FINAL LENGTHENING - A CONSEQUENCE OF ARTICULATORY AND PERCEPTUAL RESTRICTIONS?

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Introduction

The duration of speech segments varies according to the position in the word and in the phrase. In the literature some of these variations are known as initial and final lengthening.

Segmental variation has mainly been studied as an isolated phenomenon without any connection to parameters such as fundamental frequency and intensity variations.

In this study, attempts have been made to explain some of the temporal regularities of spoken Swedish such as, e.g., "final lengthening" by means of articulatory and perceptual restrictions on the speed of fundamental frequency change.

Segment durations

Observations

In an investigation reported previously (Lyberg 1977), vowel duration measurements were made for an invariant "probe" sequence [-ˈdɑ:g-], where position at the word and phrase levels was systematically varied. The results from the study can be summarized by the following points:

a) The duration of the test word vowel is longer when the word is at the end of a phrase, at least when the test word vowel is followed by fewer than two unstressed syllables.

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b) In phrase-final positions, the duration of the vowel segment decreases as a function of the number of preceding main stresses.

c) In all other positions, the duration of the vowel does not show any systematic variations depending on the position in the phrase.

Model based on a lengthening process

If the "shortest" inherent duration of the speech segments is used as a basic input parameter, it seems possible to describe the durational patterns of Swedish utterances by means of the following expression:

$$D = (u(2a_p + a_w - 2) + u(1 - 2a_p - a_w) \cdot k \cdot (1 + a_w)^{-\alpha} (1 + b_p)^{-\beta}) D_1$$

where $u(n) = \begin{cases} 1 & \text{if } n \geq 0 \\ 0 & \text{if } n < 0 \end{cases}$

D = the segment duration of a given main stress vowel in a word and in a phrase

D_1 = the inherent "shortest" duration of the vowel segment.

a_w = the number of syllables that follow at a given point.

a_p = the number of main stresses that follow at a given point.

b_p = the number of main stresses that precede at a given point.

α, β, k = constants.

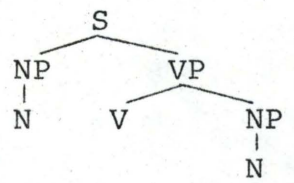
Contrary to the earlier models (Lindblom and Rapp 1973, Lyberg 1977) the constants used in the present model are totally independent of the metric structure of the test words.

Fundamental frequency change

Observations.

Some of the sentences of the speech material used in an earlier investigation (Lyberg 1977) were also used in this investigation in order to study the frequency contour for two of the speakers (JJ, PEN). The sentences used appear in Table 1.

Table 1

Sentence	syntactic structure
Dag Dagen Dagobert Idag	S | NP | N
Dag berömmer Dagobert Dagobert berömmer Dag	

The experimental results are presented for one of the two speakers in figs. 1 and 2. Every point in the diagrams represents a mean value of ten comparative samples.

The fundamental frequency contour at the end of the sentences consists of a maximum followed by a minimum value. This phrase-end signalling will always occur in the final word of the sentences and different cases will occur depending on the metric structure of the final word:

a) The final word consists of only one syllable. Both the maximum and the minimum have to be manifested in the same syllable.

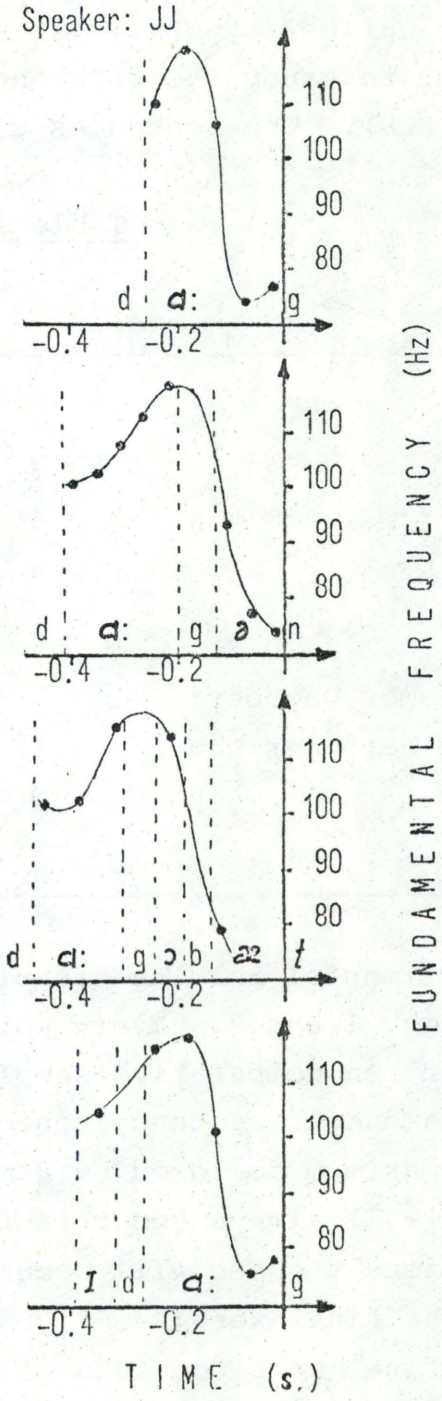


Figure 1

The fundamental frequency contours of the one-word sentences [dɑ:g], [dɑ:gən], [dɑ:gɔbæt], [ɪdɑ:].

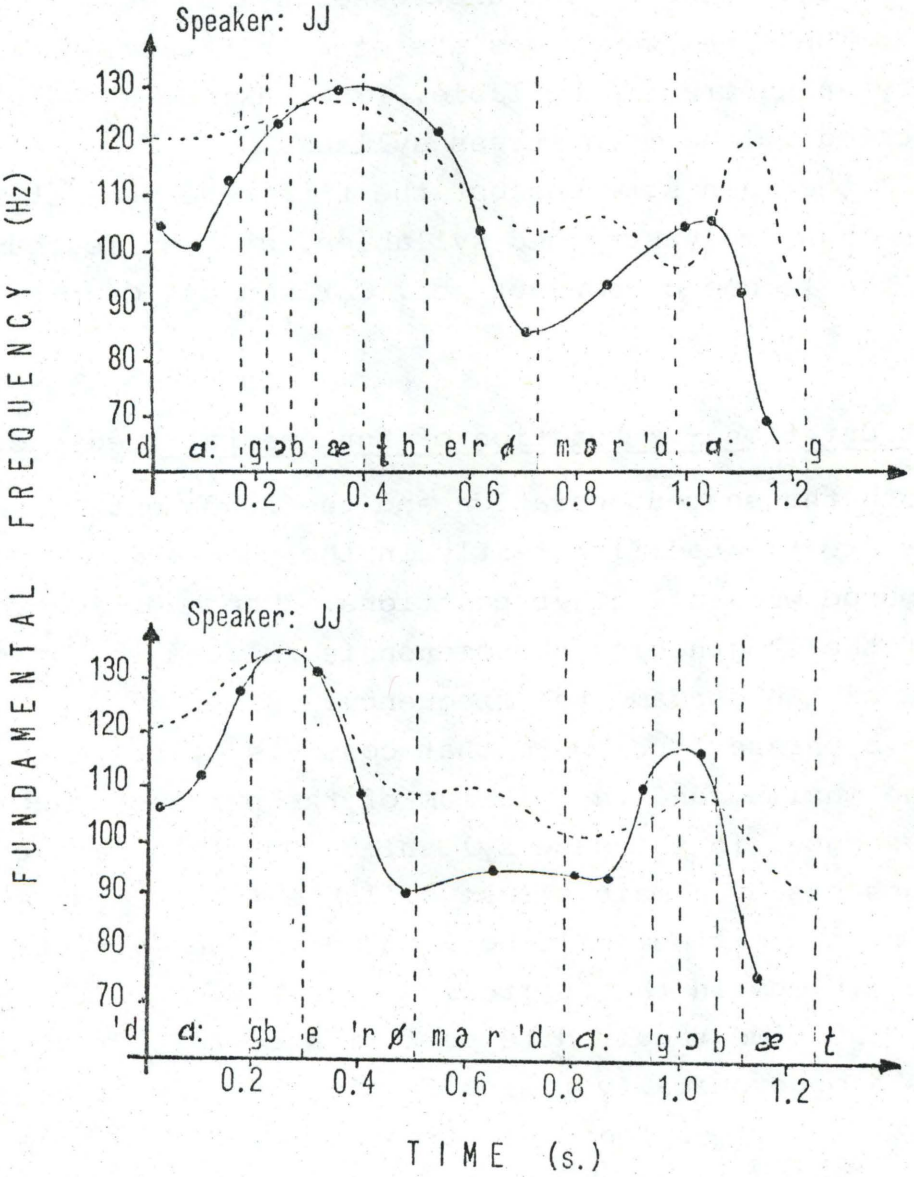


Figure 2

The fundamental frequency contours of the sentences ['dɑ:gɔbæt be'rømər'dɑ:g] and ['dɑ:gbe'rømər'dɑ:gɔbæt].

b) The final word consists of a main stressed syllable followed by an unstressed syllable. The minimum value is then located in the unstressed syllable but the maximum will still occur in the main stress syllable.

c) The final word consists of a main stress syllable followed by two unstressed syllables. Both the maximum and the minimum are located in the unstressed syllables.

d) The final word consists of a main stress syllable preceded by an unstressed syllable. The maximum and the minimum are located in the main stress syllable.

All the main stresses but the final one when it is followed by less than two unstressed syllables, are manifested by a minimum in the frequency contour (cf. Carlson and Granström 1973).

Segment duration - a function of fundamental frequency change?

Both the segment duration and the fundamental frequency contour are treated differently in the phrase final position as compared with all other positions. The question then arises whether the lengthening phenomenon is related to the phrase-end command of the fundamental frequency.

In a phrase final word that consists of only one syllable, both the maximum and the minimum of the phrase-end command have to be executed in the same syllable. But in a phrase final word that consists of a main stress syllable followed by an unstressed syllable, the maximum will be located in the main stress syllable and the minimum in the unstressed syllable.

If the time required to perform a certain frequency deviation is a monotonically rising function of the frequency deviation, it is obvious that the stressed vowel in a phrase final word like /dag/ is longer than the stressed vowel in e.g. /dagen/.

The segment duration is thus only prolonged when it is necessary in order to perform the required fundamental frequency deviation. The variation of the segment duration at different

places in a sentence is then only a secondary effect of the signalling by means of the fundamental frequency.

References

Carlson, R. and B. Granström 1973: "Word accent, emphatic stress and syntax in a synthesis by rule scheme for Swedish", STL-QPSR 2-3/1973, p. 31-36

Lindblom, B. and K. Rapp 1973: "Some temporal regularities of spoken Swedish", PILUS (Papers from the Institute of Linguistics, University of Stockholm) No. 21

Lyberg, B. 1977: "Some observations on the timing of Swedish utterances", Journal of Phonetics 5, p. 49-59