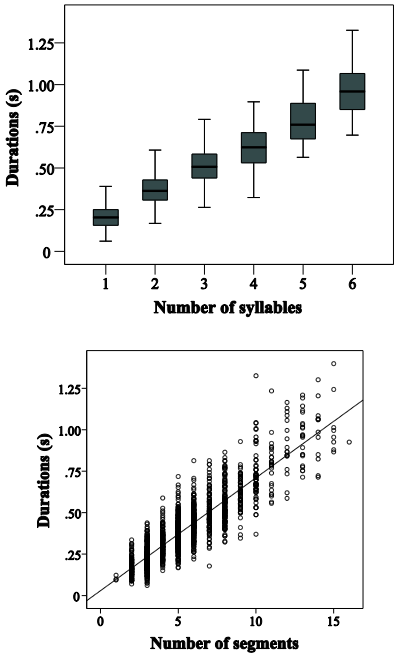
No. syl. st+s	Durations (ms)					
	Stems		Suffixes		Total words	
	mean	SD	mean	SD	mean	SD
1+1	217	69	214	66	409	118
2+1	369	89	217	80	570	135
3+1	518	118	218	75	723	173
4+1	621	143	167	67	812	190
5+1	797	150	168	73	988	179
6+1	977	160	217	68	1174	205

The durations of both the suffixed words and the stems showed linear changes across the increasing number of syllables. Linear regression analysis confirmed that there are significant interactions between the durations of the suffixed words as dependent factors and the number of syllables and number of segments of the suffixed words as the two independent factors ($F(2, 1674)=1302.25$; $p< 0.001$). The two independent factors explain 60% of the durational changes of the words.

Statistical analysis revealed that there are also significant differences in the stem durations depending on the number of syllables and the number of segments as the two independent factors ($F(2, 1674)=3229.8$; $p<0.001$) where their effects explained 79.4% of the total variance of the stem durations. No significant difference was found, however, in the interactions depending either on syllables or segments of the suffixed words and the stems since syllables and segments also correlate with each other. The shortening effect on the durations of both the suffixed words and the stems as a consequence of the increasing number of syllables could clearly be demonstrated (Fig. 1).

The durational changes of the stems seem to be highly steady across increasing numbers of syllables. The stem durations appear between 70% and 80% of the total duration of the following stem class (ratios were calculated as 'shorter stem duration/longer stem duration*100'). The durational ratio of the mono-syllabic stems was exceptionally less than that of the disyllabic stems (58.8%). The durational ratios of the suffixed words show a similar tendency. The standard deviation data also show an increasing tendency across the number of syllables in the case of both stems and suffixed words.

Figure 1: Durations of the word stems with various numbers of syllables (top) and segments (bottom).



A substantial difference was found in the stem durations depending on their word class (mean duration of nouns: 280 ms and of verbs: 330 ms). Verbs are shorter than nouns in terms of the number of their segments (4.92 segments for verbs and 6.16 segments for nouns, on average).

3.2. The effect of increasing number of syllables on suffix durations

The range of the durations of all suffixes appeared between 0.17 s and 0.22 s. Durations of the suffixes did not show significant differences depending on the number of syllables of the stems they were added to (see Table 1 for details). However, the number of segments the suffixes consist of had a significant effect on the stem durations (Mann–Whitney test: $Z= –3.722$; $p<0.001$). Stem durations are longer with 2-segment suffixes than with 3-segment suffixes (430 ms vs. 396 ms, on average), particularly with the lower number syllable stems.

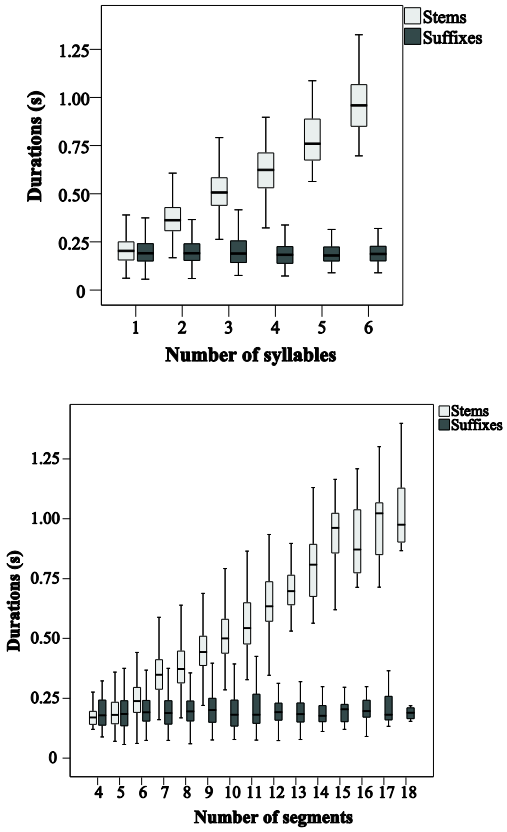
The durations of the suffixes turned out to be significantly different depending on the number of their segments (Mann–Whitney test for *-ba/-be* vs. *-ban/-ben*: $Z= –7.814$; $p<0.001$, and for *-ta/-te* vs. *–tam-/tem*: $Z= –8.639$; $p<0.001$). However, no significant difference was found in the durations of the homophonous suffixes *-nak/-nek* being either nominal or verbal suffixes. The durations of the suffixes did not turn out to be significantly different

depending on the word class of the stem (mean duration of the nominal suffixes: 190 ms, while that of the verbal suffixes was 200 ms).

3.3. Durational interactions of stems and suffixes

Data show that word stem durations vary depending on the number of syllables they contain, while durations of the suffixes used are stable (Fig. 2).

Figure 2: Durations of stems and suffixes of words with various numbers of syllables (top) and segments (bottom).



Linear regression analysis was conducted also on normalized data (in terms of ratios expressed by the 'stem and suffix duration/suffixed word duration*100'). As expected, the increasing number of syllables and segments (as independent factors) had a significant effect on the normalized durational stem data as dependent variables ($F(2, 1674)=710.134$; $p<0.001$); the findings explain 45.69% of the total variance. The effect of the same independent factors on the durations of the suffixes was also statistically significant ($F(2, 1674)=257.18$; $p<0.001$), explaining 23.4% of the total variance.

The stem and suffix duration ratios show systematic changes depending on the number of stem syllables. The durations of the suffixes of monosyllables are close to identical. The ratios of the suffixes of the disyllabic and three-syllable stems decrease (58.8% and 42%, respectively), while the ratios of the suffixes of the stems containing more than 3 syllables are about 20% of the stem durations with no changes across the increasing syllables (Fig. 2).There is a slight but significant interaction between the durations of the stems and the suffixes ($R^2=0.025$; $F(1, 1674)=44.56$; $p<0.001$).

4. CONCLUSIONS

This study focused on the durations of word stems, suffixed words, and suffixes, as well as on their interactions, depending on the increasing number of syllables. Both our hypotheses, that (i) the increasing number of stem syllables would have a shortening effect on the stem durations, and (ii) the word-final suffixes used in this study would not show durational changes depending on the number of syllables of the stems, could be confirmed.

As expected, speakers articulated long stems faster than short stems [9], the changes correspond to a linear function. The present data seem to support the findings reported by Lehiste [15] that the stem is shortened when adding suffixes. However, this is not the only explanation in our case since the shortening of the stems is also a consequence of the increasing number of syllables.

Phrase-final lengthening was assumed as a speaker's strategy to inform the listeners to the cohesion of the elements [20]. In line with this assumption, we think that the unvarying durations of the analysed suffixes might refer to the speakers' intention to facilitate the processing of grammatical and syntactic agreement information for the listener [6]. This assumption can be strengthened by our finding that the speakers tended to articulate 1-, 2- and 3-syllable stems slower when they carried 2-segment suffixes as opposed to those having longer (3-segment) suffixes. The speaker's unconscious goal would be to make some durational balance for the listener in the case of the words that are the most frequent ones in Hungarian as to their lengths.

A twofold phonetic control is hypothesized over the durations of the suffixed words that occur in the middle of the phrases in spontaneous utterances. The first one is supposed to be responsible for the shortening of the stems with a high number of syllables while the other one is responsible for keeping the duration of the final suffix unchanged. We might conclude that there is in fact a morphophonological code that seems to control the temporal patterns of suffixed words in an agglutinating language.

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