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Phonemic Quantity, Stress, and the Half-Long Vowel in Finnish

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Abstract: An experiment was conducted to compare the duration of the final vowels in Finnish disyllabic words which have short stressed initial syllables - CVCV(V) - with that in words with long stressed initial syllables - CVVCV(V), CVCCV(V), CVVCCV(V). It was found that in the first group the final short and long vowels were systematically longer than in the second group. This is taken to suggest that stress interacts with phonemic quantity: on the initial syllable in the CVCV(V)-words there is a conflict between the phonemic duration of the vowel and the use of duration as a stress cue. This is resolved by spreading the stress-induced duration to the second syllable. Thus even if the domain of stress is a syllable, its realization is not independent of the rest of the phonological structure but it operates in concert with it.

1. Introduction

The representation of time has long been a problem in the phonological description of speech. One argument, for example, concerns whether long segments are 'long' or whether they are clusters of two short segments. There is no single solution to this question, but the decision seems to depend on language-particular facts. Apart from phonemic quantity distinctions, there is also allophonic variation in terms of duration. The English lengthening of vowels before voiced consonants is a well-known example of this kind of alternation. This lengthening is not predicted from 'universal phonetics' but is a language-specific phenomenon. This kind of allophonic behavior can be present even in a language which has distinctive quantity. For example, Finnish has a 'half-long' vowel which occurs as the second vowel in CVCV-structures. It is about 1.5 times longer than the first, stressed vowel. It is also significantly longer than corresponding vowels in words with long initial syllables. Also long final vowels are significantly longer after short initial syllables than after corresponding long syllables, and geminates, too, tend to be longer after short stressed vowels than after long stressed vowels. It seems that these lengthening phenomena relate to the interaction of phonemic vowel quantity and stress on the first syllable. If so, then Finnish would seem to illustrate why Jakobson and Trubetzkoy suggested that no language can have both distinctive stress and distinctive quantity.

Stress serves a demarcative function in Finnish. Primary word stress is on the first syllable of the word and after that there are secondary stresses on roughly each odd-numbered non-final syllable (Karlsson, 1982, 150). Vowels and consonants have a phonemic quantity opposition and this opposition is present in both stressed and unstresssed syllables. Thus a stressed syllable may contain either a short or a long vowel. A syllable may have any one of the following structures:

(1) a. (C)V b. (C)VV c. (C)VC d. (C)VVC e. (C)VCC

I will call (1a) a short syllable and all the others long. On the average a long vowel is twice as long as the corresponding short vowel (Wiik & Lehiste, 1968; Lehtonen, 1970) and stressed vowels are longer than corresponding unstressed vowels. There is one exception to this last generalization, however: the half-long vowel (Wiik & Lehiste, 1968; Lehtonen, 1970), which is phonemically short. Thus, in the following word the second, unstressed [a] is significantly longer than the first, stressed [a]:

(2) kala 'fish'

Wiik and Lehiste also note that "the long unstressed vowels are longer when preceded by a short stressed vowel than when preceded by a long stressed vowel" (1968, 570). Actually the final vowel is shorter after any stressed long syllable, not just one containing a long vowel (Lehtonen, 1970, 126). Karlsson states that Finnish has an allophonic rule that lengthens a short vowel after an initial CV-syllable (1982, 151). He gives the following rule to account for this (ibid., 152):

/V/ ---> [longer] / # CV.(C)___

Note: as compared to the context # CV $\left\{ \begin{matrix} V \\ C \end{matrix} \right\}$. (C) ____

The note is added because, he explains, we cannot state durational relations in absolute terms. None of the above authors associates the two lengthenings, i.e., those of short and long vowels, to the same underlying cause. Nor is any explanation offered for the lengthening of the long vowel. The geminate lengthening is also usually seen as a separate, unexplained phenomenon (Karlsson 1982); note though Lehtonen (1970, 152).

The vowel phenomenon is not a case of final lengthening because the final vowels, short and long, are lengthened only after a short initial syllable and not after corresponding long syllables. That is, the final vowel in CVCV(V)-words is longer than the final vowel in, e.g., CVVCV(V), CVCCV(V) and CVVCCV(V)-words. We can thus note two facts here:

(a) the second, unstressed vowel in CVCV words is longer than the stressed first vowel even if stressed vowels are generally longer than corresponding unstressed vowels.

(b) both long and short second vowels are on the average considerably longer after a short first syllable than after a long initial syllable.

Wiik and Lehiste (1968) explain the half-long vowel as follows: the second vowel is lengthened in order to create a certain ratio between the vowels thereby signalling the phonemic quantities of these two and at the same time establishing a particular word structure, i.e., CVCV. This takes place within a two-syllable sequence which is taken to be the fundamental prosodic unit in Finnish. Also Karlsson notes that the realization of vowel quantity depends on the structure of the whole word as is implicit in his rule above (1982, 72). Lehtonen presents similar ideas (1970). If it is true that the second vowel is lengthened in order to create a certain ratio which is needed for the identification of the vowel durations, then

the lengthening to half-long serves a distinctive function at the disyllabic level. This proposal, however, does not include any explanation for why the ratio between the vowels in the CVCV-words without the half-long vowel could not serve this putative distinctive function.

Kohler has proposed a solution similar to the one above which would solve the problem mentioned: the syntagmatic relations between the vowels in CVCV and CVVCVV words must be different in order not to neutralize the two structures under various "higher-order timing levels of tempo, rhythm, and intonation" (1986: 269). This would be, according to Kohler, the motivation for the half-long vowel in Finnish with the resulting differences in the V1/V2-ratios in CVCV and CVVCVV words. However, this suggestion leaves unexplained why also the long vowel in CVCVV words gets lengthened. There is no corresponding word for CVCVV which might possibly have the same ratio between the vowels to form the analogous pair to the CVCV and CVVCVV pair. Also, as we will see below, this study does not provide unequivocal support for the proposal that the syntagmatic relations between the vowels indeed remain the same under various "higher-order timing levels."

Lehiste (personal communication) has offered another possible explanation which would solve the problems found above: there is a tendency to make all the basic prosodic units -- i.e., the disyllabic sequences -- isochronous. However, the data given in Lehtonen (1970, 126) do not support this view. The differences between the various disyllabic structures are considerable. Also, since the long final vowel in CVCVV is lengthened it would seem to go against this tendency. If the final vowel in CVCV structures is lengthened in order to create structures isochronous with, e.g., CVVCV, then the lengthening of the final VV in CVCVV is counterproductive.

Lehtonen explains the presence of the half-long vowel by proposing that the domain of stress in Finnish is a sequence of two moras (1970, 151). Word stress would have "some standard minimum duration or amount of energy whose domain is the two-mora group" (ibid.). This would explain the half-long vowel: "the articulation of segmental sounds should...be synchronized with this imagined energy pulse" (ibid.). And since the second mora in a CVCV-word falls on the second syllable, the half-long vowel is created. Lehtonen's explanation is very similar to mine (below) but for the notion that the domain of stress is two moras. First, it is not obvious to me why the second mora should become lengthened. Furthermore, since diphthongs do not behave like other two-mora sequences (in the following words the second vowel in the second word is half-long but not in the first: [tuo] 'bring!' vs. [ta.o] 'forge!'; see below) it seems that something other than a specific domain is more important. Lehtonen mentions that quantity distinctions need to be maintained, and I propose that this is the major factor in play. Stress simply makes segments longer but it does not have any specific two-mora domain.

The central fact here seems to be that the half-long and the lengthened long vowel both occur after a short initial syllable and not after long initial syllables; also geminates get longer after short stressed vowels than after long stressed vowels. Important, too, is that unstressed vowels are in general shorter than corresponding stressed vowels except in CVCV-words which again involves the short initial syllable.

If we consider what the phonetic correlates of stress are, an alternative to the above explanations may be found. The usual phonetic cues to stress are intensity, pitch and duration. A particular language may use these to a different degree each so that even though they all are actively employed, maybe only one gives the decisive cue (e.g., Lehiste, 1970, 138). Since Finnish has a quantity opposition we might not expect it to use the duration cue very much in signalling stress. But clearly it does use duration since stressed syllables are longer than the unstressed ones. If we assume that duration is one of the important stress cues in Finnish then we may understand the behavior of the vowels after stressed CV-syllables.

I propose that the exceptional length of the second syllable vowel after stressed CV-syllables results from a conflict between the phonemic quantity opposition at the segmental level and the use of duration as a stress cue at the suprasegmental level. Since stress would lengthen the vowel of a CV-syllable, this might create an unwarranted neutralization. To resolve this conflict between the use of duration at two different but simultaneous levels the lengthening as a signal of stress spreads over to the second syllable in a CVCV(V) word. Consequently, the final vowel is longer than it would be if the first syllable were long. This same explanation extends to the geminates.

Estonian, which also has initial stress and quantity opposition (on the first syllable), has a similar property as shown by Lehiste:

> ...the duration of the vowel on the second syllable, which is not independently contrastive, is inversely proportional to the quantity of the first syllable...This is especially clear in case of short first syllables, which are followed by unstressed syllables whose vowel is usually about 1.5 times as long as the short vowel of the stressed syllable. (1970, 50)

Also Hungarian, where the relevant characteristics are the same as in Finnish and Estonian, may have this same phenomenon. Fónagy reports on earlier research showing that unstressed syllables may be louder and longer than preceding stressed ones. The examples he gives are cases where the initial stressed syllable is short (1966, 234). The fact that these three languages share the lengthening may be suggestive of a general interaction between stress and phonemic quantity and not just a genetic characteristic of these particular Finno-Ugric languages.

This paper reports an experiment done in order to provide evidence in support of the prosposed interpretation of the half-long vowel. The main focus of the experiment was on the following:

(a) the durations of the final vowels after short and long stressed syllables will be compared

(b) the ratios between the vowels in disyllabic sequences with different word structures will be compared

A secondary aim was to see if also the geminates become longer under the various rates and discourse conditions as predicted by earlier findings. Essentially the experiment replicated some earlier studies but new

variables like speech rate and sentence position/sentence stress were included. These are especially important if we want to determine whether the ratios can indeed serve a distinctive function; if they can, they should remain largely the same under all discourse conditions. I also expected that the final vowels are significantly longer after stressed short syllables than after stressed long syllables. Thus I did not expect my findings to be different from the earlier ones in this respect, but I wanted to see that the facts will be the same regardless of speech rate and various discourse contexts and that they will be the same for both short and long final vowels.

2. Methods

Lehtonen in the above study looked at words in naturally occurring sentences which were read in isolation and where the test-words were in neutral sentence stress positions. I replicated his study with some modifications. I had the words under consideration in two sentence positions, in three sentence stress conditions and in two speech rates. The sentence positions were initial and medial; the sentence stress conditions were initial neutral declarative sentence stress, initial contrastive stress, and medial neutral stress following contrastive stress; the speech rates were fast and normal. The complete corpus can be found in the appendix. About two thirds of the sentences (set I) were given a context in parentheses immediately before each sentence; the subjects were instructed to read aloud only the test sentence. The rest of the sentences (set II) had no context given. Each list of the test sentences was read six times in normal speech rate and six times "as fast as they could". Each reading of the list used a different random order of the test sentences; each set was printed on a separate sheet. The speech rates alternated in a random order. The test words contained only vowels and voiceless plosives; the word after the test word always began with a voiceless plosive. The CVCC syllable-type is excluded from the comparisons. Also, since the final consonant has no effect on the duration of the other segments in the word (Lehtonen, 1970), the words to be examined have open final syllables.

In the first part, the final vowels of the words were studied. In set I only vowels of the same vowel quality were compared, in set II it is always [a], short or long, that occurs at the end of a word. The comparisons shown in Table I were made.

Table I

Set I			Set II		
CVCV - CVVCV	[kato] -	[kaato]	CVCV - CVCVV	[tupa] -	[tupaa]
CVCCV		[katto]			
CVVCCV		[taatto]	CVCV - CVVCVV	[tupa] -	[piikaa]
CVCV - CVVCCV	[piki] -	[piikki]	CVCCVV		[takkaa]
		[tuutti]	CVVCCVV		[taakkaa]
CVCCV		[tutti]	CVCVV - CVVCVV	[tupaa] -	[piikaa]
			CVCCVV		[takkaa]
			CVVCCVV		[taakkaa]

For the geminates only three word pairs were examined: [katto] - [taatto], [tutti] - [tuutti] and [takkaa] - [taakkaa]. The measurements were made from the wave-form using the sfm wave-form editor on the New England Digital computer. The beginning and end of each vowel was measured from voice onset to subsequent voice offset. The consonant duration was measured from the end of voicing at the consonant implosion to the beginning of voicing for the next vowel.

The second part consisted of obtaining the V1/V2-ratios of each test word in each experimental condition in order to see, first of all, if the ratios are constant. Also it will have to be established if any particular discourse condition has a systematic effect on the ratios.

Three subjects were used, two females and one male. One of the females had lived all her life in Helsinki, the other most of her adult life also in Helsinki; the male subject grew up in central Finland but had lived over ten years in Helsinki. One female had been in the USA about half a year, the other female nine years, the male for 2.5 years. All subjects had university degrees ranging from BA to PhD.

3. Results

In comparing the average durations of the vowels which occurred after the initial CV-syllable with those occurring after CVV, CVC or CVVC-syllables it was found that the former were significantly longer across both the three sentence stress conditions and the two speech rates. This lengthening after a stressed CV was present in both short and long vowels. Figures 1 through 3 give the averages of the second syllable vowels in milliseconds, first in all conditions combined, then by rate and by emphatic conditions. The sets to be compared are:

(a) [kato] vs. [kaato], [katto], [taatto]

(b) [tupaa] vs. [piikaa], [takkaa], [taakkaa]

(c) [piki] vs. [piikki], [tutti], [tuutti].

The consonants preceding the vowels in (b) and (c) are different, but they are always voiceless plosives so that there should not be any great differential effects (the vowels are measured from the voice onset). The P-values in the figure captions were obtained from a two-tailed t-test, where the mean vowel duration after CV-syllables was compared with the combined mean value of the final vowels in the other three word structures in each comparison set.

We can note in figure 1 that the final vowel averages in the CVCV(V) structures are significantly different from the other three structures. The male speaker was a fast speaker even in his normal rate which shows in his mean values being smaller than those of the female speakers. In figure 2 we compare the averages by speech rate. The difference in rate did not have any effect on the durational differences, although, as expected, the averages were shorter in fast rate than in normal rate. In figure 3, likewise the various emphatic conditions do not seem to have any influence on the differences.

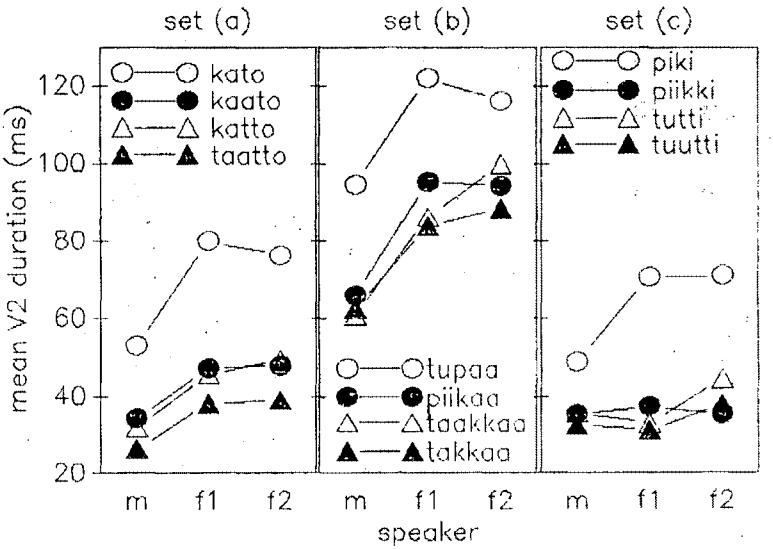


Fig. 1: Mean 2nd vowel durations for all conditions combined. Probability that V2 in CV__ context is the same as in other 3 words in each comparison set: $P < 0.0001$. Speakers: m = male, f1 = female 1, f2 = female 2.

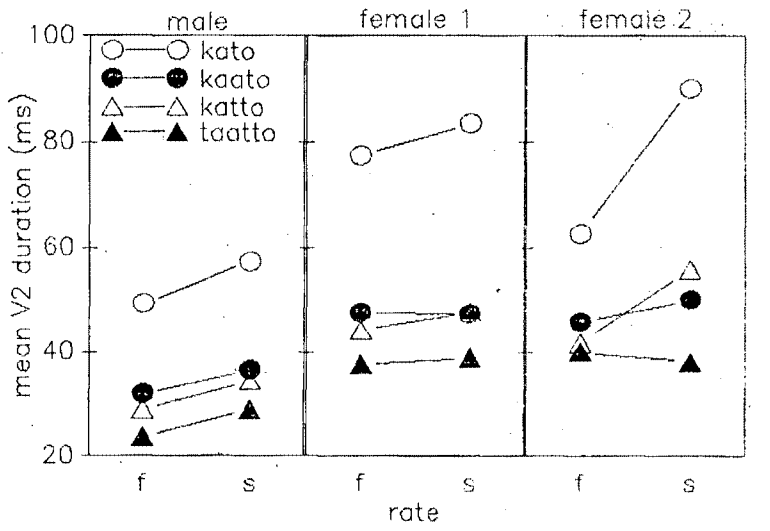


Fig. 2a: Mean second vowel durations for words in comparison set (a), for each speech rate (slow or fast) for each speaker. Probability that the vowel in kato is the same as in the other three words $P<0.0001$ for both speeds for all three subjects.

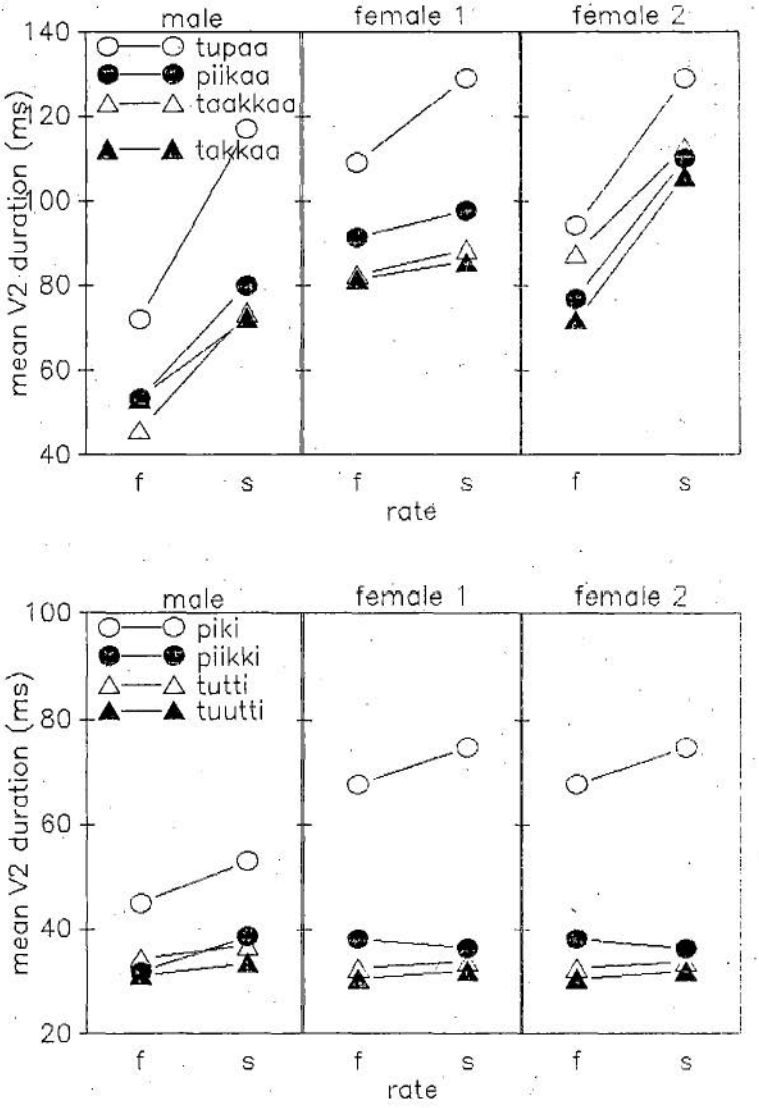
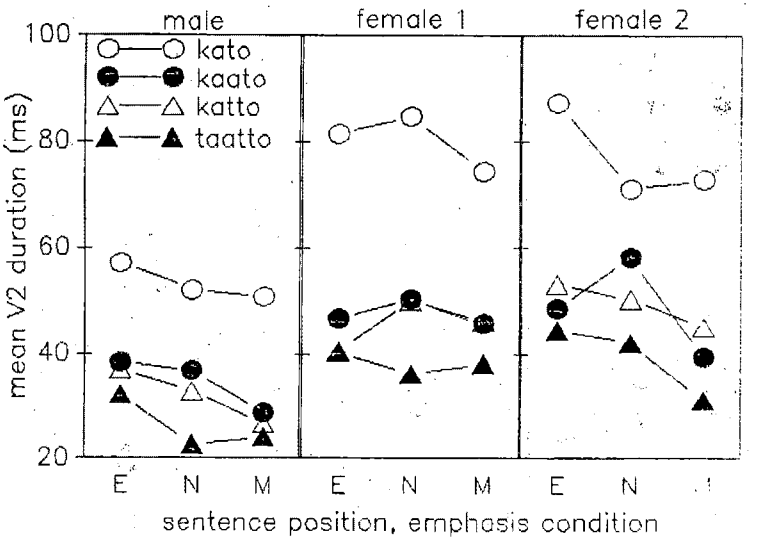


Fig. 2b-c: Mean second vowel durations for words in comparison sets (b) and (c), for each speech rate (slow or fast) for each speaker. Probability that the vowels in the CV__ context are the same as in the other 3 words in each set is P<0.0001 for both speeds for all 3 subjects, except P<0.005 for f2's tupaa at fast rate.



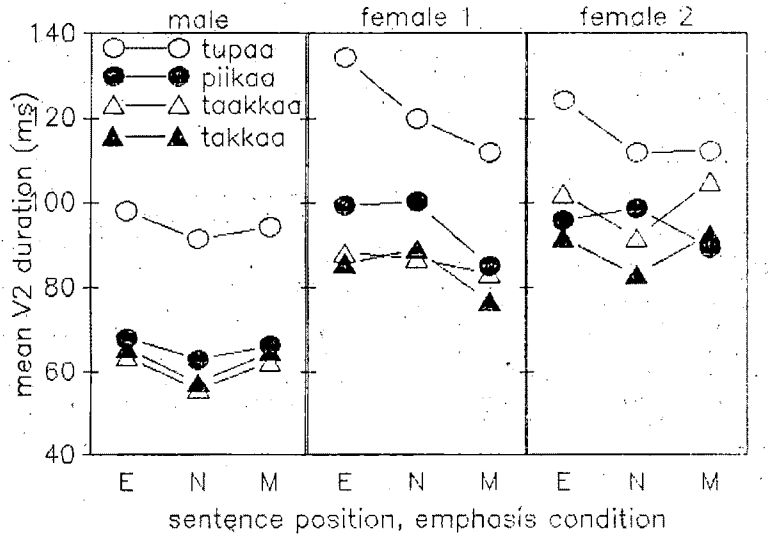


Fig. 3a-b: Mean second vowel durations for words in comparison sets (b) and (c), for each sentence position for each speaker. Positions plotted along x-axis: N = Neutral, initial sentence position, E = Emphatic, initial sentence position, M = Medial, post-emphatic position. Probability that the vowels in the CV__ context are the same as in the other three words in each set is P<0.001 for all 3 positions for all 3 subjects, except P<.02 for male and female 2 in set (b).

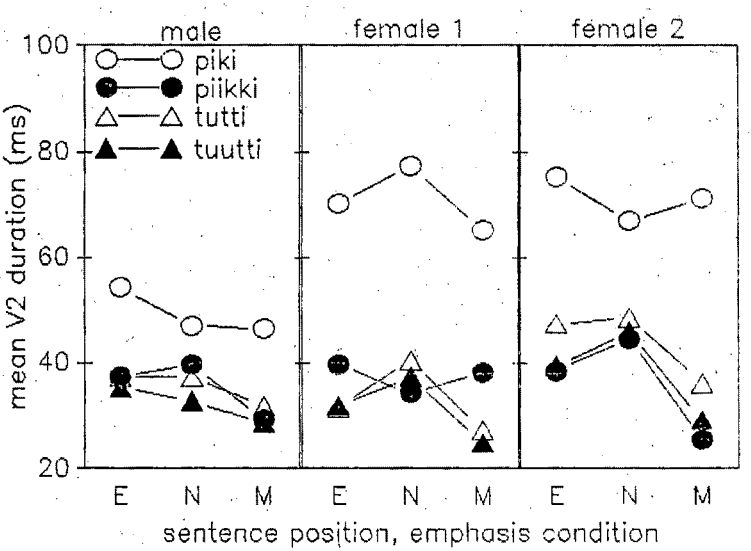


Fig. 3c: Mean second vowel durations for words in comparison set (c), for each sentence position for each speaker. Positions plotted along x-axis as in Fig. 3a-b. Probability that the vowels in the CV__ context are the same as in the other three words in each set is P<0.0001 for all 3 positions for all 3 subjects.

Another goal of the experiment was to present data about the V1/V2-ratios in the test words. An analysis of variance was performed and the results are given in Table II. This analysis turned out to be rather inconclusive. It shows some degree of interspeaker variation such that the corresponding ratios are not the same across different speakers. But also there may be a tendency within one speaker to maintain similar ratios across the various conditions. If this is present it is only a tendency though since there are significant differences between the ratios under different testing conditions. These discrepancies may be due to diverse factors, and thus this needs more study. However, no particular discourse context (i.e., neither emphasis nor rate) seems to have a systematic effect on the ratios.

Table II.

V1/V2-Ratios by rate and emphatic conditions

a. Male

		Rate			Sentence Position			
word		normal	fast	P	Neutral	Emphatic	Medial	P
kato	x	1.08	.88	.002	.95	1.09	.90	.07
	sd	.16	.20		.24	.20	.14	
kaato	s	3.34	2.84	.41	2.97	2.68	3.54	.49
	sd	1.78	1.63		1.96	.64	2.06	
katto	x	2.10	2.20	.84	1.63	1.84	2.86	.08
	sd	.70	1.99		.75	.06	2.04	
taatto	x	4.28	3.71	.48	4.30	2.96	4.68	.17
	sd	1.81	2.63		2.22	.73	2.95	
tupa	x	.90	.91	.90	.86	.97	.87	.54
	sd	.21	.26		.16	.27	.25	
tupaa	x	.50	.63	.01	.53	.62	.53	.24
	sd	.12	.15		.19	.14	.10	
piikaa	x	1.16	1.22	.52	1.03	1.24	1.30	.02
	sd	.21	.27		.19	.18	.28	
takkaa	x	.90	1.17	.02	1.03	1.12	1.11	.77
	sd	.15	.44		.36	.45	.39	
taakkaa	x	1.47	1.56	.28	1.40	1.55	1.58	.16
	sd	.22	.27		.17	.23	.28	

b. Female 1

		Rate			Sentence Position			
word		normal	fast	P	Neutral	Emphatic	Medial	P
kato	x	.96	.97	.73	.94	1.03	.93	.007
	sd	.11	.08		.09	.09	.06	
kaato	x	3.35	2.78	.001	2.93	3.28	2.85	.15
	sd	.58	.39		.52	.74	.27	
katto	x	1.91	1.87	.07	1.71	2.14	1.80	.01
	sd	.31	.46		.27	.47	.32	
taatto	x	3.75	3.30	.008	3.56	3.64	3.50	.24
	sd	.49	.46		.62	.45	.46	
tupa	x	.76	.09	.06	.79	.76	.83	.39
	sd	.11	.08		.11	.11	.10	
tupaa	x	.56	.63	.03	.59	.52	.63	.02
	sd	.08	.09		.09	.07	.07	
piikaa	x	1.32	1.25	.14	1.24	1.34	1.31	.28
	sd	.15	.14		.19	.10	.11	
takkaa	x	.98	.99	.83	.92	1.02	1.01	.11
	sd	.13	.10		.10	.09	.13	
taakkaa	x	1.61	1.56	.33	1.56	1.61	1.60	.72
	sd	.14	.17		.11	.18	.16	

Table II. (cont.)

c. Female 2

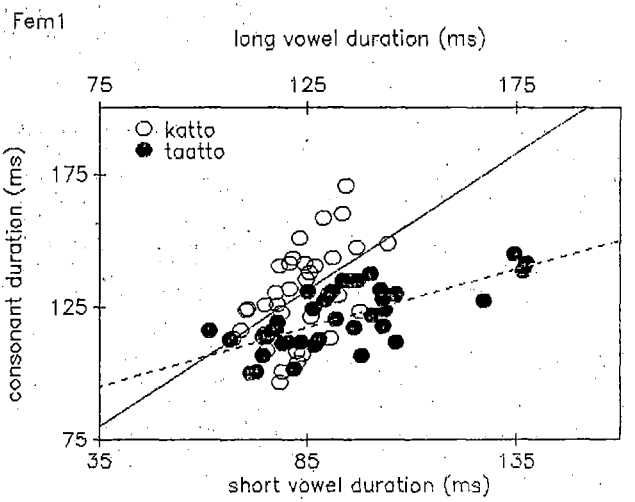
word		Rate: normal	Rate: fast	P	Sentence Position: Neutral	Sentence Position: Emphatic	Sentence Position: Medial	P
kato	x	.76	.85	.02	.76	.85	.81	.23
	sd	.10	.12		.08	.10	.14	
kaato	x	3.07	2.26	.03	1.81	2.86	3.15	.01
	sd	1.05	1.04		.35	.96	1.29	
katto	x	1.49	1.52	.78	1.49	1.47	1.55	.86
	sd	.22	.47		.56	.16	.30	
taatto	x	3.53	2.82	.23	2.37	3.20	4.06	.05
	sd	.79	2.34		1.04	1.33	2.26	
tupa	x	.71	.69	.66	.70	.76	.62	.01
	sd	.08	.14		.11	.13	.08	
tupaa	x	.51	.52	.71	.47	.55	.52	.08
	sd	.07	.09		.06	.07	.08	
piikaa	x	1.07	1.17	.11	1.00	1.18	1.15	.03
	sd	.15	.17		.11	.14	.19	
takkaa	x	.66	.76	.05	.69	.79	.61	.02
	sd	.12	.15		.14	.13	.08	
taakkaa	x	1.12	1.07	.51	1.08	1.27	1.02	.01
	sd	.18	.21		.17	.25	.13	

A secondary aim of the study was to look at the geminate durations. They were generally longer after short stressed vowels than after long stressed vowels. These differences, however, were not as dramatic as those found in vowels. In some instances the differences were tendencies not seen in the averages. But the overall means do not take into account token variability in speech rate in that there is not a match between words produced in a certain rate in one set with words produced in the same rate in the other set. If we want to consider this variability in rate we can take the duration of the V1 as an indicator of the overall rate and plot the geminate duration against it; now differences become observable. In figure 4, the X-axes have been adjusted so that the minimum values of the two types are aligned. If we compare cases where the means are significantly different (e.g., katto versus taatto for female 1 in figure 4a) and where they are not significantly different (e.g., the same words for female 2 in figure 4b), we can see that the separation of the regression lines is the same in both.

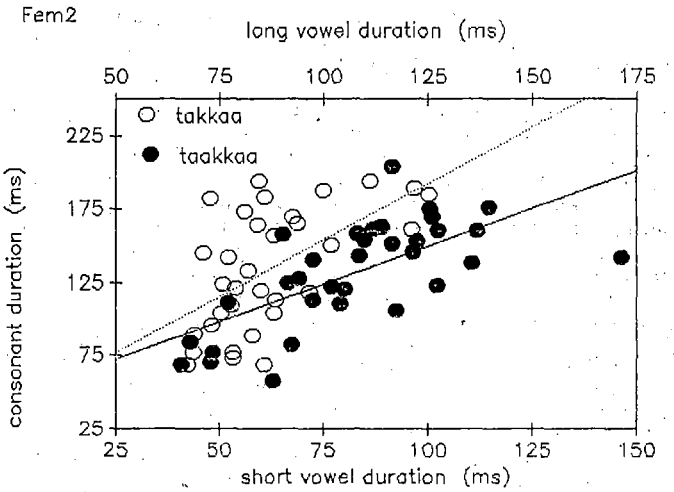
4. Discussion

My proposal is that it is the conflict between the use of duration as a stress cue and the need to maintain phonemic quantity distinctions that is responsible for the lengthening of short and long vowels after short stressed syllables. Thus we could modify Karlsson's rule as follows to include also long vowels and to note that stress is relevant, not just the syllable structure:

/V(V)/ ---> [V(V)ː] / (C)V́.(C)___



Means significantly different



Means not significantly different

Fig. 4: Geminate consonant duration plotted against preceding long or short vowel duration in all tokens of katto and taatto produced by female 1 (top) and female 2 (bottom). Dashed and dotted lines are regression curves fitted to the two sets of data points.

We need not state any conditions now but simply suggest that the vowel lengthens. Long vowels in Finnish are clusters of two identical vowels which is reflected in the representation [VV]. Thus [V:] and [VV] are kept distinct.

Because of the lengthening of the final vowel, a certain ratio between the vowels is obtained in, e.g., words of the structure CVCV and one proposed explanation for the half-long vowel was the creation of this particular target ratio. Lehiste (personal communication) suggests that if the ratio indeed is used in the recognition of the phonemic quantity of the vowels, the differences between the ratios must be large enough to be perceived. But it seems that whether the ratio differences are large enough or not may not be an issue as the ratios possibly are not even constant.

If it is indeed the interaction between stress and phonemic quantity that is responsible for the lengthening of the second vowel then we would expect that in polysyllabic words like, e.g., CVCVCVCV the last vowel would be longer than or equal in duration to the third vowel which has secondary stress (this is found in Estonian - Lehiste, 1970, 51), and that the last vowel would be longer in these structures than when preceded by a long syllable.

Lehtonen suggested that the domain of stress is two moras. If this is so, then we would expect the distribution of stress to be the same over any two adjacent moras. For example, if we have words like:

(3) a. [ta.e] 'guarantee' [ta.o] 'forge!' (. is a syllable boundary)

b. [tie] 'road' [tuo] 'bring!'

we would expect that in all of the above words the two vowels are either of the same duration or that in all of them the first or the second is longer than the other. But in fact in (3.a.) the final vowel is half-long unlike in (3.b.) (Karlsson, 1982, 152). If this is true, then my proposal would explain the difference between the identical final vowels in the words above. Diphthongs in Finnish always involve two short vowels. Contrasts like *[tuuo] and [tuo] or *[tuoo] are not possible. However, the first vowel in words of type [ta.o] and [ta.e] may be long. Consider the following: [mu.as.sa] 'with, along' vs. [muu.as.sa] 'in a certain...'; [si.an] 'of the pig' vs. [sii.an] 'of the white fish'; [li.an] 'of the dirt' vs. [lii.an] 'too (+adjective)'. Hence, since Finnish has contrast between CV.VC and CVV.VC words, there is the danger that the short first vowel might become too long by stress and thus be perceived as a long vowel. Therefore the duration of the stress spills over to the next syllable and the first vowel remains short. But in words where no contrast can be found between structures .CVVV. and .CVV. (both monosyllabic), the stress-duration is more evenly distributed across the vowels in the syllable.

It has been proposed that in some Finnish dialects the occurrence of the half-long vowel has threatened the CVCV/CVCVV contrast and that this would be the source of the so called "general gemination" of the medial consonant in the CVCVV structures: [sanoo] 'he says' becomes [sannoo] (Karlsson, 1982, 153). But if it is true that long vowels are longer after

initial CV-syllables than after long syllables then there should not be any danger of losing a contrast: the final vowels in CVCV and CVCVV are both lengthened, not only in CVCV. In this study all three speakers had a significant difference ($P < .00001$) between the final vowels in [tupa] and [tupaa]. For one speaker, Female 1, the final vowels in [tupa] vs. [piikaa], [takkaa], [taakkaa] were not significantly different ($P < .95$) while in [tupa] and [tupaa] they were ($P < .00001$). This was not the case for the other speakers: they had significant differences also in these instances. By these data we may suggest that the general gemination is caused by the same phenomenon as the half-long vowel in other dialects but in this one only the lengthening falls on the immediately following consonant.

The lengthened vowels and geminates seem to indicate that Finnish is struggling with the property that caused Jakobson and Trubetzkoy to claim that in no language can we have simultaneously free stress(accent) and free quantity. If a language were to have both of these properties then it could have on the same syllable both contrastive stress à la English <dígest>/<digést> and contrastive quantity à la Finnish <lika>/<liika> 'dirt/excess'. If we had an imaginary word like [latáaja] where there is both contrastive stress and quantity on the second syllable it would be hard to tell what caused the long vowel. If we have a short stressed vowel in place of the long, [latája], then this short vowel would be lengthened by the stress and again we would not know what we have there on that syllable. The introduction of a lengthened mora after a short stressed vowel illustrates one strategy to solve this problem without neutralization. If a language were to develop this kind of conflict involving the expression of distinctive stress and distinctive quantity we would expect it to get rid of one of these. And this is what has actually happened in languages which have acquired both of these as phonemic realities (Anderson, 1984).

5. Summary

Eight different word structures were studied, CVCV(V), CVVCV(V), CVCCV(V) and CVVCCV(V), in two different sentence positions, under three different sentence stress conditions and in two different speech rates. The results show that vowels, short and long, are longer after stressed short syllables than after long stressed syllables. Geminates show the same tendency after short stressed vowels. I interpret these facts to be the resolution of a conflict between the phonemic shortness of the vowel at the segmental level and the use of duration as a stress cue at the suprasegmental level: in order to avoid making the first vowel too long in which case it might neutralize with the long vowel, the duration associated with stress spills over to the following mora. This study did not lend unequivocal support to the use of ratios between vowels in the identification of their phonemic quantities. My proposal unifies some phenomena in Finnish which are usually considered to be independent. The half-long vowel is not unique because it behaves exactly like the extra-long long vowel. Also, the lengthened geminate is found after identical contexts: only after a short stressed vowel. These lengthenings relate to the realization of time in the stream of speech and they show that we cannot produce simultaneously something that must take only a little time and something that would make it longer.

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Appendix

the corpus of utterances

SET I

Kato tuhosi kauran. failure destroyed oats	'Bad year destroyed the oat harvest.'
KAto§ kauran tuhosi.	'It was the bad year (and not something else) that destroyed the oak harvest.'
TUhosi kato kauran.	'It was indeed the bad year that...'
Kaato tuhosi kannan. felling destroyed base	'Hunting destroyed the base.'
KAAto kannan tuhosi.	'It was hunting that destroyed the base.'
TUhosi kaato kannan.	'Hunting did indeed destroy the base.'
Katto tummui palossa. ceiling darkened fire-in	'The ceiling got dark in the fire.'
KATto palossa tummui.	'It was the ceiling that got dark in the fire.'
TUMmui katto palossa.	'The ceiling did indeed get dark in the fire.'
Piki putosi katolle. tar fell roof-on	'The tar fell on the roof.'
PIki katolle putosi.	'It was the tar that fell on the roof.'
PUtosi piki katolle.	'The tar did indeed fall on the roof.'
Piikki putosi katolle. awl fell roof-on	'The awl fell on the roof.'
PIIKki katolle putosi.	'It was the awl that fell on the roof.'
PUtosi piikki katolle.	'The awl did indeed fall on the roof.'

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§Capitalization indicates emphasis

Taatto käveli kovaa. 'Grandpa walked fast.'
grandpa walked fast

TAATto kovaa käveli. 'It was grandpa who walked fast.'

KAveli taatto kovaa. 'Grandpa did indeed walk fast.'

Tutti putosi pojalta. 'The pacifier fell from the boy.'
pacifier fell boy-from

TUTti pojalta putosi. 'It was the pacifier that fell from the boy.'

PUtosi tutti pojalta. 'The pacifier did indeed fall from the boy.'

Tuutti putosi pojalta. 'The (icecream)cone fell from the boy.'

TUUTti pojalta putosi. 'It was the cone that fell from the boy.'

PUtosi tuutti pojalta. 'The cone did indeed fall from the boy.'

SET II

Tupa pilkotti puiden takaa. 'The cottage showed behind the trees.'
cottage showed trees behind

TUpa puiden takaa pilkotti. 'It was the cottage (and not something else) that showed behind the trees.'

PILkotti tupa puiden takaa. 'The cottage did indeed show behind the trees.'

Tupaa pikotti puiden takaa. 'Part of the cottage showed
cottage-partit. showed trees behind behind the trees.'

TUpaa puiden takaa pilkotti. 'It was part of the cottage ...'

PILkotti tupaa puiden takaa. 'Part of the cottage did indeed...'

Piikaa kehuttiin kovasti. 'The maid was praised a lot.'
maid-partit. praised a lot

PIIkaa kovasti kehuttiin. 'It was the maid who was praised a lot.'

KEhuttiin piikaa kovasti. 'The maid was indeed praised a lot.'

Takkaa kehuttiin kovasti. fireplace-partit. praised a lot	'The fireplace was praised a lot.'
TAKkaa kovasti kehuttiin.	'It was the fireplace that was praised a lot.'
KEhuttiin takkaa kovasti.	'The fireplace was indeed praised a lot.'

Taakkaa kevennettiin kahdesti. load-partit. lightened twice	'The load was made lighter twice.'
TAAKkaa tuolla kevennettiin. over-there	'It was the load over there that was lightened.'
KEvennettiin taakkaa kahdesti.	'The load was indeed lightened twice.'