Segmental context effects on temporal realization of Estonian quantity

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Abstract. The Estonian three-way quantity system is a robust foot-level compensatory mechanism of the stressed and the unstressed syllable durations. Beneath the three-way foot-level contrast, the quantity oppositions can be realized by seven different segmental combinations of the initial vowel and the following intervocalic consonant length. In this work we investigated the effects of context dependency on durational patterns marking this 7-way contrast. We observed a strong influence of the word initial consonant and vocalic quality context on the durations of individual segment in different quantity combinations. The results show a complex relation between the intrinsic phonetic properties and suprasegmental features. The effects of segmental context and natural variation of phonetic realization might in some cases combine to be greater than average differences between quantity degrees.

Estonian three-way quantity:
• Opposition between short, long and overlong (Q1, Q2, Q3) is realized by the stressed-to-unstressed syllable rhyme duration ratio.
• Stressed syllable rhyme duration is achieved by combining the length of the vowel and the coda consonant, enabling minimal sepetes of CVCV-sequences based on seven segmental combinations.

Intrinsic properties of segments interact with quantity:
• The difference between Q1, Q2 and Q3 segments is not symmetrical (greater between Q1 – Q2 than between Q2 – Q3).
• The intrinsic properties of sound segments have non-linear effect on the quantity-related duration variability.
• Vowel quality can shift the perceived short-long category boundary.

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All possible quantity combinations of CVCV sequence.

Consonant context (papi vs. tapi):
• [p] always longer than [t].
• In [t]-context the final [i] is shortened (in some Q2 and Q3 quantity combinations).
• Only occasional effects on V1 and intervocalic C.

Vocalic context (papi vs. pipa):
• [a] is longer than [i], but this has a complex non-linear pattern.
• V1 [i] is shortened more if it is long, and less, if followed by a long C2.
• V2 [a] is the most lengthened in Q1, but the intrinsic lengthening effect is the smallest or not significant in Q3.

The interaction (papi vs. tipa):
• The interaction with vocalic context neutralizes the main effect of the consonant context: the difference between [t] and [p] duration becomes minute.
• In interaction with the consonant context [i] is extra shortened and [a] is lengthened.

Overlaps of overall duration patterns (Fig. 2)
• A small amount of durational overlaps is present for most combinations of segmental context and quantity.
• Overall duration patterns of a-1 tokens is closer to that of median patterns of the higher quantity while i-a tokens are more similar to the lower quantity medians.
• Overlaps are considerably more frequent for tokens with initial [t].

Results

Context effects on segmental durations (Fig. 1)

For each of the four segments in the CVCV target word, linear mixed effect models with the segment duration as a dependent variable, both vocalic context and word initial consonant as independent factors were fitted separately for each quantity combination. For each quantity combination, papi is taken as the reference value. The second row (pap) plots the main effect of the initial consonant context, the following row, pipa, the main effect of vocalic context, and the last, tipa, the interaction of both. The numbers on the segments are the estimated differences (in milliseconds) compared to the base values and are shown only if the effect is significant.

Different intrinsic duration of segments and their different sensitivity to lengthening effects might lead to considerable overlaps in durational patterns pertaining to distinct quantity combinations. The colors in Fig. 1 illustrate this point. Panel Fig. 1a) compares the mean durational pattern of a Q3 [t:p:i] with a mean pattern of Q2 CV-C:V quantity combination. The naturally shorter duration of [i] compared to [a] combined with the additional shortening due to [t] context reduced the expected Q2-Q3 difference in V1 duration. At the same time, the lengthening of word final [a] due to interaction with initial [t] further reduces the overall difference between duration patterns. As a result, at least when it comes to segments Q3 [t:p:i] is not considerably different from an average token from Q2 CV:C:V category. Similar trends and consequences can be observed in the other two cases comparing Q2 and Q3 words with mean patterns from Q3 and Q2 categories, respectively.

Conclusions

We have identified several influences of segmental quality on durational patterns of seven quantity combinations present in the system. The interactions are not linear nor are they limited to the effects of intrinsic phoneme durations; they also involve the place of articulation of the word initial consonant. The durational differences marking quantity contrast are in some cases not robust enough to make the contextual effects negligible. The listeners most likely process the primary temporal cues of quantity contrast in a context-dependent manner.