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17 *Nina Thorsen*

The tonal manifestation of Danish words containing assimilated or elided schwa

1. INTRODUCTION [1]

In my first analysis of Standard Danish intonation (Thorsen 1978) I observed that words with a syllabic consonant in the first post-tonic (arisen through assimilation of schwa) deviated tonally from words with a vowel in the same position. The normal stress group pattern has a (relatively) low stressed syllable followed by a rapid rise or jump up to the first post-tonic, which constitutes the peak of the pattern; post-tonics after the first one describe a more or less steep fall. In words with assimilated schwa in the post-tonic the fundamental frequency (Fo) maximum did not occur until the second post-tonic syllable, though the first one clearly rose above the low stressed syllable. I speculated that this might be an expression of a (partial) tonal assimilation accompanying the assimilation of schwa. However, from Rischel (1970) it would seem that tonal assimilation of schwa-syllables is at least not an obligatory corollary of segmental schwa-assimilation. Rischel made a study of how syllable number is distinguished acoustically in words of the type *hårde* - *hårdere* [ˈhɒ·ʌ ˈhɒ·ʌʌ] and *faldne* - *faldende* [ˈfalnə ˈfal̩nə] (hard (pl.) - harder; fallen (pl.) - falling). His informants did not behave uniformly, but for some of them he reports that, apart from some not quite stable durational differences in the consonants, the peak in the rising-falling tonal pattern occurred much earlier, relatively to the end of the word, in tri- than in disyllabic words. It is tempting to reformulate this finding and say that, in the material in question, the peak of the tonal pattern occurred in the first post-tonic syllable: hence it would occur very near the end of the word in words with only one post-tonic, whereas there must be a subsequent fall in words with several post-tonics. This amounts to saying that segmental assimilation of schwa in the first post-tonic syllable was not accompanied by tonal assimilation, at least not to the extent that the Fo peak was delayed until the end of the word, i.e. till the second post-tonic. (The subjects in Rischel's study spoke a rather conservative norm, and the recordings represented a high level of distinctness; Rischel, personal communication.)

2. DELIMITATION OF THE SUBJECT

Brink and Lund (1975), henceforth BL, contains a thorough treatment of schwa assimilation, its phonetic and commutative consequences, in particular the durational aspects, which have been subjected to empirical, instrumental investigations, though on a rather modest scale (§ 32). BL are less explicit and also somewhat contradictory about tonal relations. On p. 194-195 they state that the sound which replaces schwa is clearly syllabic, not through lengthening of the neighbouring sound but <u>due to intonation</u> [emphasis supplied, NT]; the difference between *faldne* [ˈfalnə] and *faldende* [ˈfall̩nə][2] (fallen (pl.); falling) is tonal, the former having two pitches, the latter three pitches (cf. Rischel's (1970) results above). However, on p. 197 we are told that "pure" schwa assimilation leads to extra length in e.g. *luen og* (the flame and), which will thus still contrast with *luner* (shelter (vb.)): [ˈlu·unʌ - ˈlu·nʌ], <u>although the second [u] in *luen og* by interval reduction loses its independent, syllable-constituting pitch</u> [emphasis supplied, NT].

(1) The generality of the "delayed" Fo peaks mentioned in the introduction should be established. In other words: will syllables with assimilated schwa behave differently tonally from syllables with unassimilated schwa? Or do schwa-syllables as such deviate? And how does a succession of two schwa syllables behave?

According to BL (p. 198ff) words like *vissen* and *pukkel* (withered; hump) are distinguished from *visne* and *pukle* ((to) wither; (to) slog away) through a lengthening of the preceding consonant in the /-VCCə/ structure, i.e. [ˈvesṇ ˈb̥ʰɔg̊ḷ] versus [ˈves·ṇ ˈb̥ʰɔg̊·ḷ]. This lengthening of a preceding consonant takes place in groups of two consonants after a short vowel when the first of them has less sonority[3] than the second, syllabic one. The same lengthening is found when /ə/ becomes [ʌ] in the environment of /r/ which is then vocalized, e.g. in *tømre*, *blafre* ((to) do carpentry; (to) flicker): [ˈd̥ˢœm·ʌ ˈb̥lɑf·ʌ].

I have previously argued (e.g. in Thorsen 1980 and 1982a) that syllables and segments do not carry specific Fo movements, but they float on a more or less invariable Fo wave. In other words, the syllables and segments are aligned with the Fo patterns, not vice versa, a state of affairs which leads naturally to a condition where the course of Fo in syllables consisting, say, of short vowels surrounded by unvoiced consonants can be viewed as a truncation of the more extensive movements we get with syllables consisting of long vowels and voiced consonants. There is ample evidence that this is indeed the case when the duration of words and syllables is not interfered with, e.g. through compensatory lengthening, but

(2) those instances where schwa assimilation is said to lengthen a preceding consonant, as well as lengthening due to /r/-vocalization, call for empirical investigation. In particular the tonal consequences, if any, of the durational variation should be established.

To further illustrate the relation between segmental structure and Fo in the stress group I included in the material two sets of words whose behaviour is specifically mentioned by BL (p. 195-197) and which are otherwise quite uncontroversial:

(3) Assimilation of schwa to a preceding voiced consonant after a short vowel, like *skille* ((to) separate) leads to a particularly long syllabic consonant, and clearly longer than after long vowel as in e.g. *skele* ((to) squint). Furthermore,

the first part of this extra long syllabic consonant has been formed before the second pitch is initiated. [I would rephrase this: the Fo peak is later relative to the start of the consonant in syllabic consonants after short than after long vowels.]

(4) Elision of word final schwa after an unvoiced consonant does not result in any compensatory lengthening of the unvoiced consonant, and accordingly *passe, pas; stikke, stik* ['b̥ʰas 'sd̥eg̊] ((to) fit, passport; (to) prick, prick (imp.)) no longer contrast due to this syncope of schwa, as it must be termed. [However, we might get a compensatory lengthening of the preceding vowel and/or a compensatory tonal movement (even if partial), in other words a compression of the low + high Fo movement characteristic of a sequence of stressed plus unstressed syllable into the stressed vowel of such words.]

3. PROCEDURES

A total of 8 tri-, 59 di- and 2 monosyllabic words of varying segmental structure, cf. above, succeeded by an unstressed function word, were embedded in terminal declarative utterances. The material was recorded six times by four subjects. The tapes were processed with hardware equipment and measured by hand. Average Fo tracings of each word by each subject were drawn. From the average measurements and tracings the results are derived. For reasons of space, only a sample of Fo tracings by one of the four subjects is shown here in figure 1. For further documentation, see Thorsen 1982b.

4. RESULTS

It appears clearly from the recordings that schwa does not assimilate to its surroundings with equal ease in all phonological contexts. After a single post-vocalic sonorant (like *males, kande* ((to) be painted, jug), etc.) schwa is assimilated almost without exception, and likewise between an obstruent and a

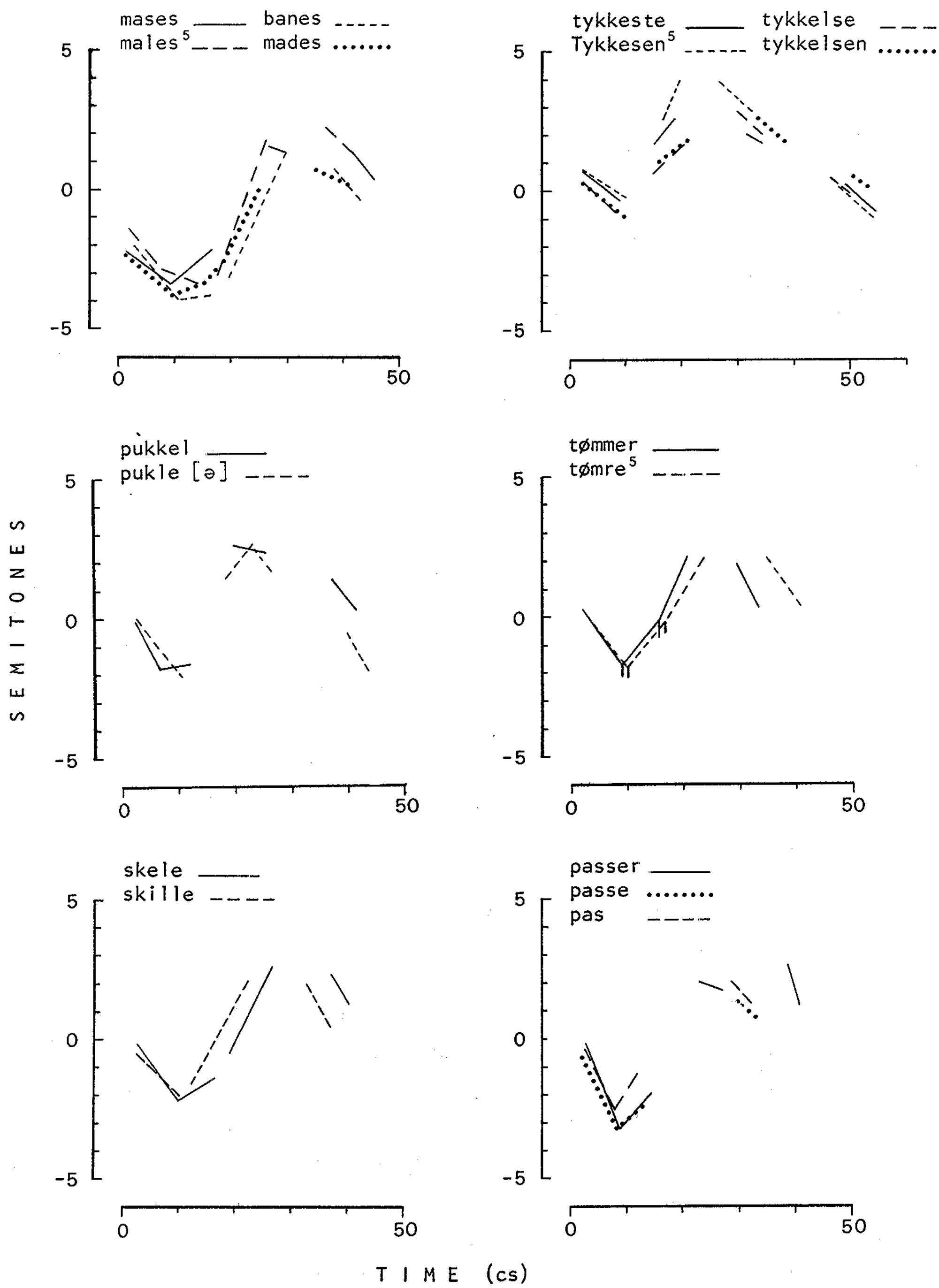

Figure 1

Fundamental frequency tracings (averages) of a sample of the test words plus succeeding unstressed function word by one of the four subjects (male). A raised numeral after the signatures in each frame indicates the number of items behind the average tracing, if it deviates from six. [ə] indicates that the vowel was pronounced in the word in question. Zero on the logarithmic frequency scale corresponds to 100 Hz.

sonorant (as in *tykkelse*, *pukkel* (thickness, hump), etc.). Schwa assimilation in the /ˈ-VCCə/ type does not occur as frequently; moreover, the likelihood of such assimilation is far greater when the post-vocalic consonant is a sonorant (like *gamle* (old - pl.)) than when it is an obstruent (like *pukle* ((to) slog away)). The latter condition also holds for [ʁ]-vocalization. Complete schwa-elision after a post-vocalic unvoiced consonant is comparatively rare in the style of speech that this material represents, except maybe after a short vowel plus fricative (like *passe* ((to) fit)).

4.1 Peak location and syllabic consonant versus [ə] versus other vowels

From inspection of the average Fo tracings it appears that the Fo peak may be located in the first post-tonic syllable (as, e.g., in *pukkel* in figure 1); it may lie in the second post-tonic syllable (as e.g. in *mades med* ((to) be fed with)), or it seems to be located between the two (as in *Tykkesen* (invented proper name)). Peak locations later than the second post-tonic do not occur (see further Thorsen 1982b, p. 64). Words with two successive schwa-syllables do not distinguish themselves from words with one /ə/, and they again do not behave differently from words with other vowels ([i ʌ e]) in the first post-tonic, as far as location of the Fo peak is concerned, and all these words may be considered together vis-à-vis words with a syllabic consonant, cf. table I. First of all, there are considerable individual differences: two subjects have the Fo peak in the first post-tonic syllable in the vast majority of words, two other subjects divide their words roughly equally between the three categories. - However, individual differences apart, it turns out that there is indeed <u>a tendency for more occurrences of later Fo peaks when the second syllable is carried by a consonant</u>. χ^2 tests on the distribution of words in the left and right blocks of table I reveal significant differences with one subject and with subjects' total.

Table I

Distribution of words according to the location of the Fo maximum: in the first post-tonic (A), between the first and second post-tonic (B), or in the second post-tonic syllable (C). All words in the material are included: words with a vowel in the first post-tonic syllable (left), and words with a syllabic consonant (right). The distribution of words in the three categories is compared across the two blocks in a χ^2 test. p is given if 0.05 or better.

	[V]				[C̩]		
	A	B	C		A	B	C
NRP	32	4	1	p<0.01	18	9	5
JR	37	1	0		28	4	0
BH	10	15	11		4	13	15
NT	13	11	8		14	5	8
total	92	31	20	p<0.025	64	41	28

4.2 Peak location and further segmental differences

The 69 words may be subgrouped according to their segmental phonetic structure and tested for differences in Fo peak location. It turns out that (1) there is no significant difference between peak locations in words with a syllabic consonant after a short versus a long vowel (as in *skille* - *skele*). (2) There is a tendency for later Fo peaks when a syllabic consonant directly follows the stressed vowel (as in *skille*) than when a consonant intervenes (as in *pukkel*), but (3) there is no apparent difference between words like *pukkel* and *pukle*, i.e. the lengthening of the consonant preceding the syllabic one in the /'-VCCə/ structure has no obvious tonal consequences in terms of Fo peak location. The majority of these words have the Fo peak located in the first post-tonic. See Thorsen (1982b) for further documentation of these statements. All these facts are connected with durational relations, cf. below.

4.3 Peak location and duration

4.3.1 Constant Fo patterns

As noted above in section 2, I have suggested a description of the Fo pattern pertaining to the prosodic stress group in Standard

Danish in terms of an essentially invariant low + high-falling Fo wave upon which the segments and syllables are superposed. This makes intrasyllabic Fo movements predictable from the shape of the wave where they hit it (falling, rising, etc.). The Fo pattern is simply truncated when the stress group does not contain sufficient segmental material for a full low + high rise (+ fall) to develop. Thus, e.g., a stress group consisting of one stressed syllable with a short vowel surrounded by unvoiced consonants will not turn up with a time compressed low + high Fo movement, but will be simply falling. See further Thorsen (1982a).

With an account along these lines the variation in Fo peak location with respect to the first post-tonic syllable observed in the present material should be correlated with differences in duration: if the stressed plus first post-tonic syllable together are too short to make it to the peak of the wave, the first post-tonic will be located on the rising flank, and the peak will then be "delayed" and lie in the second post-tonic syllable only. Note, though, that strictly speaking it is not the Fo peak which is delayed but the first post-tonic which arrives too early.

To establish the relation between Fo peak location and duration the duration from the onset of the stressed vowel to the offset of voicing in the post-tonic was measured, and the hypothesis is, then, that this entity ("S+P") will be shorter in words whose Fo peaks are mainly located later than the first post-tonic, and vice versa. In table II all the words of the material are included, and the average duration (mean of means) of S+P in words with the peak located in the first post-tonic (A), between the first and second post-tonic (B), and in the second post-tonic syllable (C) is given. Even though each group includes words of somewhat different segmental structure and duration, the hypothesis advanced above is borne out: S+P is longest in words with the Fo peak in the first post-tonic and shortest in words with the peak in the second post-tonic; the majority of these differences are statistically significant. However, subjects differ among themselves with respect to the absolute values. Thus, e.g., with JR an S+P of about 17 cs is sufficient for a full (fall-) rise to occur, a duration which is almost certain to truncate the rise with NRP, BH and NT and to shift the peak to the second post-tonic.

Table II

Average duration of the stressed and first post-tonic syllable in words grouped according to the location of the Fo maximum (A) in the first post-tonic syllable, (B) between the first and second post-tonic syllable, and (C) in the second post-tonic syllable. Standard deviations on means, s, are given as well as the number of items, N, behind each mean. Tests of significance (student's one-tailed t-test) between means in different columns have been performed, and p is given if smaller than 0.05.

		A	B	C		
NRP	$\bar{X}$ =	25.0 cs	23.7 cs	17.2 cs	A>B:	not sign.
	s =	3.12 -	3.11 -	3.40 -	B>C:	$p<0.0005$
	N =	50	12	10	A>C:	$p<0.0005$
JR	$\bar{X}$ =	20.2 cs	14.1 cs		A>B:	$p<0.0005$
	s =	3.76 -	2.81 -			
	N =	66	8			
BH	$\bar{X}$ =	24.9 cs	21.3 cs	20.3 cs	A>B:	$p<0.0005$
	s =	2.23 -	3.59 -	4.23 -	B>C:	not sign.
	N =	16	25	29	A>C:	$p<0.0005$
NT	$\bar{X}$ =	27.1 cs	24.8 cs	21.0 cs	A>B:	$p<0.05$
	s =	4.99 -	3.42 -	4.33 -	B>C:	$p<0.005$
	N =	26	25	20	A>C:	$p<0.0005$

4.3.2 Segmental structure

The 69 words may be subgrouped according to their segmental structure and tested for differences in the duration of S+P. (1) In section 4.2 above I noted that there are no significantly later peak locations in words with syllabic consonant after a short vowel than after a long vowel. However, there is a trend towards longer S+P in long vowel words (like *skele*) than in short vowel words (like *skille*). This apparent discrepancy between peak location and S+P duration is due to the fact that even the shorter S+P's are long enough to contain the full Fo rise. (2) There was a tendency for later Fo peaks in words where the syllabic consonant directly succeeds the stressed vowel than where a consonant intervenes. This difference corresponds to a durational one: S+P tends to be longer in words where a consonant intervenes between stressed vowel and syllabic consonant. (3) There were no differences in peak location in words of the /'-VCCə/ versus /'-VCəC/ structure, which all had a majority of early peaks, and this is due to the fact that S+P in all these words is generally long enough to contain the full Fo rise from the trough to the peak of the wave.

Finally, the duration of S+P in pairs of words which are minimally different segmentally, but which did have a difference in peak location was compared. Out of a total of 15 word pairs, distributed over all four subjects, only three pairs do not have statistically significant differences in the S+P duration.

Documentation for the statements in this section can be found in Thorsen (1982b).

4.3.3 Correlating the height and duration of Fo rises

Due to the structure of the word material there are few instances where Fo is continuously rising-falling and where the location of a physically manifest Fo turning-point (maximum) can be accurately and unmistakably located in time and frequency. It is therefore not possible to see how constant are the time and frequency coefficients of Fo peaks relative to the preceding minimum in the stressed vowel. (According to the description of stress group patterns as more or less invariable Fo waves and to the results reported above, one would expect the peak of the pattern to be fairly constant in both dimensions relative to the preceding trough, everything else being equal, i.e. for a given vowel height and for a given position of the stress group on the intonation contour: early or late, high or low, cf. Thorsen 1980.) - Another aspect of the 'constant wave' description can be tested, however: the magnitude of the rise from the minimum in the stressed vowel should be positively correlated with its duration (because the pattern is truncated by unvoiced consonants rather than time compressed. In other words: the sooner a rise is cut off, the smaller it will be). Such a positive correlation does indeed exist, cf. table III. Considering that a straight line is probably not the best representation of these data points (since the rising movements are generally parabolic rather than rectilinear), and considering also the varying segmental make-up of the words (higher/lower stressed vowel, different succeeding consonants), these correlation coefficients (between 0.78 and 0.94) are comfortably high and highly significant ($p < 0.0005$).

Table III

Pearson Product Moment Correlations (r) between the height of the rise (in Hz) from the Fo minimum in the stressed vowel and the duration (in centiseconds) of this rise. The slope (Hz/cs) of the least squares regression line, the number of data pairs, N, in the calculations, and t and p are given.

		NRP	JR	BH	NT
r	=	0.94	0.78	0.90	0.81
Slope	=	1.98	1.43	2.46	2.21
N	=	53	58	56	52
t	=	19.5	9.37	15.4	9.72
p	<	0.0005	0.0005	0.0005	0.0005

4.4 Schwa assimilation and duration

4.4.1 Syllabic consonants after long and short vowels

Syllabic consonants after short vowels should be longer than after long vowels, cf. section 2 (3), and so they are, generally by about 3-4 cs. The difference in vowel duration is always larger than the difference in the consonants, and the duration of vowel plus consonant is longer in the long vowel words (like *skele*) than in the short vowel words (like *skille*). See further Thorsen (1982b).

According to BL's description (p. 197) that the first part of the extra long syllabic consonant after a short vowel has been articulated before the second pitch is initiated and according to my own account above of Fo patterns, words like *skele-skille* should have identical Fo courses, but the long vowel/consonant boundary should be shifted upwards on the rising Fo flank relative to the short vowel/consonant boundary. This description covers one subject perfectly well, but with three subjects the words with non-high vowels deviate: it seems that the Fo rise as a whole is shifted to the right in the long vowel words, see e.g. *skele/ skille* in figure 1, but more so with the [æ·] than with [e·], and not at all with [u·]. I cannot at present explain this phenomenon: If the difference in Fo pattern were simply one of short vowel versus long vowel it should at least generalize to all vowel qualities (if not necessarily to all speakers). The effect could be due to the long vowels being extra long through compensatory lengthening (which can neither be proved nor disproved the way the material is structured), and one could well imagine such a process to hold up or discontinue or stretch the normal course of Fo patterns, but then again it should at least generalize to all vowels (if not all subjects); furthermore such a compensatory lengthening should take place also when the long vowel is succeeded by an obstruent and schwa is elided (as in *skabe̸, gyse̸* (closets, (to) shudder)), which is not the case, cf. section 4.4.3 below. See Thorsen (1982b) for documentation.

These held-up or delayed Fo rises are worthy of a closer inspection because whatever the cause, they are an indication that Fo patterns may under some conditions be more actively controlled by the speaker than I have previously assumed. For instance, a variety of Copenhagen Danish ('Low Copenhagen' in BL's terminology, p. 605-608) has a lengthening of short vowels in stødless syllables. Will such syllables have delayed Fo rises, and will this be one of the means by which short and long vowels are distinguished acoustically and perceptually (in pairs like e.g. *skille-skele*)?

4.4.2 Lengthening of the preceding consonant

According to BL (p. 198ff), the post-vocalic consonant preceding the syllabic one in the /ˈ-VCCə/ type is lengthened when the syllabic consonant is the more sonorous of the two. Also, they claim the syllabic consonant to be longer when it derives from /Cə/ than from /əC/. When the post-vocalic consonant is an obstruent there is a clear tendency towards the obstruent being longer in the /ˈ-VCCə/ type, but the difference is fairly small (1-3 cs) and the rule is not without (random) exceptions. Moreover, these lengthenings are not confined to instances where schwa is assimilated, they occur also when schwa is pronounced. There is evidence in the present material to suggest that the criterion for lengthening of a preceding post-vocalic consonant is not the narrower one of their mutual sonority relation but a question of the post-vocalic consonant being, phonetically, an obstruent - which is lengthened - or a sonorant - which is not, and the lengthening takes place whether schwa is actually dropped or not. See further Thorsen (1982b). The syllabic consonant shows a clear tendency to be longer (by 2-4 cs) when it derives from /Cə/ than when it derives from /əC/, irrespective of the nature of the preceding consonant, but there are also (random) exceptions to this rule.

Lengthening due to [ʁ]-vocalization is fairly straightforward: when [ʁ] is vocalized the preceding consonant is longer in the /-Crə/ than in the /-Cər/ type. BL may be correct in stating (p. 367) that lengthening is obligatory when [ʁ] is vocalized but only optional when [ʁ] is pronounced, since the only instances of non-significant differences in the duration of the post-vocalic consonant occur when [ʁ] is in fact pronounced. See further Thorsen (1982b).

4.4.3 Schwa elision and duration

When schwa is dropped word finally after an unvoiced consonant (as in *skabė̸*, *gysė̸*, *stoppė̸*, *passė̸*) it leaves no trace in the durational pattern. There are hardly any significant differences in the duration of post-vocalic consonants in words with elided schwa versus non-elided schwa. Nor are there consistent and significant differences in the duration of the stressed vowel in words with elided schwa versus words with pronounced [ə] or [ʌ]. See further Thorsen 1982b for documentation.

If a (partial) compression of the Fo pattern into the stressed vowel takes place when schwa is elided, then the slope of the Fo rise from the minimum in the stressed vowel should be steeper than when schwa (or any other vowel) is pronounced. Such steeper rises are indeed found in some words with some subjects. However, it is not a general pattern. Secondly, there are also considerable (but random) differences in the slope of the Fo rise within the stressed vowel in otherwise comparable pronounced disyllables. Thirdly, some words with schwa elision have no rise at all. The variation observed in the movement of the stressed vowels should be ascribed to a slight variation in the exact timing of the vowel with respect to the trough of the Fo wave, cf. section 4.3.1.

Apparently, there are really no grounds for positing a general compensation of any sort (durational or tonal) when word-final schwa is elided after unvoiced consonants, as also foreseen by Brink and Lund (1975). The implication of that is that there is probably no context at all for compressed Fo patterns in Standard Danish.

5. CONCLUSION

From the present investigation it would seem that if and when words with a syllabic consonant in the first post-tonic syllable turn up with an incomplete Fo pattern in the sense that the Fo peak is not coincident with the first post-tonic but is shifted (relatively) in time towards the second post-tonic, this is not a particular characteristic of syllables with assimilated schwa as such, but it is a consequence of the durational reduction involved in some instances of schwa assimilation. Furthermore, the height of the rise of Fo from the minimum in the stressed vowel and the duration of the rise are fairly highly correlated. These findings support a view of the stress group pattern as a more or less time and frequency invariant entity upon which syllables are superposed in accordance with their time structure.

There are indications that under certain (probably rather narrowly defined) circumstances an Fo pattern may be held up in its course - or stretched in time - but the reverse phenomenon - time compressed patterns - does not seem to occur at all.

The durational structure of words with schwa assimilation conforms to Brink and Lund's (1975) predictions (except that none of the "rules" are without randomly occurring exceptions): Syllabic consonants after short vowels are longer than after long vowels; syllabic consonants deriving from /Cə/ are longer than those deriving from /əC/; in a group of two consonants between a stressed vowel and schwa (/ˈ-VC_1C_2ə/) C_1 is lengthened if it has less sonority than C_2 (alternatively: "if C_1 is an obstruent and C_2 a sonorant") - likewise, C_1 is lengthened if C_2 is /r/, whether [ʁ] is vocalized or not.

NOTES

1) This is a very condensed version of a paper published in Annual Report of the Institute of Phonetics, University of Copenhagen 16, 1982, p. 37-100, to which I shall refer extensively for documentation.

2) I have translated Brink and Lund's Dania transcriptions into IPA and also occasionally supplied a phonemic transcription. - Syllabicity is indicated here with a dot under the consonant, long vowels with one dot after the symbol.

3) According to Brink and Lund (p. 193) sonority decreases through the consonants as follows: [ĭ w ð]; [ɣ l ʁ]; [m n ŋ]; [v]; unvoiced consonants.

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