

The domain of phrase-final lengthening in Estonian

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Abstract

The purpose of the current study was to investigate phrase-final lengthening (PFL) in Estonian. Three thus far unresolved questions were addressed: firstly, which prosodic constituents are affected most by PFL; secondly, whether PFL affects the short, long and overlong quantity contrast irrespective of the segmental composition (vowel vs. consonant quantity), and thirdly, whether progressive lengthening occurs in Estonian such that the nearer a segment to the final boundary the more it is lengthened. We found that in Estonian PFL affected the main bearer of the quantity and additionally the final-syllable rhyme in the long and overlong quantities. Progressive lengthening only occurred if the segments were not in adjacent final position. The general conclusion from these results is that a Structure-based model explaining PFL is the most suitable model for our data.

1. Introduction

Although phrase-final lengthening (PFL) has been shown to occur in numerous languages (e.g. Cambier-Langeveld, 1997 for Dutch; Turk & Shattuck-Hufnagel, 2007 for English; Krull, 1997 for Estonian; Nakai et al., 2009 for Finnish), its domain within the final word has scarcely been addressed. The purpose of the current study is to address this question via an analysis of Estonian which, because it has a three way quantity contrast for both vowels and consonants, enabled us to study PFL in interaction with phonological vowel (VQ) and consonant quantity (CQ). We not only investigated which prosodic constituents were influenced most by PFL and whether there is progressive lengthening in Estonian (i.e. whether greater lengthening occurs the nearer a segment is to the final boundary), but also if PFL influenced VQ- and CQ-words differently. We discuss our results of Estonian in terms of three different models explaining PFL, a Structure-based, a Content-based and a Hybrid-based model (Turk & Shattuck-Hufnagel, 2007).

Estonian differentiates between short (Q1), long (Q2) and overlong (Q3) vowels and consonants respectively. The quantity distinction is not the property of single vowels and consonants, but operates on the level of a disyllabic foot, of which the first syllable is stressed and the second is unstressed (Lehiste, 1960). In VQ-words, the quantity distinction affects only the vowel of the first syllable and in CQ-words only the intervocalic consonant (see Table 1 and 2 for examples). The quantity degrees differ in the duration ratio between the first and the second syllable of the disyllabic foot (Lehiste, 1960). Typical ratios are 2:3 for

Q1, 3:2 for Q2, and 2:1 for Q3 as first found by Lehiste (1960) and later confirmed by others (e.g. Krull, 1992; Asu et al., 2009). Besides these temporal characteristics, the three quantities of VQ-words also differ in their peak alignment. While the peak of VQ3-words occurs early in the vowel of the first syllable, the peak of VQ2- and VQ1-words is realised late in the vowel (e.g. Lehiste, 1960, 1997; Krull, 1992; Asu et al., 2009). For CQ-words no comparable peak alignment differences were found (e.g. Lehiste, 1997; Krull, 1992).

Previous studies showed effects of PFL for Estonian read and spontaneous speech at both the word (Lehiste, 1981; Mihkla, 2006) and the segment level (Krull, 1997; Eek & Meister, 2003; Asu et al., 2009). Nevertheless all the studies investigating PFL in Estonian only analysed VQ-words. Furthermore the studies analysing the segment level of PFL mainly concentrated on the vowels of the VQ-words, but not on the consonants (with the exception of Eek & Meister, 2003). The influence of PFL on the segment level in Estonian for disyllabic VQ-words of the form $C_1V_1C_2V_2$ (VQ1), $C_1V_1V_1C_2V_2$ (VQ2) and $C_1V_1V_1V_1C_2V_2$ (VQ3) can be summarised as follows: while a lengthening of the vowel of the final syllable (V_2) seems to be quite stable, a lengthening of the vowel of the first syllable (V_1) was found to be rather unstable across both studies and quantity degrees (Krull, 1997; Eek & Meister, 2003; Asu et al., 2009). Asu et al. (2009) found PFL for V_1 and V_2 in all three quantity degrees for both pitch-accented and deaccented words. By contrast, Krull (1997) reported PFL of V_1 and V_2 in VQ3-words only, whereas in VQ2-words V_1 was never lengthened and in VQ1-words phrase-final lengthening of one or both vowels was found to be speaker-dependent. Eek & Meister (2003) found an influence of PFL on V_2 and C_2 in all three quantity degrees and a lengthening of V_1 for VQ2- and VQ3-words, but not for VQ1-words. There was evidence for progressive lengthening in the data of Eek & Meister (2003), i.e. the more final a segment was the more it was lengthened.

Previous studies have used three major classes of models for explaining PFL, namely a Structure-based, a Content-based and a Hybrid view model (Turk & Shattuck-Hufnagel, 2007). The Structure-based view rests on the assumption that PFL lengthens a fixed part of speech defined by linguistic structure, e.g. the final-syllable rhyme (Turk & Shattuck-Hufnagel, 2007; Wightman et al., 1992). In the Content-based view, the domain of PFL is independent of the linguistic structure (Turk & Shattuck-Hufnagel, 2007) and depends instead on a so-called lengthening gesture as e.g. in the π -gesture framework (e.g. Byrd & Saltzman, 2003; Byrd et al., 2006). The π -gesture – an abstract prosodic gesture – is anchored with its middle at the end of the final syllable and overlaps with the segmental gestures. During this overlap, the articulation of the segmental gestures is slowed down and the segments are lengthened (Byrd et al., 2006). In the Hybrid

view (Turk & Shattuck-Hufnagel, 2007), PFL operates over a structurally fixed domain, e.g. the rhyme of the final syllable, but in those cases where the rhyme cannot be lengthened unlimitedly to preserve phonological quantity contrasts, earlier parts of speech can also be influenced (Cambier-Langeveld, 1997 for Dutch).

Studies investigating the domain of PFL in American English have shown that only syllable rhymes were affected (Turk & Shattuck-Hufnagel, 2007; Wightman et al., 1992), which could be interpreted in the sense of the Structure-based model of PFL. Whereas Turk & Shattuck-Hufnagel (2007) found an effect of PFL on both the rhymes of the final and the main stressed-syllable, Wightman et al. (1992) reported an influence of PFL only on the rhyme of the final syllable. Turk & Shattuck-Hufnagel (2007) also found progressive lengthening.

Two hypotheses were tested in the current study: firstly whether, as has been found for American English (Turk & Shattuck-Hufnagel, 2007), the domain of PFL in Estonian is the rhyme of the stressed and the final syllable (in which case it could be explained with the Structure-based model of PFL); and secondly whether there is progressive lengthening in Estonian as found for American English (Turk & Shattuck-Hufnagel, 2007) and for Estonian VQ-words (Eek & Meister, 2003).

2. Method and Materials

Nine native speakers (age range 21-31 years; 3 male, 6 female) of Standard Estonian participated in the experiment. The subjects were paid for their participation. The recordings were conducted by the first author with a high quality headset microphone in a recording studio in Tartu, Estonia.

Table 1: Target words with vowel quantity.

VQ1 (short) (words in gen. sg. and nom. sg.)	VQ2 (long) (words in gen. sg.)	VQ3 (overlong) (words in part. sg.)
/lɤma/ ('made-up word')	/lɤ:ma/ ('flame')	/lɤ::ma/ ('flame')
/mimi/ ('Mimi')	/mi:mi/ ('mime')	/mi::mi/ ('mime')
/mini/ ('miniskirt')	/mi:ni/ ('mine')	/mi::ni/ ('mine')
/mɤna/ ('spell')	/mɤ:na/ ('low tide')	/mɤ::na/ ('tide')

Disyllabic target words only differing in either the quantity of the vowel of the first syllable or in the quantity of the intervocalic consonant were chosen for the

purposes of studying the interaction between PFL and quantity (Table 1 and 2). With the exception of one target word, all words were existing Estonian lexical items.

Table 2: Target words with consonant quantity.

CQ1 (short) (words in gen. sg. and nom.sg.)	CQ2 (long) (words in gen. sg.)	CQ3 (overlong) (words in part. sg. and ill. sg.)
/hala/ ('moaning')	/halla/ ('frost')	/hal:la/ ('frost')
/hæli/ ('Häli')	/hælli/ ('cradle')	/hæl:li/ ('cradle')
/lina/ ('linen')	/linna/ ('city')	/lin:na/ ('city')
/nime/ ('name')	/nimme/ ('loin', only nom. sg.)	/nim:me/ ('loin', only ill. sg.)

The target words were embedded in carrier phrases designed to elicit a falling H*+L pitch accent on the target word and with the target word in narrow focus position (Table 3). There were two different carrier sentences: in one of the two sentences, the target word was in absolute sentence-final position (final context) and in the other, there were two unstressed syllables following the target word (non-final context). Because of differences in the grammatical category of the target words, the carrier sentences for the overlong quantity degree differed from those for the short and long quantity degree. Also due to grammatical differences, another carrier sentence had to be used for the target word *nimme* in the overlong quantity degree.¹

Table 3: Carrier sentences.

Quantity degree	Final context	Non-final context
Short/Long	<i>Sa leidsid ____.</i> (‘You found ____.’)	<i>Sa leidsid ____gi ju.</i> (‘You found ____, too.’)
Overlong	<i>Sa nägid ____.</i> (‘You saw ____.’)	<i>Sa nägid ____gi ju.</i> (‘You saw ____, too.’)

The *SpeechRecorder* recording software (Draxler & Jänsch, 2004) was used for the recordings. The carrier sentences were presented as answers to questions. The software prompted first the question and then the corresponding answer on the screen of a notebook computer. Only the carrier sentences were recorded.

¹ *Sa lõikad nimme.* (‘You - cut - into the loin.’) – *Sa lõikad nimmegi ju.* (‘You – cut - into the loin, too.’)

Not every subject read all of the target words. Each target word was recorded once in the final context and once in the non-final context.

The recorded sentences were automatically segmented with the help of the Munich Automatic Segmentation System MAUS (Schiel, 1999) and the segmentation was corrected manually. The utterances were controlled for the pitch accent via an auditory and a visual analysis. Only those utterances realised with a falling H*+L pitch accent were used for the analysis. After excluding those utterances produced with an H+L* pitch accent or with reading errors, a total of 103 (58%) utterances of vowel quantity and 99 (57%) utterances of consonant quantity remained for the analysis.

To determine whether PFL had an effect on segment duration the percentage lengthening of each segment of all phrase-final words (PFL_{perc}) was calculated separately for each segment and quantity degree from

$$PFL_{perc} = 100[(DurF_{mean} - DurNF_{mean}) / DurF_{mean}]$$

where $DurF_{mean}$ is the mean duration of the appropriate segment of all phrase-final words, (e.g. V₁ of all final VQ3-words) and $DurNF_{mean}$ the mean duration of the appropriate segment of all non-final words in milliseconds.

All analyses were carried out with the help of the R-software combined with the EMU/R-package (Harrington, 2010). For the statistical analysis, mixed models in R were used. Significance values were obtained via a comparison of a mixed model with and without the appropriate independent factor.

3. Results

Two hypotheses were tested: firstly, whether PFL in Estonian only affects syllable rhymes, and secondly, whether there is progressive lengthening in Estonian.

PFL occurred in both VQ- and CQ-words at the word and the segment level. Almost all segments were lengthened in the final context, but to a different degree (Figures 1, 2 and 3).

Mixed models with segment duration as the dependent variable, with independent factor Finality (two levels: final vs. non-final) and with the Speaker and Target Word as random factors were used to determine those segments which were lengthened significantly separately for each segment and for each quantity degree (Tables 4 and 5). We also tested whether these results were influenced by including or excluding the random factor Word.

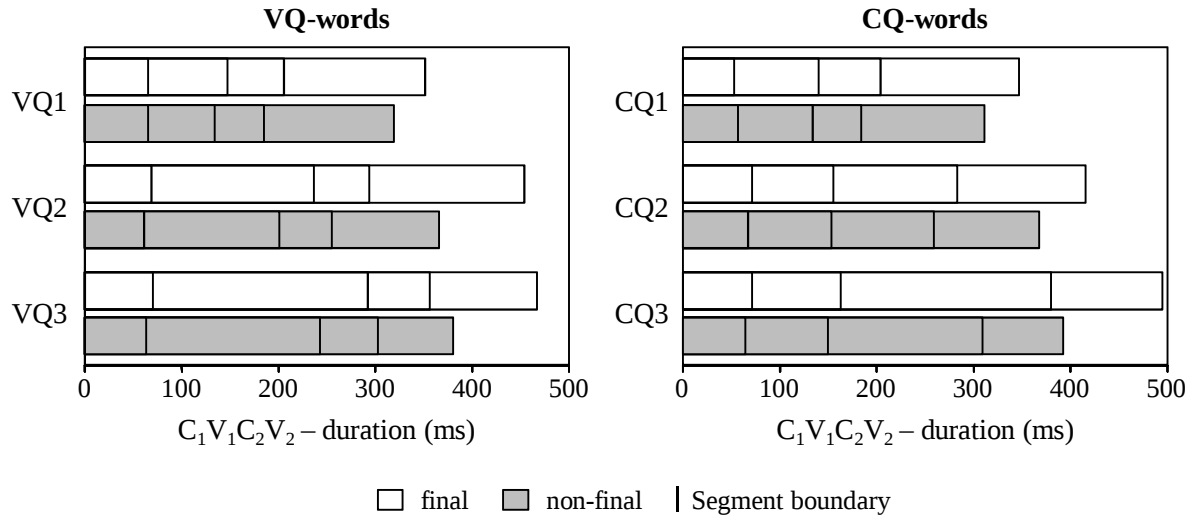


Figure 1: Segment durations of VQ- and CQ-words in final (unshaded) and non-final (shaded) position for the three quantities.

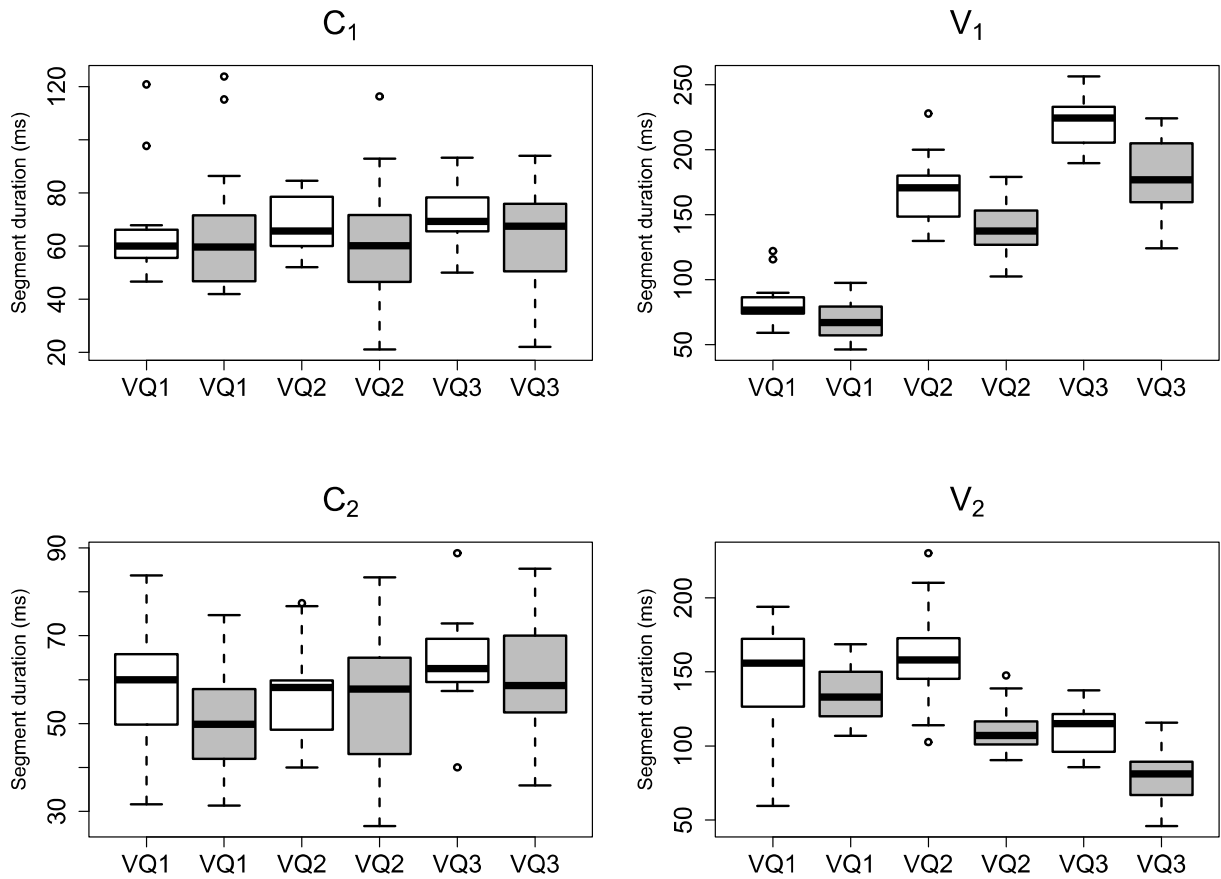


Figure 2: Segment durations of final (unshaded) and non-final (shaded) VQ-words separately for the three quantities (VQ1, VQ2 and VQ3).

Table 4: The influence of Finality on the segment duration of VQ-words (Significant values of the random factor Word are in *italics*).

Segment	VQ1	VQ2	VQ3
C ₁	non-significant	non-significant	non-significant
V ₁	$\chi^2[1]=7.9, p<0.01$	$\chi^2[1]=11.7, p<0.001$	$\chi^2[1]=16.5, p<0.001$
C ₂	$\chi^2[1]=5.4, p<0.05$ $\chi^2[1]=11.5, p<0.001$	non-significant $\chi^2[1]=8.8, p<0.01$	non-significant $\chi^2[1]=14.7, p<0.001$
V ₂	non-significant	$\chi^2[1]=26.4, p<0.001$	$\chi^2[1]=18.5, p<0.001$
Word	non-significant	$\chi^2[1]=25.9, p<0.001$	$\chi^2[1]=18.8, p<0.001$

The significantly lengthened segments (Tables 4 and 5) were influenced differently by PFL (Figure 2 and 3) depending on the quantity degree (Q1 vs. Q2 vs. Q3) and the quantity type (VQ- vs. CQ-words). In both VQ1- and CQ1-words, V₁ and C₂ were lengthened, whereas in VQ2- and VQ3-words V₁ and V₂ were affected by PFL. CQ2- and CQ3-words showed a lengthening of C₂ and V₂ and, in the case of CQ3-words, also a lengthening of C₁.

Progressive lengthening was only found for VQ2-, VQ3- and CQ1-words.

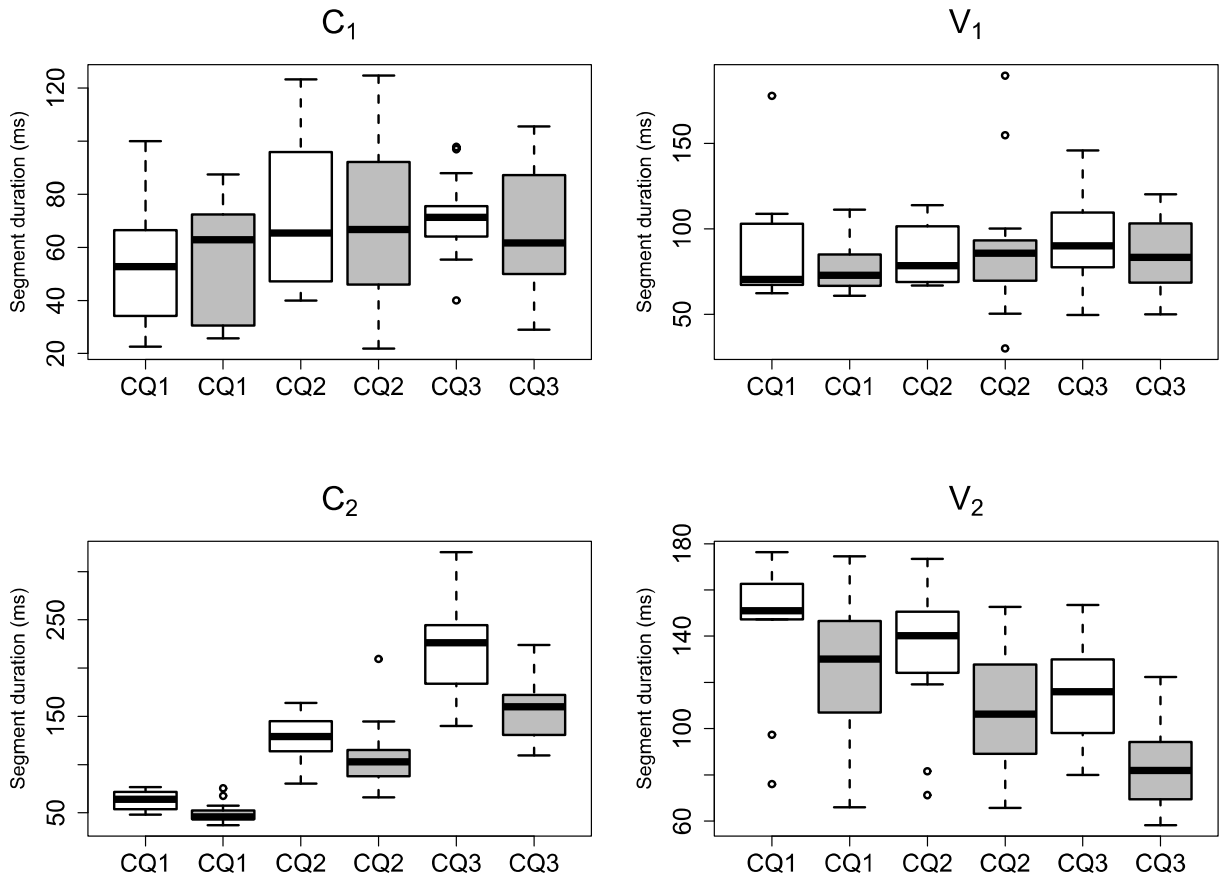


Figure 3: Segment durations of final (unshaded) and non-final (shaded) CQ-words separately for the three quantities (CQ1, CQ2 and CQ3).

Table 5: The influence of Finality on the segment duration of CQ-words (Significant values of the random factor Word are in *italics*).

Segment	CQ1	CQ2	CQ3
C ₁	non-significant	non-significant <i>$\chi [1]=19.0, p<0.001$</i>	<i>$\chi [1]=11.1, p<0.001$</i> <i>$\chi [1]=27.3, p<0.001$</i>
V ₁	<i>$\chi [1]=4.7, p<0.05$</i> <i>$\chi [1]=6.5, p<0.05$</i>	non-significant <i>$\chi [1]=11.1, p<0.001$</i>	non-significant <i>$\chi [1]=4.1, p<0.05$</i>
C ₂	<i>$\chi [1]=7.3, p<0.01$</i> <i>$\chi [1]=3.5, p<0.1$</i>	<i>$\chi [1]=10.3, p<0.01$</i>	<i>$\chi [1]=31.9, p<0.001$</i>
V ₂	non-significant	<i>$\chi [1]=13.1, p<0.001$</i> <i>$\chi [1]=4.3, p<0.05$</i>	<i>$\chi [1]=19.2, p<0.001$</i>
Word	<i>$\chi [1]=6.1, p<0.05$</i>	<i>$\chi [1]=17.2, p<0.001$</i> <i>$\chi [1]=4.0, p<0.05$</i>	<i>$\chi [1]=34.6, p<0.001$</i>

4. Discussion

The current study investigated the influence of PFL on Estonian VQ- and CQ-words. It was found that PFL affected V₁ and C₂ significantly in VQ1- and CQ1-words; in VQ2- and VQ3-words, PFL affected V₁ and V₂; and in CQ2- and CQ3-words, PFL affected C₂ and V₂. Progressive lengthening occurred in VQ2-, VQ3- and CQ1-words.

The results from our study differ from previous results regarding PFL in Estonian. While PFL was found for V₂ in Krull (1997), Eek & Meister (2003) and Asu et al. (2009), we found V₂-lengthening only for the long and overlong quantities in our data. Nevertheless our study confirmed the results of Asu et al. (2009) who found an influence of PFL on V₁ independently of the quantity degree, while in Krull (1997) and Eek & Meister (2003) V₁ was not lengthened in every quantity degree.

An interpretation of PFL in terms of Byrd et al.'s (2006) π -gesture framework does not seem very plausible as a general explanation for Estonian. According to Byrd et al. (2006), the middle of the π -gesture should be anchored with the phrase-boundary and all segments overlapping with the π -gesture should be lengthened. As a result, PFL in Estonian starts with a certain segment of the word – that is somewhere during the π -gesture – and extends until the end of the word, i.e. subsequent segments are lengthened. Nevertheless in Estonian PFL skips some segments, e.g. in VQ2- and VQ3-words only V₂ and V₁ were lengthened, but not the consonant between them. This skipping of segments cannot be explained with the π -gesture.

The Hybrid view can explain our results for the long and overlong quantities, but not for the short quantity. In the hybrid view, lengthening should apply to the rhyme of the final syllable and possibly even to earlier segments (Cam-

bier-Langeveld, 1997) in cases where rhyme lengthening is constrained. In Estonian, the lengthening of the rhyme of the final syllable is limited for the reason that Estonian quantities differ in the duration ratio of the first and the second syllable. If only one of these syllables, e.g. the final one, is lengthened, the quantity characteristic ratios can be destroyed. Our results showed that in the long and overlong quantities indeed not only the rhyme of the final syllable was lengthened, but also parts of the first syllable. We therefore confirmed the results of Cambier-Langeveld (1997) that in cases of a lengthening constraint of the final syllable earlier parts of speech can also be lengthened. Nevertheless the Hybrid view cannot explain our result for the short quantities in which the rhyme of the final syllable was not lengthened at all.

Our results of PFL in Estonian are most compatible with the Structure-based view. Nevertheless, the results cannot be explained in terms of the rhymes of the first and the final syllable alone. This is for two reasons. Firstly, in the short quantities, the rhyme of the first syllable was not lengthened at all. Secondly, in case of CQ2- and CQ3-words, we cannot demonstrate that only the rhyme and not also the coda consonant of the first syllable was affected by PFL, because the syllable boundary lies within the intervocalic geminate. However, we found a more suitable linguistic structure which was affected by PFL in all quantities: the main bearer of the quantity contrast, i.e. V_1 in VQ-words and C_2 in CQ-words. Additionally other linguistic structures were affected depending on the quantity degree. In the long and overlong quantities, the rhyme of the final syllable was also influenced by PFL. It remains unclear why in the short quantities PFL did not affect the rhyme of the final syllable, but instead C_2 in VQ1-words and V_1 in CQ1-words.

Progressive lengthening only occurred in VQ2-, VQ3- and CQ1-words. These results are in line with previous results on VQ-words by Eek & Meister (2003) for Estonian and with the results of Turk & Shattuck-Hufnagel (2007) for American English. We did not find progressive lengthening in all quantity degrees and types: progressive lengthening only occurred if the lengthened segments were not in adjacent final position as this was the case for CQ2- and CQ3-words. However, this cannot explain the lack of progressive lengthening in VQ1-words, where the lengthened segments were not in adjacent final position, but nevertheless there was no progressive lengthening.

Acknowledgments

We would like to thank Pire Teras and Tuuli Tuisk for help with the vowel and consonant quantity triplets and the carrier sentences. This research was supported by a PhD fellowship by the *Studienstiftung des Deutschen Volkes*.

References

- Asu, E. L., Lippus, P., Teras, P., & Tuisk, T. (2009). The realization of Estonian quantity characteristics in spontaneous speech. In M. Vainio, R. Aulanko & O. Aaltonen (Eds.), *Nordic Prosody. Proceedings of the Xth conference, Helsinki 2008* (pp. 49–56). Frankfurt, Berlin, New York: Peter Lang.
- Byrd, D., & Saltzman, E. (2003). The elastic phrase: Modeling the dynamics of boundary-adjacent lengthening. *Journal of Phonetics*, 31(2), 149–180.
- Byrd, D., Krivokapić, J., & Lee, S. (2006). How far, how long: On the temporal scope of prosodic boundary effects. *Journal of the Acoustical Society of America*, 120(3), 1589–1599.
- Cambier-Langeveld, T. (1997). The domain of final lengthening in the production of Dutch. In H. de Hoop & J. Coerts (Eds.), *Linguistics in the Netherlands* (pp. 13–24). Amsterdam: John Benjamins.
- Draxler, C., & Jänsch, K. (2004). Speechrecorder – A universal platform independent multi-channel audio recording software. In *Proceedings of 4th international conference on language resources and evaluation* (pp. 559–562). Lisbon.
- Eek, A., & Meister, E. (2003). Foneetilisi katseid ja arutlusi kvantiteedi alalt (I). Häälikukestusi muutvad kontekstid ja välde. *Keel ja Kirjandus*, 46(11–12), 815–837, 904–918.
- Harrington, J. (2010). *Phonetic analysis of speech corpora*. Malden, MA: Wiley-Blackwell.
- Krull, D. (1992). Temporal and tonal correlates to quantity in Estonian. *Phonetic Experimental Research, Institute of Linguistics, University of Stockholm (PERILUS)*, 15, 17–36.
- Krull, D. (1997). Prepausal lengthening in Estonian: Evidence from conversational speech. In I. Lehiste & J. Ross (Eds.), *Estonian prosody: Papers from a symposium* (pp. 136–148). Tallinn: Institute of Estonian Language.
- Lehiste, I. (1960). Segmental and syllabic quantity in Estonian. In T. A. Sebeok (Ed.), *American studies in Uralic linguistics, Uralic and Altaic series* (pp. 21–82). Bloomington: Indiana University Publications.
- Lehiste, I. (1981). Sentence and paragraph boundaries in Estonian. In O. Ikola (Ed.), *Congressus quintus internationalis fenno-ugristarum, Turku 20.-27 VIII 1980*, Vol. 4 (pp. 164–169). Turku: Suomen Kielen Seura.
- Lehiste, I. (1997). The structure of trisyllabic words. In I. Lehiste & J. Ross (Eds.), *Estonian prosody: Papers from a symposium* (pp. 149–164). Tallinn: Institute of Estonian Language.
- Mihkla, M. (2006). Pausid kõnes. *Keel ja Kirjandus*, 49(4), 286–295.
- Nakai, S., Kunnari, S., Turk, A., Suomi, K., & Ylitalo, R. (2009). Utterance-final lengthening and quantity in Northern Finnish. *Journal of Phonetics*, 37(1), 29–45.
- Schiel, F. (1999). Automatic phonetic transcription of non-prompted speech. In J. J. Ohala, Y. Hasegawa, M. Ohala, D. Granville, & A. C. Bailey (Eds.), *Proceedings of the 14th International Congress of Phonetic Sciences, San Francisco, USA, 1-7 August 1999*, Vol. 3 (pp. 607–610). Berkeley: University of California.
- Turk, A. E., & Shattuck-Hufnagel, S. (2007). Multiple targets of phrase-final lengthening in American English words. *Journal of Phonetics*, 35(4), 445–472.
- Wightman, C. W., Shattuck-Hufnagel, S., Ostendorf, M., & Price, P. J. (1992). Segmental durations in the vicinity of prosodic phrase boundaries. *Journal of the Acoustical Society of America*, 91(3), 1707–1717.

Next contribution