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REPRO. AFDELINGEN

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E R R A T A

ARIPUC 16, 1982

p. 67, line 13 from below: "microscopic", read: "microprosodic"

p. 172, Table III

(1) First column (LS basɒ): The star should be moved one line up, from 1.2 to 1.8.

(2) Column 3 (right) (TA basɒ): 2.3* should be: -2.3*

(3) The word list to the left: There should be a hyphen after danə.

p. 174, line 23 from the top after "compounds", insert: "and IE and BJ rarely after consonant clusters and [s]".

p. 174, line 31 from the top after "from BT", insert: "and LH".

p. 196, line 7 from the top: "underlyingly stressed", read: "underlyingly unstressed".

p. 212, middle: *"han sér mig og Péter"*, read: *"han sér míg og Péter"*

p. 248, middle after "(including children)", insert: "Trier (1981) reports that he has met about one hundred members and assumes that the total number in the northern provinces of Thailand is about 200 (plus whatever number of persons there may be in Laos ordelsewhere)."

ARIPUC 16, 1982 p. 1-17

ON THE VARIABILITY IN F_0 PATTERNING AND THE FUNCTION OF F_0 TIMING IN LANGUAGES WHERE PITCH CUES STRESS*

NINA THORSEN

The basic property of pitch as a cue to linguistic stress is fundamental frequency (Fo) *change*. That leaves room for a lot of variation: in the direction of the change, the amount of change, and its exact coordination with the stressed syllable. Examples (from the literature) from a number of languages and dialects attest that they do indeed exhibit quite striking differences in the stress/Fo relationship. The decisiveness, under certain circumstances, of the timing of Fo events is illustrated by the results of a pilot experiment with a disyllabic Danish word: the location of a two semitone rise from the first to the second syllable - before or after the intervocalic sonorant consonant - will shift listeners' location of the stress.

I. INTRODUCTION

My analyses of Danish - like other recent intonation studies, e.g. Bruce (1977), Bannert (1982a) and Botinis (1982) - rest on the assumption that fundamental frequency (Fo) contours are the result of a combination of contributions from the sentence, or utterance (the intonation contour), from the stress group (the stress group pattern), from the stød (a stød movement), and from the segments (microprosodic phenomena). More specifically, they are viewed as parametric and continuous components, superposed upon each other (see for instance Thorsen

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*) To appear in a special issue of Phonetica on *Pitch Analysis*.

1979, 1980a, and forthcoming a). I shall be concerned in this paper with Fo phenomena at the level of the prosodic stress group, which are impressing by the amount of variability they exhibit in terms of patterning and timing. I have been particularly intrigued by a curious tonal dissociation of the stressed vowel from its surrounding (voiced) consonants, and I shall present the results of a first, preliminary experiment which attests the perceptual relevance of this phenomenon.

II. STRESS AND PITCH

In many languages linguistic stress and Fo, or pitch, are interrelated, e.g. in Dutch ('t Hart and Cohen 1973), in English (Fry 1958, Lieberman 1960), in Swedish (Carlson et al. 1974, Bruce 1977), in German (Klein 1980, Bannert 1982a), in Greek (Botinis 1982) as well as in Danish (Thorsen 1978, 1979, 1980a). The nature of this relationship is language and dialect specific, and so is probably also the weight which pitch has among other prosodic cues to the perception of stressed vs. unstressed syllables. Thus, Berinstein (1979), on the basis of acoustic analyses and perceptual experiments on English, Spanish, K'ekchi and Cakchiquel, finds support for a hypothesis that *"Change in Fo, increased duration, and increased intensity, in that order, constitute the unmarked universal hierarchy for perception of stress in languages with no phonetic contrasts in tone or vowel length; in languages with such contrasts the perceptual cue correlated with that contrast (i.e. Fo with tone and duration with length) will be superseded by the other cues in the hierarchy."* (p. 2).

> Danish HAS a phonological contrast in vowel length, so according to Berinstein, the hierarchy for the perception of stress would be: Fo, intensity, duration. I do not wish to dispute the primacy of Fo but I rather doubt whether intensity really comes second; besides, vowel quality is a factor not to be dismissed in a language like Danish where the system of vowels in unstressed syllables is reduced, cf. Basbøll (1968) and Rischel (1968), and where, furthermore, very considerable schwa assimilation takes place. Accordingly, I would hypothesize a hierarchy for Danish as follows: Fo, vowel duration and quality, intensity; but of course this is still an area for further experimentation.

In languages with obligatory sentence accent (or 'tonic, nucleus, focal accent, primary accent', etc.) the association between pitch and prominence is particularly evident. However, obligatory sentence accent is not a universal phenomenon among the languages that have pitch-cued stress (Danish, for instance, does not have it, cf. Thorsen, forthcoming b) and where pitch-prominent sentence accents are obligatory, other stressed syllables may still be associated with an Fo obtrusion, cf. Bruce (1977). I am concerned in the following only with the relation between neutral, non-focal stress and fundamental frequency.

If the fundamental property of pitch as a cue to stress is Fo *change*, then that leaves a lot of room for variation: in the direction of the change, the amount of change, and the exact timing of it in relation to the stressed syllable. It is this variation across languages, dialects, and speakers which is the focus of attention in this paper. However, it seems as if the *unit* which governs this pitch change is rather uniform, at least across the Germanic languages, namely *a stressed syllable plus all succeeding (secondary and) unstressed ones.* I have termed this unit a *stress group* and so has Bruce (1982) in Swedish. Rischel (forthcoming) calls it a *foot*, as do Abercrombie (1964) and Halliday (1967) (among others) for English. Kohler (1977) talks about the *Takt*. In other words, in the languages quoted, the stress group is not *syntactically* but purely *prosodically* determined, inasmuch as the stressed syllable certainly is not always word-initial and not all words are stressed. The relevance of the (Danish) stress group for prosodic structuring in general, not just for Fo patterning, is supported by an investigation of segment duration (Fischer-Jørgensen, forthcoming). Rischel (forthcoming) also argues that at a certain (surface) level in Danish phonology the *foot* is a relevant unit.

A. CROSS-LANGUAGE AND DIALECT DIFFERENCES IN THE STRESS/F_0 RELATIONSHIP

Authors are not always very specific as to the generality of the stress/Fo relation they establish, but we may assume that their statements will at least apply to "unmarked", i.e. prosodically and pragmatically neutral, utterances. Bolinger's (e.g. 1958, 1970) analyses of American English illustrate clearly that the way prominence is rendered by Fo varies with speech material, speaker attitude, etc.

In a fair number of languages the prominence associated with stressed syllables - when signalled by Fo - is reported to come about by a higher and/or rising Fo level/movement in relation to the surrounding syllables: in British and Edinburgh Scottish English (Fry 1958, Brown et al. 1980), in Spanish (L. Fant, 1980), in Finland-Swedish (which does not have a word accent opposition, Tevajärvi 1982), in K'ekchi (Berinstein, 1979), in Greek (Botinis, 1982), in Czech (Janota, 1979), in Hindi (M. Ohala, 1977), to name languages which are not otherwise strongly related.

Higher Fo on stressed syllables is commonly ascribed to the fact that, ceteris paribus, increased subglottal pressure will increase the rate of vocal cord vibration (Lehiste, 1970, p. 125). However, higher stressed syllables are far from being a universal. In Standard Danish a stressed syllable is low in relation to the succeeding post-tonic syllable; post-tonic syllables after the first one describe a gradual fall.

Some varieties of American English have high stressed syllables (Lieberman, 1960, whose subjects were mainly from the East Coast), but others may have the inverse relation, i.e. lower stressed than unstressed syllables (Dyhr, 1980) - just like Brown et al. (1980) report Glasgow Scottish English to have the inverse pattern from Edinburgh, i.e. low stressed and higher unstressed syllables.

In Standard Swedish the stressed syllable may be low *or* high, depending on the word accent; it is low in Accent I and high in Accent II, surrounded by highs and lows, respectively, cf. Bruce (1977). The situation in Dutch is somewhat different, apparently: prominent syllables may be rising, falling, or rising-falling; falling-rising movements are not reported, i. e. a stressed syllable that is lower than both preceding and succeeding material does not occur ('t Hart and Cohen 1973, 't Hart and Collier 1975, Collier and 't Hart 1978). This description seems to be applicable to German also (cf. Isačenko and Schädlich 1970, Klein 1980). Thus Dutch and German come close to being archetypical in the pitch cuing of stress, which is signalled simply by pitch change, irrespective of its direction. However, the timing of this change is not immaterial (see further below).

In Swedish the difference between the two word accents is best described as one of different timing of an Fo maximum, which is always earlier in Accent I than in Accent II (though the relevant classificatory difference may be one of high or low stressed syllable): this relation is constant across Swedish dialects, but the absolute timing of Fo maxima in Accent I and Accent II varies. Thus, in e.g. Southern (Malmö) Swedish the stressed syllable is high in Accent I and low in Accent II (because the Fo maximum is situated in the stressed and post-tonic syllables, respectively) where exactly the opposite classificatory relation holds in Standard Swedish (cf. above, and see Bruce (1977) and Bruce and Gårding (1978)).

In Danish a description along the same lines may be possible, i.e. the differences between the way various dialects pattern their stress/Fo relation may be seen as differences of timing. In a pilot experiment (Thorsen and Nielsen, 1981) designed to investigate the stress/Fo relationship in two Jutlandic areas, rural Thy and Århus, we found that the stress group patterning in the two dialects may be characterized roughly as one of high + low, as opposed to Standard Danish, where it is low + high(-falling). However, if we regard the archetypical stress-determined Fo deflection as a wave (see figure 1) we can state the differences this way: in Standard Danish the stressed syllable falls in the very earliest part of this pattern, i.e. in the trough before the rise, with the first post-tonic syllable at the peak and succeeding post-tonics on the falling flank. In Thy and Århus, the stressed syllable hits the wave on the very last part of the rise - and they differ among themselves

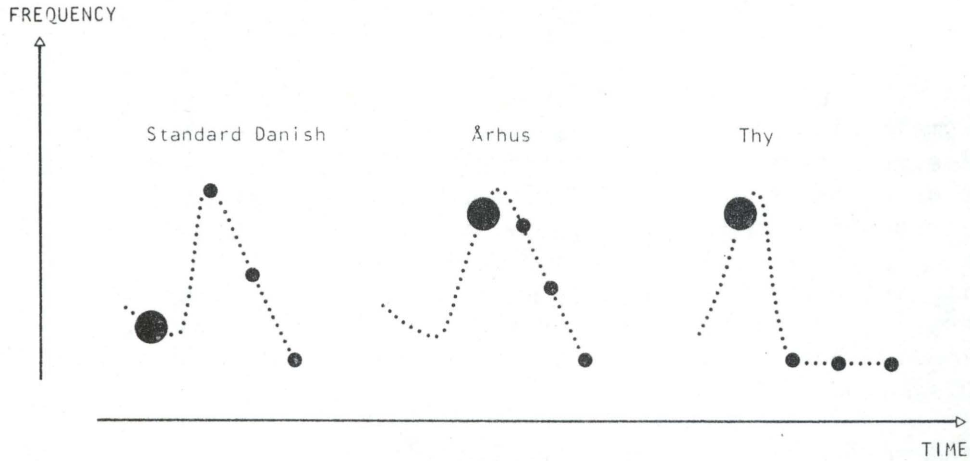

Figure 1

Stylized stress group patterns in three types of Danish: Standard Danish, Århus, and Thy. The big dots represent stressed syllables, small dots unstressed syllables.

in the slope of the falling flank, which is so steep in Thy as to bring the first post-tonic right down in the trough - and succeeding post-tonics stay low and rather level after that.

B. INTRASYLLABIC MOVEMENTS

With the above account of the relation between stress and fundamental frequency in Danish, a separate description of Fo contours within each vowel or syllable becomes superfluous, because these movements are specified by the shape of the wave where they hit it and then modified by segmental influences, cf. Thorsen (1979). (Incidentally, one would think that such segmental modifications, which are due to inherent properties of the peripheral human speech production apparatus, would be outside the control of the speaker and thus not subject to voluntary timing. But in tone languages it seems as though such perturbations are actively brought within time limits where they will not interfere with the perception of the tonal distinction in the language, cf. Hombert 1978). In Standard Danish short stressed vowels are generally falling; long vowels - which take up more space in the trough - are falling-rising (see figure 1). Both may be purely rising, however, if the wave is approached from below, as the first one in an utterance often will be, or when the preceding stress group's falling flank terminates below the level of the next stressed syllable. Of course, this may also be described as a twisting down of the start of the wave, rather than as a question of timing. The first post-tonic syllable seems to be subject to a (truly random) timing variation, since it may be purely rising, rising-falling, or purely falling. Whether e.g. the Århus and Thy dialects will turn up with similar variations in intrasyllabic movements, I cannot say at present.

C. RANGE DIFFERENCES IN THE STRESS GROUP PATTERN

Some Danish dialects are strikingly different from others in their small range of the low-high or high-low interval. Thus, the rise from stressed to post-tonic syllable in the first stress group on an unmarked (i.e. terminal declarative) sentence intonation contour is typically about 3 semitones with Standard Danish speakers (but see further below). The corresponding interval is definitely much smaller with Bornholm speakers. I do not have data from this dialect, but my impression is that the interval does not amount to more than one to two semitones.

In Standard Danish (and probably also in other dialects) there are furthermore individual differences in the range and shape of the Fo pattern (but not in its basic characteristic: low + high(-falling)). I have had six speakers for my investigations so far: one of them has a smaller rise from stressed to post-tonic than the others (it is about 2 semitones initially in declaratives), but he has a very steep fall through the succeeding post-tonics (if any), so the tonal range covered by a "full" stress group with this speaker may easily be 7 semitones. Another subject will hardly perform any fall through the post-tonics at all - they stay high and nearly level, so his corresponding total Fo pattern range is rarely above 3 to 4 semitones.

Finally, the stress group pattern is subject to a quantitative variation, ceteris paribus, according to its position on the intonation contour: early or late, high or low, see further e.g. Thorsen (1980a).

D. TRUNCATION OR COMPRESSION

Stress groups may naturally be of very different length, and at the outset three different possibilities present themselves for the patterning and timing of the Fo contour in shorter vs. longer stress groups: (1) The pattern is invariant and the segments ride upon it in certain ways (cf. above); the pattern is simply discontinued - truncated - when there is no more segmental material in the stress group. This resembles the situation in Swedish as Öhman (1965) sees it. (2) The Fo pattern is compressed in time to be contained within the segmental material at hand. This is the conclusion that Erikson (1973) reaches about Swedish. (3) The pattern may be partly truncated, partly compressed. Actually, Lyberg (1981) presents a fourth point of view: that the durational pattern is adapted to the demands of the Fo contour, i.e. the more elaborate the Fo movement, the longer the vowel, and this is how he proposes to explain final lengthening in Swedish. It seems to me, though, that Bannert (1982b) argues quite convincingly against this interpretation, and my Danish data also contradict such a hypothesis (see further below).

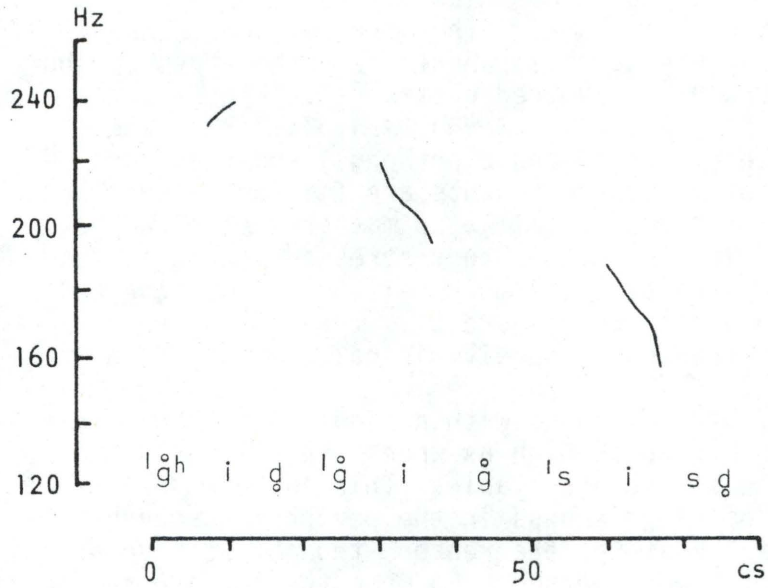

Figure 2

Fundamental frequency tracing of an utterance
Kít gík sídst. Female subject.

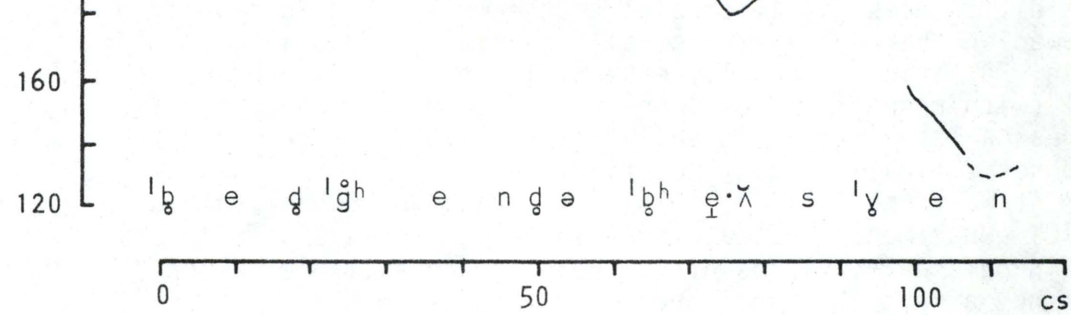

Figure 3

Fundamental frequency tracings of an utterance
Béth kéndte Pérs vén. The consonants are broken
lined. Female subject.

Thorsen (1980b) contains arguments and data in favour of a hypothesis of truncated rather than compressed Fo patterns in Standard Danish, and an illustration will suffice here. Figure 2 shows the course of Fo in an utterance *Kít gík sídst.* (Kit was the last one to leave. - The stressed vowels are indicated here with acute accents) where the three stressed short vowels are surrounded by unvoiced obstruents. Figure 3 depicts Fo in the utterance *Béth kéndte Pérs vén.* (Beth knew Per's friend.) Long vowels (and diphthongs) and the short vowels succeeded by voiced consonants are falling-rising (but the rise is smaller than the fall), no matter whether a post-tonic syllable follows or not. Short stressed vowels succeeded by unvoiced consonants are simply falling, also where no post-tonic syllable follows (figure 2). The first stressed vowel in these utterances is purely rising, cf. above.

In the same vein, stress groups with a single post-tonic syllable do not *always* rise as high as when more unstressed material follows the stressed syllable. This 'undershoot' may be due to a kind of sluggishness in the peripheral speech production mechanism. Whatever the reason, though, we have here an indication that time supersedes Fo when the two are in conflict, i.e. rather than stretch the duration of the post-tonic to make time for a complete Fo rise, the Fo movement is shrunk (Thorsen, 1980a). However, these incomplete rises are far from being the rule, so the sluggishness can clearly be counterbalanced. (I should also think that style of speech - distinct versus less distinct - plays a major role here.) Such 'active control' of Fo production becomes evident in utterances with emphasis for contrast which have considerably more elaborate Fo contours in and around the stressed syllable of the emphasized word but where there is hardly any lengthening at all, compared to prosodically neutral utterances (Thorsen, 1980a).

III. CRITICAL F_0 TIMING

As mentioned above, in the section on cross-language and dialect differences, it is crucial to the word accent distinction in Swedish that Fo rises and falls be timed appropriately. In Dutch, Fo timing is equally essential: an early rise or a late fall (with respect to vowel onset) are both prominence lending, whereas a late rise or an early fall are not, but serve other purposes ("finality" and "non-finality" for instance, see further 't Hart and Collier, 1975). Isačenko and Schädlich's (1970) experiments indicate that in German rises and falls may set in before as well as after the stressed syllable, which does not affect the prominence of the ictus, but timing differences may distinguish interrogative from non-terminal utterances (post-ictic versus pre-ictic rise), and neutral from contrastive stress (pre-ictic versus post-ictic fall).

Under certain circumstances in Danish, a difference in stress location will be manifested acoustically, inter alia, by a rather finely timed difference in Fo movement. When words like *bílligst - bilíst* ['b̥ilisd̥ - b̥i'lisd̥] (cheapest - motorist) are

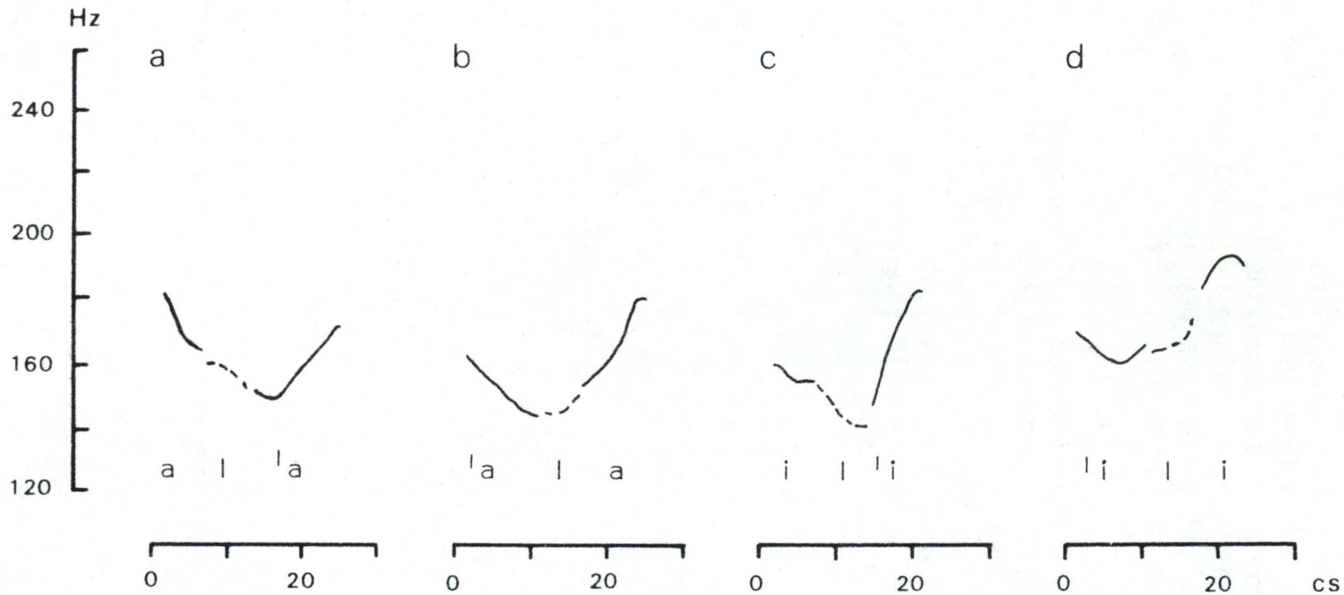

Figure 4

Fundamental frequency tracings of two pairs of words with stress on the second and first syllable, respectively: (a) *paláds*, (b) *bállast*, (c) *bilíst*, (d) *bílligst*. The consonants are broken lined. Female subject.

pronounced in isolation or preceded exclusively by unstressed words, both will have an Fo rise from the first to the second syllable, *bílligst* because this is the normal pattern on a stressed plus post-tonic syllable, and *bilíst* because the first stressed syllable in an utterance often is higher than preceding sentence initial unstressed ones. Eli Fischer-Jørgensen has kindly lent me her notes from analyses of larynx EMG and acoustic registrations of five subjects. The material comprised several minimal stress pairs, among them *bílligst* - *bilíst*, uttered in an unstressed frame. Eli Fischer-Jørgensen writes of this word-pair that when the stress is on the first syllable, the Fo rise begins before [l], and when the stress is on the last syllable, the rise begins after [l]. Figure 4 depicts Fo tracings of two pairs, *paláds* - *bállast* [b̥ʰaˈlas - ˈb̥alasd̥] (palace - ballast) and *bilíst* - *bílligst*, each word pronounced (by the author) in isolation. In *paláds* the pre-tonic is higher than the stressed syllable, but it can still be compared with *bállast* because both words have a falling-rising movement. When stress is on the second syllable, [l] continues the falling movement in the preceding pre-tonic vowel and when stress is on the first syllable, [l] initiates the rise on the succeeding post-tonic vowel. The turning points

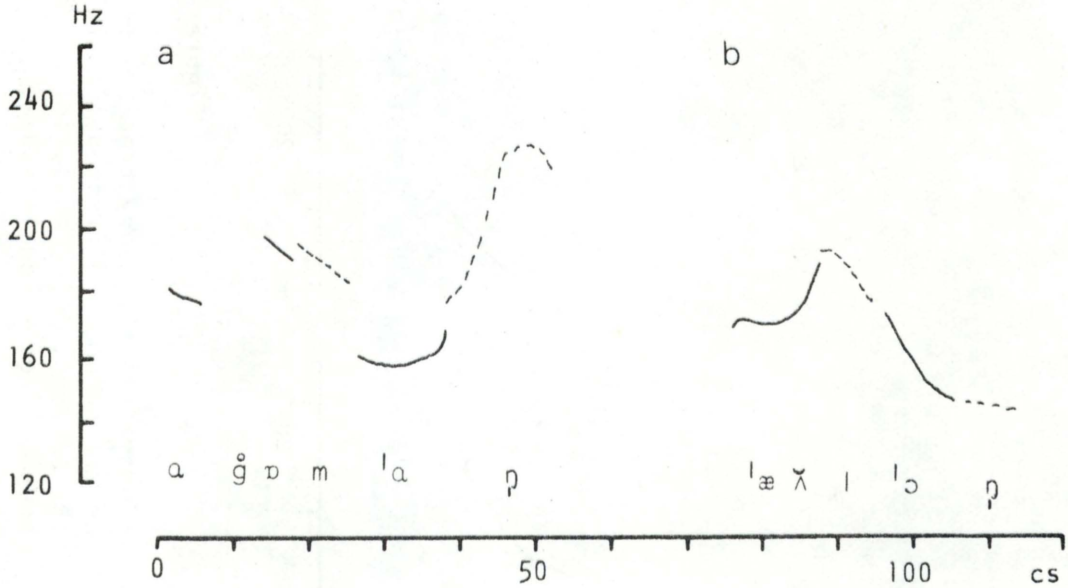

Figure 5

Fundamental frequency tracings of (a) the capitalized passage of an utterance *DER GÅR MÁNGE bússer fra Tiflis*. with contrast emphasis on *mánge*, and (b) the capitalized passage of an utterance *Dén øl ÉR LÚNken*. The consonants are broken lined. Female subject.

in the tracings are clearly just before and just after the stressed vowel, respectively. One could also say that [l] dissociates tonally from the stressed vowel or that it associates with the pre- and post-tonic vowels, respectively; or that the stress begins or ends with the stressed vowel, as hinted by the placement of the stress mark in the figure, even though the syllabification of *paláds* and *bilíst* in other respects is, unambiguously, *pa-láds* and *bi-líst*. Figure 5 gives two more examples of this curious tonal syllabification. In *Der går mánge (bússer fra Tíflis.)* (There are many buses out of Tiflis. - with contrast emphasis on *mánge*), the [m] seems to associate tonally with the preceding unstressed sequence. The second example is even stranger: In *(Dén øl) ér lún(ken).* (That beer is tepid.), the [l] from *lúnken* ties up tonally with the preceding stressed diphthong with the effect that the long vowel sound and the sonorant consonant together describe the rise-fall characteristic of a succession of a stressed plus post-tonic syllable. In other words: the dissociation between the consonant and the stressed vowel in a CV sequence is stronger than in a VC sequence to such an extent that, tonally, a consonant may skip backwards across a word-boundary! Strange as the phenomenon may seem, Eli Fischer-Jørgensen (forthcoming) finds that the way segment durations vary in some circumstances indicates some kind of boundary between a pre-vocalic consonant and the stressed vowel.

I have not seen any mention in the literature on other languages of a similar tonal phenomenon, but I strongly doubt that it should be specifically Danish. I hesitate to speculate about its implication - it is obviously a matter for further study.

A. A PILOT EXPERIMENT ON THE PERCEPTION OF F_0 TIMING IN DANISH

In order to see whether the difference in Fo timing depicted in figure 4 alone would be able to decide the location of stress, Svend-Erik Lystlund synthesized for me - on the hardware parallel synthesizer (Rischel and Lystlund, 1977) - a disyllabic [b̥ilisd̥] sequence which with a monotone Fo was as good a hybrid of *bílligst* and *bilíst* as possible. See the spectogram in figure 6. This synthesis was intended only as an informal trial, but the trend was so clear that I actually produced three stimuli: The first vowel was set at 89 Hz, the second one at 100 Hz, corresponding to an interval of 2 semitones. (With a larger interval I could only ever hear *bílligst*.) [l] was then to have the same pitch as either the first or the second vowel, corresponding to a rise after and before the consonant, respectively. Due to a possibly additive effect of (1) intrinsic Fo level differences between the high vowels and the consonant and (2) the lower intensity of the consonant, which might make an [l] of 89 Hz perceptually higher in pitch than the first vowel (see di Cristo and Chafkouloff 1977 and von Békésy 1960, p. 463), one stimulus (a̲) had an [l] 10 Hz lower than the first vowel (that value is arbitrary - I do not know how to quantify this compensation accurately), one stimulus (b̲) had an [l] of

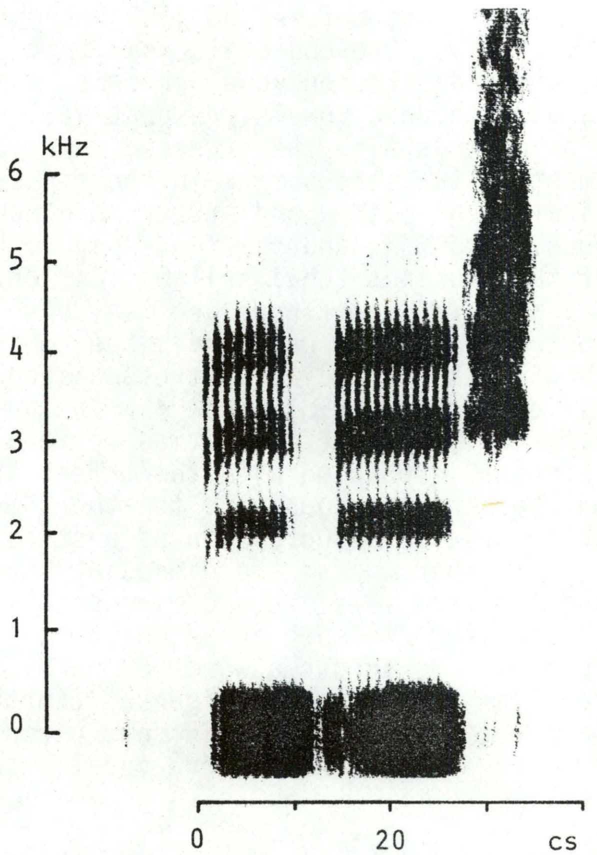

Figure 6

Spectrogram of a synthesized disyllabic sequence [b̥ilisd̥].

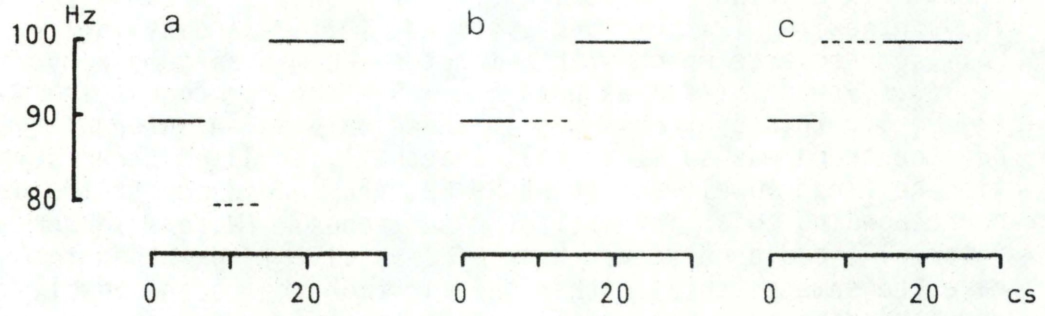

Figure 7

Stylized Fo contours in three synthesized disyllabic sequences [b̥ilisd̥], with a first vowel of 89 Hz, a second vowel of 100 Hz, and [l] of (a) 79 Hz, (b) 89 Hz, and (c) 100 Hz. The consonant is broken lined.

89 Hz, and the last one (c) had [ɪ] at 100 Hz. See stylized Fo tracings of the stimuli in figure 7. (If the rationale behind stimulus a is correct, then the pitch of the consonant in c will be higher than the succeeding vowel. This will not materially invalidate any conclusions to be drawn from the results, since the [ɪ] in this case will be even more dissociated from the preceding vowel.)

17 a-stimuli, 17 b-stimuli and 16 c-stimuli were recorded in randomized order, to yield a total of 50 stimuli to be responded to. Stimuli occurred only once, with a 2-3 second pause between them, and without any announcement of stimulus number. Subjects were asked to identify the words as *billigst* or *bilist* (forced choice). Eight colleagues and students at the institute took the test, three of them twice. They all listened over head-phones. This way, a- and b-stimuli were presented for identification 187 times each and the c-stimulus 176 times (11 runs of the test times 17 and 16, respectively).

Table I

Eight listeners' responses to three stimuli in an experiment on perceived stress location. - See further the text.

Response	Stimulus a	b	c
billigst	29 = 15.5%	59 = 31.6%	163 = 92.6%
bilist	158 = 84.5%	128 = 68.4%	13 = 7.4%
total	187	187	176

Considering the improvised character of the experiment, the results are remarkably clear, cf. table I: Stimulus a was identified as *bilist* and stimulus c as *billigst* in the majority of instances (84.5% and 92.6%, respectively). In other words, when the consonant is more closely associated with the first vowel tonally, the second vowel is perceived as stressed and vice versa. The b-stimulus received 68.4% *bilist* responses, and on the whole there is a slight majority of identifications as *bilist* (54.4%). The conclusion is unambiguous: differences in the timing of an Fo rise, before or after an intervocalic sonorant consonant, can effect a change in perceived stress location. Naturally, this will only very rarely (if ever, in free speech) be the only acoustic cue to stress location, mainly because in utterances with more than one stress group, the tonal relations to the surrounding syllables will decide the issue: with *billigst*, the stress cuing Fo rise occurs after *bil-*, whereas it occurs after *-list* with *bilist*. Furthermore, segment duration, vowel quality, degree of aspiration, etc. will help single out the stressed syllables of an utterance.

The experiment was extremely preliminary, but I think it would be very worthwhile to design a follow-up, with more parameters in variation (like vowel duration and the frequency interval between first and second vowel), as well as with higher first than second vowel.

ACKNOWLEDGEMENT

I am infinitely grateful to Svend-Erik Lystlund for his very competent assistance and cooperation: he synthesized the stimuli for the perception experiment and provided the curve material for the illustrations.

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TWO ISSUES IN THE PROSODY OF STANDARD DANISH: THE LACK OF SENTENCE ACCENT AND THE REPRESENTATION OF SENTENCE INTONATION*

NINA THORSEN

I. INTRODUCTION

As indicated by the title, this paper falls in two parts: I wish to discuss the lack of an obligatory sentence accent because, to judge from descriptions of more or less closely related languages, Standard Danish is somewhat exceptional in this respect, and I wish to discuss the tonal sequence representation suggested by Pierrehumbert (1980) and by Ladd in his contribution to this volume.

II. SENTENCE ACCENT

Sentence accent, primary accent, sentence stress, nuclear stress, tonic, focal accent, Satzakzent, etc. are more or less synonymous terms which designate the one stressed syllable in a stretch of speech which is more prominent than other stressed syllables.

The works which, implicitly or explicitly, assume the existence of a nuclear stress in British and American English are too numerous to permit an exhaustive listing. Crystal (1969) reviews past work on prosodic features and says himself (p. 207): *"There is general agreement about the internal structure of the tone-unit in English. Minimally, a tone-unit must consist of a syllable, and this syllable must carry a glide of a particular kind. This is the obligatory element, and is usually referred to (in the British tradition) as the nucleus of the tone-unit. (...) The presence of a nucleus is what accounts for our intuition of 'completeness' at the end of the unit: if it is omitted, the auditory effect is one of 'being cut short'."* Liberman and Prince (1977) - in a theoretical framework which differs from most previous descriptions of English stress - also assume a main stress which is the most prominent terminal

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element of a given constituent and is termed a *designated terminal element* (p. 259).

Halliday (1967) rather categorically associates the tonic with 'contrastive' or 'new' in the information structure. Experiments reported in Currie (1980, 1981) and Brown et al. (1980) demonstrate that this claim is far too strong: listeners are not unanimous in their tonic assignment (neither in read nor in spontaneous speech) and (consequently) a perceived tonic does not necessarily fall on the 'new' information in the utterance. Brown et al. (1980, p. 157) suggest that *"in sentences read aloud there will generally be some extension of pitch movement on the last stressed syllable. This cannot be taken as marking new information, since all items in the sentence must be new. What it does mark, we suggest, is 'sentence final'"*, which ties in well with the quotation from Crystal (1969) above.

Bolinger's (1958, 1972) account of (American) English pitch accents does not include the concept of a sentence accent, and at first glance his analysis resembles that of Dutch (cf. below). However, Bolinger (1972) is perhaps rather more categorical in the association between information structure and pitch accents than 't Hart and Collier (1979) and Terken (1980). Furthermore, Bolinger (1958) clearly implies the possibility of more and less prominent pitch accents: *"the stress ... that is the most prominent one in the utterances tested."* (p. 113), *".. the major stress .."* (p. 116). At this point, though, I wish to point to a certain difficulty in comparing descriptions across languages and authors because the pragmatic constraints (if any) of the materials analyzed are not always explicited and in any case are rarely identical across investigations.

The existence of a Satzakzent in German, falling on the most important word in the utterance, seems to be uncontested, cf. von Essen (1956), Stock (1980, p. 79-80), and Klein (1980).

Sentence accent is also an undisputed reality in Standard Swedish, cf. Bruce (1977) and Gårding (1980). Bruce (1977) is not categorical in the association of sentence accent with 'new' information, but states (p. 21): *"It seems to me that the Functional Sentence Perspective - the theme/rheme distinction - can account for a great deal of what has conventionally been attributed to emphasis and contrast."* According to Carlson et al. (1974), prosodically neutral utterances, i.e. utterances with a *non-contrastive (focus-free) stress pattern* are possible (p. 212). (Note that they seemingly equate contrast and focus.)

The relation between sentence accent and information structure may not be straightforward and there may also be a marked difference between planned and spontaneous speech with respect to the number and placement of sentence accents. I do not think that it stretches the descriptions of Standard Swedish, English and German too far, however, to conclude that in pragmatically neutral speech the last accented syllable in the phrase (or whichever the relevant chunk of speech may be) will normally be more prominent than preceding stressed syllables, a prominence which is realized by a greater duration of and a more elaborate fundamental frequency (Fo) movement within or in the immediate environment of that syllable. Under different circumstances, the context may evoke an earlier location of this prominence, for instance under conditions of contrast.

In Standard Danish, in pragmatically and emotionally neutral speech (as for instance in the reading of context free utterances), NONE of the stressed syllables is more prominent than the others. Such prominence is not evident in acoustic registrations (in duration and/or Fo contour) nor is it present auditorily. There is nothing incomplete about such prosodically neutral utterances and although they may not be very frequent in spontaneous speech, they certainly do occur, they are not unnatural, and they are very easy to elicit from speakers in a reading situation. I should add that this is a completely uncontroversial fact among Danish scholars. It appears, then, that three degrees will suffice to account adequately for the distribution of stresses in Standard Danish: main stress (assigned to the lexically stressed syllables in most non-function words), secondary stress (assigned to the second - and following - lexically stressed syllables in compounds), and weak stress, see further Basbøll (1978), Heger (1981, p. 118-119, 122), and Rischel (1972, 1975, 1980, forthcoming). In similar utterances in Standard Swedish, English, and German a fourth degree is required: the sentence accent.

In Thorsen (1980a) I report the results of acoustic analyses of emphasis for contrast in Standard Danish, which may be summarized briefly as follows: When emphasis for contrast is introduced in a sentence, the stressed syllable of the emphasized word will stand out clearly from the surroundings; this is brought about by a raising of Fo (except in initial position), an elaborate Fo rise within that syllable and a deletion of the Fo deflections (the rises from the stressed syllables) in neighbouring stress groups, to the effect that the immediate surroundings, except the first post-tonic, fall away sharply from the stressed syllable of the emphasized word, see figure 1. (Statements and syntactically unmarked questions differ with respect to the extent of the influence of emphasis on the prosodic patterns: Fo patterns two stress groups away from the emphasized word retain - at least partly - their rises to the post-tonic in statements but not in questions. It may be that more of a change is invoked in the prosodic patterns on marked intonation contours - which accompany syntactically unmarked questions - than on unmarked contours, i.e. terminal declarative sentences.) For the sake of clarity I will disregard the limited influence of emphasis in terminal declarative sentences and conclude: Short utterances with emphasis for contrast reduce <u>tonally</u> to one prosodic stress group in the sense that only <u>one</u> LOW + HIGH-FALLING pattern occurs in them. The difference between statements and questions with contrast emphasis

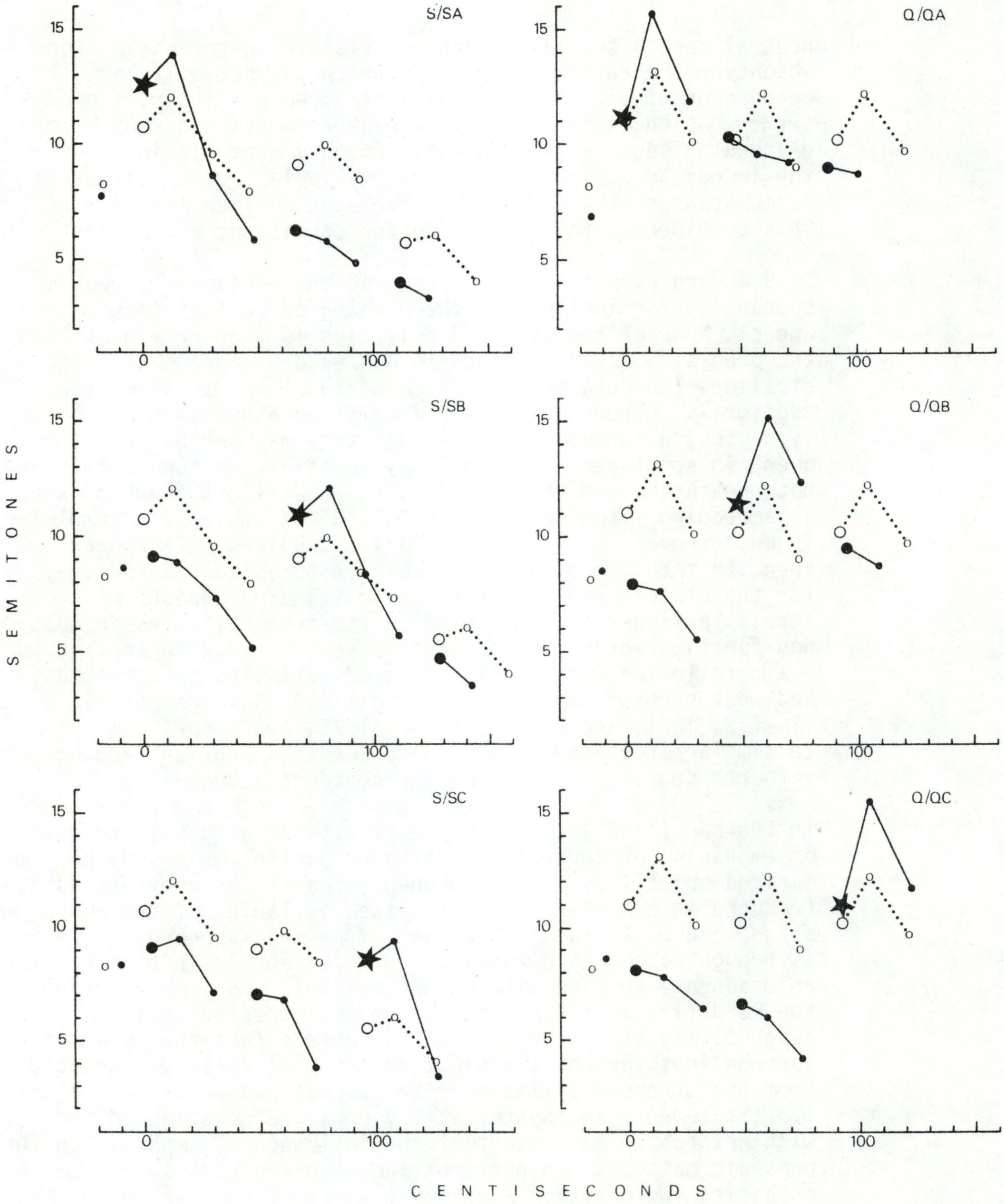


Figure 1

Stylized tracings of the course of fundamental frequency (mean of means over six readings by each of two subjects and ten readings by one subject) in statements (S - left) and questions (Q - right): prosodically neutral (empty circles - dotted lines) and with emphasis for contrast (stars and full circles - full lines) initially (A - top), medially (B - mid), and finally (C - bottom) in the utterance. Stars denote the emphasized syllable, large circles the stressed syllables, and small circles unstressed syllables. Zero on the logarithmic frequency scale corresponds to 100 Hz. See further Thorsen (1980a).

is mainly located in the movement within the emphatic syllable which rises higher in questions, and in the post-emphatic syllables which run higher in questions than in statements.

Clearly, then, Danish contrast emphasis shares some features with the acoustic manifestation of other languages' sentence accent. It is difficult to carry this comparison much further on a general basis, because there are differences between English, German and Standard Swedish: Satzakzent in German is not signalled by any special Fo movement within the stressed syllable (except if it is the last one in the utterance), but rather by what happens after it (cf. von Essen 1956, Isačenko and Schädlich 1970); word accent differences are not deleted in non-focal position in Swedish (Bruce, 1977). Furthermore, as I hinted above, some instances of sentence accent presumably fall in the category 'contrast', but the semantic/pragmatic distinction (to the extent that it can be made) and the phonetic differences (if any) between contrast and other types of prominence are rarely made explicit, with one notable exception: From Jones (1960, §§ 1049-1059) we learn that when contrast emphasis is superposed upon a sentence accent in utterance-final position, its Fo movement is even more elaborate. With contrast emphasis on some earlier word this Fo movement is moved back to that word's stressed syllable and succeeding syllables *"have the intonation of unstressed syllables"* (§ 1050). Now, his readers can conclude either that the sentence accent is deleted due to the contrast emphasis earlier in the utterance, or that it is moved back to coincide with the contrast emphasis. The decision is an arbitrary one, because whichever we choose, the fact remains that, according to Jones' description, we can distinguish phonetically between a neutral sentence accent and contrast emphasis in utterance-final position but not elsewhere.

The fact that non-final contrastive and non-contrastive sentence accents may not be distinguished phonetically and the fact that the manifestation of emphasis for contrast in Standard Danish has certain features in common with such non-final sentence accents does not of course affect my argument that Standard Danish lacks an obligatory sentence accent, because the test case remains: in pragmatically neutral utterances no special prominence is attached to the last (or any other) stressed syllable.

According to Bruce (personal communication) Southern Swedish also lacks an obligatory sentence accent, so Standard Danish is not a completely isolated case among the Nordic languages. Furthermore, Dutch also seems to defy the sentence accent analysis, but in a different manner: One or more of the lexical stresses (but not necessarily all of them) will be manifested as pitch accents, and these pitch accents are apparently all equally prominent, cf. for instance 't Hart and Collier (1979). The pragmatic rules which govern the assignment of pitch accents in Dutch are the object of a study by Terken (1980).

I am of course not blind to the fact that in spontaneous speech in Danish we certainly get uneven stress distributions, i.e. varying degrees of prominence among the stressed syllables of an utterance, without necessarily evoking the impression of emphasis for contrast. There are several reasons why I do not think this kind of emphasis is a sentence accent phenomenon: (1) There may by any number of emphasized words within one prosodic phrase. (2) If I can trust my impression from just listening, such non-contrastive emphases do not lead to a deletion of the neighbouring Fo deflections, so (3) their prominence derives from increased duration and probably intensity rather than from a stress reduction in the surroundings. Furthermore, a distinction between sentence accent and other types of prominence (emphasis) is probably also required in spontaneous speech in sentence accent languages, cf. Brown et al. (1980).

I do not know what the general psycholinguistic significance of the missing sentence accent in Danish would be, but I am certain that it is - or should be - an important feature in language teaching, both ways: Danes who omit the sentence accent in, say, English - in styles of speech where it would have been appropriate, for instance reading a scientific paper to an audience - are reported by speakers of English to sound dull, dead-pan and uninterested in their own subject. On the other hand, a Swede speaking Danish is likely to be labelled "too emphatic", "affected", etc.

III. THE REPRESENTATION OF SENTENCE INTONATION

A. THE TONE SEQUENCE APPROACH

I have previously presented data and arguments to support a view of the composition of Standard Danish intonation in terms of a layered system of simultaneous, non-categorical components, see further Thorsen (1979, 1980a, 1980b, and forthcoming). I have also argued that although the stress group and sentence intonation components are highly interactive on the concrete articulatory and physical level (where the stress group pattern is subject to quantitative variation), there may be a level in the speech production and perception processes where the two can be viewed as invariant entities, see further Thorsen (1980a). Figure 2 illustrates three stages in the superposition process, and in Thorsen (1979) an example is given of the inverse process, i.e. the decomposition of the fundamental frequency course in an utterance into its constituent components. Figure 3 summarizes the results of analyses of stress group patterns and intonation contours in short utterances.

Pierrehumbert (1980) takes a radically different approach. (Her thesis abstract is quoted verbatim in the appendix.) She suggests that Standard Danish be re-analyzed in a fashion similar to her analysis of English - in terms of a sequence of pitch accents, consisting either of mono-tonal H or L accents or bi-tonal combinations of the two (connected with "+"

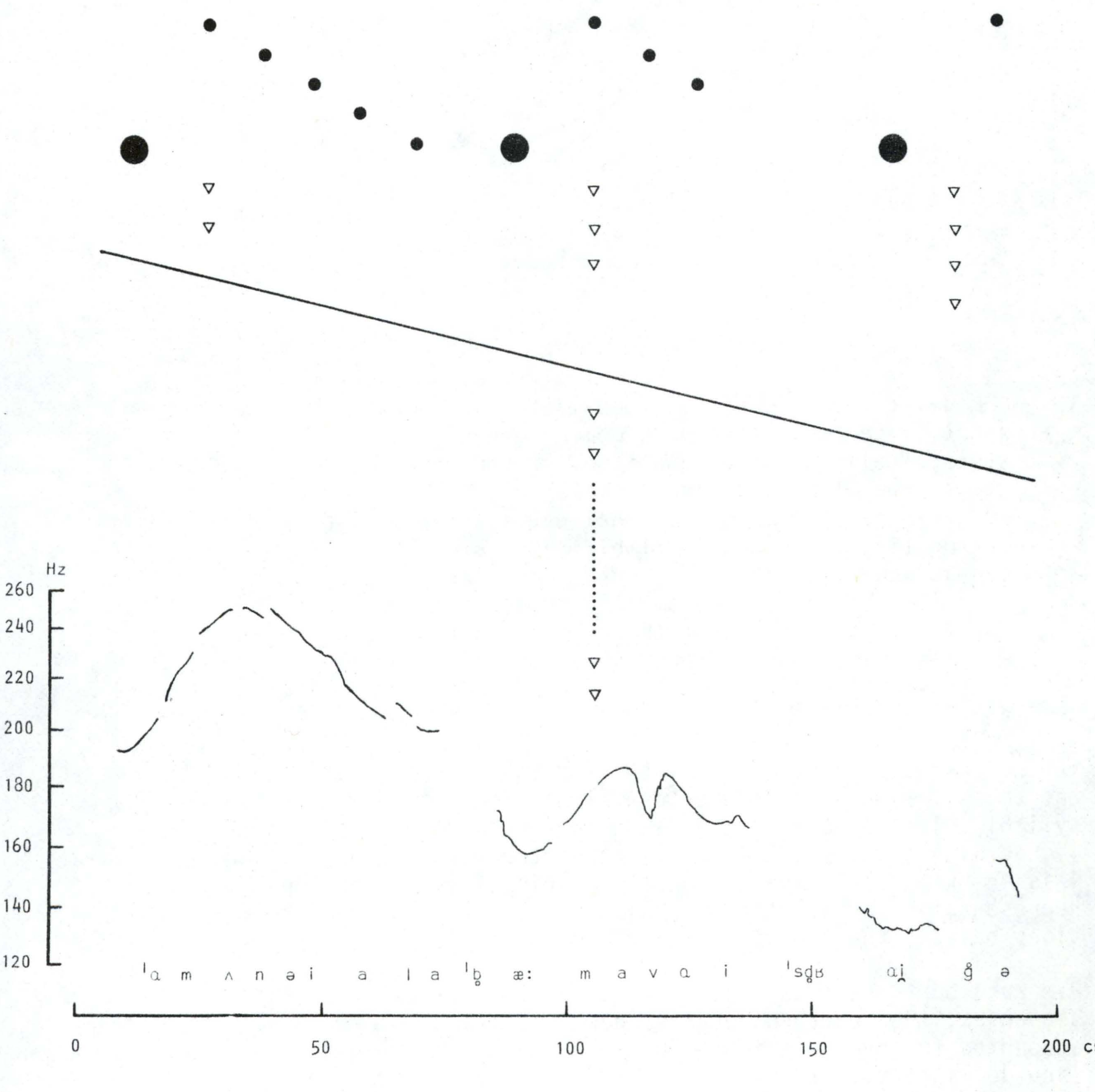


Figure 2

Illustration of the superposition principle in the production of fundamental frequency in an utterance *Ammerne i Alabama var i strejke.* (The nurses in Alabama were on strike.): Three stress group patterns of different length, superposed upon a declining sentence intonation contour, will - by way of adjustment rules and microprosodic rules - yield the Fo contour shown (spoken here by a female speaker).

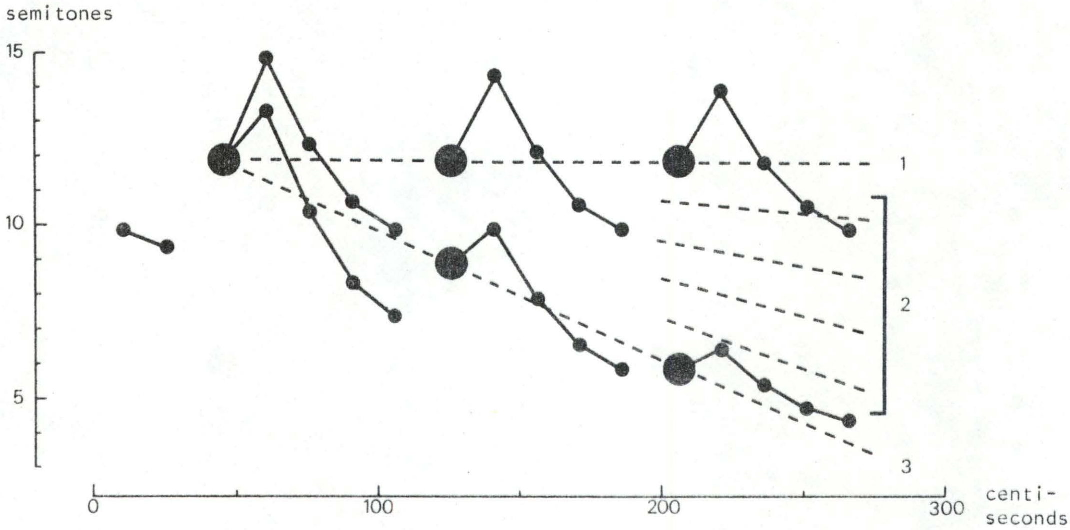
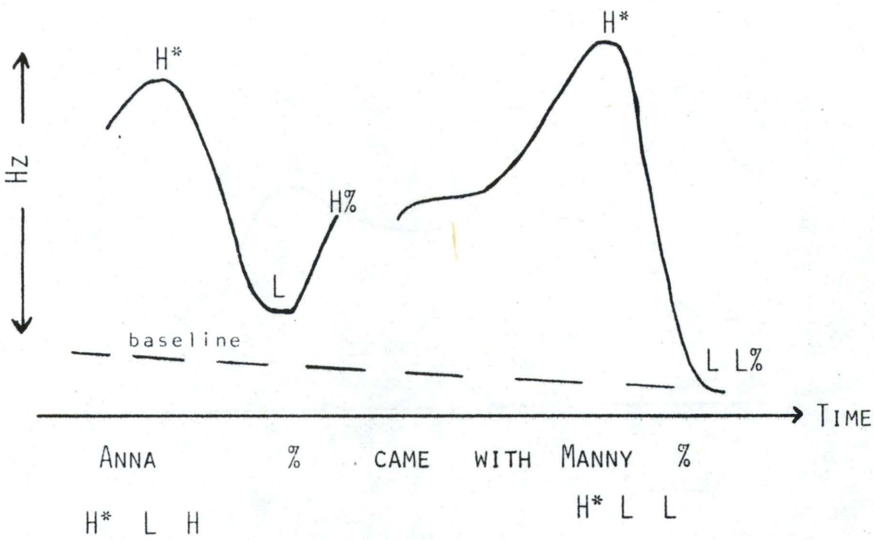


Figure 3

A model for the course of fundamental frequency in short sentences in Standard Copenhagen Danish. 1: syntactically unmarked questions, 2: interrogative utterances with word order inversion and/or interrogative particle; non-terminal declarative and interrogative sentences (variable), 3: terminal declarative utterances. The large dots represent stressed syllables, the small dots unstressed ones. The full lines represent the Fo pattern associated with stress groups and the broken lines denote the intonation contours.

in the transcriptions). In bi-tonal pitch accents, either of the tones may be the stronger one, lining up with the stressed syllable, leading or lagging behind a weaker tone. Tones aligned with stressed syllables are denoted with a star. Figure 4 is an example (from a personal communication) of the tonal representation of an utterance with different prominence relations between the two stressed syllables.

Pierrehumbert observes that in a number of terminal declarative sentences, the degree of overall downdrift is too large to be accounted for by the slight, physiologically determined, baseline declination. In order to keep within a framework of categorically different intonational units which are non-interacting and simply follow each other in time, and so maintain a description of intonation in terms of tonal sequences which together make up or, rather, which ARE the intonation of the utterance, Pierrehumbert introduces a RULE OF DOWNSTEP which will lower a H tone in the context H+L___ and H L+___, independently of the relative prominence (starring) of the tones (compare the top of figure 5 to the lower tracings). Overall downdrift is a result, then, of contextually determined downsteps which are completely locally governed. The actual scaling of a pitch accent requires no look-ahead and is totally



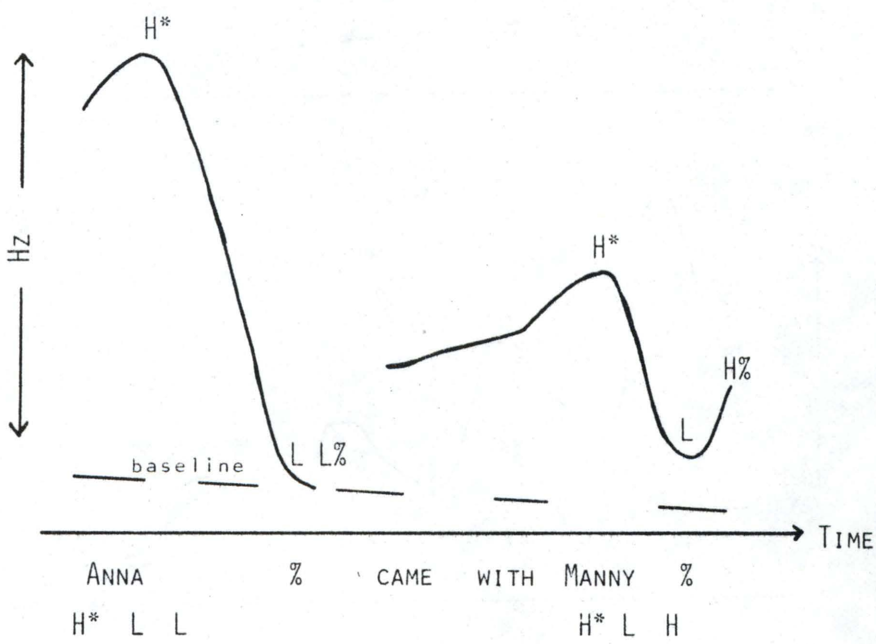


Figure 4

Fundamental frequency tracings and tonal representation of an utterance *Anna came with Manny* with different prominence relations between the two stressed syllables: *Anna* is 'backgrounded' in the upper tracing, *Manny* is 'backgrounded' in the lower one. From Pierrehumbert (personal communication).

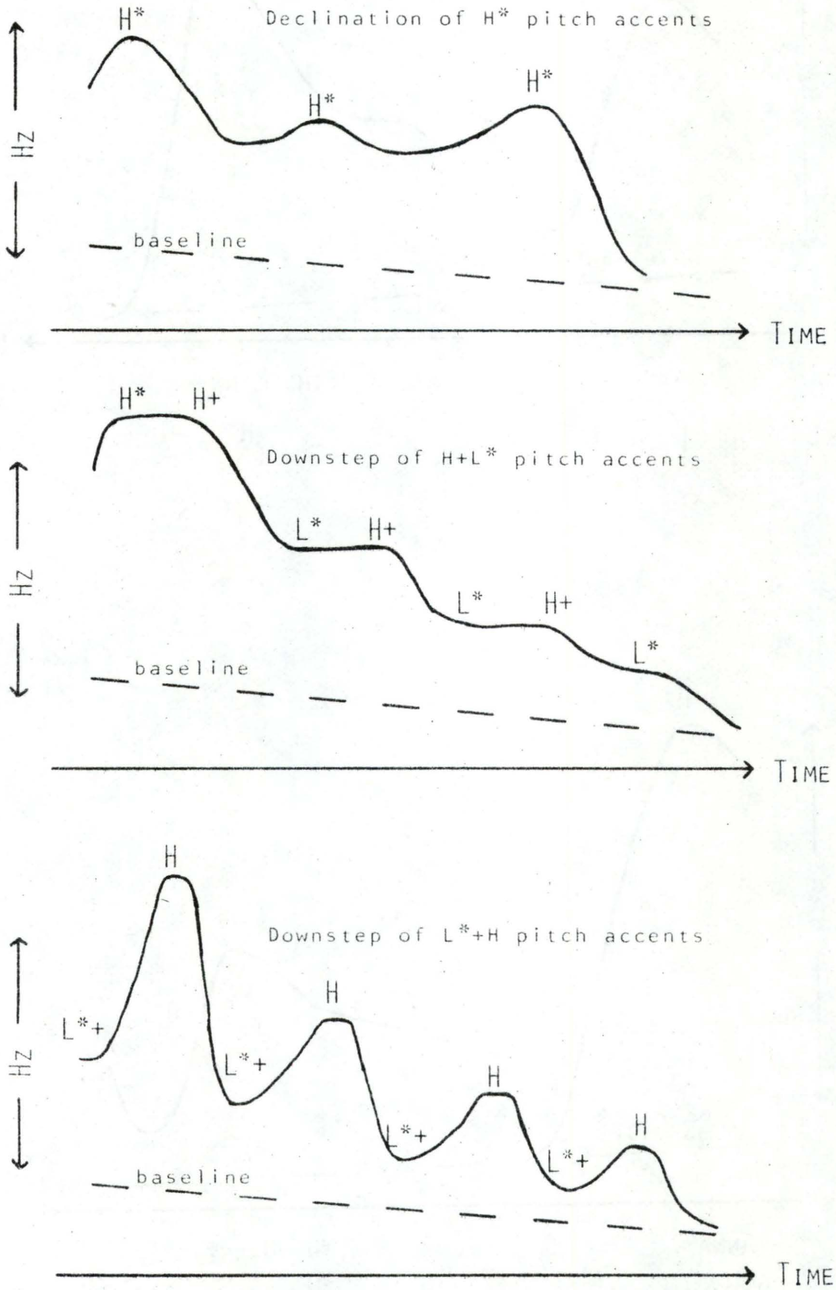


Figure 5

Three examples of fundamental frequency contours and their tonal representation: declination of H^* pitch accents (top), downstep of $H+L^*$ pitch accents (mid), and downstep of L^*+H pitch accents (bottom). From Pierrehumbert (personal communication).

specified by its tonal type, its prominence, the baseline value, and by the immediately preceding tone. Further, accents are downstepped through the utterance by a constant factor, smaller than unity, relative to the preceding H, which creates asymptotically declining contours.

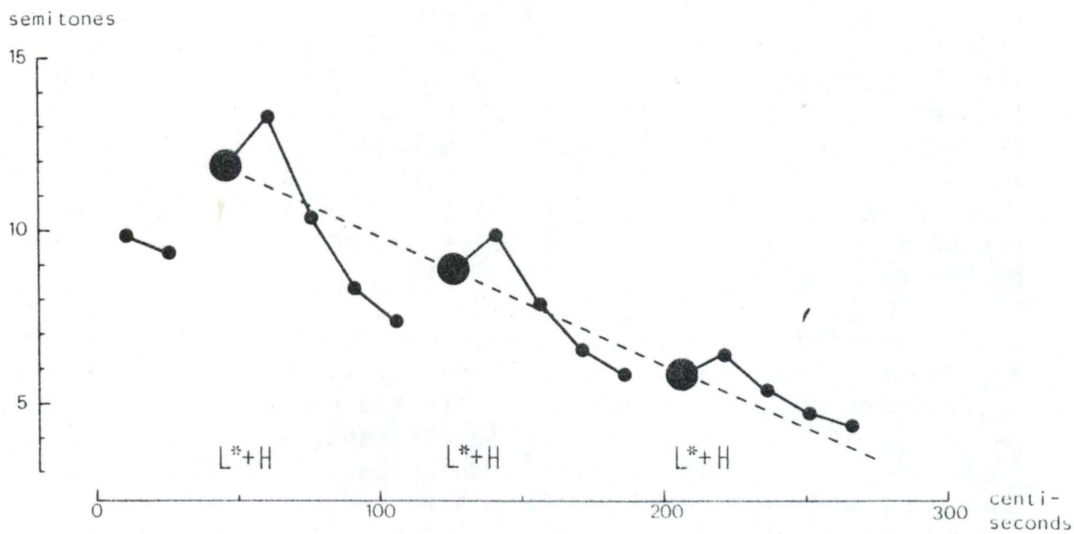


Figure 6

Model for the course of fundamental frequency in a short terminal declarative utterance in Standard Danish and its tonal representation, as suggested by Pierrehumbert (1980). See further the legend to figure 3.

Confronted with the Danish data, particularly the low-plus-high-falling stress group pattern, Pierrehumbert faces what looks like an obstacle on the surface. In her system, Standard Danish has a bi-tonal L*+H accent, cf. figure 6. If tritonal accents are to be avoided, there is no room for a L after the H in the Standard Danish pitch accent, i.e., there is no context for the downstep rule. Pierrehumbert circumvents this problem by positing a downstep rule which applies in declaratives in Danish and which downsteps L* in relation to the preceding H. She bases this on an observation from my model (figure 3 here) that the L*+H interval is constant, whereas the H L* interval varies with degree of overall downdrift; in other words, the L*+H interval is implemented in a constant way, whereas a L* dissimilates from the preceding H to varying degrees in different types of utterances. With a rule which downsteps L* in relation to the preceding H by a factor, k, which varies according to the status of the sentence, all Danish sentence intonation contours are the product of locally determined pitch accent scaling. (Pierrehumbert's first observation, that the L*+H interval is constant, is not accurate. It may be true at a more abstract level of production and perception, but not at the level where the actual physical scaling of Fo is taking place, and that is the level Pierrehumbert is dealing with where the downstep rule is concerned.)

B. PROBLEMS WITH THE TONE SEQUENCE APPROACH IN STANDARD DANISH

(i) A general point of difficulty with the Tonal Sequence approach is that it seems to operate with an open scale of degree of prominence (cf. Pierrehumbert 1980, Chapter 3 in particular). It demands of the speaker and listener (and analyst) that they can reliably and consistently produce and identify a large number of prominence degrees. If such an ability to identify highly varied prominences cannot be assumed with all speakers and hearers, the Tone Sequence theory faces a serious obstacle.

(ii) Pierrehumbert's downstep rule cannot account for the way a sequence of two successive stressed syllables (i.e. with no intervening unstressed syllables) are scaled in, say, a terminal declarative, let alone a whole utterance like *Per så Lis* [ˈb̥ʰeʌ̯ ˈsɔʔ ˈlis] (Per saw Lis), which is just as downdrifting/downstepping as utterances with unstressed material between the stressed syllables. I do not think that introducing an abstract or underlying H after the L* can solve the problem, since I do not see how an abstract tone can be a factor in the actual computation of the scaling of a succeeding tone. This difficulty with the downstep rule would disappear if L* could be downstepped in relation to the previous L*. That would be much better motivated phonetically and would also remove the difficulty that the variation in the magnitude of the rise from stressed to first post-tonic (the L*+H interval) creates. However, I suppose that since the previous L* is not always IMMEDIATELY preceding, it is unacceptable as a general context for the downstep rule to apply in, because it will disrupt the strict locality principle. This illuminates a fundamental problem with the Tone Sequence approach: Unstressed syllables after the first post-tonic (H) must get their Fo course by a phonetic fill-in rule. That is in itself reasonable enough, also in the light of my own speculations that stress group patterns may be invariant entities at a higher level in production than the concrete articulatory one. However, in order to scale the succeeding L* stressed syllable, these intermediate unstressed syllables must be disregarded; in other words, the speaker must employ some kind of phonetic 'look-back' mechanism to locate the H which - together with other factors - determines the actual frequency value of the next L*. The only reason why this phonetic mechanism might not look back one more syllable, to the preceding stressed (i.e. L*) one, is the constraint that the tonal representation and the locality principle impose. That is to say, the distinction between those features of a speaker's output which are relevant to his ongoing production and those which are not is NOT independently established but is a consequence of the theoretical framework itself. In this particular case it will prevent a phonetically more plausible downstep rule (L* is downstepped after and scaled in relation to L* rather than H), and one which would also reflect the fact that the stressed syllables are the relevant ones in a listener's identification of intonation contours, cf. Thorsen (1980b).

Ladd (in press, and this volume) modifies Pierrehumbert's theory while staying within its general framework. He finds her account of (Danish) sentence intonation contours unconvincing and introduces a downstep FEATURE, which *"gives separate representation to the overall downward slope, treating it as an independently selectable phonological phenomenon without giving up the advantages of TS* [tonal sequence] *phonetic specification."* - It seems to me that this has obvious advantages over the downstep rule, and it also solves the problem of environment mentioned above. Ladd suggests that the downstep feature be carried over to the analysis of English and together with some other modifications he achieves a rather less abstract tonal representation.

Independently of the choice of either a downstep rule and its environment or a downstep feature, there are, however, still certain points which make the Tone Sequence representation descriptively inadequate for Standard Danish:

(iii) If an intonation contour (or phrase contour) is NOT asymptotically declining, and if this is NOT due to uneven prominence of the stressed syllables, then the downstep factor or feature must of necessity take different values as it creeps along the utterance. Figure 7 offers evidence for non-asymptotically declining phrase and intonation contours; see further Thorsen (forthcoming).

(iv) Consider utterances of varying length: In the conceptually simplest case where range is constant over utterances of different length and where consequently the slope of the intonation contour (the downstep factor) is inversely proportional to the length of the utterance it spans, the downstep must be factored differently in short and long utterances, something which presumably demands a certain amount of look-ahead for its computation. In more complicated cases where range increases with utterance length, but not linearly so, the demands on the computation of the manifestation of the downstep are still harder; see Thorsen (forthcoming).

(v) Apart from their descriptive adequacy, the two representations may be evaluated in terms of their ability to reflect speech production and perception processes, to the extent that such processes are known, or at least hypothesized. The Tone Sequence theory explicitly requires no look-ahead mechanism, but we know that speakers do look ahead (see e.g. Perkell, 1980) also in the planning and execution of intonational phenomena, cf. Bruce (1981), Lehiste (1975). This fact is mirrored in the global representation of sentence intonation in the layered system. - The stressed syllables (the starred tones) in the Tone Sequence theory have no special role or

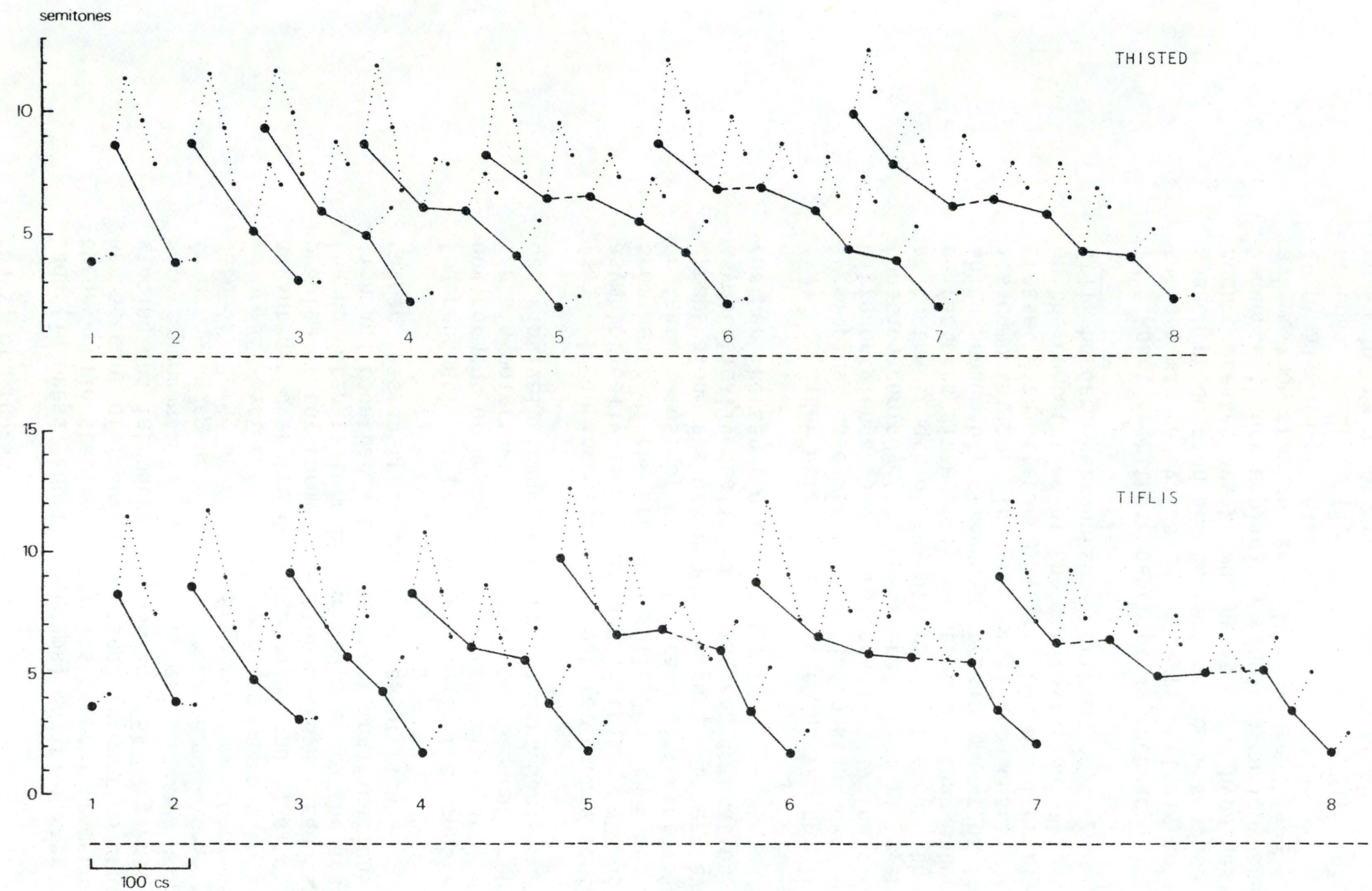


Figure 7

Intonation contours (full/broken lines) and stress group patterns (dotted lines) in two sets of terminal declarative sentences containing from one to eight stress groups. Average over four subjects (mean of means over six recordings). Large dots represent stressed syllables, small dots unstressed ones. The broken lines indicate boundaries between prosodic phrases, see further Thorsen (forthcoming). Zero on the logarithmic frequency scale corresponds to 100 Hz.

status in connection with the determination of overall downdrift (downstep), cf. the formulation of the downstep rule above - but at least in Standard Danish, the stressed syllables seem to serve as anchor-points in the identification of intonation contours and this fact is also reflected in the layered system.

To conclude: If the downstep rule or feature is to capture the amount of variability and complexity in intonation contours like those presented in figure 7, it must be a scalar and continuous feature which will often have to take different values within one and the same phrase or sentence. I.e. it must have at least some of the properties it presumably was intended to rid intonation analyses of. - It seems to me that the Standard Danish data are more easily accommodated by a descriptive system or theory that requires a look-ahead mechanism and which allows its components to be parametric, simultaneous and physically interacting than by a theory whose components are sequential and categorical and generated without look-ahead from left-to-right.

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APPENDIX

Below is quoted verbatim the abstract from Janet Breckenridge Pierrehumbert's doctoral thesis *The Phonology and Phonetics of English Intonation:*

> *"This thesis develops a system of underlying representation for English intonation. It gives an account of what different tunes are possible and how they are aligned with different texts. It characterizes the rules which map the underlying representations into phonetic realizations.*
>
> *The different tunes are described as structured strings of L and H tones generated by a finite-state grammar. The strings consist of one or more pitch accents, which are aligned with stressed syllables on the basis of the metrical pattern of the text, plus two additional tones which characterize the intonation of the end of the phrase. The pitch accents are either a tone, or a pair of tones on which a strength relation is defined. The two additional tones are the boundary tone, found at the end of the phrase regardless of the metrical structure of the text, and the phrase accent, which follows immediately after the pitch accent on the main phrase stress and controls the intonation from there to the boundary.*
>
> *Local context-sensitive rules map the string of tones into the quantitative values which determine the fundamental frequency contour. These rules apply left to right, and include downstep and upstep rules resembling those which have been studied in African tone languages. A transform of the fundamental frequency domain which makes these rules linear is proposed on the basis of experimental data. Evidence is presented that superficially nonlocal intonational characteristics, such as the overall trend of the contour, really arise from local rules. The thesis also reviews other experimental results and explains how they are accommodated within the framework proposed."*

ARIPUC 16, 1982, p. 37-100

SELECTED PROBLEMS IN THE TONAL MANIFESTATION OF WORDS CONTAINING ASSIMILATED OR ELIDED SCHWA

NINA THORSEN

69 words recorded in carrier sentences by four speakers are the basis for an acoustic analysis of fundamental frequency patterns under various kinds of schwa assimilation, instigated by a previous observation of "delayed" Fo peaks in words with assimilated schwa. It turns out that the tonal reduction or assimilation - if and when it occurs - is a function of the durational reduction involved in assimilation of schwa rather than a characteristic of schwa syllables and assimilation as such. The durational modifications involved in schwa assimilation are established.

I. INTRODUCTION

In my first analysis of Advanced 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 ˈfall̩ne] 'hard (pl.)-harder' and '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.)

II. 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 due to intonation [emphasis supplied, NT]: the difference between *faldne* [ˈfalnə] and *faldende* [ˈfall̩ne][1], 'fallen (pl.)' and '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 [see further below] 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], although the second [u] in *luen og* by interval reduction loses its independent, syllable-constituting pitch [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?

BL (p. 198ff) distinguish "pure" schwa assimilations, where the syllabic sound developed from schwa is fully as long as the original schwa, from cases where a certain durational reduction of the word is entailed. Pure assimilation is found in two instances: when schwa assimilates to a preceding vowel [which is always long since schwa does not occur after short vowels, NT] (*luen* /lu·ən/ [ˈlu·un] 'the flame'), and when schwa assimilates to a preceding voiced consonant after a short vowel (*finde* /fenə/ [ˈfenn̩] 'to find'). In all other instances the duration of the syllabic consonant is reduced compared with the total duration of unassimilated consonant and schwa, although it is longer than ordinary (i.e. unassimilated) corresponding consonants. Nonetheless, a durational distinction between syllabic consonants from /Cə/ versus /əC/ is still maintained in distinct speech, the former being less reduced than the latter. - The examples offered for this statement are *pæne, syle, hjerne, hele* [ˈb̥ʰɛ·n̩ ˈsy·l̩ ˈjæʎn̩ ˈhe·l̩] 'nice, awls, brain, whole' versus *handel, cykel, hætten* etc. [ˈhanˀl̩ ˈsyg̊l̩ ˈhɛd̥n̩] 'trade, bicycle, the hood', the latter still being clearly longer than [n] and [l] in e.g. *verdner, cykler* etc. [ˈvæʎd̥nʌ ˈsyg̊lʌ] 'worlds, bicycles'. The generality of a durational distinction between /Cə/ and /əC/ seems to be modified, though, by the passage on p. 199 where it says that *visne* and *cykle* '(to) wither' and '(to) bicycle' may, but only rarely, have a longer syllabic consonant than *vissen* and *cykel* 'withered' and 'bicycle'. However, these particular types are distinguished through a curious lengthening of the preceding consonant [emphasis supplied, NT] in the /VCCə/ structure, i.e. [ˈves·n̩ ˈsyg̊·l̩] versus [ˈvesn̩ ˈsyg̊l̩]. Lengthening of the preceding consonant takes place in groups of two consonants after a short vowel when the first consonant has less sonority[2] than the syllabic one, and the authors reason that this lengthening in the first consonant might favour a shortening of the second, syllabic one. But they also declare durational differences to be rare in the syllabic consonant in *sultne, rustne* [ˈsuld̥n̩ ˈʁɔsd̥n̩] (?) 'hungry (pl.), rusty (pl.)' (where there is no lengthening of the preceding consonant) versus *sulten, rusten* [ˈsuld̥n̩ ˈʁɔsd̥n̩] 'hungry, rusty'.

/rə ər rər/ may all fuse in [ʌ], but this is not a case of schwa assimilation (p. 212-213): /ə/ becomes [ʌ] in the environment of /r/ which is then vocalized. This process shares a feature with schwa assimilation, however: the curious lengthening of the preceding consonant as in *hamre, blafre, pebre, kvidre* [ˈhɑm·ʌ ˈb̥laf·ʌ ˈb̥ʰew·ʌ ˈg̊ʰvið·ʌ] '(to) hammer, (to) flicker, (to) pepper, (to) twitter'. In the chapter on diachronic shortening of long voiced consonant before a voiced consonant (§ 49) it is stated explicitly (p. 367) that this lengthening before /rə(r)/ is not a relict of an older state of things but a true compensatory lengthening, since the lengthening is obligatory when /r/ is vocalized, but only optional when [ʁ] is pronounced. [To my mind, a classification as "compensatory" is dubious if it ever occurs when [ʁ] is pronounced, or at least it cannot be viewed as a compensation in the on-going speech production process.]

I have previously argued (e.g. in Thorsen 1980 and 1982) 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) "Pure" assimilation of schwa to a preceding voiced consonant after a short vowel, like *finde* '(to) find' leads to a particularly long syllabic consonant, and clearly longer than after long vowel as in e.g. *bene (af)* '(to) beat it'. 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 *skaffe, skaf; stikke, stik* [ˈsg̊ɑf ˈsd̥eg̊] '(to) procure, procure (imp.); '(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 <u>into</u> the stressed vowel of such words.]

III. PROCEDURES

A. MATERIAL

Transcriptions and translations are given in Appendix I, which also reflects the different likelihood of schwa-elision in the material.

(1a) <u>syllabic consonant versus [ə]</u>

After long vowel *males banes mades* vs. *mases*

After short vowel *tælles kendes loddes* vs. *tættes plottes*

(1b) two successive /ə/-syllables with assimilated and pronounced schwa, respectively

tykkelse tykkelsen
Tykkesen tykkeste
blottelse blottelsen
Ottesen flotteste

(1c) [ə] versus [i]

bille	vs.	*billig*
flitte		*flittig*

(2) /VCCə/ versus /VCəC/ where the first consonant is a stop, a fricative, a nasal, a lateral, or a semivowel

The second consonant is /l/

pukle	vs.	*pukkel*
gafle		*gaffel*
gamle		*gammel*
padle		*saddel*

According to BL, the last pair should not exhibit the same durational pattern as the other three, since the syllabic consonant in *padle* will not be the more sonorous of the two, and furthermore the syllabic consonant in *saddel* is [ð] rather than [l].

The second consonant is /n/

mugne	vs.	*muggen*
visne		*vissen*
bulne		*bullen*
vidne		*viden*
kærne		*kærren*

bulne-bullen and *vidne-viden* should not, according to BL, exhibit the same pattern as the two uppermost pairs, since the syllabic consonant in *bulne* and *vidne* will not be the more sonorous of the two, and furthermore the syllabic consonant in *bullen* and *viden* will not be the nasal but rather [l] and [ð]. *kærne-kærren* deviates in that phonetically the second syllable in *kærren* is carried by a vocalic sound, i.e. [ə] assimilates to the non-syllabic part of the preceding diphthong, [ˈg̊ʰæʌ̆ʌn].

The second consonant is /r/

klatre	vs.	*klatter*
ofre		*offer*
tømre		*tømmer*
baldre		*kalder*
bladre		*kladder*

(3) Syllabic consonant after long versus short vowel

bane	vs.	*bande*
kane		*kande*
kugle		*kulde*
skele		*skille*

and for comparison with the four pairs above:

/V·Cə/ versus /V·əC/ *lune* vs. *lugen*

(4) Complete schwa-elision after unvoiced obstruent versus disyllables versus monosyllables[3]

After long vowel	*skabe*	vs.	*skaber*
	gyse		*gyser*
After short vowel	*stoppe*		*stopper, stop*
	passe		*passer, pas*

The words were embedded in short declarative sentences, like *Barnet skal mades med skeen. Hun elsker den gamle soldat med sablen. Der er flere skabe til pigernes tøj. Han henter en kande til mælken og fløden.* The 69 sentences and their translations are listed in Appendix II. Words that were to be immediately compared occurred in identical position in sentences that were as much alike syntactically and rhythmically as possible. The sentences were randomized and mixed with a material recorded for a different purpose, so that no more than three of the sentences ever occurred in direct succession.

B. SUBJECTS AND TECHNICAL PROCEDURE

Four phoneticians, two males (NRP and JR) and two females (BH and NT (the author)), read the material. NRP, BH and NT speak Advanced Standard Copenhagen, JR speaks a slightly more conservative variant but, as noted in Thorsen (1980, p. 199), JR does not exhibit any qualitative differences from the other subjects as far as stress group patterns are concerned. NRP, JR and BH recorded the material six times each, NT recorded it ten times. Subjects' style of speech can be characterized as conversational but distinct.

The recordings were made with semi-professional equipment (Revox A-77 tape recorder, Sennheiser MD21 microphone and larynx microphone) in a quasi-damped room at the Institute of Phonetics on Agfa PE36 tape at 7½ i.p.s. The tapes were processed by hardware intensity and pitch meters (F-J Electronics) and registered on a mingograph (Elema 800) at a paper speed of 100 mm/s. The signal from the larynx microphone was processed in the pitch meter's hold mode. In combination with adjustment of the zero-line to the lower limit of the subject's voice range and full exploitation of the record space of the mingograph galvanometer, this yields a good solution of the frequency scale, generally allowing for a measuring accuracy of 1 Hz for males and 2 Hz for females.

In unidirectional Fo courses with constant slope only the beginning and end points were measured, according to a procedure outlined in Thorsen (1979, p. 63-66). In more complex Fo courses three to six points were measured, in a manner so that the traces could be accurately reconstructed by smooth interpolation through the measuring points. The distance in time of each measuring point from the first one was measured and so was the duration of each segment, to the extent that reliable segmentation could be made. Fo and time measurements were averaged over the six (ten) recordings by each subject. The average Fo values were converted to semitones (re 100 Hz) and average tracings drawn. No correction was made for intrinsic Fo level differences between vowels.

Standard deviations on the average Fo and duration values are generally small, about 3% to 5% of the mean and very rarely exceeding 10% (they are often smaller for stressed vowels than post-tonic vowels and syllabic consonants), so production stability across different readings is rather good and the figures must be fairly reliable indications of subjects' behaviour.

Slightly stylized Fo tracings of the various words to be compared are depicted in figure 1-4. They will be referred to by subjects' initials and frame number, like NRP-7, JR-14, etc. To complete the picture of the stress group pattern, the succeeding post-tonic (a preposition in the majority of instances) is included. A raised numeral after the signature in the frames indicates the number of items from which the average is calculated, if it deviates from six (or ten, in NT's case).

In a few cases, notably with JR, only one or two periods were registered in the post-tonic vowel(s), i.e. only one measuring point is marked, and accordingly such post-tonics appear as dots in the figure, see e.g. JR-26, and it will generally be self evident which stressed syllable the dot is to be coupled with. When a sonorant consonant could be reliably segmented from the neighbouring vowel(s) it will appear in the tracings either through a discontinuity (due to different intrinsic Fo levels) or with vertical strokes underneath the tracings, see e.g. NRP-15 and NRP-19.

In some instances a subject will produce the same word in two editions: both will be included and the signature will indicate the pronunciations, see e.g. NRP-13. In other cases a subject will consistently produce a word in a manner different from the maximally reduced one I had attempted to elicit, and it will be indicated accordingly in the signature, see e.g. NRP-18.

IV. RESULTS

Note first of all that schwa does not assimilate to its surroundings with equal ease in all phonological contexts. After a single post-vocalic sonorant (like *males, kande* etc.) schwa is assimilated almost without exception, and likewise between an obstruent and a sonorant (as in *blottelse, gaffel* 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*) than when it is an obstruent (like *pukle*). 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*).

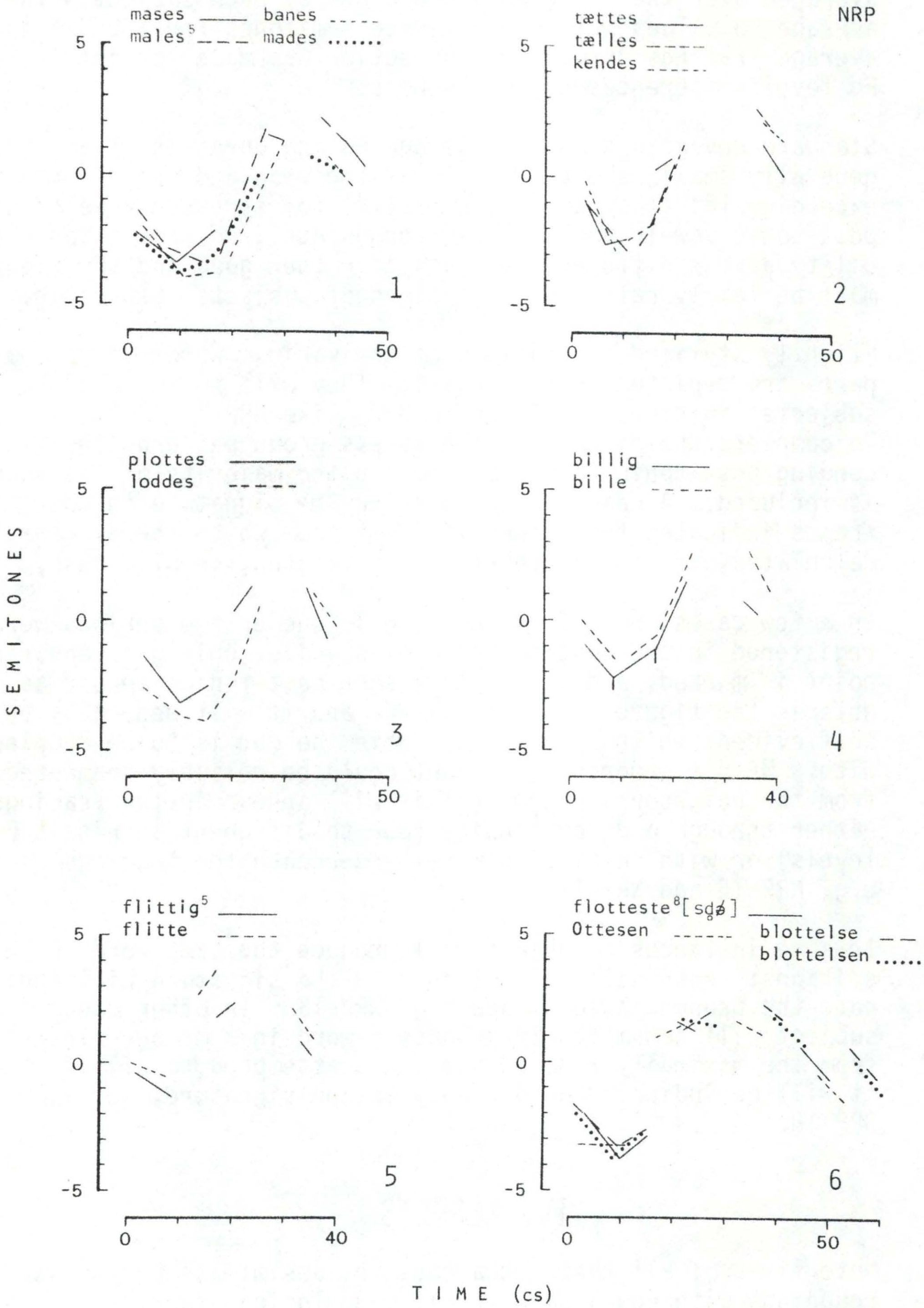
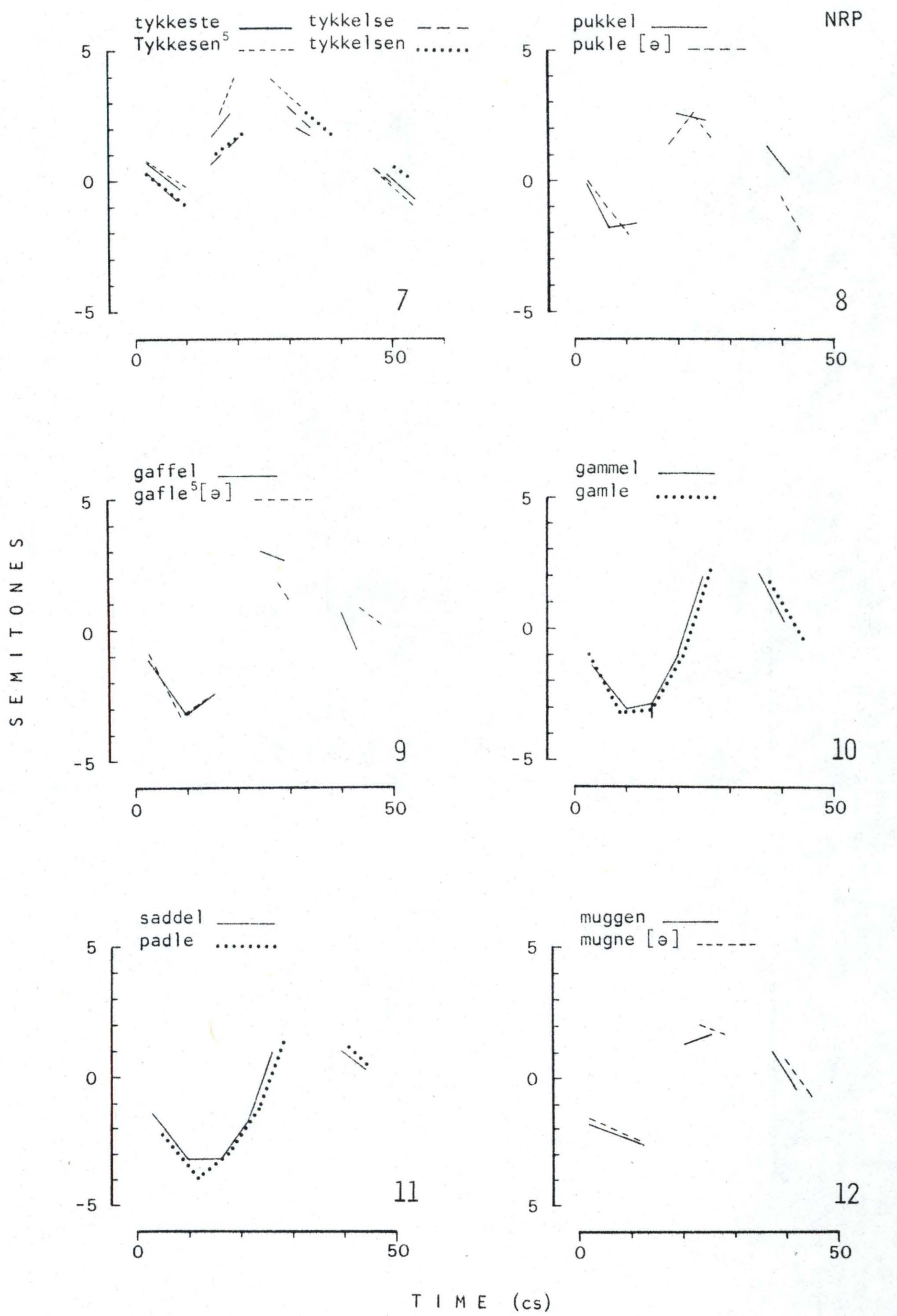
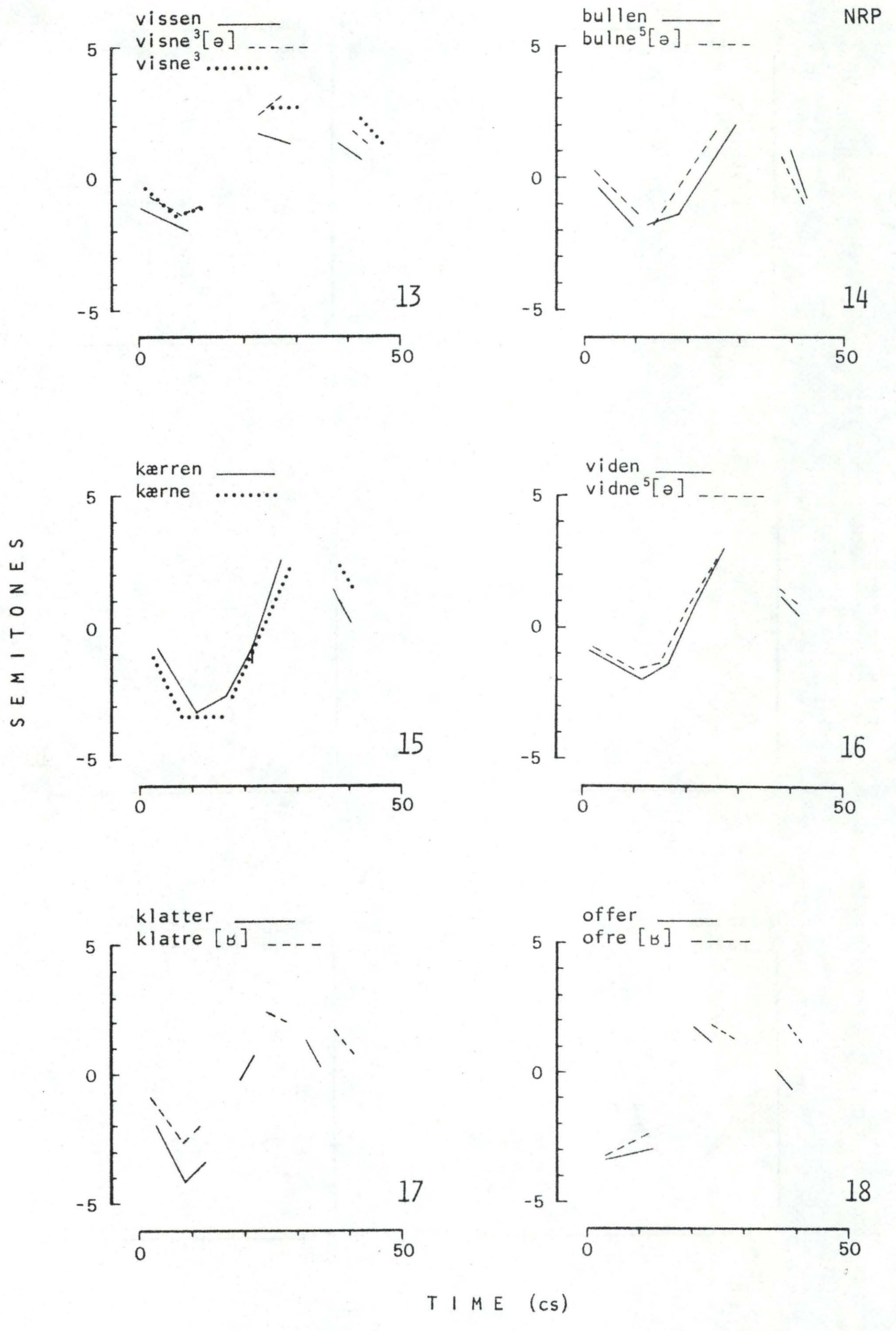


Figure 1

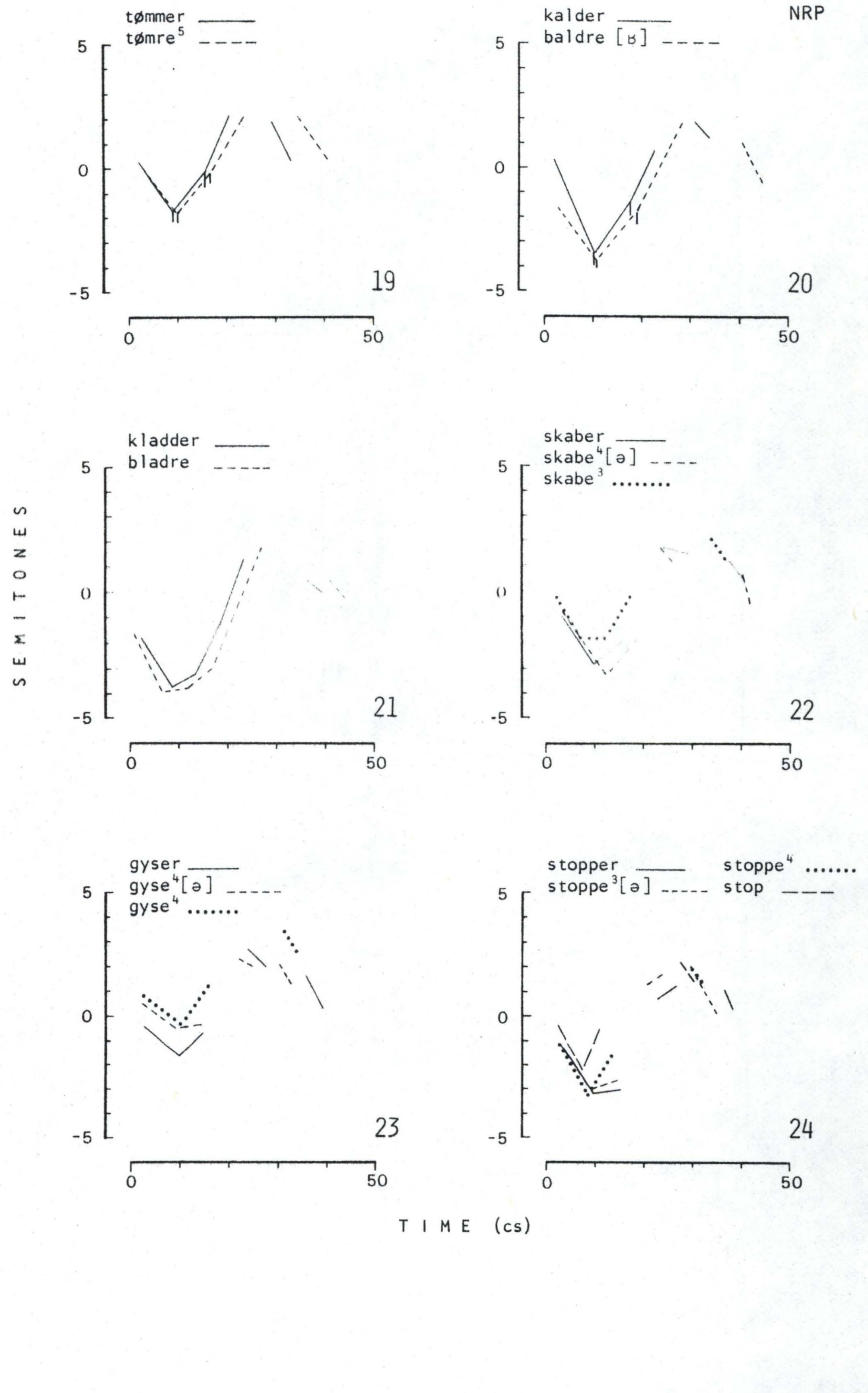
Fundamental frequency tracings (averages) of the test words of the material and the succeeding unstressed word. A raised numeral after the signatures in each frame indicates the number of items behind the average tracing, if it deviates from six. Zero on the logarithmic frequency scale corresponds to 100 Hz. Subject NRP.



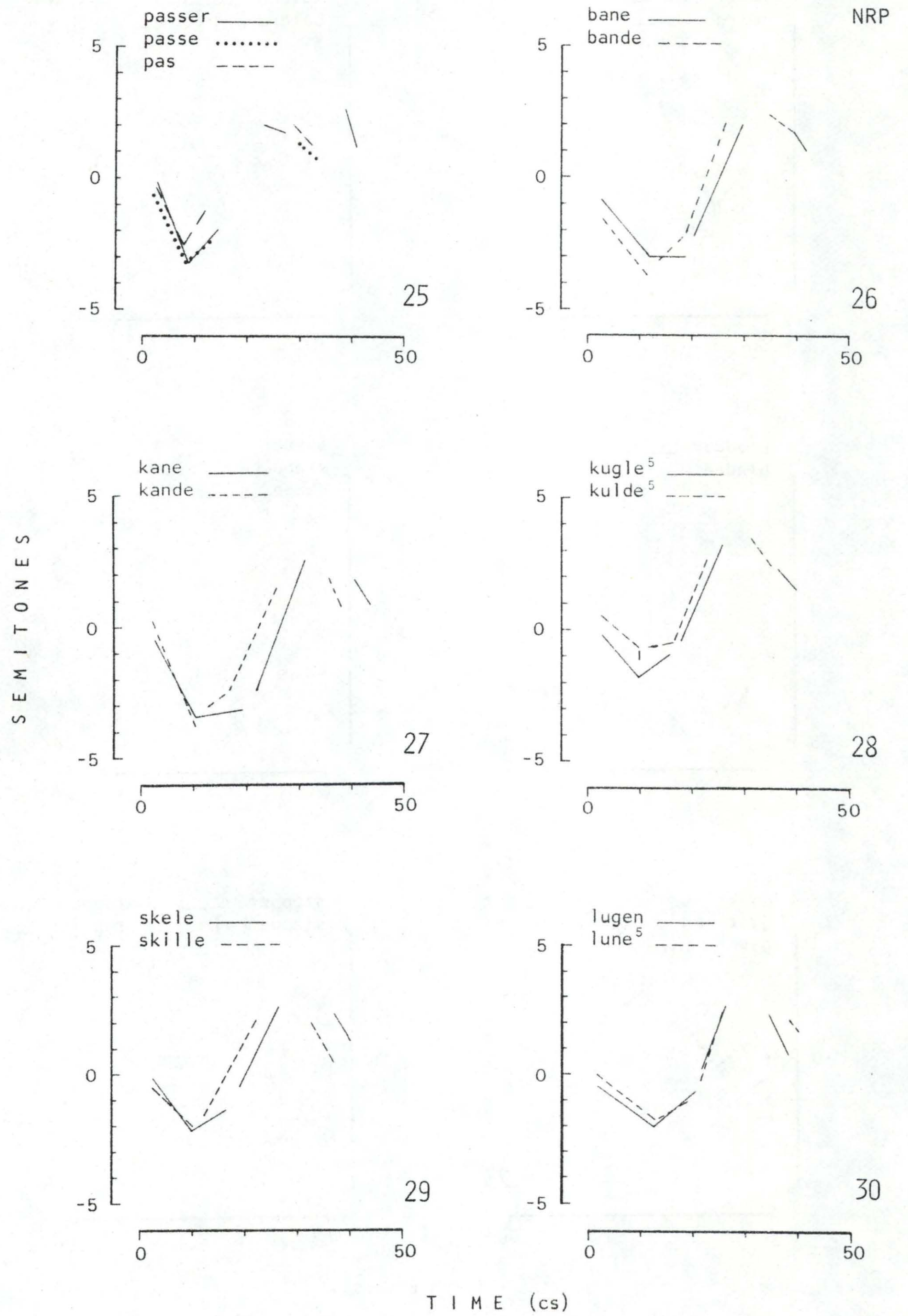
(figure 1 continued)



(figure 1 continued)



(figure 1 continued)



(figure 1 continued)

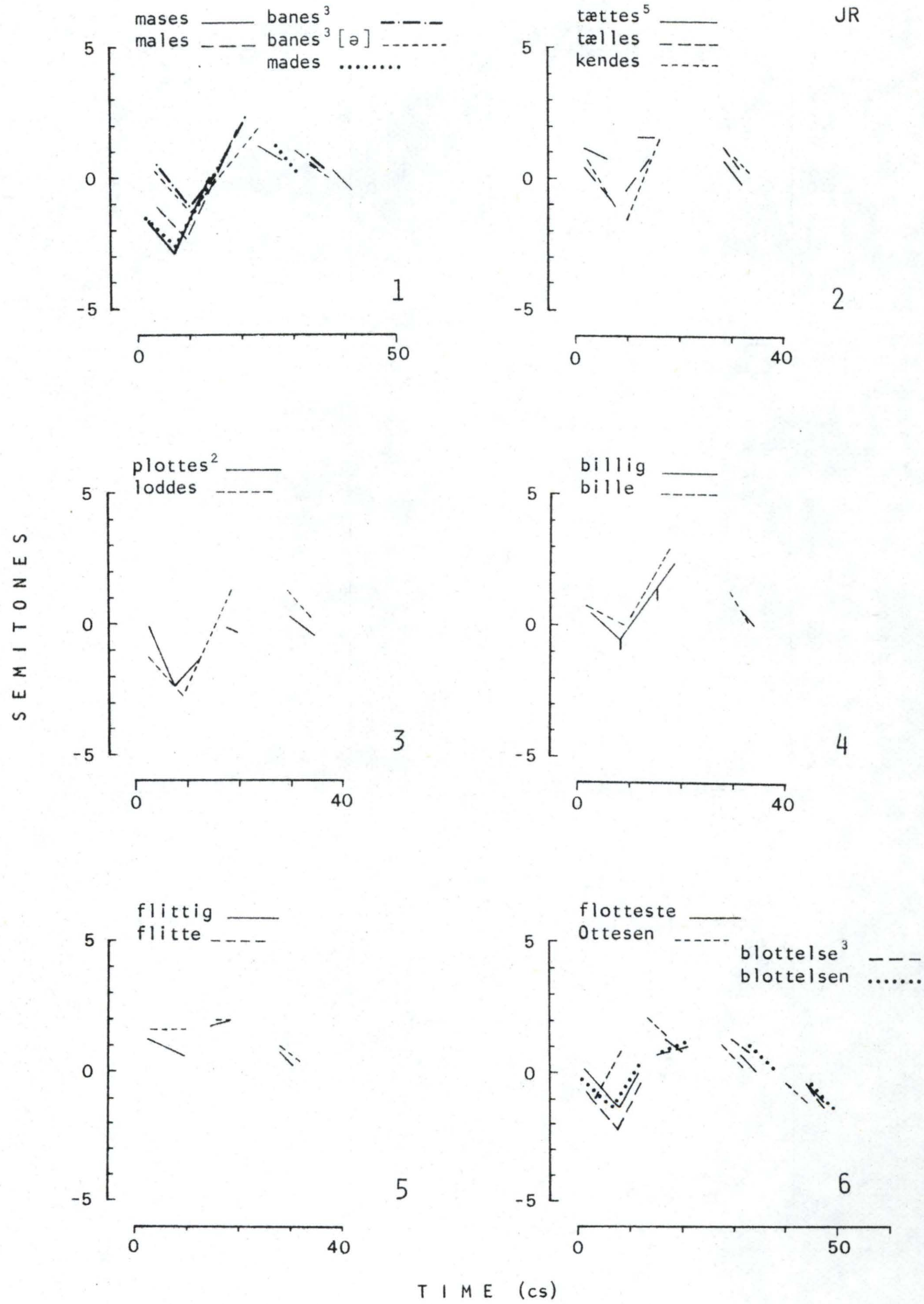
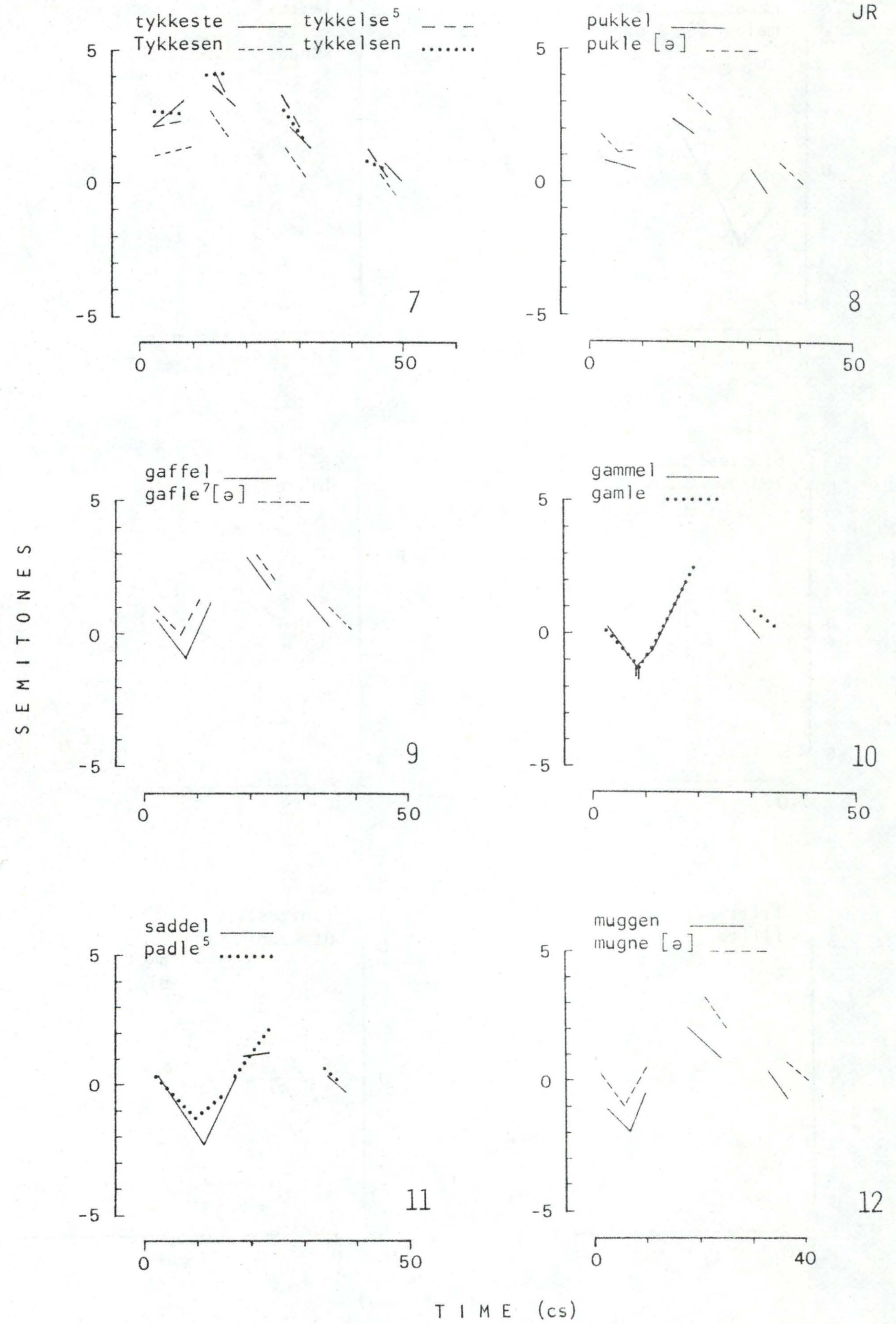
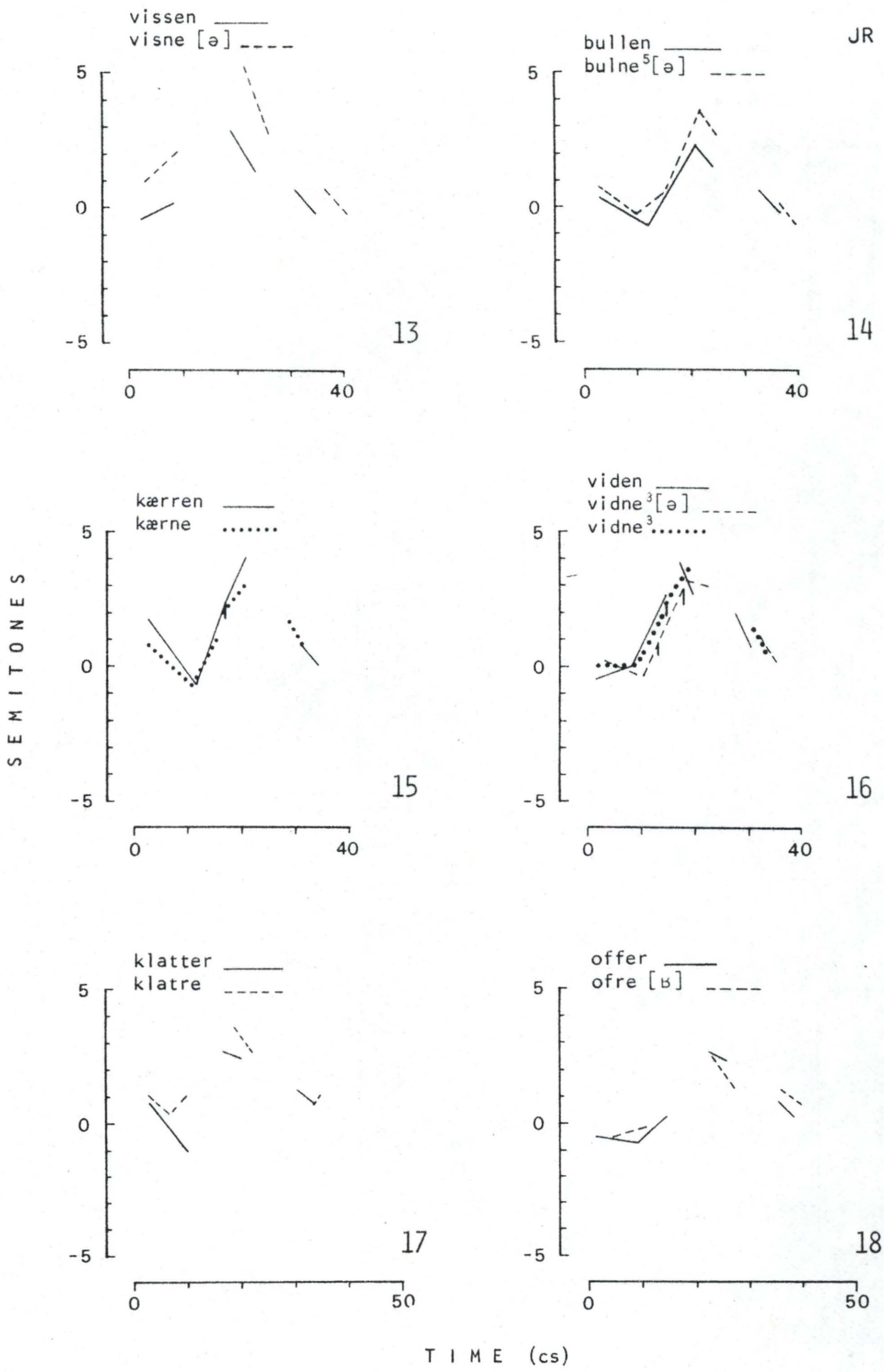


Figure 2

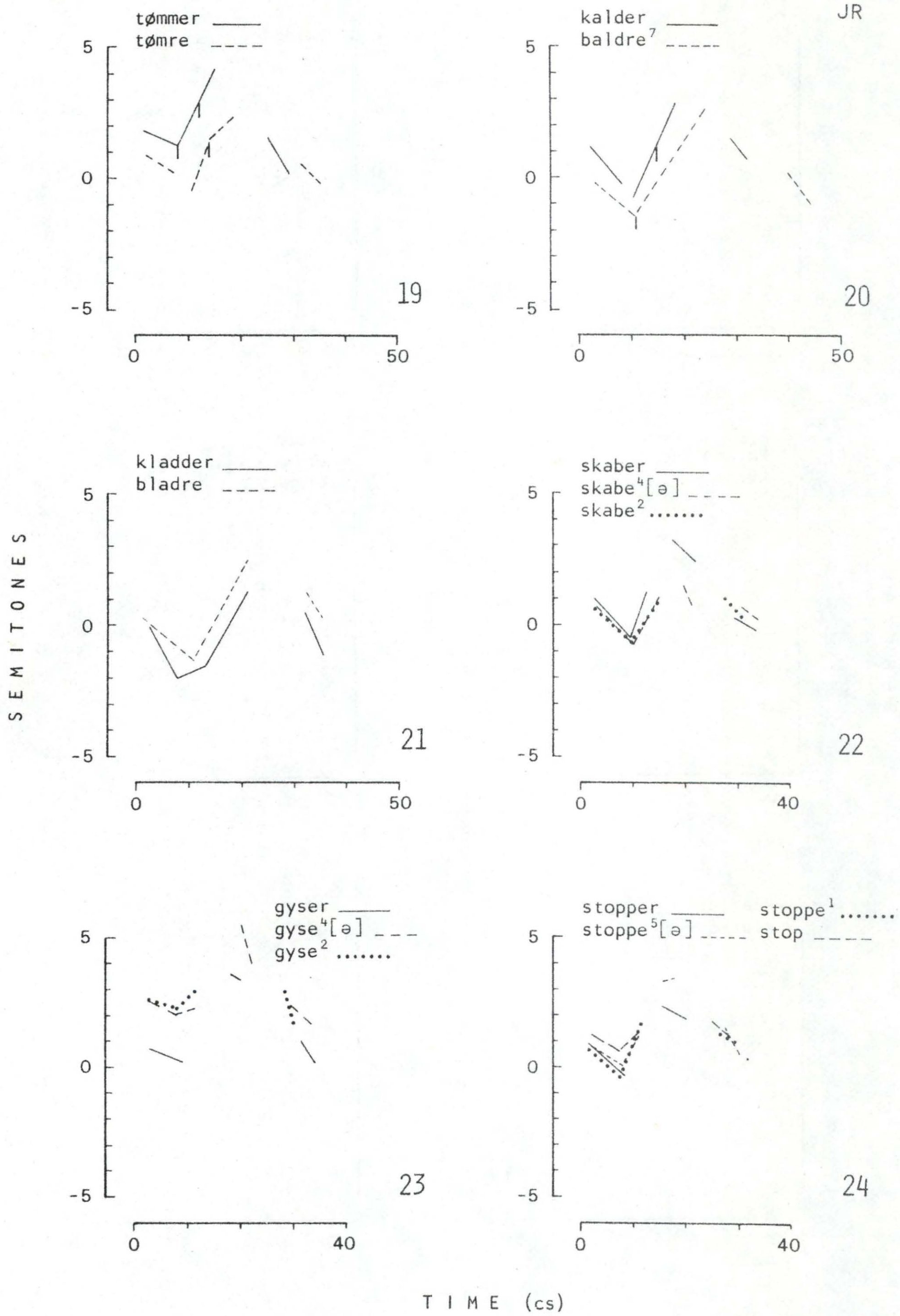
Subject JR. See further legend to figure 1.



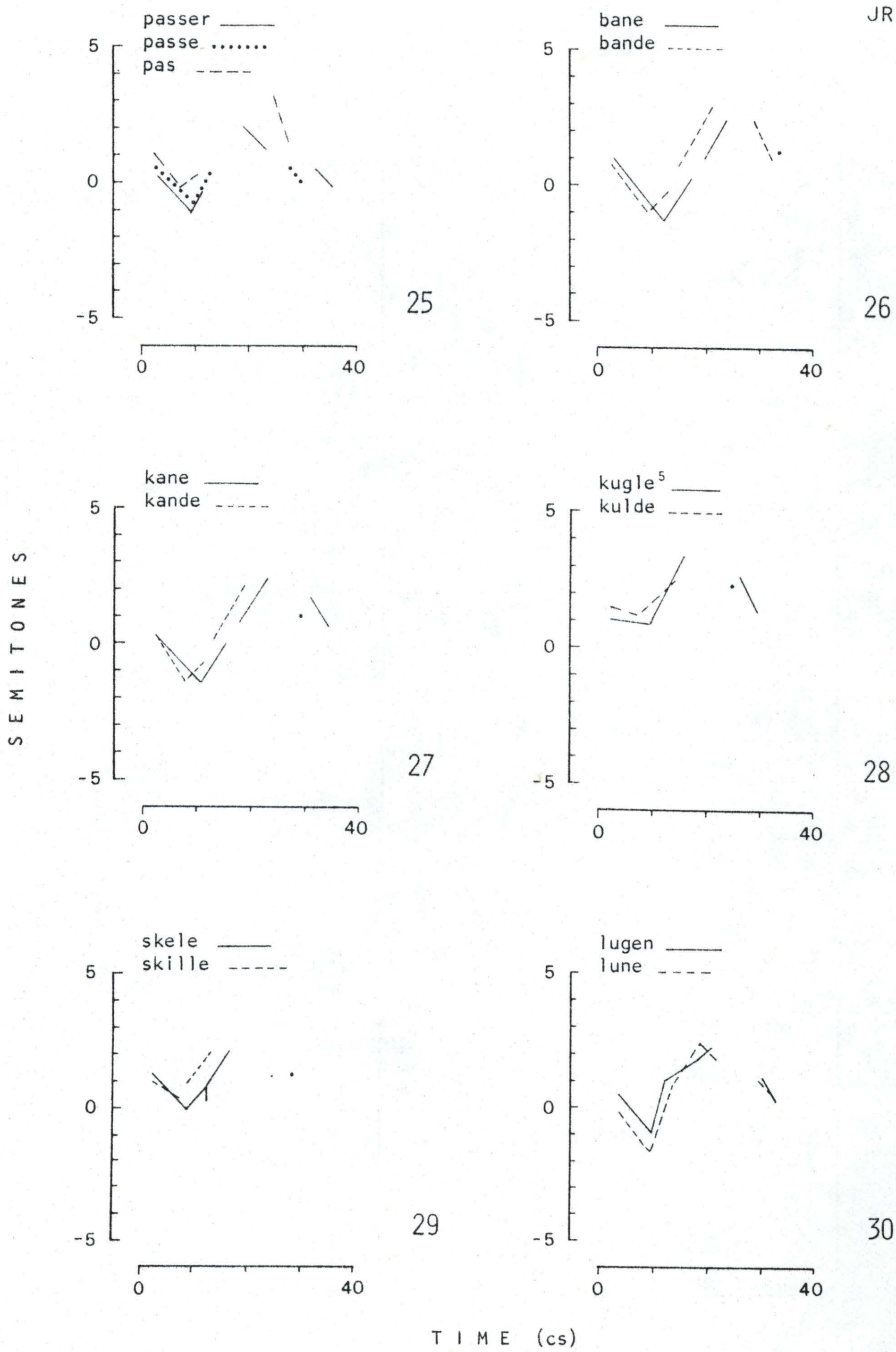
(figure 2 continued)



(figure 2 continued)



(figure 2 continued)



(figure 2 continued)

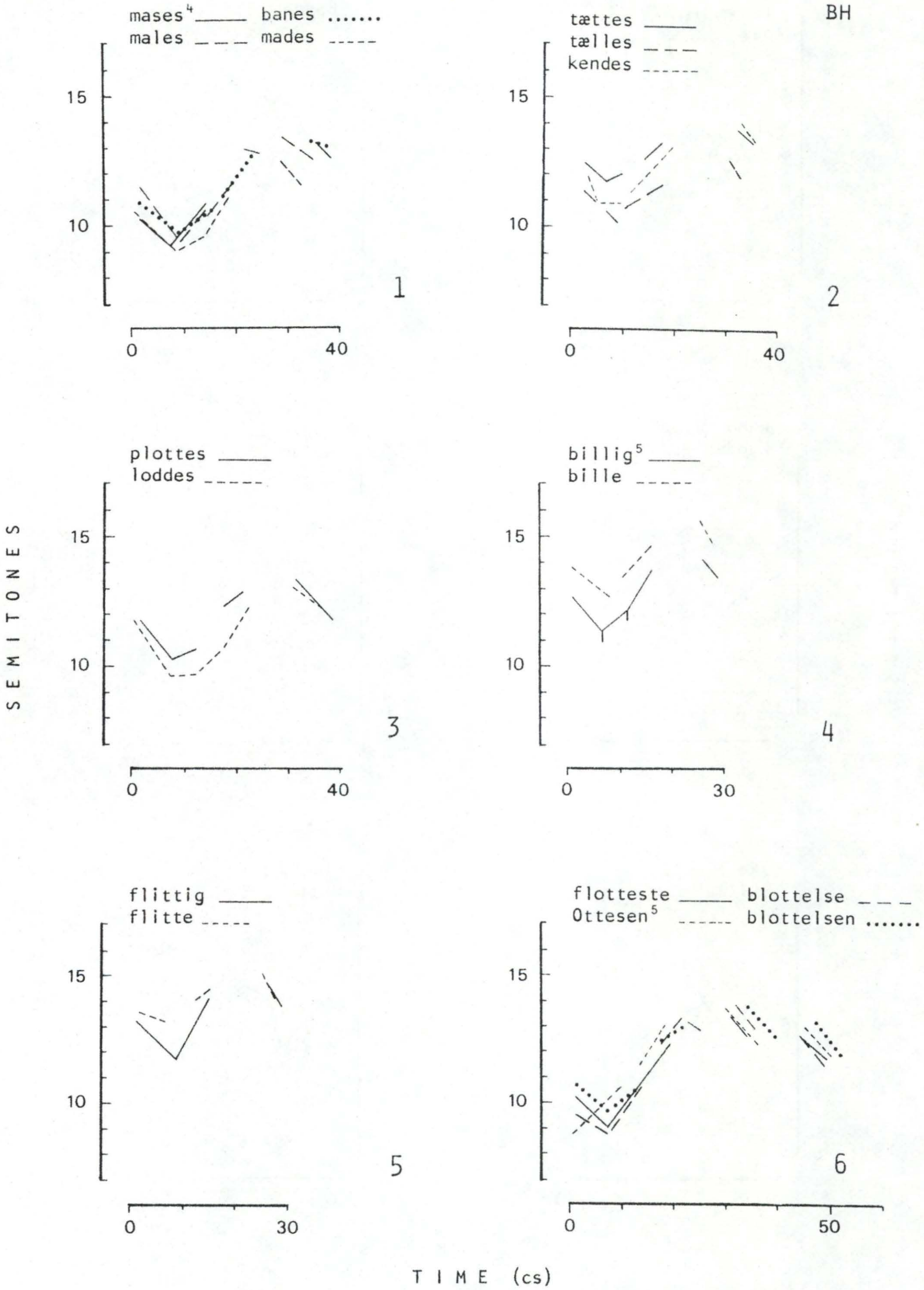
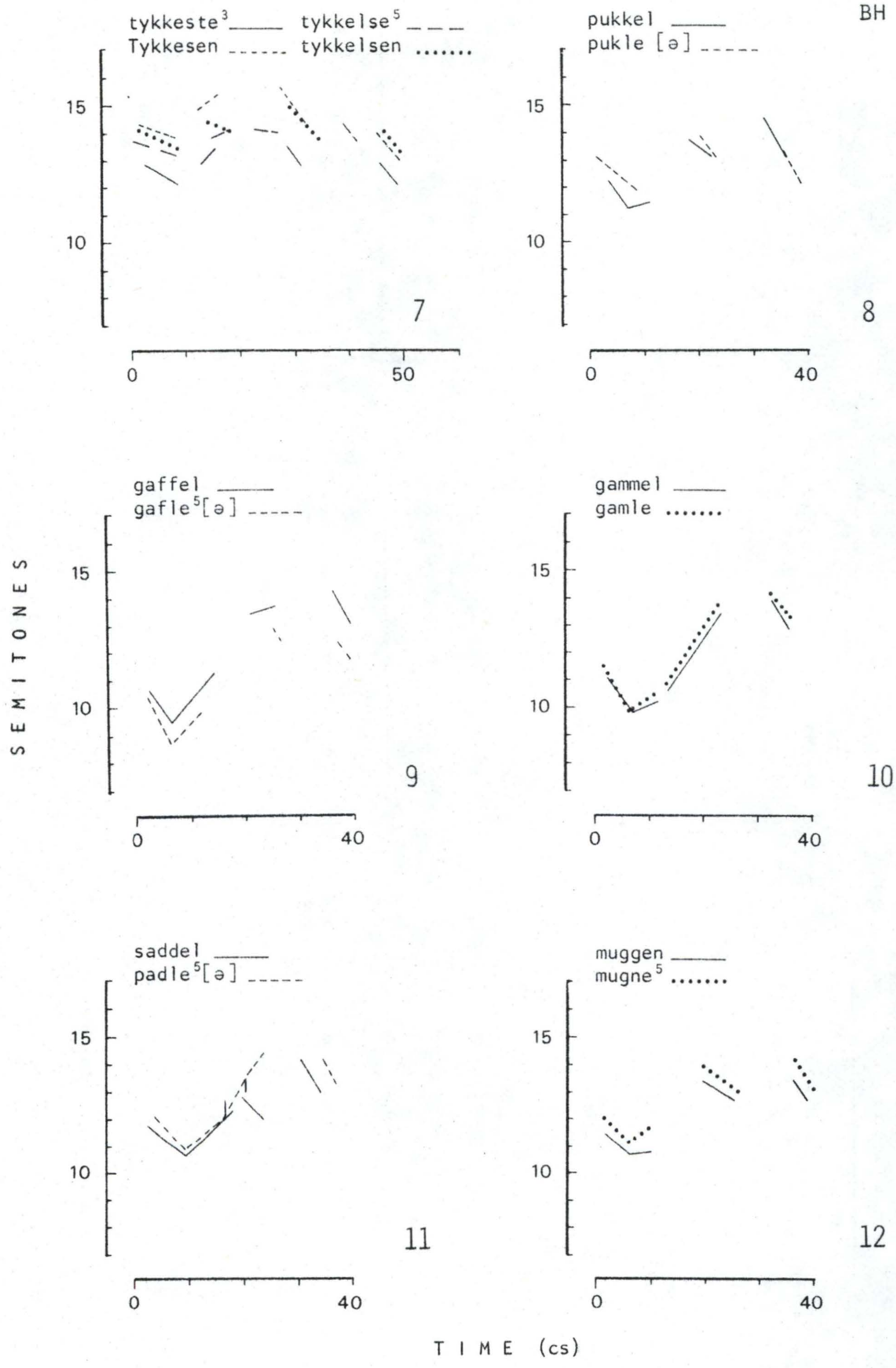
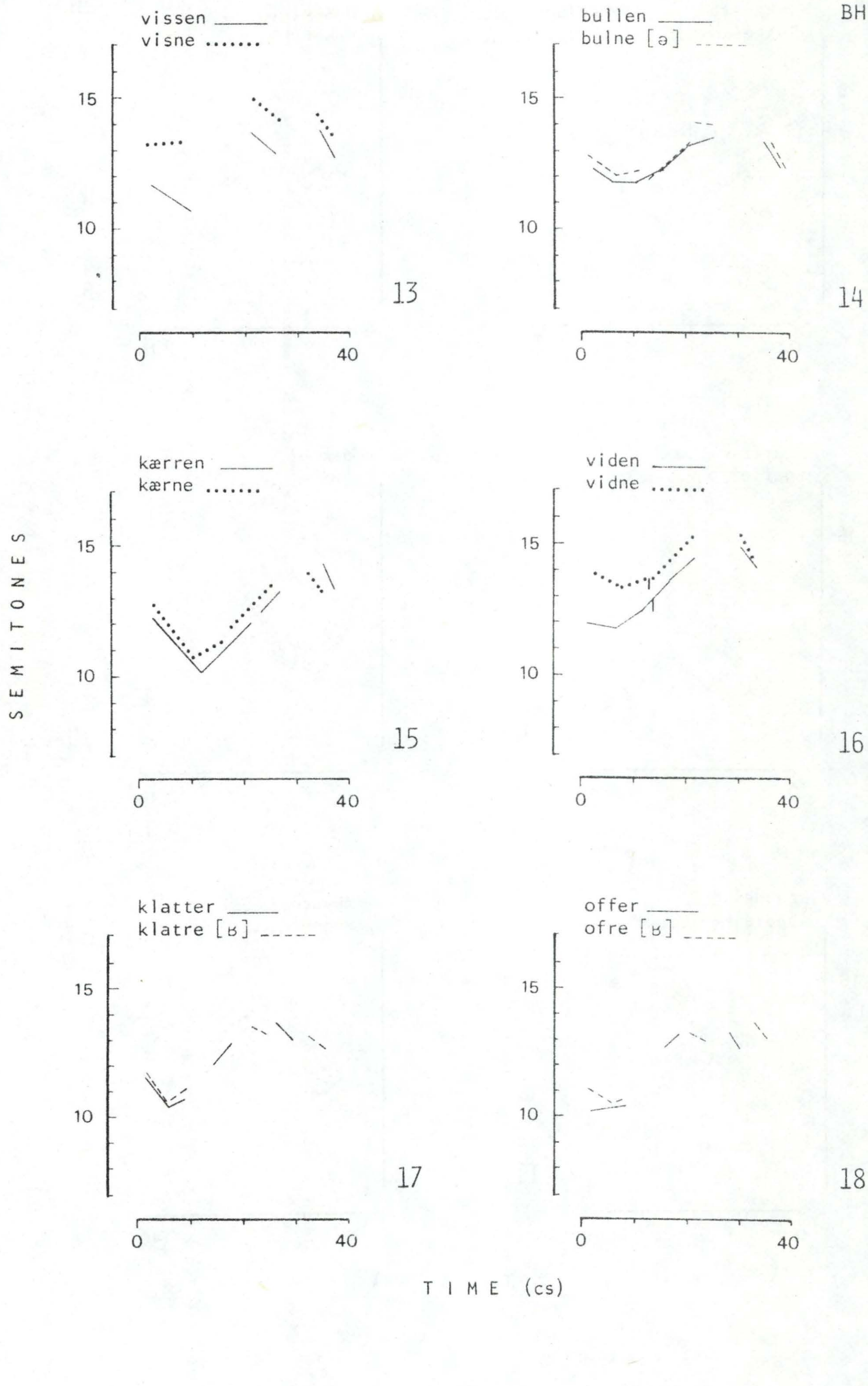


Figure 3

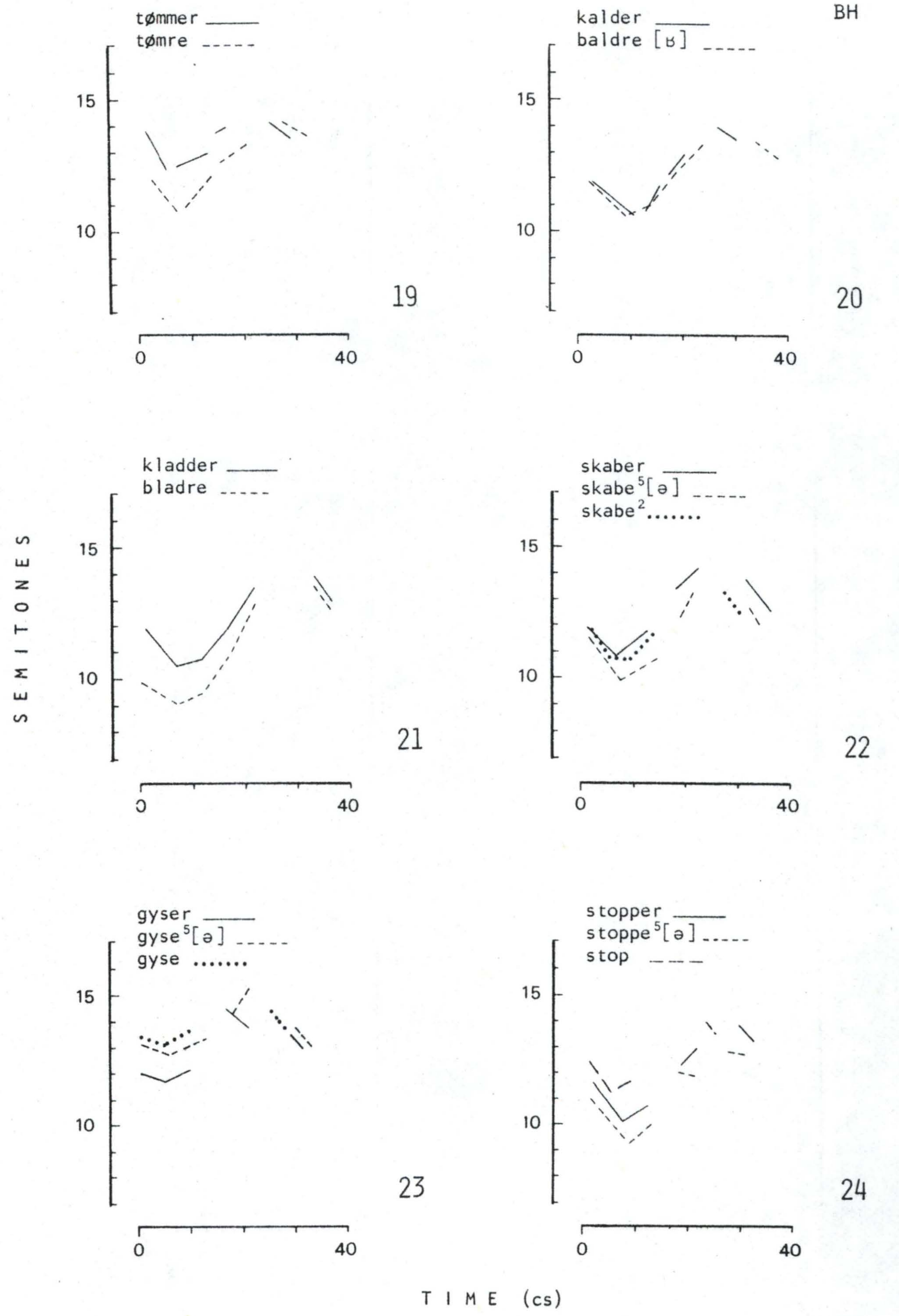
Subject BH. See further the legend to figure 1.



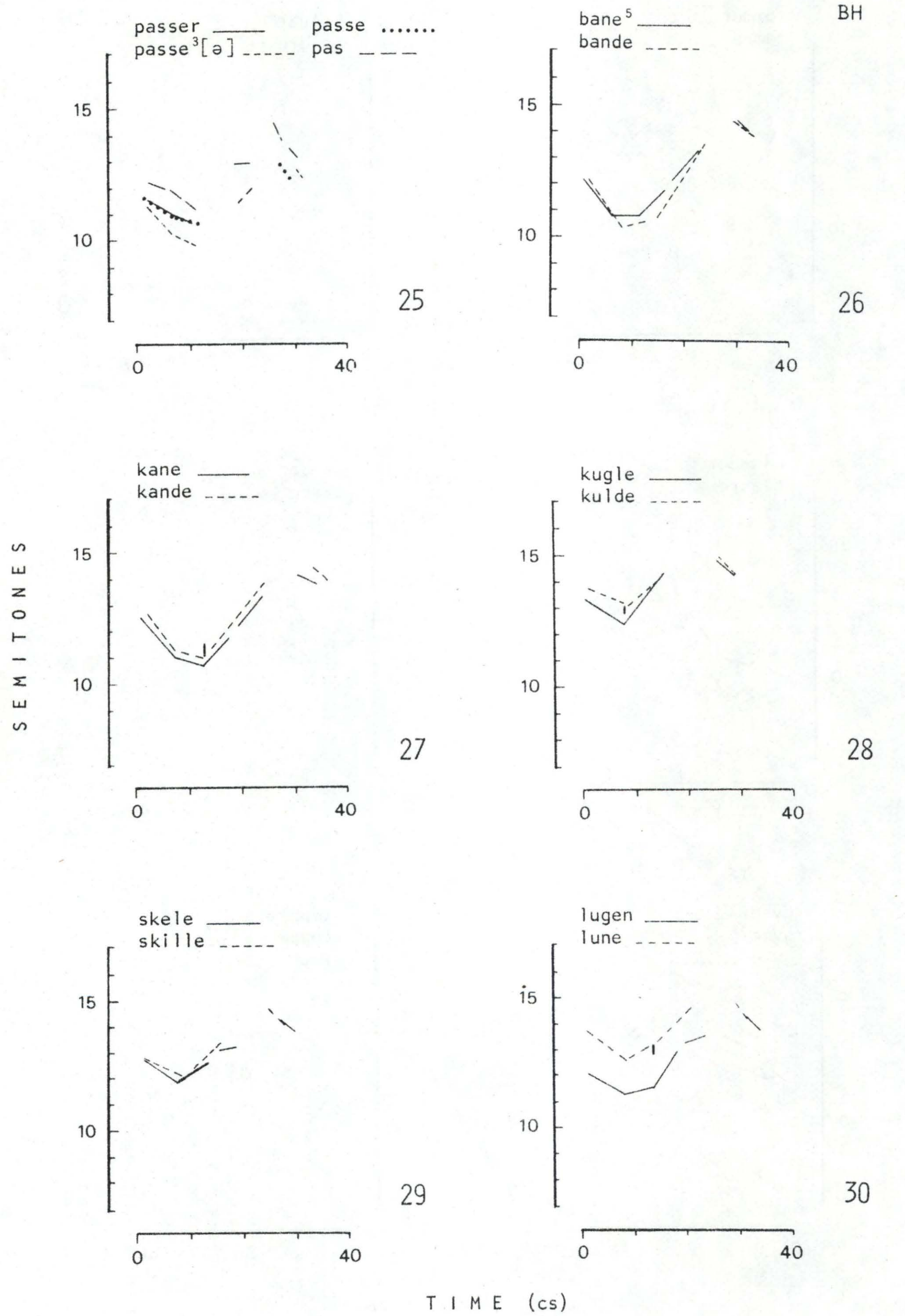
(figure 3 continued)



(figure 3 continued)



(figure 3 continued)



(figure 3 continued)

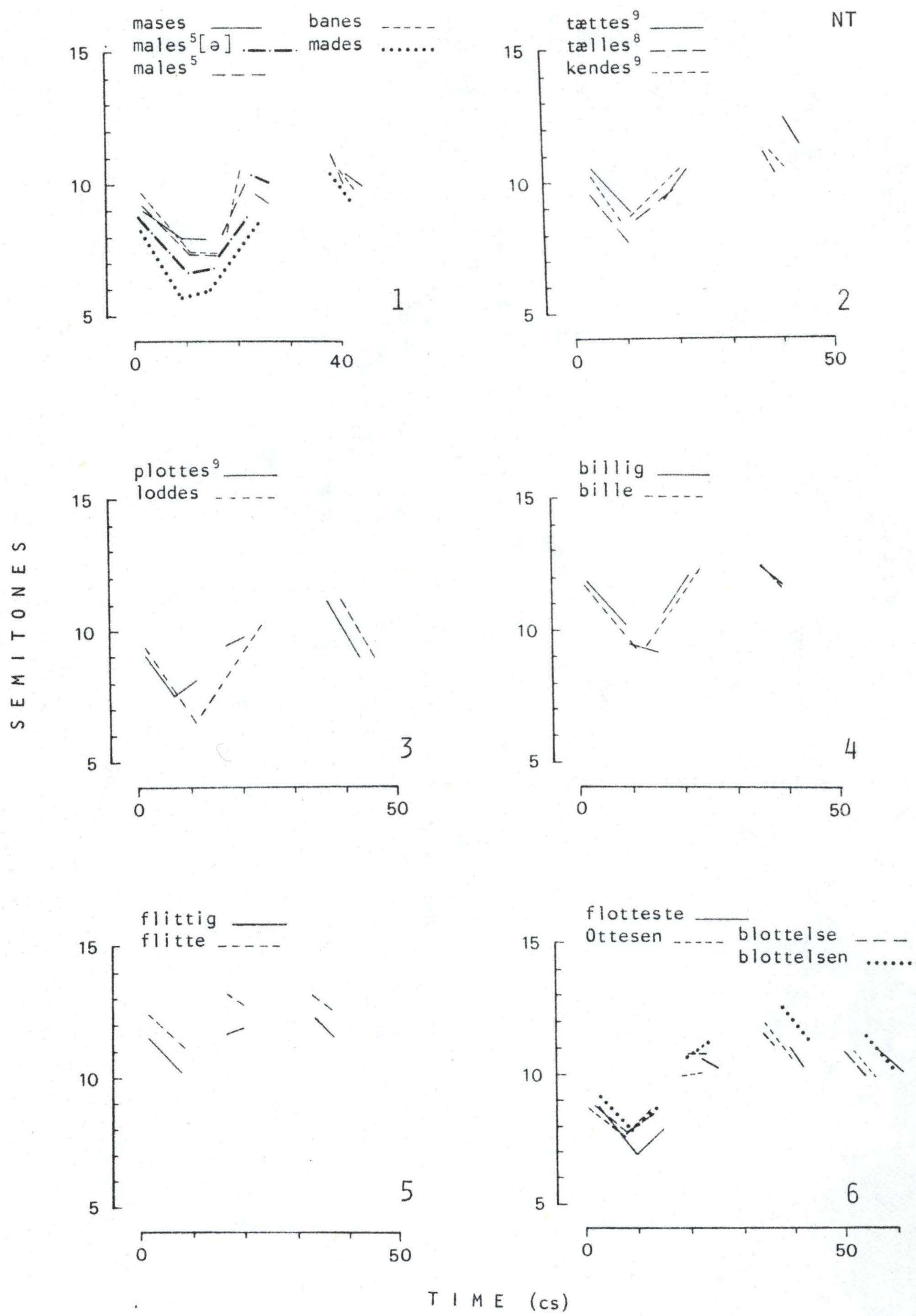
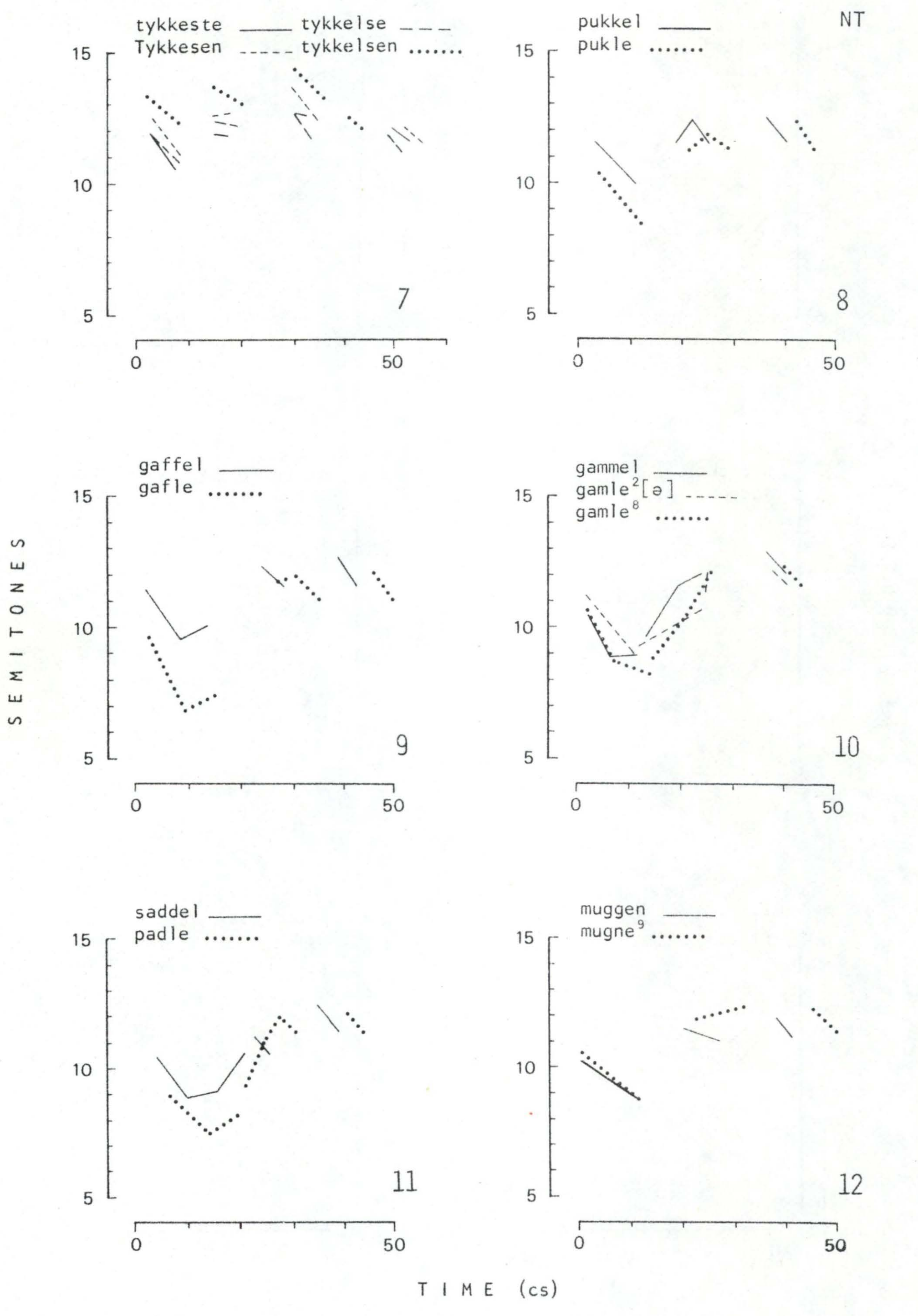
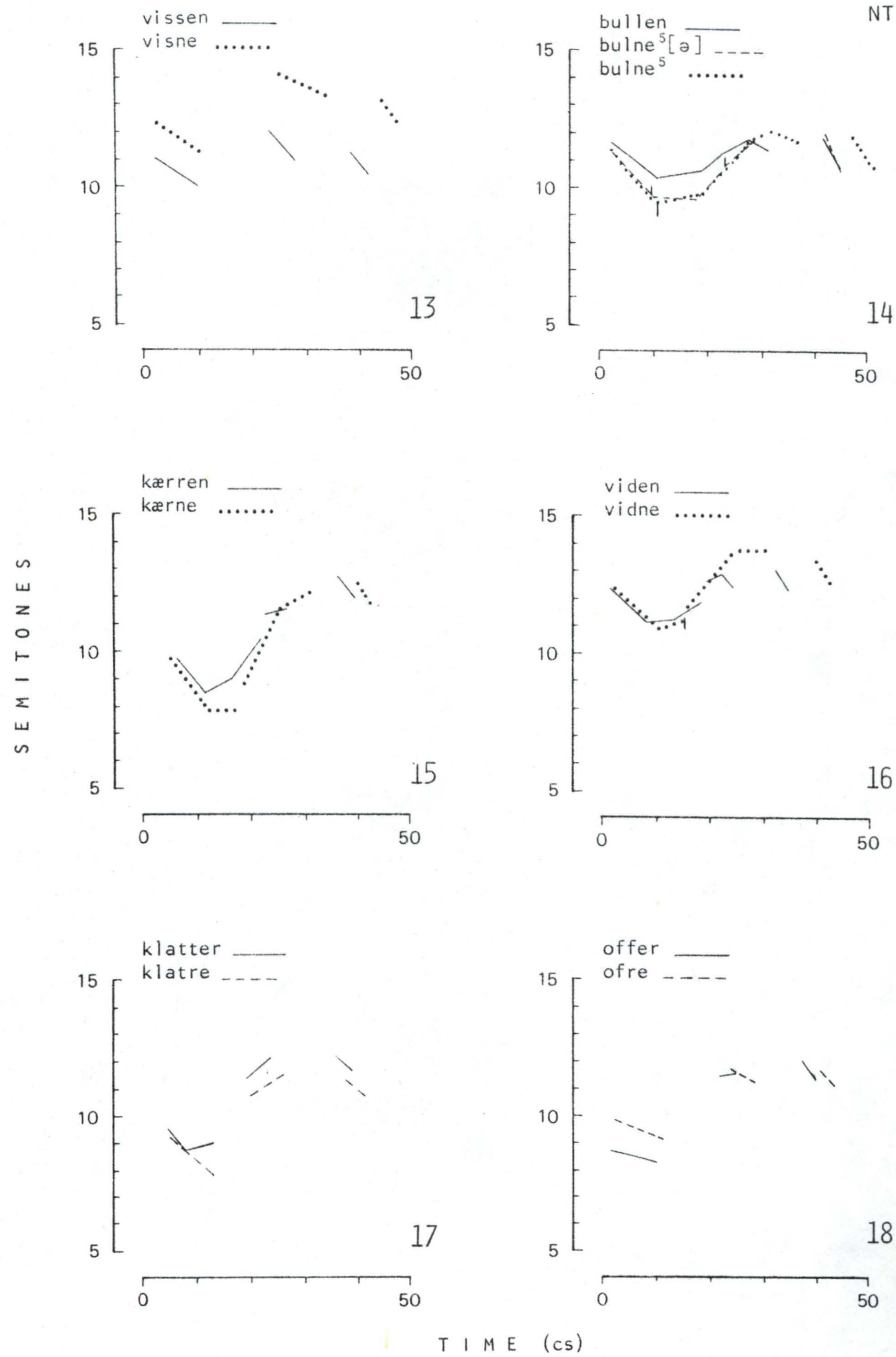


Figure 4

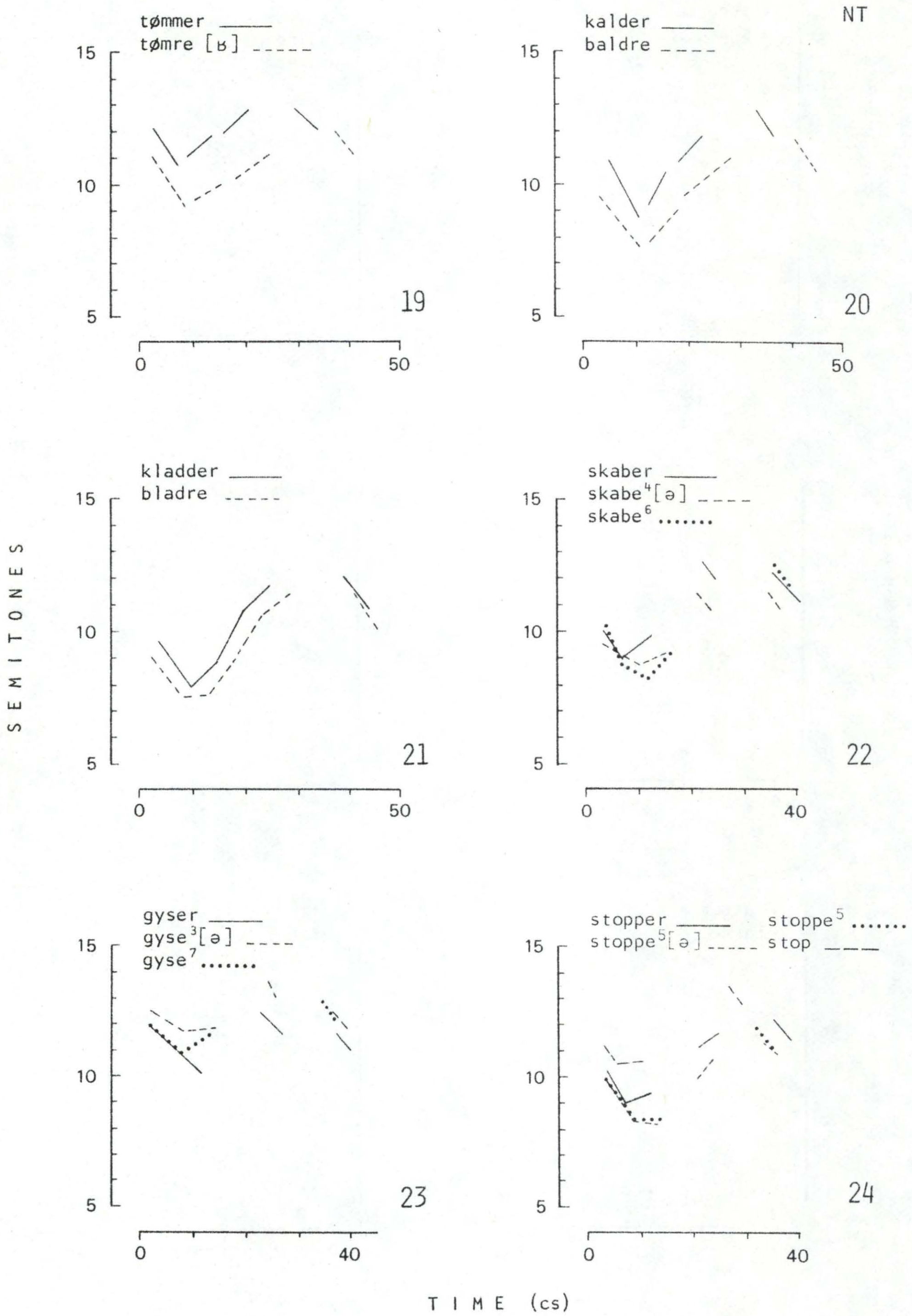
Subject NT. A raised numeral after the signatures in each frame indicates the number of items behind the average tracings, if it deviates from ten. See further the legend to figure 1.



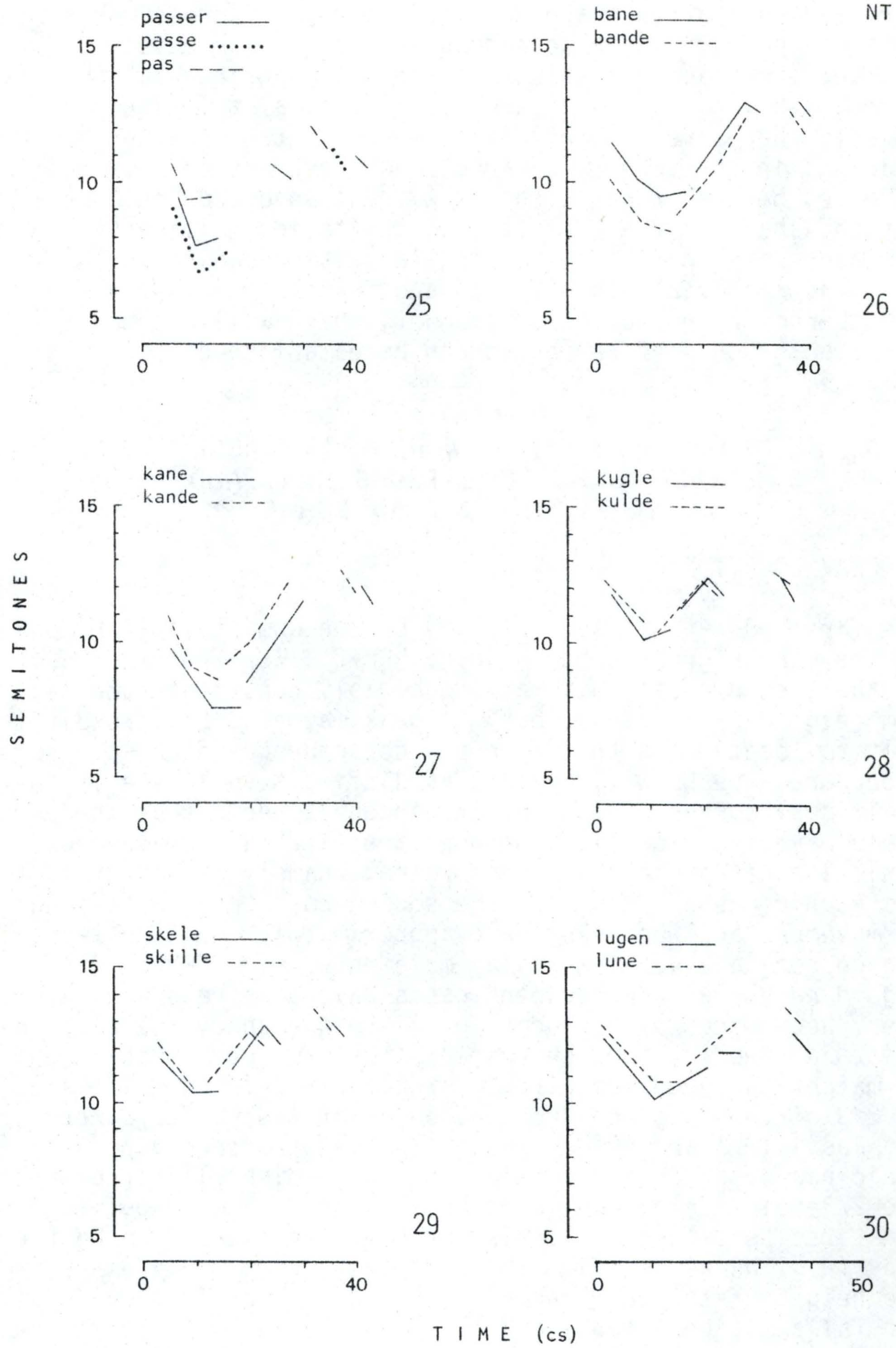
(figure 4 continued)



(figure 4 continued)



(figure 4 continued)



(figure 4 continued)

The most striking feature about figure 1-4 is how similar the stress group patterns appear to be, not just across words within a given frame but also across frames and subjects. Of course, there are variations in the low-high interval (correlated with variations in stressed vowel quality, higher or lower), there are (slight) differences in the location of the tracings in the frequency range, and there are obviously differences between words with and without unvoiced consonants. But the shape of the Fo pattern with its low falling start, the high rise and the succeeding fall is recognizable throughout practically all the figures and frames. This should be remembered in the following account, which will attempt to highlight such differences as can be established.

A. F_0 PEAK LOCATION IN WORDS WITH ASSIMILATED SCHWA, UNASSIMILATED SCHWA, AND VOWEL OTHER THAN SCHWA

1. PEAK LOCATION PROCEDURE

The first post-tonic syllable may be the unmistakable Fo peak in the stress group pattern (e.g. NRP-5 *flitte* and *flittig*) or the second post-tonic may indubitably constitute the maximum (e.g. NRP-2 *tælles*), but the peak may also be more difficult to locate (and this is not a consequence of the averaging procedure - peaks will be just as difficult to locate in the individual curves). In many instances it seems that the peak would have occurred right between the first and second post-tonic if that passage had been voiced, namely when the first post-tonic has a rising and the second post-tonic a falling Fo movement and when they have approximately the same level and do not have very extensive movements (e.g. NRP-2 *tættes*). A good number of "in between" cases have been resolved, however, according to the location on the frequency scale of the point in time within each voiced stretch which may be taken to match its perceived pitch most closely (viz. the Fo value at 2/3 of the distance from the onset of the voiced stretch, cf. Rossi 1971 and 1978), typically when the second post-tonic has an extensive falling movement which clearly brings the 2/3-point below the level of the corresponding point in the first post-tonic which is therefore considered to be the peak (e.g. NRP-4 *bille*). This procedure completely disregards the height of the peak above the preceding Fo minimum; Fo rises and falls may be extensive or minimal: a peak is a peak, be it high or slight, with the quantification adopted here.

2. INDIVIDUAL DIFFERENCES

In table I-IX (Appendix III) the information on Fo peak location is given in the shape of a simple enumeration of the number of words in the tracings that have their peak in the first post-tonic syllable (A), between the first and second post-tonic (B), and in the second post-tonic syllable (C), as judged by the average tracings in the figures. The total number of words of a particular type does not always add up to the same figure with all four subjects: some would pronounce a given word with [ə], others would assimilate it, but a subject might also pronounce the same phonological word in two different ways, in which case each pronunciation counts as a word (see figure 1-4 and appendix I). This means that although there are 69 phonologically different words in the material, the actual number is 73 with NRP, 74 with JR, 71 with BH, and 73 with NT, since they pronounced 4, 5, 3, and 6 words, respectively, in two different ways, and then one of BH's words (*tykkelse*) and two of NT's (*flotteste, passer*) defied categorization.

In the vast majority of words JR has the Fo peak in the first post-tonic syllable and so does NRP in a fair majority. These two subjects would be in good agreement, then, with what is implicit in Rischel's (1970) findings. With BH and NT the variation is greater and a good many late Fo peaks occur, cf. Table I. One reason for the difference between, on the one side, JR and NRP and, on the other side, BH and NT, a difference which is statistically significant ($p < 0.0005$), is that with BH and NT the fall of Fo in the post-tonic syllables is rather slight, wherefore a peak is not always easily determined and - due to the procedure employed - tends to be located between the first and second post-tonic or later. I do not think that this difference is a systematic male/female difference, because a slight fall through the post-tonics was also characteristic of a male subject in a previous investigation (subject SH, Thorsen 1978). The difference between NRP and JR versus BH and NT should be kept in mind through the following paragraphs.

3. SYLLABIC CONSONANT VERSUS VOWEL

In the words of part (1) (frame 1-7, table II) the distribution of Fo peaks is not significantly different with any subject, nor with subjects' total, in words with pronounced [ə] versus words with assimilated schwa. Nor is there any significant difference between the words with schwa versus the words with [i] in the post-tonic. However, a tendency appears for more words to have a later Fo peak when the first post-tonic syllable is carried by a consonant. Of course, we are not limited to part (1) in a search for a dependency between Fo peak location and phonetic composition of the post-tonic syllable. In table III are included all words in the material, and the tendency just noted appears more clearly here, the difference being significant with BH and the total. Again, no significant difference appears between schwa and any other vowel, so we may consider schwa and other vowels in the first post-tonic together vis-a-vis a syllabic consonant (table IV).

Words with two successive schwa-syllables (frame 6-7) do not appear to differ significantly from the disyllables, i.e. there is no instance of a peak located in the third post-tonic syllable and - probably due to the very limited number of items -

there is no clear systematism in peak location and segmental structure in the first post-tonic either (table V).

Concludingly, and in answer to the first set of questions in section II, we may state that there is an overall tendency - but really not very strong - for a later Fo peak location (i. e. later than in the first post-tonic syllable) in words where the post-tonic syllable is carried by a syllabic consonant than in words with a vowel (irrespective of its quality) in the first post-tonic. Peak locations later than the second post-tonic syllable do not occur. Note, however, that there are considerable differences between the subjects as to the location of Fo peaks and one (JR) has hardly any "delayed" peaks at all.

4. FURTHER SEGMENTAL DIFFERENCES

Of course, the weak overall tendency to delayed Fo peak location in words with a syllabic consonant in the first post-tonic may conceal differences within this group of words. Table VI shows that there is no significant difference between peak locations in words with a syllabic consonant after a short and a long vowel, though NRP has a tendency to later peaks after short vowels. Table VII indicates a tendency (significant with BH and NT and subjects' total) to later Fo peaks when the syllabic consonant follows directly after the vowel than when a consonant intervenes. Table VIII shows that when a consonant intervenes between the stressed vowel and the syllabic consonant it is immaterial whether the syllabic consonant derives from /Cə/ or /əC/: the majority of these words have the peak located in the first post-tonic, like they do when [ə] is pronounced. Likewise, there is no apparent tonal difference between words of the /ˈ-VCər/ versus /ˈ-VCrə/-type, whether [ʁ] is pronounced or not, cf. table IX. All these facts are connected with durational relations, cf. section B.2 below.

The data in table VIII and IX thus offer an answer to the second set of problems in section II: instances where schwa assimilation or [ʁ]-vocalization may lead to lengthening of a preceding consonant (see section C. below) have no obvious tonal consequences neither in terms of differences in Fo peak location nor in terms of differences in Fo movements, cf. frame 8-21. With table VI and frame 26-29 (and particularly table XVIII, cf. section B.) the assertion is verified that syllabic consonants after short vowels are longer than after long vowels and it is also roughly true that the Fo peak is later relative to the start of the consonant after short vowels (cf. section II (3)). - It appears from frame 30 that the one word pair in the material with a clean "pure" versus non-"pure" assimilation (in BL's terminology, cf. section II) has the expected difference in consonant and vowel durations: the consonant is longer and the vowel sound shorter in *lune* [ˈlu·n̩] than in *lugen* [ˈlu·un], but their tonal course is identical.

Incidentally, there is no support for BL's statement (p. 197) that the second [u] in *lugen* should lose its syllable-constituting pitch (cf. section II): the post-tonic syllable in the word is rising with all subjects, and constitutes the Fo maximum in the stress group with NRP and JR. (BL's example is *luen* rather than *lugen*; this difference is of no consequence for the argument, since these two words are pronounced alike at the level of distinctness where schwa assimilation takes place.)

5. PEAK LOCATION AND WORD ACCENTS

Eva Gårding (personal communication) has suggested that different tonal behaviour in the words under investigation might reflect a difference related to the Accent I/Accent II distinction in Swedish (see Gårding 1977), and she kindly supplied me with accent indications of those 53 words that have direct counterparts in Swedish. 8 of these 53 words only are "Accent I" words, namely *pukkel, gaffel, saddel, offer, tømmer, skabe, stop, pas*. In table X the distribution of the 6 polysyllabic "Accent I" and 45 "Accent II" words according to the location of the Fo maximum is shown. Fo peaks are not significantly differently distributed in the two groups of words, nor is any tonal difference apparent from the figures and there are hardly any grounds to relate such differences as have been found in the material in Fo peak location to an "underlying" Accent I/Accent II distinction.

B. F_0 PEAK LOCATION AND DURATION

1. CONSTANT Fo PATTERNS

On previous occasions (most recently in Thorsen 1982) I have suggested a description of stress group patterns in terms of an essentially invariant fundamental frequency wave upon which the segments and syllables are superposed, in a manner that makes intrasyllabic Fo movements predictable from the shape of the wave where they hit it (falling, rising etc.), Fo movements which may be modified by microprosodic microscopic (segmental) phenomena. The shape of the wave and the timing of stressed and unstressed syllables with respect to its trough and peak both vary across dialects. In Standard Danish the stressed vowel hits the wave in the trough before the fairly steep rise to the peak, which generally makes short stressed vowels falling, whereas long stressed vowels will be falling-rising (with a smaller rise than fall, see e.g. NRP-27-30, JR-27, 29, BH-27, 29, NT-27-30 where the boundary between the long vowel and succeeding sonorant consonant is clear). The height of the peak above the trough and the slope of the succeeding falling flank are subject to a certain amount of individual variation, as also witnessed by figure 1-4 here.

It seems from previous analyses that stress group patterns are simply truncated, cut short, 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 rise Fo movement, but will be simply falling (see further Thorsen 1982).

With an account along these lines, the variation in Fo peak location with respect to the first post-tonic syllables 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.

2. PEAK LOCATION AS A FUNCTION OF DURATION

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 appendix IV are assembled tables that contain such durational data. In table XI all the words of the material are included and the average duration 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 XII-XVI contain further documentation for a dependency of peak location on duration. In section A.4 above I noted that there are no significantly later peak locations in words with syllabic consonant after a short than after a long vowel, though such a tendency appears with NRP (table VI). In table XII the duration of S+P in the words behind table VI is given and it turns out that there is a significant difference between S+P in words with short and long vowel with NRP and JR, but not with BH and NT. When JR deviates from the others in having a durational difference but no difference in peak location it is of course due to the fact that the duration of S+P in words with both long and short vowel is long enough to contain a full rise.

There was a tendency for later Fo peaks in words where the syllabic consonant directly succeeds the stressed vowel than where a consonant intervenes (table VII), significant with two subjects (BH and NT). From table XIII it appears that this difference corresponds to a durational one: S+P is longer with BH (significantly so) and NT in words where a consonant intervenes between stressed vowel and syllabic consonant. The difference is very slight with NRP and JR.

Table VIII and IX showed no differences in peak locations in words of the /ˈ-VCCə/ versus /ˈ-VCəC/ structure, which all had a majority of early peaks, and from table XIV and XV it is reasonable to conclude that this is due to the fact that S+P in all these words is long enough to contain the full Fo rise from the trough to the peak of the wave.

Table XVI carries the search for a dependency of peak location on duration into greater detail. The duration of S+P(s) in pairs of words which are minimally different segmentally but which do have a difference in peak location is listed. Out of a total of 15 word pairs with different peak locations, only three do <u>not</u> have statistically significant differences in the S+P duration.

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 <u>and</u> 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 <u>can</u> 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 XVII. 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 ($p < 0.0005$).

C. SCHWA ASSIMILATION AND DURATION

1. SYLLABIC CONSONANTS AFTER LONG AND SHORT VOWELS

Syllabic consonants after short vowels (which exhibit "pure" assimilation in BL's terminology) should be longer than after long vowels, cf. section II (3) and IV.A.4. In table XVIII the duration of the vowel, syllabic consonant and their sum in four word pairs which have a clean vowel length difference is given. The syllabic consonant after a short vowel is about 3-4 cs longer than after a long vowel with three subjects, but with JR the difference is considerably smaller (between 0.6 and 2.2 cs). The difference in vowel duration is always larger than the difference in the consonants and the duration of vowel plus consonant is significantly longer in the long vowel words than in the short vowel words with three subjects.

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, the four word pairs 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 subject BH perfectly well, cf. frame 26-29, but with NRP, JR and NT the words with low vowels (*bane-bande, kane-kande*, frame 26-27) deviate: it seems that the Fo fall is extended (JR) or levelled out (NRP and NT) in the long vowel to the effect that the Fo rise as a whole is shifted to the right. With JR a rise in the final part of the long vowel is retained but this cannot be said of NRP and NT. The same tendency appears in *skele-skille* (frame 29), though less pronounced, but it is lacking in *kugle-kulde* (frame 28). 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 or disproved the way the material is structured), and one could well imagine such a process to hold up or discontinue the normal course of Fo patterns, but then again it should at least generalize to all vowels (if not all subjects), and furthermore such a compensatory lengthening should take place also when the long vowel is succeeded by an obstruent and schwa is elided (as in *skabe, gyse*), which is not the case, cf. section 3 below.

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 than I have assumed. For instance, a variety of Copenhagen Danish (Low Copenhagen in BL's terminology, p. 605-608) has a lengthening of short vowels in stød-less 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. *kulde-kugle*)?

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. Thus the post-vocalic consonant in *pukle, gafle, gamle, mugne, visne* should be longer than in *pukkel, gaffel, gammel, muggen, vissen*. Also, the syllabic consonant should be longer when it derives from /Cə/ than from /əC/. No lengthening should occur in the post-vocalic consonant of *padle, bulne, vidne* relative to *saddel, bullen, viden*. On the contrary, the post-vocalic consonant in the latter three words is the syllabic one (due to its greater sonority) and therefore it should be lengthened.

First of all, there are frequent and significant differences in the duration of the stressed vowel in the word pairs, but the differences are generally small (1-2 cs), and there is no consistent trend in their direction, cf. table XIX (a) and (b). Therefore, I shall assume that when there is a substantial difference in the duration of an unseparable vowel plus consonant(s), the stressed vowel has no part in it.

When the post-vocalic consonant is an obstruent there is a clear tendency towards the obstruent being longer in the /CCə/ 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.

Due to three subjects pronouncing [ə] and also due to segmentation difficulties *bulne-bullen* is not revealing, but from *padle-saddel* and *vidne-viden* it seems fair to conclude that the post-vocalic consonant is not lengthened, since [að] and [ið] as expected are shorter - if anything, in *padle* and *vidne*.

It is hard to say where *gamle-gammel* fits in. The pair should belong to the group of words with a post-vocalic obstruent, since [m] is less sonorous than [l] and thus both should be lengthened in *gamle*. This is hardly the case: the whole [ɑml̩] sequence is significantly longer in *gamle* with NRP and NT, but to judge from NT's data, this is mainly due to a longer syllabic consonant. With BH [ml̩] is significantly shorter in *gamle*, and with JR there is no significant difference anywhere. It is tempting to speculate that *gamle-gammel* team up with *padle-saddel* etc. in which case 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.

The syllabic consonant shows a clear tendency to be longer (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 (table XIX (c)) is fairly straightforward: when [ʁ] is vocalized the preceding consonant is longer in the /-Crə/ than in the /-Cər/ type. The considerable differences in *klatre-klatter* are partly due to the intervocalic flap-like stop in *klatter* being particularly short. BL may be correct in stating 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.

3. SCHWA ELISION AND DURATION

From table XX it seems that when schwa is dropped word finally after an unvoiced consonant (*skabø, gysø, stoppø, passø*) it really leaves no trace in the durational pattern. There are hardly any significant differences in the duration of the postvocalic consonants and only one word (NT-*passø*) has a longer consonant word finally after schwa-elision. Nor are there consistent and significant differences in the duration of the stressed vowel in words with elided schwa versus disyllabic words with pronounced [ə] or [ʌ] (*skabø* and *passø* with NT have a longer vowel than *skabe, skaber* and *passer*, but *gysø* with BH and *passø* with NRP have shorter stressed vowels than *gyser* and *passer*, respectively).

Incidentally, Fischer-Jørgensen (1964 and forthcoming) found a consistent trend towards longer stressed vowels in disyllables than monosyllables, ceteris paribus. In utterance medial position the difference averaged 2.5 cs. In the present (limited) material this rule is not without exceptions: three monosyllables (of a total of eight) do not have significantly shorter vowels than their disyllabic partners (JR's *stop*, BH's and NT's *pas*).

The slope of the Fo rise from the minimum in the stressed vowels (in semitones per second) is indicated to the right in table XX. If a (partial) compression of the Fo pattern into the stressed vowel takes place when schwa is elided, then these slopes should be steeper than when schwa (or any other vowel) is pronounced. Such steeper rises are indeed found in some words with some subjects (NRP *skabø, gysø, stoppø;* JR *gysø, stoppø;* NT *skabø, gysø, passø*). 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 disyllabic words (NRP, JR and NT *skabe-skaber*). Thirdly, some words with schwa elision have no rise at all (BH *passø;* NT *stoppø*). This variation in the movement of the stressed vowels should be ascribed to a variation of the exact timing of the vowel with respect to the trough of the Fo wave, cf. section B.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. The implication of that is that there is probably no context at all for compressed Fo patterns.

V. 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 most 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 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 lenghtened if it has less sonority than C_2 (alternatively: "if it is an obstruent") - likewise, C_1 is lengthened if C_2 is /r/, whether [ʁ] is vocalized or not.

NOTES

1) 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.

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

3) Monosyllables with long vowel invariably take stød and since the stød may have tonal side-effects, monosyllables were excluded.

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APPENDIX I

Transcription and translation of the 69 words in the material - syllabicity is indicated with a dot under the symbol, duration with one dot after the symbol. The transcriptions are idealized from the point of view of the investigation, i.e. subjects may well deviate and pronounce a schwa where a syllabic consonant was "intended", or pronounce [ʁ] rather than vocalize it, or he/she may produce the same word in two editions - as indicated on the right hand side.

(1)

			NRP	JR	BH	NT
males	[ˈmæ·l̩s]	to be painted				∅/ə
banes	[ˈb̥æ·n̩s]	to be cleared		∅/ə		
mades	[ˈmæ·ð̩s]	to be fed				
mases	[ˈmæ·səs]	to be mashed				
tælles	[ˈd̥ˢɛll̩s]	to be counted				
kendes	[ˈg̊ʰɛnn̩s]	to be recognized				
loddes	[ˈlʌðð̩s]	to be soldered				
tættes	[ˈd̥ˢɛd̥əs]	to be sealed				
plottes	[ˈb̥ʰlʌd̥əs]	to be plotted				
bille	[ˈb̥ill̩]	beetle				
billig	[ˈb̥ili]	cheap				
flitte	[ˈflid̥ə]	fleam				
flittig	[ˈflid̥i]	diligent				
tykkelse	[ˈd̥ˢyg̊l̩sə]	thickness				
tykkelsen	[ˈd̥ˢyg̊l̩sn̩]	the thickness				
Tykkesen	[ˈd̥ˢyg̊əsn̩]	invented proper name				
tykkeste	[ˈd̥ˢyg̊əsd̥ə]	thickest				
blottelse	[ˈb̥lʌd̥l̩sə]	exposure				
blottelsen	[ˈb̥lʌd̥l̩sn̩]	the exposure				
Ottesen	[ˈʌd̥əsn̩]	proper name				
flotteste	[ˈflʌd̥əsd̥ə]	finest NRP: ˈflʌd̥əsd̥∅				

(2)

			NRP	JR	BH	NT
pukle	[ˈb̥ʰɔg̊·l̩]	to slog away	ə	ə	ə	
pukkel	[ˈb̥ʰɔg̊l̩]	hump				
gafle	[ˈg̊ɑf·l̩]	to pinch	ə	ə	ə	
gaffel	[ˈg̊ɑfl̩]	fork				
gamle	[ˈg̊ɑm·l̩]	old, pl.				ə̸/ə
gammel	[ˈg̊ɑml̩]	old, sg.				
padle	[ˈb̥ʰaðl̩]	to paddle			ə	
saddel	[ˈsaðð̩l]	saddle				
mugne	[ˈmɔg̊·n̩]	to go mouldy	ə	ə		
muggen	[ˈmɔg̊n̩]	mouldy				
visne	[ˈves·n̩]	to wither	n̩/ə	ə		
vissen	[ˈvesn̩]	withered				
bulne	[ˈb̥ul·n̩]	to swell	ə	ə	ə	ə̸/ə
bullen	[ˈb̥ul̩n]	swollen				
kærne	[ˈg̊ʰæʌ̆n̩]	to churn				
kærren	[ˈg̥æʌ̆ʌn]	the cart				
vidne	[ˈvið·n̩]	to testify	ə	ə̸/ə		
viden	[ˈviðð̩n]	knowledge				
klatre	[ˈg̊ʰlad̥·ʌ]	to climb	ʁ		ʁ	
klatter	[ˈg̊ʰlad̥ʌ]	(he) blots				
ofre	[ˈʌf·ʌ]	to sacrifice	ʁ	ʁ	ʁ	
offer	[ˈʌfʌ]	sacrifice				
tømre	[ˈd̥ˢœm·ʌ]	to do carpentry				ʁ
tømmer	[ˈd̥ˢœmʌ]	(he) empties				
baldre	[ˈb̥al·ʌ]	to smash	ʁ		ʁ	
kalder	[ˈg̊ʰalʌ]	(he) calls				
bladre	[ˈb̥lað·ʌ]	to turn over the leaves				
kladder	[ˈg̊ʰlaðʌ]	drafts				

(3)			NRP	JR	BH	NT
bane	[ˈb̥æ·n̩]	track				
bande	[ˈb̥ann̩]	to swear				
kane	[ˈg̊ʰæ·n̩]	sleigh				
kande	[ˈg̊ʰann̩]	jug				
kugle	[ˈg̊ʰu·l̩]	ball				
kulde	[ˈg̊ʰull̩]	coldness				
skele	[ˈsg̊e·l̩]	to squint				
skille	[ˈsg̊ell̩]	to divide				
lune	[ˈlu·n̩]	warm				
lugen	[ˈlu·un]	the hatch				

(4)						
skabe	[ˈsg̊æ·b̥]	closets	ə̸/ə	ə̸/ə	ə̸/ə	ə̸/ə
skaber	[ˈsg̊æ·b̥ʌ]	(he is) putting on an act				
gyse	[ˈg̊y·s]	to shudder	ə̸/ə	ə̸/ə	ə̸/ə	ə̸/ə
gyser	[ˈg̊y·sʌ]	thriller				
stoppe	[ˈsd̥ʌb̥]	to stop	ə̸/ə	ə̸/ə	ə	ə̸/ə
stopper	[ˈsd̥ʌb̥ʌ]	(he) stops				
stop	[ˈsd̥ʌb̥]	fill				
passe	[ˈb̥ʰas]	to fit			ə̸/ə	
passer	[ˈb̥ʰasʌ]	calipers				
pas	[ˈb̥ʰas]	passport				

APPENDIX II

The 69 test words of the material in their carrier sentences and their translations.

(1)

Huset skal males med penslen.
The house should be painted with the brush.

Kartoflen skal mases med gaflen.
The potato should be mashed with the fork.

Barnet skal mades med skeen.
The child should be fed with the spoon.

Vejen skal banes med traktor.
The road should be cleared with a tractor.

Klassen skal tælles til frokost.
The class will be counted at lunch.

Cyklen kan kendes på farven.
The bike is recognized by its colour.

Taget skal tættes til vinter.
The roof must be sealed before the winter.

Tinnet skal loddes med omhu.
The pewter must be soldered with care.

Kurven skal plottes med omhu.
The curve must be plotted with care.

Bredde og tykkelse skal passe til hinanden.
Width and thickness must match each other.

Bredden og tykkelsen skal passe til hinanden.
The width and the thickness must match each other.

Tyndesen og Tykkesen skal hjælpe hinanden.
Mr. Skinny and Mr. Stout should help each other.

Den største og tykkeste skal hjælpe de mindste.
The biggest and stoutest one should help the smaller ones.

Det værste var en blottelse til højre for midten.
The worst was an exposure to the right of the middle.

Det værste var blottelsen til højre for midten.
The worst was the exposure to the right of the middle.

Det er Johansen og Ottesen til højre i billedet.
It is Johansen and Ottesen to the right in the picture.

Det er den største og flotteste til højre i billedet.
It is the biggest and finest to the right in the picture.

Der sidder en bille til venstre på bladet.
There is a beetle to the left on the leaf.

Den er lille og billig til glæde for kunden.
It is small and cheap to the customer's benefit.

Der ligger en flitte til venstre på bordet.
There is a fleam to the left on the table.

Han er nøjsom og flittig til glæde for konen.
He is modest and diligent to his wife's pleasure.

(2)

Han begynder at pukle til ære for chefen.
He begins to slog away to please his boss.

Han begynder at gafle til maden igen.
He begins to pinch at his food again.

Hun elsker den gamle soldat med sablen.
She loves the old soldier with the sword.

Han prøver at padle til festen på øen.
He tries to paddle to the party on the island.

De begynder at mugne til vinter igen.
They begin to moulder in the winter again.

De begynder at visne til sommer igen.
They begin to wither in the summer again.

Den begyndte at bulne til aften igen.
It began to swell in the evening again.

Han prøver at kærne til påske igen.
He tries to churn at Easter again.

Han prøver at vidne til fangernes fordel.
He tries to testify to the advantage of the prisoners.

Han begyndte at klatre på klippen igen.
He began to climb the cliff again.

Han prøver at ofre til guden igen.
He tries to sacrifice to the god again.

Hun elsker at tømre på huset i ferien.
She loves to do carpentry on her house during vacations.

Han prøver at baldre karaflen på bordet.
He tries to smash the carafe on the table.

Han begynder at bladre fra midten og ud.
He begins to turn over the leaves from the centre and outwards.

Det ligner en pukkel til højre for bjerget.
It looks like a hump to the right of the mountain.

Han bruger sin gaffel til andet end spisning.
He uses his fork for other things than eating.

Han ligner en gammel soldat fra ryggen.
He looks like an old soldier from the back.

Han henter en saddel til hesten i boksen.
He fetches a saddle for the horse in the loosebox.

Den er gammel og muggen til vinter igen.
It is old and mouldy in the winter again.

Den er gammel og vissen til sommer igen.
It is old and withered in the summer again.

Den er rødlig og bullen til aften igen.
It is red and swollen in the evening again.

Han sidder på kærren til venstre for kusken.
He sits on the cart to the left of the coachman.

Han bruger sin viden til fangernes fordel.
He uses his knowledge to the advantage of the prisoners.

Han sidder og klatter på dugen igen.
He is blotting the tablecloth again.

Han bringer et offer til guden igen.
He is sacrificing to the god again.

Han sidder og tømmer ballonen med håndkraft.
He is emptying the balloon by hand.

Han sidder og kalder på barnet i sengen.
He is calling the child in the bed.

Han prøver med kladder fra starten igen.
He tries with drafts from the start again.

(3)

Han begyndte at bande til skræk for sin kone.
He began to swear to his wife's alarm.

Det er den bedste bane til brug for galoppen.
It is the best track for the gallop.

Han henter en kande til mælken og fløden.
He fetches a jug for the milk and the cream.

Hun købte en kane til pigernes heste.
She bought a sleigh for the girls' horses.

Det blev regn og kulde til galoppen iår.
It was rainy and cold at the gallop this year.

Han støbte en kugle til kanonen igår.
He cast a ball for the cannon yesterday.

Det er bedre at skille til venstre igen.
It is better to divide on the left side again.

Han begyndte at skele til pigen igen.
He began squinting at the girl again.

De er gode og lune til brug i december.
They are good and warm for use in December.

Han sidder ved lugen til venstre for døren.
He is sitting in the hatch to the left of the door.

(4)

Der er flere skabe til pigernes tøj.
There are several closets for the girls' clothes.

Han sidder og skaber sig midt under festen.
He is putting on an act during the party.

Han begyndte at gyse på grund af historien.
He began to shudder on account of the story.

Det ligner en gyser på grund af plakaten.
It looks like a thriller to judge from the placard.

Forløbet skal stoppe så tidligt som muligt.
The course of events must be stopped as soon as possible.

Han bremser og stopper så tidligt som muligt.
He brakes and stops as soon as possible.

Han ryger et stop så tidligt som muligt.
He smokes a fill as early as possible.

Façonen skal passe til formålet.
The shape should match the purpose.

Han bruger en passer til tegningen.
He uses calipers for the drawing.

Han henter et pas til formanden.
He fetches a passport for the foreman.

APPENDIX III

In tables I-X the words in figure 1-4 are categorized according to the location of their Fo maximum (A) in the first post-tonic syllable, (B) between the first and second post-tonics and (C) in the second post-tonic syllable. The number of words in each category is listed for each subject and subjects' total. The distribution of the words in the three categories is compared across words with different segmental structure: The data may meet the requirements for a χ^2 test on the basis of a 3x2 contingency table or they may only meet the requirements for a χ^2 test on the basis of a 2x2 contingency table, cf. Siegel (1956). If χ^2 is not applicable in the 2x2 case either, the Fischer exact probability test is applied. p is given if smaller than 0.05.

Table I

Distribution of words according to the location of the Fo maximum. All words in the material are included. See further the introduction to appendix III.

	A	B	C	total
NRP	50	13	10	73
JR	66	8	0	74
BH	16	26	29	71
NT	29	24	20	73
total	161	71	59	

Table II

Distribution of words according to the location of the Fo maximum. Words from part (1) of the material, frames 1-7 in figure 1-4: words with [i] in the first post-tonic (left), with [ə] (mid) and with a syllabic consonant (right). See further the introduction to appendix III.

	[i]			[ə]			[ç̩]		
	A	B	C	A	B	C	A	B	C
NRP	2	0	0	5	3	0	3	3	5
JR	2	0	0	7	1	0	8	3	0
BH	0	2	0	1	5	2	0	3	7
NT	0	2	0	2	1	4	2	4	5
total	4	4	0	15	10	6	13	13	17

Table III

Distribution of words according to the location of the Fo maximum. All words in the material are included: words with a vowel other than [ə] in the first post-tonic syllable (left), with [ə] (mid) and words with a syllabic consonant (right). See further the introduction to appendix III.

	Vowel other than [ə]			[ə]				[C̩]		
	A	B	C	A	B	C		A	B	C
NRP	18	1	1	14	3	0		18	9	5
JR	20	0	0	17	1	0		28	4	0
BH	3	10	7	7	5	4	$p<0.05$	4	13	15
NT	8	8	3	5	3	5		14	15	8
total	49	19	11	43	12	9	$p<0.01$	64	41	28

Table IV

Distribution of words according to the location of the Fo maximum. 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 left block of data is a summation of the left and mid blocks of table III. See further the introduction to appendix III.

	[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

Table V

Distribution of words according to the location of the Fo maximum. Trisyllabic words from part (1c) of the material (frame 6-7 in figure 1-4): words with [ə] in the first post-tonic syllable (left) and words with syllabic [ḷ] (right). See further the introduction to appendix III.

	[ə]			[C̣]		
	A	B	C	A	B	C
NRP	2	2	0	1	1	2
JR	4	0	0	3	1	0
BH	0	3	1	0	3	0
NT	0	1	2	1	1	2
total	6	6	3	5	6	4

Table VI

Distribution of words according to the location of the Fo maximum. Words ending in [-V·C̣(s)] or [-VVC̣] versus [-VC̣(s)] ([C] = [l n]): *males, banes, mades, kærne, bane, kane, kugle, skele, lune* versus *tælles, kendes, loddes, bille, saddel, bande, kande, kulde, skille*). See further the introduction to appendix III.

	[-V·C̣(s)]			[-VC̣(s)]		
	A	B	C	A	B	C
NRP	6	2	1	2	5	2
JR	8	1	0	7	2	0
BH	0	3	6	0	0	9
NT	1	6	2	1	5	3
total	15	12	9	10	12	14

Table VII

Distribution of words according to the location of the Fo maximum. Words with a syllabic consonant in the first post-tonic syllable after a (long or short) vowel or diphthong versus a consonant (*males, banes, mades, tælles, kendes, loddes, bille, saddel, kærne, viden, lune, bane, bande, kane, kande, kugle, kulde, skele, skille* versus *tykkelse, tykkelsen, blottelse, blottelsen, pukle, pukkel, gafle, gaffel, gamle, gammel, padle, mugne, muggen, visne, vissen, bulne, vidne*). See further the introduction to appendix III.

	[-V(·)C̩(C)]				[-VCC̩]		
	A	B	C		A	B	C
NRP	9	7	3		8	2	2
JR	16	3	0		10	1	0
BH	0	4	15	$p<0.0005$	2	10	0
NT	3	11	5	$p<0.001$	10	4	3
total	28	25	23	$p<0.001$	30	17	5

Table VIII

Distribution of words according to the location of the Fo maximum. Words ending in /-Cəl/ and /-Cən/ versus /-Clə/ and /-Cnə/ (*pukkel, gaffel, gammel, muggen, vissen,* versus *pukle, gafle, gamle, padle, mugne, visne, bulne, vidne*), where /ə/ is assimilated in the /-CəC/ type (left), where [ə] is pronounced in the /-CCə/ type (mid), and where /ə/ is assimilated in the /-CCə/ type (right). See further the introduction to appendix III.

	[C̩] /-CəC/			[ə] /-CCə/			[C̩] /-CCə/		
	A	B	C	A	B	C	A	B	C
NRP	5	0	0	6	0	0	2	1	0
JR	5	0	0	6	0	0	3	0	0
BH	2	3	0	4	0	0	1	3	0
NT	2	2	1	1	1	0	7	1	0
total	14	5	1	17	1	0	13	5	0

Table IX

Distribution of words according to the location of the Fo maximum. Words ending in /-Crə/ versus /-Cər/ (*klatre, ofre, tømre, baldre, bladre* versus *klatter, offer, tømmer, kalder, kladder*), where [ʁ] is pronounced in the /-Crə/ type (left), where /r/ is vocalized in the /-Crə/ type (mid), and where /r/ is vocalized in the /-Cər/ type (right). See further the introduction to appendix III.

	[ʁʌ] /-Crə/			[C·ʌ] /-Crə/			[Cʌ] /-Cər/		
	A	B	C	A	B	C	A	B	C
NRP	3	0	0	2	0	0	3	1	1
JR	1	0	0	4	0	0	5	0	0
BH	1	2	1	0	1	0	0	3	2
NT	0	0	1	3	1	0	3	1	1
total	5	2	2	9	2	0	11	5	4

Table X

Distribution of words according to the location of the Fo maximum. 45 (left) and 6 (right) polysyllabic words whose Swedish counterparts have Accent II and Accent I, respectively. Two different pronunciations of the same phonological word count as two words here, which is why individual totals do not add up to 45 and 6, respectively. See further the introduction to appendix III.

	"Accent II"			"Accent I"		
	A	B	C	A	B	C
NRP	33	8	7	5	1	1
JR	44	5	0	6	1	0
BH	8	16	22	2	3	2
NT	18	17	10	3	2	2
total	103	46	39	16	7	5

APPENDIX IV

In table XI-XVI the average duration in centiseconds (mean of means) of the stressed and first post-tonic syllable is given for various groups or pairs of words. Duration is measured from the onset of the stressed vowel to the offset of voicing in the post-tonic. 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 (table XI-XV) or between word pairs (table XVI) have been performed, and *p* is given if smaller than 0.05.

Table XI

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 syllables, and (C) in the second post-tonic syllable. See further the introduction to appendix IV.

		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: $p<0.0005$

Table XII

Average duration of the stressed and first post-tonic syllable in the two groups of words in table VI. See further the introduction to appendix IV.

		[-V·C̣(s)]		[-VC̣(s)]
NRP	$\bar{X}$ =	26.6 cs	p<0.005	22.5 cs
	s =	3.15 -		2.70 -
	N =	9		9
JR	$\bar{X}$ =	20.7 cs	p<0.025	16.9 cs
	s =	4.75 -		3.39 -
	N =	9		9
BH	$\bar{X}$ =	22.0 cs		20.8 cs
	s =	3.22 -		3.34 -
	N =	9		9
NT	$\bar{X}$ =	26.5 cs		23.8 cs
	s =	3.47 -		3.39 -
	N =	9		9

Table XIII

Average duration of the stressed and first post-tonic syllable in the two groups of words in table VII. See further the introduction to appendix IV.

		[-V(·)C̣(C)]		[-VCC̣]
NRP	$\bar{X}$ =	24.6 cs		24.9 cs
	s =	3.49 -		3.0 -
	N =	19		12
JR	$\bar{X}$ =	18.9 cs		19.5 cs
	s =	4.33 -		2.65 -
	N =	19		11
BH	$\bar{X}$ =	20.4 cs	p<0.005	24.4 cs
	s =	5.47 -		2.45 -
	N =	19		12
NT	$\bar{X}$ =	25.1 cs		27.2 cs
	s =	3.52 -		4.47 -
	N =	19		17

Table XIV

Average duration of the stressed and first post-tonic syllable in the three groups of words in table VIII. See further the introduction to appendix IV.

		a	b	c	
		[C̩] /-CəC/	[ə] /-CCə/	[C̩] /-CCə/	
NRP	$\bar{X}$ =	25.4 cs	26.0 cs	27.2 cs	
	s =	1.97 -	1.60 -		
	N =	5	6	3	
JR	$\bar{X}$ =	20.8 cs	23.6 cs	20.5 cs	b>a: $p<0.025$
	s =	2.15 -	1.61 -		
	N =	5	6	3	
BH	$\bar{X}$ =	25.1 cs	25.4 cs	25.3 cs	
	s =	1.79 -	1.34 -		
	N =	5	4	3	
NT	$\bar{X}$ =	26.3 cs	29.2 cs	30.2 cs	c>a: $p<0.025$
	s =	1.66 -		3.91 -	
	N =	5	2	8	

Table XV

Average duration of the stressed and first post-tonic syllable in the three groups of words in table IX. See further the introduction to appendix IV.

		a	b	c	
		[ʁʌ] /-Crə/	[C·ʌ] /-Crə/	[Cʌ] /-Cər/	
NRP	$\bar{X}$ =	26.0 cs	24.5 cs	21.1 cs	
	s =			1.54 -	
	N =	3	2	5	
JR	$\bar{X}$ =	25.3 cs	22.0 cs	20.0 cs	
	s =		3.05 -	3.09 -	
	N =	1	4	5	
BH	$\bar{X}$ =	23.4 cs	22.7 cs	20.3 cs	a>c: $p<0.025$
	s =	1.53 -		3.33 -	
	N =	4	1	5	
NT	$\bar{X}$ =	24.9 cs	26.1 cs	23.1 cs	
	s =		3.49 -	1.69 -	
	N =	1	4	5	

Table XVI

Average duration of the stressed and post-tonic syllable(s) in words with a pairwise comparable segmental structure and a difference in Fo peak location: (A) in the first post-tonic, (B) between the first and second post-tonic, and (C) in the second post-tonic syllable. Duration from stressed vowel onset till the offset of voicing in the second post-tonic is given when one word in a pair has the peak located in the second post-tonic. See further the introduction to appendix III.

NRP			$\bar{X}$	s	N	
mases	(A)	[æ·sə]	27.8 cs	1.14 cs	5	p<0.0005
males	(B)	[æ·l̩]	23.0 -	1.00 -	5	
tættes til	(B)	[ɛd̥əs d̥ˢe]	39.5 -	1.22 -	6	p<0.0005
tælles til	(C)	[ɛll̩s d̥ˢe]	36.3 -	0.52 -	6	
bane	(A)	[æ·n̩]	29.7 -	1.21 -	6	p<0.0005
bande	(B)	[ann̩]	26.0 -	0.63 -	6	
kane	(A)	[æ·n̩]	31.0 -	1.26 -	6	p<0.0005
kande	(B)	[ann̩]	25.2 -	0.75 -	6	
kugle	(A)	[u·l̩]	25.6 -	0.89 -	5	p<0.0005
kulde	(B)	[ull̩]	21.4 -	1.14 -	5	
JR						
tættes	(A)	[ɛd̥ə]	13.4 -	1.14 -	5	not sign.
tælles	(B)	[ɛll̩]	13.3 -	0.81 -	6	
kugle	(A)	[u·l̩]	16.6 -	0.55 -	5	p<0.0005
kulde	(B)	[ull̩]	13.3 -	0.52 -	6	
BH						
mases med	(A)	[æ·sə]	39.0 -	2.71 -	4	p<0.025
males med	(C)	[æ·l̩]	34.7 -	2.73 -	6	
bille til	(C)	[ill̩ d̥ˢe]	28.7 -	1.86 -	6	not sign.
billig til	(B)	[ili d̥ˢe]	29.4 -	0.89 -	5	
pukle	(A)	[ɔg̊lə]	23.7 -	0.52 -	6	p<0.05
pukkel	(B)	[ɔg̊l̩]	22.5 -	1.38 -	6	
kærne til	(B)	[æʌ̆n̩ d̥ˢe]	34.7 -	4.72 -	6	not sign.
kærren til	(C)	[æʌ̆ʌn d̥ˢe]	37.2 -	2.99 -	6	

(continued)

(Table XVI continued)

NT		$\bar{X}$	s	N	
gafle	(A) [ɑf·l̩ˀ]	33.9 cs	2.28 cs	10	p<0.0005
gaffel	(B) [ɑfl̩ˀ]	27.3 -	0.95 -	10	
mugne	(A) [ɔg̊·n̩]	33.3 -	1.58 -	9	p<0.0005
muggen	(B) [ɔg̊ŋ̩ˀ]	26.7 -	0.82 -	10	
kærne til	(B) [æʌ̆n̩ d̥ˢe]	41.5 -	1.72 -	10	p<0.005
kærren til	(C) [æʌ̆ʌn d̥ˢe]	38.9 -	1.52 -	10	
bane	(A) [æ·n̩]	30.1 -	0.99 -	10	p<0.01
bande	(B) [ann̩]	28.7 -	1.25 -	10	

Table XVII

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

APPENDIX V

In table XVIII-XX the duration (in centiseconds) of vowels and consonants in the word pairs of parts (3), (4) and (2) of the material is listed. Standard deviations, s, and the number of items, N, behind each mean are given. Tests of significance (student's t-test) have been performed, and *p* is indicated if smaller than 0.05.

Table XVIII

Average duration of the long and short vowel and the syllabic consonant in the words of part (3) of the material. Vowel and consonant could not always be separated, and their summed value is given.

		V	C	V+C
NRP				
bane/bande	$\bar{X}$ =	18.2/11.7	11.5/14.3	29.7/26.0 cs
N= 6/6	s =	0.75/1.03	1.38/0.82	1.21/0.63 cs
	p <	0.0005	0.005	0.0005
kane/kande	$\bar{X}$ =	19.2/10.5	11.8/14.7	31.0/25.2 cs
N= 6/6	s =	0.98/0.84	0.75/0.52	1.26/0.75 cs
	p <	0.0005	0.0005	0.0005
kugle/kulde	$\bar{X}$ =	16.8/10.2	8.8/11.2	25.6/21.4 cs
N= 5/5	s =	0.84/0.84	0.84/0.45	0.89/1.14 cs
	p <	0.0005	0.0005	0.0005
skele/skille	$\bar{X}$ =	17.0/ 9.3	8.5/11.7	25.5/21.0 cs
N= 6/6	s =	1.10/0.52	1.22/0.82	1.87/1.10 cs
	p <	0.0005	0.0005	0.0005
JR				
bane/bande	$\bar{X}$ =	16.7/12.3	7.3/ 8.5	24.0/20.8 cs
N= 6/6	s =	0.82/0.82	0.52/1.38	0.63/1.47 cs
	p <	0.0005	0.05	0.0005
kane/kande	$\bar{X}$ =	15.7/10.5	7.5/ 8.2	23.2/18.7 cs
N= 6/6	s =	1.03/1.38	0.84/1.60	0.75/0.82 cs
	p <	0.0005	-	0.0005
kugle/kulde	$\bar{X}$ =			16.6/13.3 cs
N= 5/6	s =			0.55/0.52 cs
	p <			0.0005
skele/skille	$\bar{X}$ =	12.2/ 7.0	4.6/ 6.8	16.8/13.8 cs
N= 5/6	s =	1.64/0.89	1.14/0.98	2.28/1.17 cs
	p <	0.0005	0.0005	0.025

(continued)

(Table XVIII continued)

			V	C	V+C
BH					
	bane/bande	$\bar{X}$ =	17.0/13.5	7.0/11.5	24.0/25.0 cs
	N= 5/6	s =	1.22/1.05	1.22/0.84	1.87/1.41 cs
		p <	0.0005	0.0005	-
	kane/kande	$\bar{X}$ =	17.3/12.8	8.0/12.7	25.3/25.5 cs
	N= 6/6	s =	1.97/0.41	1.67/1.97	2.88/2.17 cs
		p <	0.0005	0.005	-
	kugle/kulde	$\bar{X}$ =	/8.8	/8.6	17.7/17.4 cs
	N= 6/5	s =	/0.84	/0.89	1.37/0.89 cs
		p			-
	skele/skille	$\bar{X}$ =	14.0/ 9.0	5.2/ 8.5	19.2/17.5 cs
	N= 6/5	s =	0.63/0.89	0.98/1.05	1.60/1.87 cs
		p <	0.0005	0.0005	-
NT					
	bane/bande	$\bar{X}$ =	17.2/13.2	12.9/15.5	30.1/28.7 cs
	N= 10/10	s =	1.23/0.92	1.29/0.97	0.99/1.25 cs
		p <	0.0005	0.0005	0.01
	kane/kande	$\bar{X}$ =	17.7/13.8	12.8/14.1	30.5/27.9 cs
	N= 10/10	s =	0.95/0.92	1.14/0.99	1.51/1.10 cs
		p <	0.0005	0.01	0.0005
	kugle/kulde	$\bar{X}$ =	13.8/ 8.6	9.8/13.7	23.6/22.6 cs
	N= 10/10	s =	1.14/0.70	0.79/1.25	0.97/1.16 cs
		p <	0.0005	0.0005	0.05
	skele/skille	$\bar{X}$ =	14.0/ 9.1	10.2/12.5	24.2/21.6 cs
	N= 10/10	s =	0.82/0.74	1.03/0.97	1.23/0.70
		p <	0.0005	0.0005	0.0005

Table XIX

Average duration of selected segments in the word pairs of part (2) of the material. If a subject's pronunciation deviates from the maximally reduced one in the /-CCə/ type it is noted to the right of subjects' initials, cf. appendix I (2). If a word is pronounced in two ways, only the maximally reduced one is included here. See further the introduction to appendix V.

(a)

pukle/pukkel		[ɔ]	[g̊]	[l̩]	[lə]
NRP [ə]	$\bar{X}$ =	10.0/11.3	10.3/6.8	/5.2	4.5/
N= 6/6	s =	0.63/0.82	2.42/1.17	/0.75	1.52/
	p <	0.01	0.005		
JR [ə]	$\bar{X}$ =	7.2/7.3	8.3/5.0	/6.2	6.3/
N = 6/6	s =	0.41/0.82	0.82/0.00	/0.41	0.52/
	p <		0.0005		
BH [ə]	$\bar{X}$ =	8.3/10.8	10.7/5.7	/6.0	4.7/
N= 6/6	s =	1.21/1.34	1.21/0.82	/1.10	0.52/
	p <	0.005	0.0005		
NT	$\bar{X}$ =	11.5/10.8	8.4/6.7	9.4/7.0	
N=10/10	s =	0.97/0.63	1.17/0.82	1.84/1.33	
	p <	0.05	0.0005	0.005	

gafle/gaffel		[ɑ]	[fl]	[f]	[l̩]
NRP [ə]	$\bar{X}$ =	13.3/14.3	12.6/12.8	/8.3	/4.5
N= 5/6	s =	0.52/0.52	0.55/0.75	/1.21	/1.05
	p <	0.005			
JR [ə]	$\bar{X}$ =	10.1/10.8	8.9/11.0	/5.8	/5.2
N= 7/6	s =	0.69/0.75	1.21/0.63	/0.75	/0.75
	p <		0.005		
BH [ə]	$\bar{X}$ =	11.8/15.0	12.6/11.7	/5.7	/6.0
N= 5/6	s =	1.64/1.10	2.61/2.07	/0.52	/2.19
	p <	0.005			
NT	$\bar{X}$ =	14.4/12.9		11.1/9.2	8.4/5.2
N=10/10	s =	0.84/0.88		0.57/1.23	1.84/0.79
	p <	0.005		0.0005	0.0005

(continued)

(Table XIX continued)

gamle/gammel		[ɑ]	[m̩]		[ɑm̩]
NRP	X̄ =	/12.7	/11.0		25.2/23.7
N= 6/6	s =	/0.82	/0.63		1.76/1.21
	p <				0.05
JR	X̄ =	9.0/9.2	9.7/9.2		18.7/18.3
N= 6/6	s =	0.89/0.41	1.37/0.98		1.03/0.82
	p <				
BH	X̄ =	11.6/11.5	11.4/12.7		23.0/24.2
N= 5/6	s =	1.14/0.55	0.55/1.51		1.00/1.47
	p <		0.05		
			[m]	[l̩]	
NT	X̄ =	12.3/12.0	7.4/7.0	7.6/5.8	27.3/24.8
N= 8/10	s =	0.46/0.47	1.06/1.33	1.77/1.03	1.28/1.03
	p <			0.025	0.0005
padle/saddel		[að]	[l]	[aðl]	
NRP	X̄ =			27.5/25.2	
N= 6/6	s =			1.38/0.55	
	p <			0.005	
JR	X̄ =	15.4/17.5	7.4/5.2		
N= 5/6	s =	0.55/1.38	0.89/0.75		
	p <	0.005	0.005		
BH [ə]	X̄ =	16.8/18.2	3.8/5.2		
N= 4/6	s =	1.26/1.94	0.96/0.75		
	p <		0.025		
NT	X̄ =	19.4/19.6	10.8/5.1		
N=10/10	s =	1.26/1.43	1.14/1.10		
	p <		0.0005		

(b)

mugne/muggen		[ɔ]	[g̊]	[nə]	[n̩/ŋ̍]
NRP [ə]	X̄ =	10.8/12.0	9.8/7.0	6.3/	/6.3
N= 6/6	s =	1.17/1.79	1.17/0.89	1.51/	/1.03
	p <		0.0005		
JR [ə]	X̄ =	8.8/8.8	9.3/6.5	7.5/	/7.2
N= 6/6	s =	0.98/0.75	1.03/1.22	0.84/	/1.17
	p <		0.005		
BH	X̄ =	9.6/9.5	8.8/8.3		8.2/7.7
N= 5/6	s =	1.14/1.38	1.30/1.03		1.03/1.03
	p <				
NT	X̄ =	11.0/9.9	9.7/8.1		12.7/8.7
N= 9/10	s=	0.87/0.74	1.12/0.88		1.50/0.82
	p <	0.005	0.005		0.0005

(continued)

(Table XIX continued)

visne/vissen		[e]	[s]	[nə]	[n̩]
NRP	$\bar{X}$ =	10.3/9.7	11.7/11.3		6.7/6.7
N= 3/6	s =	- /0.52	- /1.75		- /1.03
	p <				
JR [ə]	$\bar{X}$ =	8.5/7.7	10.3/9.2	5.8/	/5.8
N= 6/6	s =	0.55/1.03	0.52/1.17	0.75/	/0.75
	p <		0.05		
BH	$\bar{X}$ =	8.8/9.8	11.7/10.0		6.8/6.8
N= 6/6	s =	1.33/0.41	1.51/1.79		1.60/1.60
	p <				
NT	$\bar{X}$ =	10.4/10.0	12.7/11.5		11.1/6.9
N=10/10	s =	0.84/0.67	1.06/0.71		2.42/1.20
	p <		0.005		0.0005
bulne/bullen		[u]	[l]	[n]	[lnə]
NRP [ə]	$\bar{X}$ =	11.0/9.3	/11.8	/7.2	14.0/
N= 5/6	s =	1.41/1.21	/1.60	/1.72	1.41/
	p <	0.025			
		[ulnə/ul̩n]			
JR [ə]	$\bar{X}$ =	24.4/22.5			
N= 5/6	s =	1.14/1.38			
	p <	0.025			
		[u]	[l]	[uln]	
BH [ə]	$\bar{X}$ =	10.3/	10.5/	20.8/27.5	
N= 6/6	s =	1.75/	2.81/	1.47/1.87	
	p <			0.0005	
NT	$\bar{X}$ =	11.0/10.2	25.8/21.7		
N= 5/10	s =	0.71/0.92	1.48/1.57		
	p <	0.05	0.0005		
vidne/viden		[iðnə/iðn̩]			
NRP [ə]	$\bar{X}$ =	24.2/26.7			
N= 5/6	s =	1.30/2.25			
	p <	0.025			
		[ið]	[n]		
JR	$\bar{X}$ =	12.7/15.2	7.3/4.0		
N= 3/6	s =	- /1.47	- /0.63		
	p <				
BH	$\bar{X}$ =	11.8/14.2	12.2/9.8		
N= 6/6	s =	1.72/1.33	2.93/1.17		
	p <	0.025	0.05		
NT	$\bar{X}$ =	15.5/18.2	15.2/6.0		
N=10/10	s =	1.35/0.79	1.03/0.67		
	p <	0.0005	0.0005		

(continued)

(Table XIX continued)

kærne/kærren		[æʌ̆(ʌ)]	[n]
NRP	$\bar{X}$ =	15.5/20.0	12.8/6.2
N= 6/6	s =	0.55/1.79	1.17/0.75
	p <	0.0005	0.0005
JR	$\bar{X}$ =	14.3/17.5	5.5/3.5
N= 6/6	s =	1.63/1.05	0.55/0.55
	p <	0.005	0.0005
BH	$\bar{X}$ =	16.5/21.5	9.7/6.7
N= 6/6	s =	1.38/1.38	2.34/0.82
	p <	0.0005	0.005
NT	$\bar{X}$ =	16.4/21.4	14.7/5.0
N=10/10	s =	0.84/0.84	1.34/0.82
	p <	0.0005	0.0005

(c)

klatre/klatter		[a]	[d̥]
NRP [ʁ]	$\bar{X}$ =	10.2/11.3	12.0/4.3
N= 6/6	s =	0.41/0.82	1.26/1.03
	p <	0.01	0.0005
JR	$\bar{X}$ =	9.0/10.2	8.0/4.3
N= 6/6	s =	0.00/0.75	0.89/0.82
	p <	0.005	0.0005
BH [ʁ]	$\bar{X}$ =	9.5/9.3	11.3/3.7
N= 6/6	s =	1.22/1.63	1.03/0.82
	p <		0.0005
NT	$\bar{X}$ =	11.8/12.7	6.4/4.0
N=10/10	s =	0.42/0.48	0.70/0.82
	p <	0.005	0.0005

ofre/offer: the stressed vowel could not be segmented from the preceding sound in *ofre*; three subjects pronounced the [ʁ] which was devoiced and could not be reliably segmented from the preceding [f].

		[f]
NT	$\bar{X}$ =	12.4/9.9
N=10/10	s =	1.43/0.88
	p <	0.0005

(continued)

(Table XIX continued)

tømre/tømmer		[œ]	[m]	
NRP	$\bar{X}$ =	8.8/7.8	6.6/5.0	
N= 5/6	s =	0.84/0.98	0.89/0.89	
	p <		0.01	
JR	$\bar{X}$ =	6.5/6.5	6.7/5.2	
	s =	0.55/0.84	0.52/0.41	
	p <		0.0005	
BH [ʁ]	$\bar{X}$ =	6.5/5.5	8.4/7.5	
N= 6/6	s =	0.55/1.22	1.34/ -	
	p <			
NT [ʁ]	$\bar{X}$ =	8.5/6.4	7.3/6.9	
N=10/10	s =	0.71/0.52	0.82/0.74	
	p <	0.0005		
baldre/kalder		[a]	[l]	[lʌ]
NRP [ʁ]	$\bar{X}$ =	10.3/10.2	7.3/4.6	
N= 6/5	s =	0.52/0.45	1.03/0.55	
	p <		0.0005	
JR	$\bar{X}$ =	10.9/10.2		15.6/4.3
N= 7/6	s =	0.69/0.75		1.13/0.52
	p <			
BH [ʁ]	$\bar{X}$ =	11.3/10.8	5.8/5.3	
N= 6/6	s =	1.21/0.75	0.96/0.52	
	p <			
NT	$\bar{X}$ =	10.2/10.6	7.5/5.2	
N=10/10	s =	0.61/0.97	0.97/0.79	
	p <		0.0005	
bladre/kladder		[aðʌ]		
NRP	$\bar{X}$ =	26.0/22.3		
N= 6/6	s =	1.26/0.82		
	p <	0.0005		
JR	$\bar{X}$ =	20.5/20.8		
N= 6/6	s =	0.55/1.47		
	p <			
BH	$\bar{X}$ =	22.7/22.2		
N= 6/6	s =	1.63/1.72		
	p <			
NT	$\bar{X}$ =	28.8/25.0		
N=10/10	s =	1.62/1.25		
	p <	0.0005		

Table XX

Average duration of the stressed vowel and postvocalic consonant in the words of part (4) of the material. *skabe̸* was followed by *til* and [b̥d̥^{s}] could not be separated. See further the introduction to appendix V. For reasons of clarity *p* is given only for the comparisons between words with elided schwa and disyllabic words. The Fo rise in the stressed vowel (in semitones per second) is given to the right.

	V $\bar{X}$ / s /N		C $\bar{X}$ / s /N		Fo rise in semitones/ second
NRP					
skabe	18.0/0.82/4		3.8/0.96/4		20
skabe̸	15.3/ - /3		-		33
skaber	15.3/0.82/6		6.2/2.23/6		15
gyse	13.8/0.50/4		8.0/ - /3		4
gyse̸	14.0/0.82/4		6.3/0.96/4	$p<0.005$	29
gyser	13.5/1.38/6		9.0/1.26/6		18
stoppe	14.3/ - /3		5.0/ - /3		9
stoppe̸	12.5/0.58/4		6.5/0.58/4		32
stopper	13.7/1.03/6		6.3/1.37/6		4
stop	10.8/0.75/6		5.5/1.05/6		43
passe̸	12.2/0.75/6	$p<0.025$	5.7/0.52/6		18
passer	13.5/1.05/6		7.7/0.82/6		23
pas	11.3/0.52/6		5.7/1.03/6		34
JR					
skabe	13.8/0.50/4		4.5/0.58/4		36
skabe̸	13.5/ - /2		-		31
skaber	11.7/0.52/6		4.7/0.52/6		53
gyse	9.8/1.26/4		9.3/0.50/4		7
gyse̸	9.5/ - /2		9.5/ - /2		20
gyser	9.0/0.00/6		7.3/1.03/6		-
stoppe	10.0/0.71/5		4.4/1.14/5		39
stoppe̸	10.0/ - /1		5.0/ - /1		50
stopper	9.0/0.89/6		4.8/0.98/6		-
stop	9.5/0.55/6		5.7/0.52/6		20
passe̸	11.7/1.21/6		5.0/0.63/6	$p<0.005$	21
passer	10.7/1.21/6		6.5/0.84/6		38
pas	9.2/1.17/6		4.7/0.82/6		16

(continued)

(Table XX continued)

	V $\bar{X}$ / s /N		C $\bar{X}$ / s /N		Fo rise in semi-tones/ second
BH					
skabe	15.0/1.22/5		5.0/0.71/5		23
skabø	13.5/ - /2				12
skaber	13.0/0.63/6		5.0/0.00/6		14
gyse	14.0/0.71/5	$p<0.005$	5.6/0.55/5		10
gysø	10.7/1.97/6		6.2/1.94/6		10
gyser	10.8/0.75/6		5.3/1.03/5		10
stoppe	13.6/1.14/5		-		16
stopper	13.0/1.26/6		5.2/0.45/5		12
stop	9.7/0.82/6		5.3/0.52/6		10
passe	10.3/ - /3		7.7/ - /3		-
passø	11.5/0.84/6		4.8/0.75/6	$p<0.005$	-
passer	10.3/1.37/6		7.0/1.10/6		-
pas	11.0/0.00/6		4.5/0.84/6		-
NT					
skabe	13.8/0.96/4	$p<0.05$	7.0/0.82/4		8
skabø	15.0/0.84/6	$p<0.0005$	-		20
skaber	11.3/0.82/10		8.0/0.82/10		15
gyse	14.3/ - /3		9.0/ - /3		2
gysø	13.3/1.89/7		8.3/0.49/7		16
gyser	11.5/0.85/10		9.0/1.05/10		-
stoppe	13.4/0.89/5		6.4/1.14/5		-
stoppø	12.2/1.64/5		8.0/2.35/5		-
stopper	11.4/0.52/10		7.2/0.63/10		6
stop	9.8/0.63/10		7.5/0.71/10		2
passø	15.0/0.94/10	$p<0.0005$	9.4/0.84/10	$p<0.005$	17
passer	13.1/0.74/10		8.4/0.70/10		7
pas	13.3/0.82/10		7.5/0.71/10		2

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THE EFFECT OF HIGH AND LOW VOWELS ON THE FUNDAMENTAL FREQUENCY IN SINGING: SOME PRELIMINARY OBSERVATIONS

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AND
NIELS REINHOLT PETERSEN

Fundamental frequency was measured in high and low vowels in solo-singing. The effect of vowel height on Fo in singing was smaller than in speech, but it was shown to be highly significant. The results of a subsequent listening test indicated that listeners seemed to compensate perceptually for the inherent fundamental frequency differences when listening to solo-singing.

I. INTRODUCTION

There is evidence from a great number of languages that high vowels tend to have a higher Fo than do low vowels, everything else being equal (see e.g. Di Cristo and Chafkouloff 1977, Hirst, Di Cristo and Nishinuma 1979, Johansson 1976, Ladefoged 1964, Lehiste 1970, Lehiste and Peterson 1961, Neweklowsky 1975, Peterson and Barney 1952, Reinholt Petersen 1978).

Whether a similar effect is to be found in singing has - to our knowledge - not been subject to systematic research. One study touches upon this question, viz. Hagerman and Sundberg 1980, who investigated how accurately singers could treat fundamental frequency in barbershop singing, which is a type of male quartet singing, where vibrato is avoided and where great accuracy of intonation is required in order to avoid beats. The authors state (p. 42) that "*The accuracy with which the fundamental frequencies are chosen in barbershop singing is extremely high and does not seem to depend on the vowel to any great extent*". However, in the material the chords were made up by EITHER [mɑ] OR [mo] syllables, and the statement quoted refers to the finding that it made no difference whether a given interval was sung on [mɑ] or on [mo] syllables. It would have been interesting to see what had happened if different vowel qualities had been used in the same chord.

The purpose of the pilot experiment reported below was to investigate the effect of vowel height on the fundamental frequency in solo-singing and - for the sake of comparison - in spoken language. We chose solo singing as the object of study because we believed that this type of singing would provide the most favourable conditions for eliciting a possible effect of vowel height on Fo.

II. METHOD

The vowels *a* and *u* were inserted in the nonsense word *ˈmVmVmi* in all possible combinations (i.e. *u-u*, *u-a*, *a-u*, and *a-a*), and the words were embedded in the carrier phrase *stavelserne* ..... *forkortes* [ˈsg̊avəlsʌnə ····· fʌˈg̊ʰɒːd̥əs][1].

The carrier tune used for the singing of the material was

for the soprano, and

for the tenor, the musical interval between the vowels in the test sequences being the minor third between E_2 and G_2 and between E_3 and G_3 , respectively. The four test sentences were arranged in a list in twelve different randomizations. The first and last randomizations were used as dummies and not submitted to subsequent measurement.

Two subjects participated in the experiment, one tenor (BE) and one soprano (MG, co-author of the present paper). They are both trained, semi-professional singers and university students of musicology (MG also of phonetics).

In a preparatory recording session with the singer MG, a slight Fo downdrift of about one semitone was observed during recording. In order to counteract this a sinus tone of 440 Hz was played to the subjects as a reference before the singing of each sentence. The recordings took place in a sound treated room, and the subject was standing in front of the microphone at a distance of about 50 cm. The equipment used was a Sennheiser MD21 microphone and a semi-professional REVOX A77 tape recorder. The list was first sung, and after a short break spoken by the subjects, who were instructed in singing to use no vibrato and in reading to use a neutral declarative intonation.

After the recording session had been finished it was discovered that in speaking the list BE had made reading errors in the greater part of the *mamumi* words, mostly by substituting the word *mamamu*, which by the way does not occur in the list. These errors had passed unnoticed by the experimenter during recording. There had been no problems in singing, and it was, therefore, decided not to recall the subject for another recording session, and to make do with the remaining (correctly rendered) test words.

The following acoustic registrations were made of the material: duplex oscillogram, two intensity curves, and a fundamental frequency curve. Since the fundamental frequency was only in a few cases completely level all through the vowels but drifted slightly, Fo was measured at a point two thirds from vowel onset. The Fo at this point represents, according to Rossi 1971 and 1978, a good approximation to the perceived pitch of short Fo glides.

III. RESULTS AND DISCUSSION

All measurements were converted into semitones relative to 440 Hz, and means and standard deviations were computed. The data are tabulated in table I, and the means are displayed graphically in figure 1.

Table I

Mean fundamental frequencies (in semitones relative to 440 Hz) and standard deviations in the four test sequences in speech and singing. The numbers 1 and 2 above the columns refer to the first/stressed vowel and the second/unstressed vowel, respectively.

		MG		BE	
		1	2	1	2
u-u	speech	-14.71 0.323	-11.72 0.598	-17.39 0.375	-16.53 0.458
	singing	-4.96 0.170	-1.66 0.153	-16.78 0.259	-13.88 0.236
u-a	speech	-14.85 0.437	-12.25 0.430	-17.64 0.491	-17.48 0.301
	singing	-4.83 0.196	-2.08 0.290	-16.78 0.121	-14.22 0.130
a-a	speech	-17.92 0.420	-13.70 0.352	-21.57 0.419	-17.72 0.482
	singing	-5.30 0.200	-2.34 0.254	-17.16 0.177	-14.12 0.200
a-u	speech	-17.37 0.537	-12.96 0.385	- -	- -
	singing	-5.40 0.097	-1.93 0.267	-17.28 0.207	-13.91 0.240

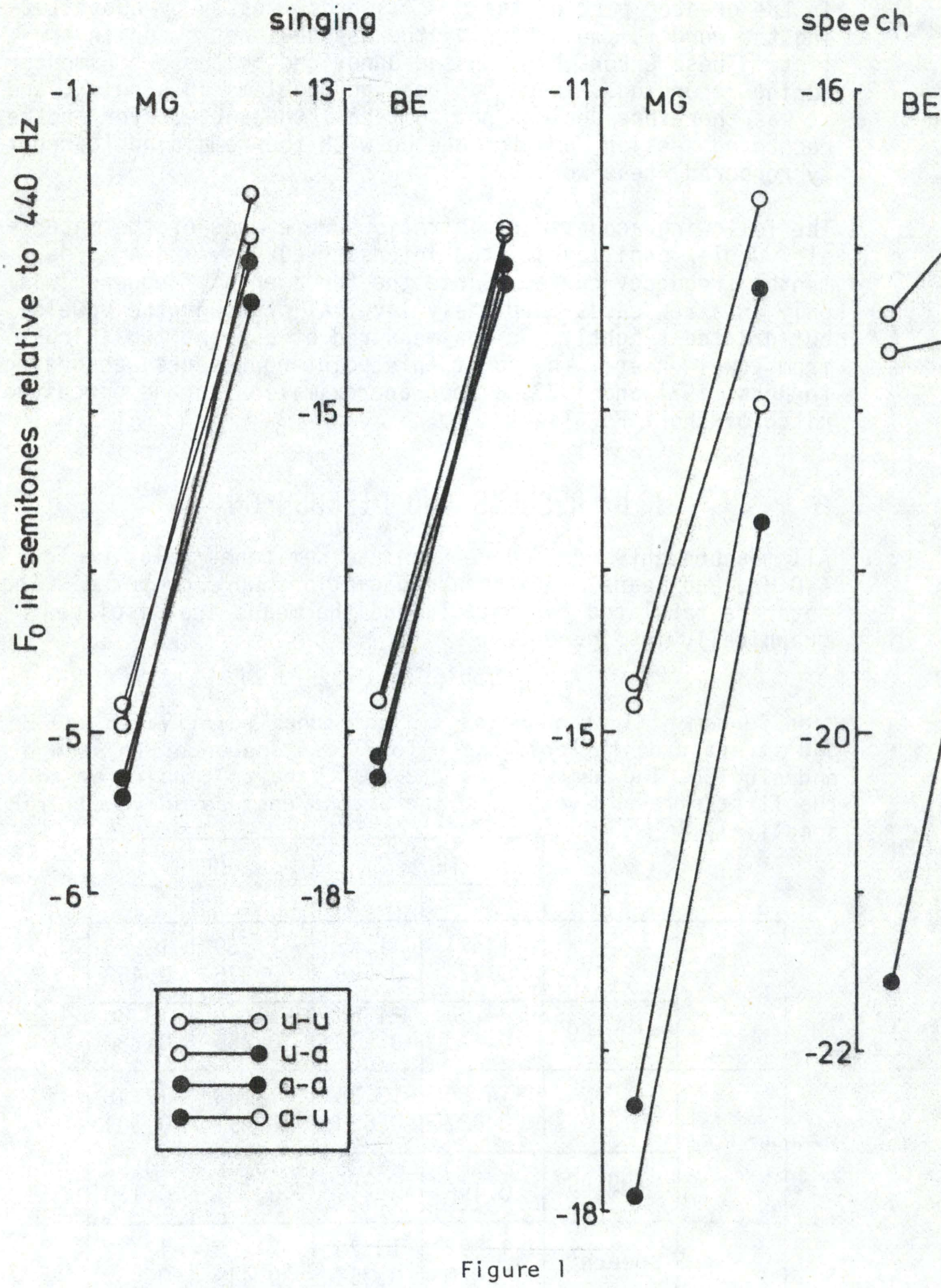

Figure 1

Mean fundamental frequencies in semitones relative to 440 Hz in singing and speech for the two subjects MG and BE. The two vowels in each test sequence are connected by lines.

The differences between *u* and *a* in speech and singing are given in table II, which also shows the results of a series of t-tests applied to the data. In speech the differences are in all cases statistically significant and are comparable in magnitude to the findings of previous investigations of inherent Fo level variation in Danish (see Reinholt Petersen 1978, 1979, and 1980).

Table II

Differences in semitones between means of *u* and *a* in speech and singing. The levels of significance acheived are indicated by ++ ($p<0.01$) and + ($p<0.05$).

		1st/stressed vowel		2nd/unstressed vowel	
		$m^{u}_{a}mu$	$m^{u}_{a}ma$	mum^{u}_{a}	mam^{u}_{a}
MG	speech	2.60++	3.07++	0.52+	0.74++
	singing	0.44++	0.47++	0.42++	0.41++
BE	speech	-	3.93++	0.95++	-
	singing	0.50++	0.38++	0.34++	0.21+

In singing the differences are much smaller than in speech, but yet statistically significant in all cases as can be seen from table II. In comparing speech and singing it may be pointed out that the within-group variability (cf. table I) is considerably smaller in singing than in speech. The overall within-group variance for speech is 2.562 and for singing 0.043, and the difference between these variances is statistically significant ($F=59.744$ $p<0.01$).

These findings indicate that subjects, when necessary - as in singing - can minimize not only the random fundamental frequency variation but also the systematic Fo variation arising from differences in vowel height, i.e. they are able to counteract an effect on Fo which is assumed to be an automatic consequence of properties inherent in their speech production system. A similar tendency has been reported by Hombert 1976a, who found that the effect of consonant type on Fo in the following vowel seems to be smaller in a tone language (Yoruba) than the effect normally found in non-tonal languages.

Although smaller than in speech the existence of an effect of vowel height on the fundamental frequency in singing has been clearly demonstrated and, as appears from table III and figure 2, this effect gives rise to appreciable differences among the realizations of the intended musical interval of a minor third (i.e. 3 semitones) between the first and the second

Table III

Means and standard deviations in semitones for produced intervals in singing.

	MG	BE
a-u	3.37 0.284	3.47 0.245
a-a	3.04 0.116	2.95 0.266
u-u	2.90 0.245	3.30 0.120
u-a	2.56 0.211	2.75 0.304

vowel in the test sequences. As could be expected the smallest intervals produced are found in *u-a* sequences and the largest in *a-u* sequences. The differences between the two types of sequences approach one semitone (0.72 for MG, and 0.81 for BE). A one-way analysis of variance applied to all four types (*a-u, a-a, u-u, u-a*) showed a statistically significant effect on the size of the produced intervals (MG: F=17.995, p<0.01, BE: F=22.756, p<0.01).

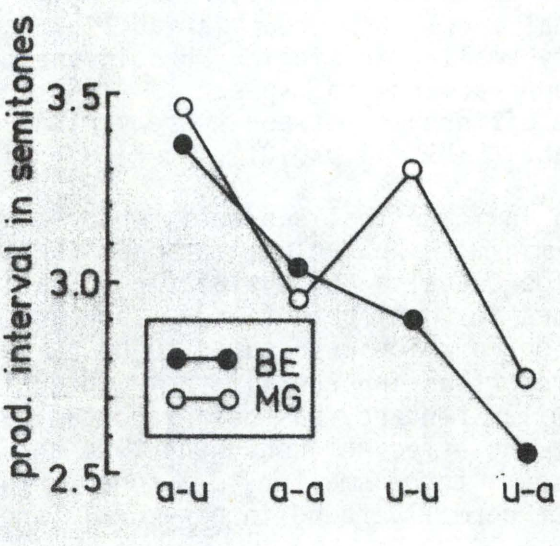

Figure 2

Mean produced intervals in semitones.

It is also seen from figure 2 and table III that in extreme cases (*a-u* for MG, and *u-a* for BE) the produced intervals deviate by nearly half a semitone from the theoretical value of 3 semitones of the intended minor third. Sundberg (1978, p. 65f) and Hagerman and Sundberg (1980, p. 40) report data on deviations from theoretical values when subjects adjusted successive synthetic tones to different musical intervals. The mean deviations were always below 0.1 semitones, and this implies that the deviations found in the present experiment are certainly above the threshold of detection.

Why, then, did the subjects not detect their deviations when listening to their own voices during recording? One explanation could be lack of skill on the part of the subjects. This is unlikely, however, considering their educational background and their experience as semi-professional performers, but, of course, the possibility cannot be precluded. Another explanation could be that they, listening to their own voices, and listeners in general, listening to solo-singing, perceptually compensate for the effect of vowel height on the fundamental frequency. A compensation of this kind has been found in speech by Hombert (1976b) and Rosenvold (1981).

In order to try out this explanation, a listening test was arranged in which a highly competent listener (a staff member of the Institute of Musicology) was asked to evaluate the intervals produced by the subjects.

By means of a sampling, editing and test generating program implemented on the PDP/8 computer of the Institute of Phonetics the test intervals were cut out of the carrier tune, stored and played back to the listener in the order in which they had occurred in the original recording. Each interval was repeated 3 times followed by a pause of four seconds for the listener to put down his response. The first and last four stimuli (i.e. the first and last randomizations) were regarded as dummies so that only those responses were analysed which correspond to intervals having been measured. Thus ten responses were given to each of the four different test sequences. The listener was instructed to evaluate the intervals on a seven-point scale ranging from fully acceptable (1) to not acceptable (7).

After the test the listener complained that he had found the task extremely difficult, and that he had not always felt certain that he had perceived the stimuli as music. The listener's difficulties can, perhaps, be explained by the fact that the stimuli were rather short and had been stripped of their musical context. Therefore the results of the test as presented below should be taken with some reservation.

It should be expected, under the hypothesis of compensation for inherent Fo level differences, that the location on the scale of the bulk of the responses would be independent of the heights of the vowels in the intervals responded to. If, on the contrary, the listener had made no perceptual compensation

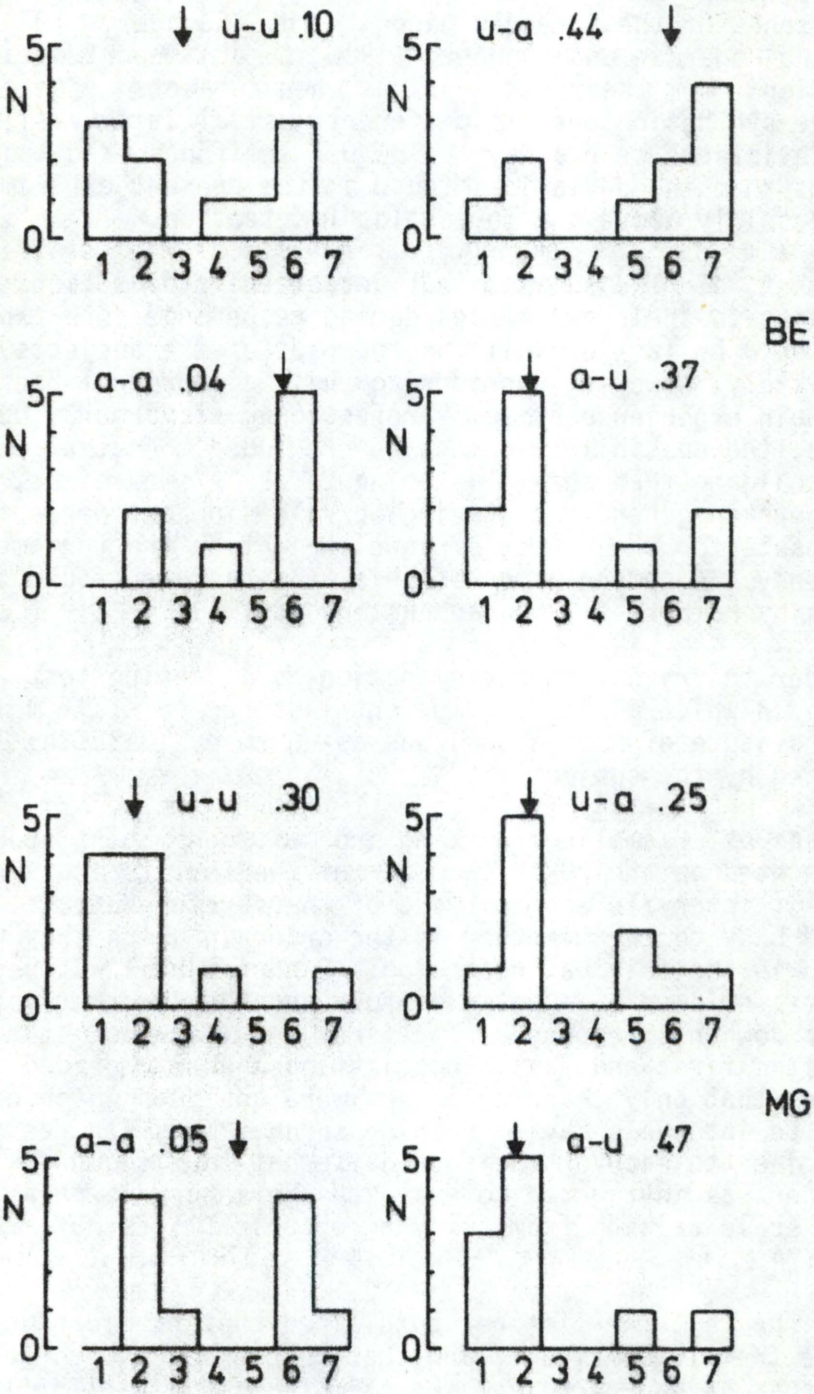

Figure 3

Distributions of responses on a seven-point scale to each of the four test sequences. 1 is "fully acceptable" and 7 is "unacceptable". In each panel in the figure the median of the response distribution is indicated by an arrow and the size of the deviation from the theoretical value of 3 semitones is stated.

for the effect of vowel height on Fo, the location of the responses on the scale should be expected to vary as a function of the deviation of the produced intervals from the theoretical value of 3 semitones.

The distribution of responses to each of the four types of test interval is presented in figure 3. The arrows in the figure indicate the medians of the response distributions, and for the sake of comparison the measured deviations are given. The response patterns do not seem to reveal any obvious relationship between deviations from theoretical values and the location of the central tendencies of the responses. MG has large deviations in *u-u*, *u-a*, and *a-u* intervals, but all these intervals have received responses at the "acceptable end" of the scale, whereas the *a-a* interval, which shows the smallest deviation, received the greatest number of responses at the "unacceptable end" of the scale. For BE similar discrepancies are revealed between response patterns and size of the deviations of the produced intervals from theoretical values. These findings speak in favour of the hypothesis that listeners perceptually compensate for inherent Fo level differences in solo-singing.

In order to obtain a quantitative evaluation of the question of a relation between produced intervals and response distributions the data for each subject were submitted to a χ^2-test. The χ^2-test, however, requires the expected frequency in each cell to be 5 or more. Since this requirement could not be met by the arrangement of the present data in four stimulus conditions, seven response categories and 40 responses, it was neccessary to regroup the data as follows: The responses were dichotomized into one group comprising the categories 1 through 3, and one comprising the categories 4 through 7. In regrouping the stimulus conditions the two test sequences having the smallest deviations from the theoretical value of 3 semitones were combined into one group, and the two having the largest into another. The resulting 2x2 matrices are shown in table IV which also gives the values obtained for χ^2 together with the probabilities of the occurrence of these values under H_o, i.e. under the hypothesis of no association between stimulus and response.

Table IV

Matrices of dichotomized stimulus categories versus dichotomized response categories. For further explanation see text.

BE	response cat. 1-3	response cat. 4-7	
large dev. (*a-u*)+(*u-a*)	10	10	20
small dev. (*a-a*)+(*u-u*)	7	13	20
	17	23	40

χ^2=0.921

0.40>p>0.30

MG	response cat. 1-3	response cat. 4-7	
large dev. (*u-u*)+(*a-u*)	16	4	20
small dev. (*a-a*)+(*u-a*)	11	9	20
	27	13	40

χ^2=2.849

0.10>p>0.05

For BE the effect of deviation size on the response distributions are clearly non-significant. For MG, however, there is a significant effect at the 10 percent level, but it should be noted that the effect goes in the opposite direction of what is to be expected, large deviations having been judged acceptable in more cases than small, and small deviations having been judged unacceptable in more cases than large ones.

Thus, if it can be assumed that the stimuli have been listened to as music (cf. the complaints of the listener mentioned above), it is justified to conclude that the effect of vowel height on Fo in solo-singing, the existence of which has been clearly demonstrated, and which gives rise to gross distortions of the intended musical intervals, seems to be perceptually compensated for by listeners to solo-singing and by singers listening to their own voices.

IV. NOTE

1. This represents the more distinct pronunciation used in singing. In speech the rendering is [ˈsd̥awl̩sʌnə ··· fʌˈg̊ʰɒːd̥əs].

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THE NEW COMPUTER FOR THE SPEECH SYNTHESIS GROUP

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AND
O. BERTELSEN

I. INTRODUCTION

In 1981 the Speech Synthesis Group at the Institute of Phonetics obtained a grant from the Thomas B. Thrige Foundation and the Tuborg Foundation for the purchase of a PDP11/60 computer system. The computer was acquired in November 1981 and installed in the laboratory where the required physical conditions have been provided (ventilation, cooling, and electricity). In December a grant from the faculty made it possible to further enhance the system by installing a huge background storage device together with a magnetic tape station.

II. SPECIFICATION OF THE NEEDS

In specifying the computer system we have aimed at a solution which would fulfil the following demands:

1) Hardware and software support for both real-time and multi-user time-sharing applications. I.e. we must have a fast response time generating synthetic speech for interactive purposes and yet have all the advantages of a time-sharing system: Programme development, editing facilities, and data preparation for several users.

2) The hardware should be serviceable to the technical staff of the laboratory. The operating system and utility programmes should appear as a comprehensive, versatile, and fail safe tool for the user so that we will not have to re-invent the wheel.

3) Choice of a computer which has already become a de facto standard in various phonetic laboratories for better portability of programmes and for the exchange of experience.

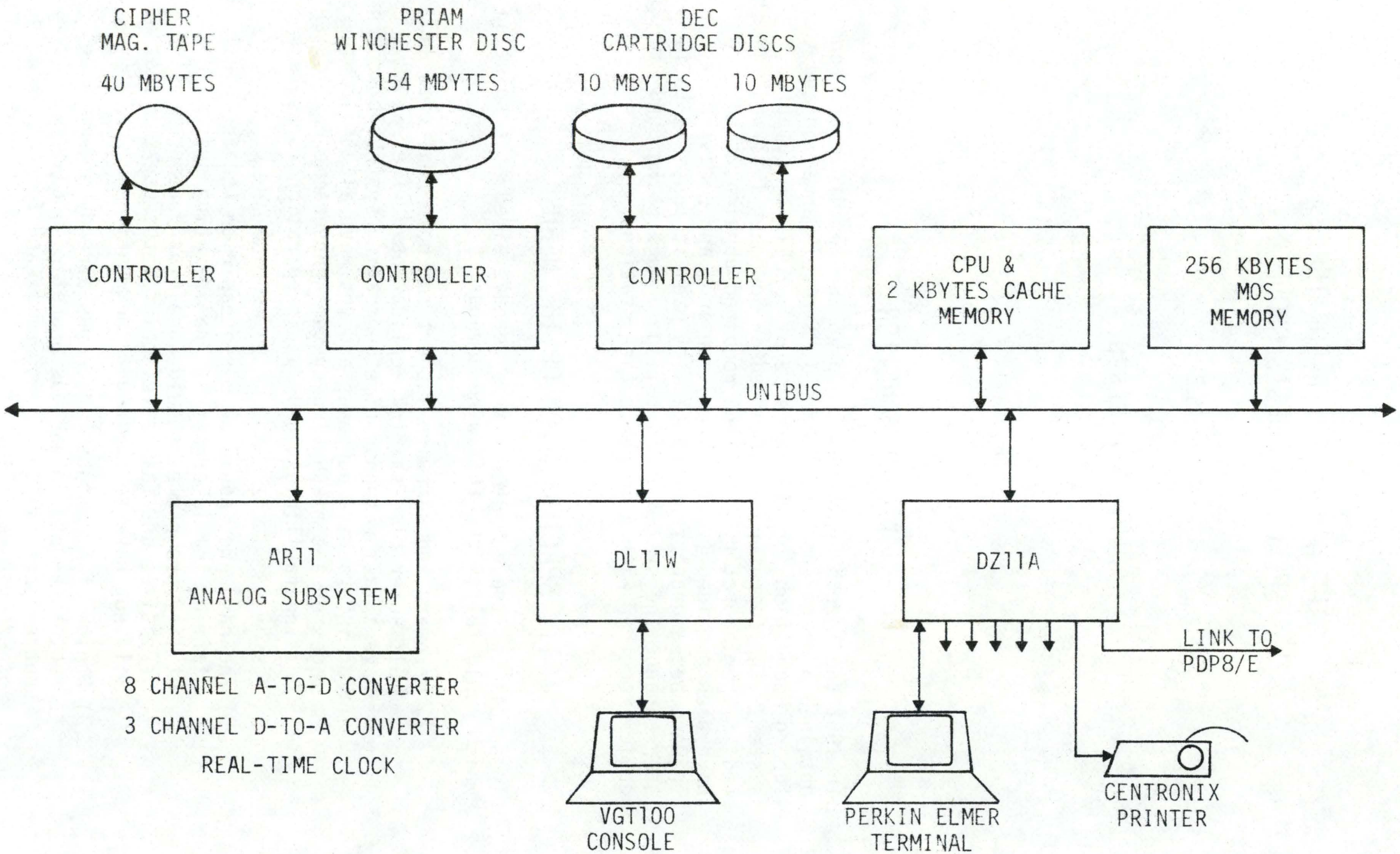

Figure 1

The PDP11/60 computer configuration

III. THE COMPUTER CONFIGURATION

The PDP11/60 cpu contains the usual eight general purpose 16 bit registers, the arithmetic unit, microprogramme/sequencer, extended instruction set, and UNIBUS arbitration logic. Integral parts of the computer are the floating point instruction set and the 2 kbytes cache memory/memory management unit. The cache memory is a high speed bipolar memory that maintains a copy of the previously selected portions of main memory for faster access of instructions and data. The memory management unit performs two basic functions:

1) Relocation of virtual memory addresses to physical memory addresses.
2) Protection against unauthorized access.

Main memory is a 256 kbytes MOS device with associated ECC-logic (Error Checking and Correcting) capable of correcting single bit errors and reporting multiple errors.

As background storage devices two 10 Mbytes RL02 disc drives (Digital Equipment Corporation) and one 154 Mbytes winchester disc drive (Priam) are used. For back-up and off line data storage a 40 Mbytes mag-tape station (Ciper nine track 1600/3200 bpi) is also connected.

Up to eight terminals can be connected to the DZ11A terminal multiplexer apart from the VGT100 console terminal (DEC) which is hooked up at the DL11W interface. For the time being the multiplexer handles one Perkin Elmer terminal, one Centronix printer, and a communication channel to the PDP8/E laboratory computer.

The AR11 constitutes an analog subsystem for signal processing and generation. It includes a sixteen channel 10 bits analog to digital converter, two 10 bits digital to analog converters, and a programmable real-time clock. The convertion time for the A-to-D converter is 33 microseconds, and 20 microseconds for the D-to-A converter.

IV. SOFTWARE

The computer was purchased with an RT11 operating system and a Fortran 4 c-licence included. Shortly after the installation, however, we had the UNIX version 7 operating system running on the computer[1], which has proved very useful for our purpose.

V. NOTE

1. We are greatly indebted to a group of students from DIKU, and especially Mr. Dennis Olsson, who installed the UNIX operating system on the PDP11/60.

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SPEECH SYNTHESIS AT THE INSTITUTE OF PHONETICS

PETER HOLTSE

This paper gives a brief description of the more important research involving speech synthesis at the Institute of Phonetics since the Institute was founded in 1966. Further, it provides a status report for ongoing research in the shape of a more detailed account of our current activities and future plans.

I. HISTORY

1. HARDWARE SYNTHESIZER

The first workable synthesizer was constructed at the Institute in the late 1960'es when Jørgen Rischel built an electronic synthesizer. At first ambitions were low, and a machine capable of producing isolated vowels was developed (Rischel, 1966). It was, however, soon followed by a very sophisticated dynamically controlled synthesizer capable of producing connected speech of a quality only limited by the skill of the operator and the time available.

The synthesizer and its control panel is described in detail in Rischel and Lystlund (1972). As documented here it is a very versatile instrument for perceptual research since it is capable of producing almost any conceivable speech sound (and quite a few non-speech sounds). However, the complexity of its control structure (it is a parallel formant synthesizer with twenty variable parameters) makes the task of producing anything like connected speech forbidding. Yet, the analogue control panel, with its facilities for interactive modification to any part of the speech signal and with immediate auditory feedback, is almost unrivalled for sequences of one or two syllables.

Of course, the synthesizer has its drawbacks. Thus, one source of continuous irritation has always been that the settings of the knobs of the control panel can only be adjusted by hand, i.e. the information on the panel cannot be saved for later use in any way. Furthermore, since the whole system is constructed in analogue technique it needs extensive calibration if exact control over, for instance formant frequencies, is needed.

The natural answer to these deficits was to simulate the actions of the control panel on the computer. A program doing this was operational on the Lab PDP-8 computer in 1977 (described in an internal report: Holtse (1978)). This program added visual feedback to the system since it would display the settings of the control panel on a graphic terminal. However, somehow the computer control program never became as popular as the old analogue control panel. Maybe because the immediate access to all parameters provided by the knobs of the control panel had to be substituted by keyboard commands, which many people find less attractive.

As might have been expected from a hybrid system, the problem of analogue drift was actually enhanced by the added computer control. When people type "335 Hz", they like to think that they get 335 Hz and not "something between three and four hundred". Although it was possible, in principle at least, to calibrate the simulated control panel quite accurately, this remained a time consuming task. And some of the problems, for instance that of calibrating formant amplitudes, have never really been solved.

In spite of obvious drawbacks the synthesizer has been used - either with its original analogue control panel or under computer control - in a number of perceptual studies, mostly dealing with vowel perception (Holtse (1973), Reinholt Petersen (1974 and 1976), and Rosenvold (1981)). Although largely undocumented its value as a pedagogical tool has been considerable thanks to the possibilities of interactive work.

2. LIBRARY OF SPEECH SOUNDS

Quite early, the idea of having a library of standard settings for the more common speech sounds occurred. The need for such a library was the more obvious since the complex control structure of the synthesizer made the proper working of the machine very much a job for specialists.

At the same time the Telecommunications Research Laboratories of Copenhagen became interested in the possibilities of producing synthetic speech by rule. This problem had not been given much thought at the Institute of Phonetics, where most people were interested in speech perception in a very general way. However, it was felt that there was enough common interest to initiate a small research project in synthesis by rule, and a first system was developed. It is described in Holtse (1974).

The system consisted largely of a library of formant coded speech sounds and a set of interpolation routines. The system would accept input in phonetic transcription, and it produced intelligible Danish words of two or three syllables. However, control of prosodic information was extremely primitive, and longer sequences needed hand editing of pitch and duration to become intelligible.

A more sophisticated prosodic control system was not developed. Mainly because at that time the phonetic description of Danish pronunciation was insufficient to allow meaningful rules concerning pitch and duration to be formulated.

3. SIMULATION OF PHONOLOGICAL RULES

Although not strictly speech synthesis the work on computer testing of phonological rules documented in Basbøll and Kristensen (1974 and 1975) should be mentioned in this connection. Their computer program would accept a sort of underlying phonological structure as input and produce a rather detailed phonetic transcription as output. (It would actually produce several different transcriptions since the authors were particularly interested in the problems of alternative pronunciations in different styles of speech.)

As the transformation rules of the system were developed, the "underlying structure" gradually approached standard Danish orthography. And it was realized that it might be possible to produce a Danish text-to-speech system - even if the accepted view among phoneticians had been that the pronunciation of Danish text cannot be predicted without access to the meaning of the text.

At that time the plan was to use the output of the rule testing program as input to the synthesis program mentioned in the previous paragraph. This plan was, in fact, never carried out since both projects were discontinued before it could be tried.

II. CURRENT ACTIVITIES

Towards the end of the 1970'es several people expressed an interest in combining the research in Danish phonology with the work on analysis and synthesis of Danish speech. In particular, the idea of producing a complete text-to-speech system for Danish was beginning to mature. Till then the development of such a system had been of only limited interest to phoneticians and phonologists. But the thought of combining the research efforts of several linguistic-phonetic areas was appealing from both a theoretical and a practical point of view.

A serious difficulty for the project was that it needed considerably more computer power than could be made available at the Institute of Phonetics, where the economic crisis was beginning to make itself noticeable. However, a Danish synthesis-by-rule system would be of practical value to many people outside the academic community. And the newly formed project group received sufficient support from, in particular, the telecommunications world, to obtain a grant from the Thomas B. Thrige's Foundation and the Tuborg Foundation for the purchase of the necessary equipment. (The computer system is described elsewhere in this issue.)

Since then, our activities have been centered in two areas: 1) Development of suitable Danish text-to-phonetic transcription algorithms, and 2) Development of support tools for further research in speech synthesis. The first part, the orthographic/phonological research, is described in the paper by Peter Molbæk Hansen (this issue), while the rest of the present paper is devoted to a description of the planned support system.

A. SURVEY OF SYNTHESIS SUPPORT FACILITIES

Figure 1 shows the logical connections between various parts of the support system. The figure shows four main components: At the top (labelled "A") is traditional phonetic/phonological research.

The models and descriptions of Danish being developed here are, as far as possible, coded in a special formal language, in its syntax very like the notation known from "The Sound Pattern of English" (Chomsky and Halle (1968)). The rules and descriptions are then processed on the computer by a Rule Compiler (shown in section "B" of figure 1) to produce the actual speech synthesis program (section "C").

The idea of having a special speech synthesis computer language is not our own. It was first described by Carlson and Granström (1974). Our own compiler is in fact modelled closely on the Swedish compiler, and we have profited immensely from discussions with Rolf Carlson and Björn Granström.

The text-to-speech conversion program produced by the Rule Compiler is planned to take a string of ASCII text in normal Danish orthography as input and from this produce a set of time varying control parameters which, when fed into the appropriate speech synthesizer will eventually produce the corresponding spoken word.

Alternatively, the control parameters generated by the text-to-speech program may be stored on disk files and manipulated by the Phonetic Debugging System shown in section "D" of figure 1. The purpose of the parameter editor and its associated display programs is to put as many as possible of the facilities of the old hardware control panel previously mentioned at the disposal of the phoneticians (and hopefully provide a few new ones).

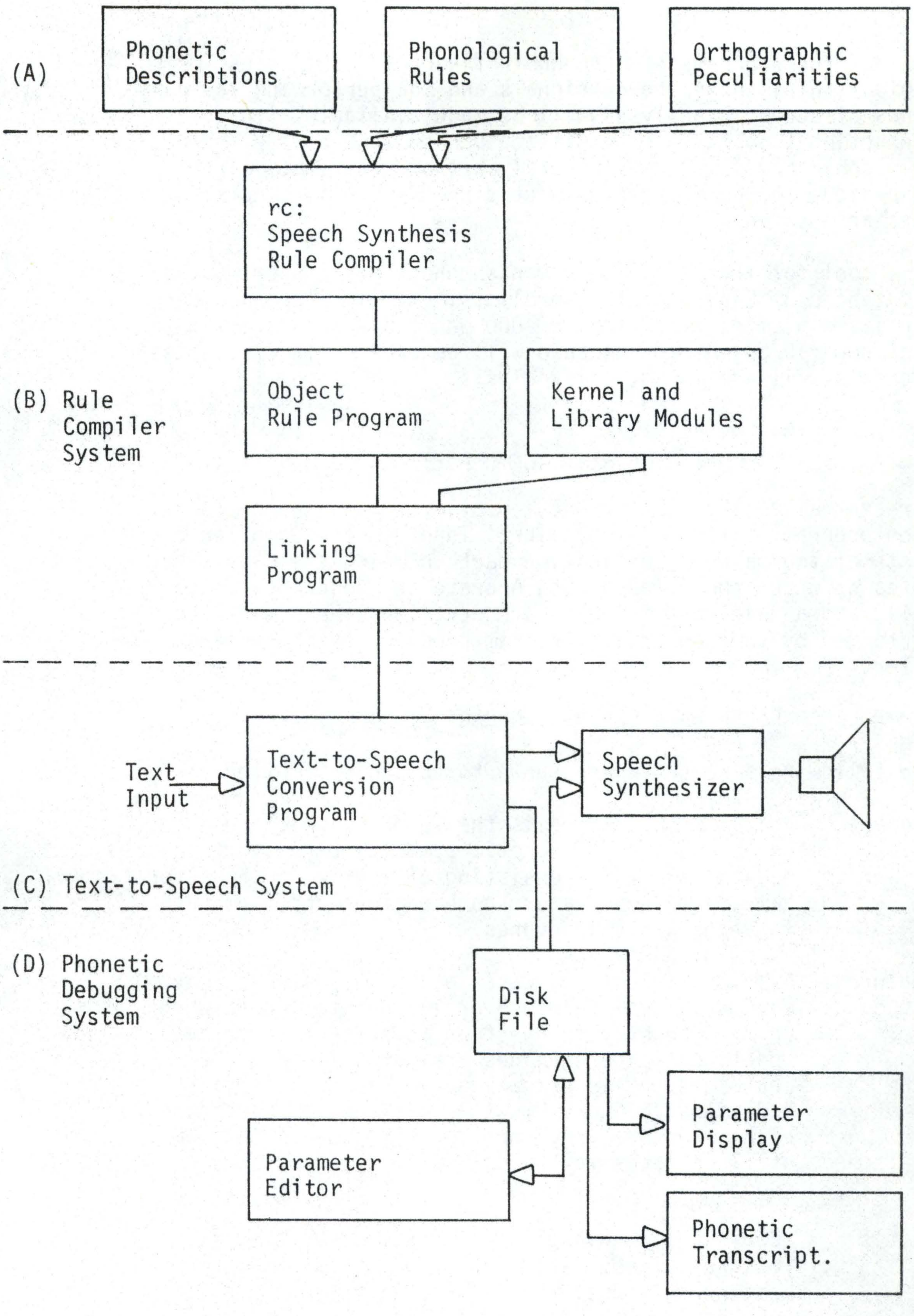

Figure 1

Block diagram of Synthesis Support System

Besides the programs etc. shown in figure 1, facilities for digital sampling of speech signals and for performing various kinds of acoustic analyses will be made available. In this connection a database of digitized Danish speech is planned. This could be useful as a general sort of reference, although we believe the majority of phonetic problems will need special data in any case.

As a tool for the analysis of Danish phonology and orthography a database of Danish texts, wordlists, etc. is planned. Currently, a dictionary of some 50.000 words has been read in (Holmboe (1978)). The database will be accessible for statistical as well as syntactical analysis.

B. THE RULE COMPILER

Our central tool in the production of a text-to-speech conversion program is the Rule Compiler. Input to the Compiler consists of two parts: A definition part in which the data structures on which the rules are to operate are described in detail, and a Rule Part in which are described the actions to be performed by the conversion program produced by the Rule Compiler.

1. RULE COMPILER DATA DEFINITION PART

The following structures are known to the Rule Compiler:

Segments — The basic data type is the segment, which roughly corresponds to a phonetic symbol. Each segment is a data structure consisting of a Name, a Character Name, a unique Feature combination, and from zero to three acoustic chunks.

Features — Features are binary descriptive labels which may assume values of "plus" or "minus" to denote whether the property in question is present or absent. Undefined feature values are not allowed. The Feature "seg" is predefined in the Rule Compiler. Additional Features must be defined as belonging either to the [+seg] or [-seg] group. A maximum of 31 Features may be defined for each of the two groups.

Labels — Labels are combinations of one or more specific Feature values. They are merely notational conveniences. Thus, the Label "V" for Vowel could reasonably be used as shorthand for the Feature combination [-cons, +voc, +syll].

Chunks — Chunks are the acoustic descriptions of the individual segments. Typically a short vowel will consist of only one chunk, while a plosive consonant may contain two or three.

Each chunk consists of a set of Variables and a set of Parameter structures.

Variables are integer values used to describe the chunk. Two Variables are predefined in the Rule Compiler: "dur" and "rank". "dur" defines the physical duration of the chunk in milliseconds. "rank" defines which chunk should dominate over the neighbours when the chunks are combined to make connected speech.

Parameters are integer values corresponding to the control parameters of the speech synthesizer on which the output of the rules will eventually be applied. For each Parameter a data structure is defined, consisting of a Target value, an Internal Transition time, and an External Transition time. The two transition times describe the respective points in time when the Parameter should either leave one Target or reach the next Target.

Typical Parameters would be "f1": frequency of first formant, or "f0": pitch of voiced excitation.

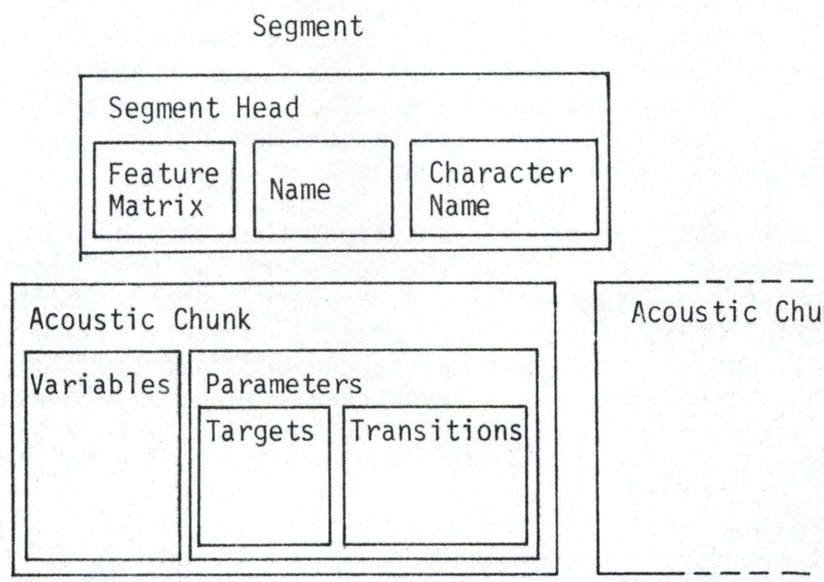

Figure 2

Structure of a Segment

Apart from the Segment data type, the Rule Compiler recognizes "integer" and "real" global variables. These are variables which do not belong to particular Segments and may be used for computations or temporary storage within the rules.

All data structures must be defined prior to their use in any rule.

As will be noted all data structures are segmental, i.e. words and syllables are indicated by special delimiting segments. This procedure is according to tradition. However, the notation of rules applying to higher levels than the segment tends to become extremely complicated. We are therefore presently considering introducing structures like syllables and words in the Rule Compiler.

2. RULE COMPILER RULE DESCRIPTION PART

The object of the Rule Compiler is, as previously mentioned, to produce a computer program which will convert a string of ASCII characteris representing Danish orthography into time varying control parameters needed by a speech synthesizer. This is accomplished as follows.

The conversion program reads a string of characters up to (and including) the first sentence delimiter (comma, period, etc.). For each character a copy of the Feature combination for an appropriate Segment, as determined from a user supplied mapping table, is transferred to a Work Buffer. All transformations within the Rule Part apply to the contents of this buffer, i.e. to sets of Feature combinations.

A context sensitive grammar describes the transformations to be carried out. Logically, the Rule Part may be divided into two phases: A Categorial and a Parametric phase. During the Categorial phase only Features or sets of Features are transformed. Specific Features may be changed, deletions are carried out by removing the relevant Feature matrix from the Work Buffer, and insertions are accomplished by copying complete Feature matrices from the definition tables to the Work Buffer.

When the program enters the second, parametric, phase all Feature matrices in the Work Buffer are mapped back onto the definition tables and the relevant acoustic Chunks are copied from the definition tables to the Work Buffer. Thus, changing Feature combinations within the Categorial phase has direct consequences for the choice of physical descriptions, i.e. the choice of allophones.

During the Parametric phase the contents of Variables and Parameter structures may be modified to reflect details of coarticulation, and adjusted values of duration and pitch may be computed to simulate the appropriate speech rhythm and intonation.

When all rules have been applied interpolations between the Parameter Target values of the Work Buffer are performed. These values are the final output of the conversion program.

Throughout the rule part special Print commands may be inserted. These commands will cause the contents of the Work Buffer at that stage to be printed in phonetic script, using the Character Names of the Segment definition tables (always assuming that the Feature combinations of the Work Buffer can be mapped back onto the Feature matrices of the definition tables). Alternatively, a special Trace facility may be turned on. This will cause the contents of the Work Buffer to be printed every time the Buffer is modified by a rule, thus giving a trace of the effect of individual rules.

3. SPEECH SYNTHESIZER

The Rule Compiler is not designed to operate with any particular speech synthesizer, although we have all the way been thinking in terms of a formant coded synthesizer. Instead, the Rule Compiler derives its knowledge about the synthesizer which will eventually use its output from a set of definition tables. This strategy will allow us to configure the same phonetic/phonological rules for a variety of different speech synthesizers.

Currently no hardware synthesizer is connected to the computer, and we rely on the fast PDP-11/60 to simulate the whole process. Using a simulated synthesizer will, of course, give great flexibility in the choice of "machine", but the response time is relatively slow, and the system will have to be augmented with various hardware devices.

C. APPLICATIONS OF THE SPEECH SYNTHESIS SYSTEM

The speech synthesis system described here is planned primarily as a research system. Therefore the programs have been designed to be easily modified rather than being optimized for space requirements or speed of execution. However, we believe that the output of the Rule Compiler will be such that it should be possible eventually to transfer it to, for instance, a microprocessor ROM in order to build a sort of production version.

As it is, the system will be immediately available as a tool for testing phonological and phonetic hypotheses and for refining the exact description of Danish pronunciation. This kind of basic research is, of course, the background for any progress in the development of practical applications of speech synthesis.

Actually, for much of the phonological work to be done, speech output will not be required or even wanted. In these cases a phonetic transcription might well be the preferred output. Incidentally the phonological rule system could also produce the raw version of various kinds of pronouncing dictionaries for Danish.

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THE CONSTRUCTION OF A GRAPHEME-TO-PHONE ALGORITHM FOR DANISH

PETER MOLBÆK HANSEN

The paper presents the main strategy and some preliminary results of the current work with the construction of a grapheme-to-phone algorithm forming part of a text-to-speech algorithm for Danish. The paper also discusses the main difficulties connected with this work, and a brief report of the present status of the project is given.

I. INTRODUCTION

This paper reports on the ongoing work with the construction of a grapheme-to-phone or rather text-to-phonetic representation algorithm forming part of the text-to-speech project for Danish on which more general information is given by Peter Holtse elsewhere in this report.

The paper is divided into three main sections. In section II the main features of the algorithm are presented. In section III some details of the orthographic component of the algorithm are described, and examples of the interplay between rules and exceptions are given. In section IV a few remarks on current and future work are given.

II. GENERAL DESCRIPTION OF THE ALGORITHM

In this section the main features and components of the grapheme-to-phone algorithm (henceforth GTPA) will be described. General, language-independent problems connected with the construction of text-to-speech algorithms will not be mentioned directly. A concise overview with useful references is found in Sherwood (1981).

A. REGULARITIES AND EXCEPTIONS

The algorithm should be mainly rule-oriented, i.e. both orthographic and phonological phenomena which can in any reasonable sense be described as regularities should be stated as formal transformation rules not referring to the identity of single words.

The main problems that arise when one attempts to apply this requirement to Danish have to do with the fact that Danish orthography has serious drawbacks from the point of view of its relation to pronunciation. As is well known, it is not the case that Danish orthography is consistent in the sense that the pronunciation of any given word can be derived from its spelling by a limited set of exceptionless rules governing the correspondence between letters (letter combinations) and sounds (sound combinations). If that were the case, it would be easy to make a fail safe (and efficient, cf. section III) GTPA at word level. Danish orthography does not even meet the much weaker requirement that the pronunciation of any given word be inferable from its spelling in a unique, if not necessarily simple way, cf. the existence of heterophonic homographs in which - paradoxically enough for an alphabetic writing system - Danish orthography abounds (cf. e.g., the words [hu:'l] 'hollow' and [hɔl] 'hole' which are both spelled *hul*, see further section III). If the latter requirement were met, a fail safe GTPA could still in principle be constructed, although it would have to cope with difficulties of the kind to be discussed in section III.

The main strategy must take as its point of departure that Danish orthography is nevertheless rich in partial regularities as regards the correspondence between spelling and pronunciation. The existence of the above mentioned drawbacks only means that a GTPA for Danish can neither be 100% fail safe nor consist exclusively of exceptionless rules.

The strategy underlying the construction of the GTPA is based upon a specific interpretation of two general (and, of course, well known) concepts: regularities and exceptions. These two concepts are in turn applied to two different areas: the area of feature assignment to letters, and the area of letter-to-segment-transformation.

B. THE TWO COMPONENTS

The general principles underlying the GTPA - the construction of which is far from completed - are shown in outline in figure 1. There are two components, a component taking care of exceptional spellings (henceforth XCO) and a rule component (henceforth RCO). The task of the XCO is to take care of exceptional spellings and change them into spellings which are consistent with the rules of the RCO in the sense that these will apply in an unrestricted way to the output of the XCO and yield a correct output. This also implies that the XCO supplies information

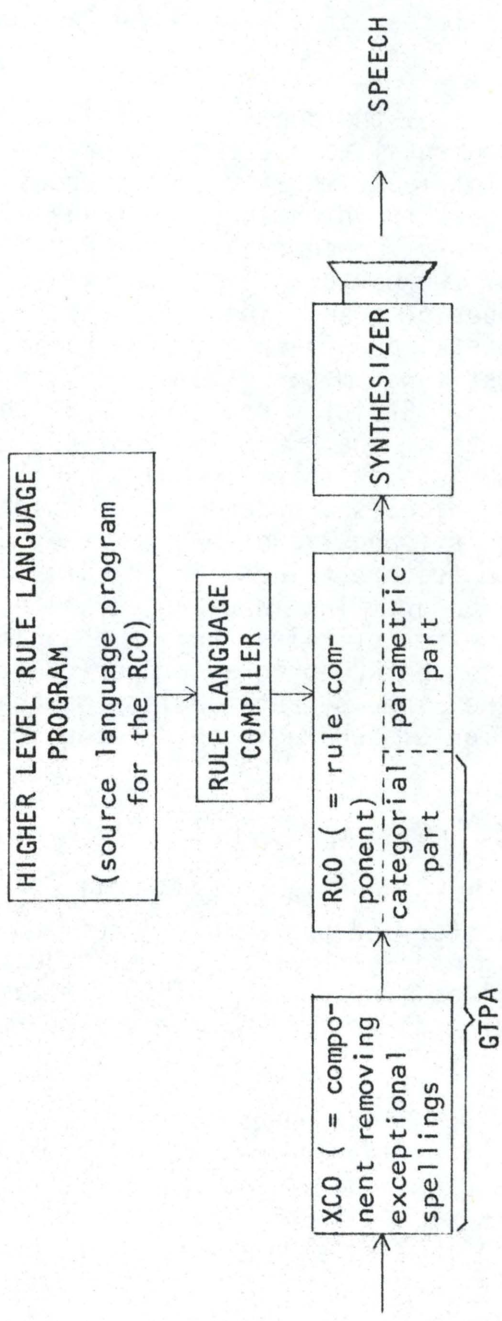

Figure 1

Schematic representation of the components of the text-to-speech-system.

which is necessary in order to predict the pronunciation of the sentence even if such information is not directly extractable from the orthographic form of the sentence (in particular information on syntactic and/or prosodic properties of the sentence). The output of the XCO will be referred to as "consistent notation".

The XCO takes an orthographic input, one sentence at a time, transforms it to consistent notation, assigns a bundle of binary feature values to each letter of the sentence, and delivers the output to the RCO.

The RCO transforms its input (i.e. the consistent notation with feature values assigned to segments) to a set of numeric values organized in a way which is (at least ideally) isomorphous with the relevant acoustic parameters to which they are translated in the speech synthesizer proper. Conceptually, the RCO may be described as consisting of two parts: 1) a categorial part dealing with an integral number of quasi-linguistic entities, viz. prosodic elements, segments, and features; 2) a parametric part dealing with quasi-acoustic parameter values to which the categorial elements are mapped. Strictly speaking, only the first of these conceptual parts of the RCO is part of the GTPA. Technically, however, the RCO is planned to be one monolithic algorithm, viz. a set of exceptionless, ordered rules which all have equal formal status irrespective of whether they apply to parameter values or to feature values. Such rules are to be formulated in a higher programming language, a "rule language"; in other words, the set of rules forms a program which in turn is translated to the RCO-program proper by means of a special compiler (cf. the paper by Peter Holtse on the construction of a rule compiler elsewhere in this report).

C. THE CONCEPT OF "INITIAL VALUE"

It is an important property of the RCO that there will be no formal distinction between letter and phonological segment ("phonological segment" being used here as a common denominator for any bundle of feature values irrespective of whether it is near the upper end (the input end) or the lower end (the output end) of the algorithm).

It is nevertheless clear that some of the early rules must take care of what may be thought of as letter-to-systematic phoneme rules or the like, namely in cases where a letter corresponds to more than one segment. In such cases a strategy of "optional initial value" will be applied. This strategy may best be illustrated by an example: The letter *e* has three main phonological correspondences: /e:/ as in *del* 'part', /ɛ/ as in *let* 'easy', and /ə/ as in *gade* 'street'. If *e* is assigned the initial value of one of these segments, two rules must take care of assigning it the other values in the appropriate contexts. Thus from the point of view of number of rules, the three potential initial values will be equally costly. Since rules of this kind are not phonological rules in a traditional sense, the decision of which value to choose for the letter *e* must be based on other considerations. Here considerations of program efficiency should be allowed to play a role. In phonological derivations of SPE type a rule is not generally evaluated from the point of view of its actual applicational burden, i.e. the actual number of times the structural description of a rule is met when that rule tries to apply to actual running text. Such considerations are of great importance when the algorithm is to be implemented by a computer program.

In the actual example there is absolutely no doubt that from the point of view of efficiency the initial value of *e* should be (the feature composition of) /ə/: /ə/ is by far the most common value of *e*, and the sum of successful applications of rules changing *e* to /e:/ and /ɛ/ in any normal Danish text would be far less than the sum of successful applications of one of these rules and a rule changing *e* to /ə/ which would be needed if either /e:/ or /ɛ/ were chosen as the initial value of *e*.

In most cases of a one-to-many relation between letter and phonological segment it is not conspicuous, however, which one of several (in most cases only two) possible initial values will yield the lowest actual applicational burden. It is a simple task, however, to have the program itself count the number of successful applications of any rule; thus it is possible to arrive at a non-arbitrary choice between alternative solutions by applying alternative versions of the algorithm to a representative (preferably long) text.

D. THE USE OF "FEATURES"

For each letter/segment a high number of binary features is available. This gives a high degree of freedom in assigning feature values to a letter/segment. It is obvious that no phonological system as such will use all these features; this means that one can define and use features for other than phonological purposes. One can, e.g., define a feature ±dummy to characterize certain letters which for some reason are best treated as a group. Of course one is free to use the same features in later stages of the RCO in some phonologically or phonetically interpretable way. In section III the "orthographic" use of a dummy feature will be exemplified.

III. ORTHOGRAPHIC PROBLEMS

In this section the main problems with the XCO and their possible solutions will be discussed. The main task of the XCO is to take care of exceptions. If a word or a portion of a word exhibits a spelling which, given a set of rules, will be incorrectly processed by the RCO, that word or portion of a word must be changed in some way or other.

A. ONE-ROOT WORDFORMS

It is clear that one of the main problems connected with the construction of an XCO is the fact that Danish - like other Germanic languages - is characterized not only by the existence of a great deal of more or less lexicalized compounds, but also by the relative freedom to form new compounds from lexical material. In this section I shall restrict myself to illustrate some of the problems which remain if we presuppose that the compound problem can be solved in some way or other. In other words, I shall refer only to problems connected with one-root-wordforms.

One-root-wordforms by and large have the following structure: optional prefix + root + optional suffix + optional inflexional ending which can be either one of the consonants *s* and *t* or a mono- or disyllabic structure with schwa as the vowel(s).

Many of the orthographic irregularities of such wordforms are cases where a letter combination at the beginning or at the end of a root is identical to the spelling of a prefix or a suffix: in a word like *afsløre* 'reveal' the initial *af-* is the common high frequency prefix /av/ in which the phoneme /v/ is spelled *f*. It is absolutely clear that the great majority of words beginning with *af-* are /av/-prefixed words. This calls for the following rule in the RCO:

$$\#\text{af} \rightarrow \#\text{av}$$

Since, however, rules in the RCO are supposed to be exceptionless, the XCO must take care of a handful of words in which initial *af-* belongs to the root and is pronounced /af/: *afasi* 'aphasia', *aften* 'evening', and a few others. If these words were handed over to the RCO without change, they would be incorrectly processed by the above mentioned rule. The XCO must make these words immune, as it were, to that rule. One way of doing this is to have their *f* changed to something else, e.g. a dummy segment *F*, whose feature composition could be identical to that of *f* except for one dummy-feature for which "normal" segments have minus, whereas dummy segments like *F* have plus.

In order to make such a change the XCO must identify the words to be changed, and this involves certain problems. A root like *afasi* may occur in inflected forms like *afasien, afasiens, afasier, afasiers, afasierne, afasiernes*, the various inflexional endings being obviously irrelevant to the phenomenon under consideration. Only as much of a wordform as will uniquely identify the root, should appear in the exception list, and in most cases this means that only one entry per root need to be listed. In the case of *afasi*, however, this is not entirely fail safe: it is entirely possible to form a word like *afasiatisere* 'to make less Asiatic in type', in which *af-* is the /av/-prefix. One way of solving this problem is to have two entries in a left-end exception list, i.e. a list of exceptions which are scanned by the XCO from the beginning of the words: *afasi#* and *afasie*, the latter entry taking care of the inflected forms. Incidentally, such a solution is a good illustration of the need for analyzing compounds, since a compound like *afasiproblemer* would only be correctly processed if it appeared as *afasi#problemer* at this stage of the XCO.

As a parallel example concerning the final portion of roots, consider wordforms ending in *-erne*. The vast majority of wordforms ending in this letter combination are definite plurals of nouns. But in words like *cisterne* 'cistern', *lanterne* 'lantern' and a few others, *-erne* belongs to the root and is pronounced [ɛrnə], whereas in the "normal" case, i.e. in definite plurals, both vowels are schwa. Such words, or rather as much of the final portion of such words as will uniquely identify the root, may be listed in a right-end list of exceptions together with information specifying what the root should be changed to in order for it to be processed correctly by the RCO.

At the moment left-end and right-end exception lists appear as data structures organized as arrays of pairs of character strings, the first member of each pair being the orthographic identifier of a root, and the second member being the corresponding exchange-string. The pairs are sorted alphabetically according to their first member so as to allow for a fast binary search algorithm.

B. VOWEL LENGTH IN STRESSED SYLLABLES

It is not always clear what to call a rule and what to call an exception to a rule. In word final stressed syllables the vowel is in most cases short if followed by more than one consonant, cf. *vask* 'wash', *mælk* 'milk', *vand* 'water'; however, in some cases - most notably in perfect participles of verbs - it is long: *vist* 'shown', *målt* 'measured'. If it is followed by one consonant only, the vowel is either long or short, cf. *sal* 'hall', *lys* 'light', *ben* 'leg', *fatal* 'fatal' with long vowel, and *bal* 'ball', *kys* 'kiss', *ven* 'friend', *metal* 'metal' with short vowel. In the former case there is a clear statistic dominance of wordforms with short vowel, whereas in the latter case the number of wordforms with long vowels is approximately balanced by the number of wordforms with short vowel. Irrespective of whether short or long vowel before a single consonant is chosen as the normal case, many words must be listed as exceptions. One might, of course, base a decision upon a frequency investigation of the two types in running text, but it seems more insightful to exploit the fact that in the overwhelming majority of nonfinal stressed syllables the vowel is long if followed by one consonant and short if followed by more than one consonant. That is, we may state a general rule that lengthens vowels before a single consonant. This implies, of course, that a few polysyllables and many monosyllables with a short vowel followed by one consonant and many words with a long vowel followed by two or more consonants must be listed as exceptions and supplied with appropriate exchange-strings causing them to be treated correctly by the RCO. In this case the exchange-strings can be used to take care of another problem. It is a general rule that stressed word final syllables with short vowel take stød if their vowel is followed by a sonorant consonant which in turn is followed by a consonant letter, irrespective of whether or not the last of these consonant letters actually corresponds to a pronounced consonant, cf. *skovl* [sgʌuʼl] 'shovel' and *vand* [vanʼ] 'water'. Some of the words which have to be listed as exceptions because they have a short stressed vowel before a single consonant letter have stød, others do not have stød. One way of combining information about stød and length in the exchange-strings assigned to such exceptions would be to distinguish them from each other as well as from words with a long vowel by (1) supplying the stødless exceptions with an *h* after the vowel letter (thus rendering them immune to stød assignment, since *h* is voiceless and thus cannot take stød, and at the same time preventing them from having their vowel lengthened because of the cluster), and (2) supplying the stød-syllables with an *h* after the postvocalic sonorant consonant letter if the vowel is to be short (thus making these syllables meet the structural description of the stød assignment rule, yet rendering them immune to the vowel lengthening rule). For instance, *hav* [hau̯] 'sea', *sov* [sʌuʔ] 'slept', *tal* [tal] 'number', and *ven* [vên] 'friend' might be listed as exceptions and supplied with the exchange-strings *hahv, sovh, tahl*, and *vehn*, respectively. A rule eventually deleting *h* in such positions would then be needed in the RCO.

It must be borne in mind that the task of the XCO is primarily of a nonlinguistic nature and that all sorts of shortcuts and hocuspocus devices should be allowed in this part of the algorithm. This is also essential from the point of view of making the XCO a fast and efficient tool: Since most of these exceptions are concerned with a word final syllable, they should probably be listed in the right-end exception list so as to minimize the computer time needed to compare - one character at a time - the text words with the items of the list.

At the moment an operational XCO works in the following way:

1. read a word from the input text.
2. check whether the word or any initial portion of it matches a member of the left-end exception list. If it does, exchange the word or the (initial) portion of it that matches the pattern with the corresponding exchange-string member of the exception list.
3. if the final portion of the word can be identified with an inflexional ending found in the list of endings, strip the ending off, i.e. identify the stem final letter.
4. check whether the stem or any final portion of it matches a member of the right-end exception list. If it does, exchange the stem, or the (final) portion of it that matches the exceptional pattern, with the

corresponding exchange-string member of the exception list.

5. ready to take next word.

C. COMPOUNDS

There can be no doubt that the existence of compounds of varying depth is a serious obstacle to constructing a fast and efficient XCO. At present it seems almost inevitable that some sort of morphemic analyzer along the lines of the one used in the MITALK text-to-speech system for American English (see Allen, 1981) must be integrated in the algorithm as a sort of preprocessor. This implies that the list of exceptions/exchange-strings must simply be a root-lexicon which has to be consulted for each word in the input text. If such a lexicon must be constructed anyway, one might as well include information concerning word class, syntactic behaviour, and the like, since such information will probably turn out to be indispensable to the correct prediction of syntactically determined stress reductions.

The inclusion of a root lexicon would also solve the problem of predicting stress placement in polysyllabic root morphs. Rischel's work in this field (Rischel, 1969) should of course be consulted, but it must be remembered that his rules are not concerned with orthography. For instance, in a root lexicon there would have to be information to the effect that the *æ* in *mausolæum* and the *o* in *petroleum* are long, since stress rules of the type set up by Rischel rely heavily upon the distinction between long and short vowels.

D. HOMOGRAPHS

Unfortunately, Danish orthography has rather an abundance of heterophonous homographs. In most cases such pairs of homographs consist of a noun and a non-noun, cf. *hul* [hɔl] 'hole' vs. *hul* [hu:'l] 'hollow', *bad* [bað] 'bath' vs. *bad* [ba:'ð] 'asked, prayed', and many others. The existence of homographs presents a difficulty which cannot be solved in any principled way in a text-to-speech algorithm as long as semantic information is beyond the scope of the system. It may be mentioned in passing, however, that the fact that one member of a pair of homographs is often a noun, whereas the other is not, makes it possible in certain cases to exploit the syntactic behaviour of different word classes and thus circumvent the lack of semantic information. E.g. *hul* can be resolved if it is preceded by the indefinite article *et*, in which case it must be the noun; but such devices are expensive (each one will cost one more "rule"), and they cannot, of course, be integrated in the algorithm in any principled way.

IV. CURRENT AND FUTURE WORK ON THE GTPA

Since the main difficulties with constructing a GTPA lie in the XCO, the current work is concentrated on extracting regularities from the Danish orthographic conventions.

This work is a sort of trial and error procedure. Tentative rules are stated on the basis of partial orthographic regularities. The consequences of such tentative rules are tested by feeding the operational GTPA program - which was developed during the spring and summer of 1982 and which runs on the PDP11/60 computer assigned to the text-to-speech project - with hopefully representative samples of running text. In each such test the result may either be that it is found worth while to elevate the provisional rule to a genuine rule, which in the majority of cases leads to the establishment of a corresponding set of exceptions; or the result may be that the rule is discarded.

The operational GTPA program can also be used to test phonological rules of Danish in much the same way as the DANFON project (cf. Basbøll and Kristensen, 1975).

The data on which the tentative rules are based is a Danish dictionary (Holmboe, 1978) which is stored on disc, and which can therefore be manipulated at will by means of text processing programs.

There is no doubt that, apart from the problems arising from the existence of homographs, the problems of deriving reliable allophonic representations from orthographic text can in principle be solved at the word level. Indeed, this goal seems within reach in the course of a few months. The integration of syntactically determined aspects of Danish pronunciation still awaits thorough research.

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SEGMENT DURATION IN DANISH WORDS IN DEPENDENCY ON HIGHER LEVEL PHONOLOGICAL UNITS

ELI FISCHER-JØRGENSEN

This paper presents data concerning differences in segment duration in Standard Danish due to syllable number, position in the utterance and (based on a very restricted material) syntactic boundaries and word boundaries. It is shown that the tendency to shortening of stressed vowels according to number of following syllables which has been found in many languages, is not valid for Danish, which, on the contrary, has vowel lengthening in disyllables of the type CVCə compared to monosyllables. The historical and dialectal background of this phenomenon is discussed. It is further shown that Danish has final lengthening, although of less magnitude than e.g. English, and that word boundaries seem to be of limited importance, except for the vowel lengthening in disyllables.

I. INTRODUCTION

For many years it has been accepted as a general rule that the more sounds (or syllables) a phonological unit contains, the shorter are its individual segments. This rule is found, in different wordings, in the textbooks of classical phonetics published around 1900. Jespersen (1897-99, p. 508, and again 1914) quotes Rask for the observation that vowels in monosyllables like Danish *far* are longer than in disyllables like *fare* and Sweet for the remark that the diphthong in *tail* is longer than in *tailor*. He adds himself the Danish examples *fa'en* (a shortened form of *fanden*, which may, however, be disyllabic), *fane* and *fanejunker*. Jespersen explains the difference by assuming that the longer a series of sounds the speaker is going to produce, the more he tends to increase his tempo, and he mentions the frequent shortening of the first member of compounds in the historical development of Danish and English as a result of this tendency.

Sievers (1901) formulates the rule by saying that the more syllables a measure or rhythmic foot ("Sprechtakt") contains the shorter are the individual syllables. He gives the examples *heil, heilig, heilige, heiligere* and *fahl, fahle, fahlere* and mentions that the shortening is particularly clear in long vowels.

Some of the first measurements were undertaken by E.A. Meyer. He compared a large number of monosyllables and disyllables, both for English (1903) and German (1904) and stated that the vowel is shorter in disyllables.

In the following years similar differences were found for a number of languages, e.g. Hungarian (Meyer and Gombocz 1909 (cit. Elert 1964) and Tarnóczy 1965 (cit. Lehiste 1970), Spanish (Navarro Tomás 1916 and Menzerath and Oleza 1928 (cit. Elert 1964)), Lappish (Äimä 1918), Swedish (Öhman 1961) and Dutch (Nooteboom 1972), so that it looks as if it might be a universal phenomenon. In general the rule has been formulated in terms of vowel length in words of one, two and three syllables; but as most of the older studies were based on isolated words, it was not possible to decide whether the relevant higher unit is the word, the foot, the tone group or the utterance, or whether they all, to a smaller or larger degree, play a role, perhaps in a hierarchical manner.

Since the end of the sixties an increasing number of studies have been concentrated on this problem and on the differences of duration due to the position within the unit (e.g. "final lengthening"), and various explanations have been proposed and discussed. Most of these studies are based on English, Swedish and Dutch material, and the most important contributions have been made by Ilse Lehiste and Klatt for English, Lindblom for Swedish, and Nooteboom for Dutch. Lindblom and Klatt have attempted to set up mathematical formulas permitting to predict segment durations in different surroundings, e.g. for the purpose of speech synthesis.

In the beginning of the period the word was at the center of interest. Lehiste (1970) quotes some earlier investigations and concludes that in some languages the word as a whole has a certain duration that tends to remain relatively constant, involving a decrease of the duration of the segmental sounds when their number increases (see also Malmberg 1944). In Lehiste (1971) it is shown that the words *steady, skiddy* and *skitty*, said in isolation, are considerably shortened compared to *stead, skid, skit*. It is emphasized that all sounds, not only the vowels, are shortened. These examples present an extreme case. Not only is the stem shorter in the disyllables, but the whole word, including *-y* is shorter (which seems to be mainly due to the fact that *d* is flapped in the disyllables). Generally, disyllables are somewhat shortened, but not to the extent that the whole word is equal to or even shorter than the corresponding monosyllable.

Lindblom (1968) and Lindblom and Rapp (1971 and 1973) investigated nonsense words of the type *da:d, dá:dad, dá:dadad, dadá:d, dadadá:d* and found a shortening of the stressed vowel depending on the number of added weak syllables. In 1971 the differences are explained on the basis of a power law derived from the tendency to constant word length. Lindblom and Rapp observed that preceding syllables shorten the duration of the stressed vowel much less than following syllables. This was also found by Nooteboom (1972a) for a comparable material spoken by Dutch subjects, and by Lehiste (1975); i.e. final syllables remain long. Moreover, the difference between mono- and disyllabic words was found to be much larger than that between disyllabic and trisyllabic words (in Lehiste 1975 the latter shortening is very small and non-significant). There is thus a close relation to the phenomenon of final lengthening, i.e. the tendency to lengthen the final word, and particularly the final syllable in prepausal position. This relationship is taken into account in Lindblom's model (1973) and has led him to a new explanation (1976): the 'short term memory' explanation, which is based on the assumption that in speech production the words to be pronounced are stored in a buffer of restricted capacity: the more units entering the buffer the more are those already there compressed, until a certain minimum limit is reached. There will thus be more compressing due to following syllables than to preceding syllables, and the last syllable need not to be compressed. (According to Lindblom 'final lengthening' should therefore be termed 'non-final shortening'). This is quite an appealing theory. However, it does not seem to apply as well to shortening on a higher level, i.e. to the shortening of words (not syllables) according to their position. In sentences with repetition of nonsense words of the types *da:d*, or *dadá:d* (Lindblom et al., 1976) there was more shortening of the last word due to an increasing number of preceding words than of the first word due to an increasing number of following words. There was a clear difference only between final and non-final position, not decreasing duration according to the distance from the end, and the difference was small for *dá:dadad*. Real words, like *dag, dagen* and *Dagobert* presented approximately the same pattern, but *Dagobert* did not show any difference at all according to added words. It has also been shown by Kohler et al. (1982) that it does not matter whether you add one or two stressed words after a given word in a sentence (the test words were *Seide* and *Seite*); and Lehiste (1980a) showed that the length of the frame may be important for the duration of the test word but not its place in the beginning or the end of a frame (apart from the prepausal position). Lehiste (1973) also found a lengthening of the last foot in sentences consisting of four feet, but no difference between the preceding feet. This is probably the reason why Lindblom supposes the capacity of the buffer to be rather small (about 3 syllables according to his example (1976, p. 54)).

Others consider 'final lengthening' to be real lengthening. Klatt (1976) explains it as a deceleration of motor activity at the end of an utterance. Lyberg (1979, 1981) thinks that final lengthening is due to the fact that the extensive Fo contour in final position requires a certain duration of the last sonorant. Umeda (1972) has made a similar proposal.

However, a somewhat less pronounced lengthening has often been found within the utterance at syntactic boundaries. In American English publications this is called phrase final lengthening, whereas Lyberg uses the term 'phrase' in the sense of 'utterance'. Such lengthening is observed by Klatt (1975 and 1976), by Klatt and Cooper (1975), and by Oller (1973). Oller found that even combinations of attributive adjective and noun, where no break should be expected, show lengthening of the stressed syllable when it is word final, at least for nonsense adjectives like *the babáb apple is on the table* compared to *the bábab apple* ..., and concludes that the word boundary is of importance. It might, however, also be the two stresses coming closely after each other in *the babáb ápple* and thus the rhythmic foot (or measure) that is decisive. Klatt and Cooper (1975) found influence by both phrase and word boundaries. - In the interior of the sentence, however, no particular Fo contour should be expected. Thus the Fo contour does not explain everything, and Bannert (1982a and 1982b) has adduced evidence from Swedish and German against any decisive influence of the Fo contour on duration.

Lyberg further maintains that the difference according to syllable number in the word is only found in utterance final position (due to the Fo contour), and that opposite findings are due to the use of nonsense words. But in his own examples the *a* of *Dagobert* is shorter than that of *dag* and *dagen* in all positions, and *dagen* is shorter than *dag* for one of the three subjects.

Various others have also found differences according to syllable number outside the final position. It appears from Oller's graphs (1973) that the difference in duration of the stressed *a* in *bab, bábab* and *bábabab* is also found within the sentence at syntactic boundaries and even in attributive position. Klatt and Cooper (1975) have shown the same for real words: *deal* has a longer [iː] than *dealer*, and *fish* a longer [ɩ] and [ʃ] than *fishing* medially in a short sentence. Elert (1964) also found differences between the vowels of monosyllables and disyllables medially in Swedish sentences. These shortenings can hardly be explained by Lindblom's model either.

Lindblom's words were not pronounced finally, but in the short frame *'say ... again'*, and in various other cases the words were also spoken in frames, e.g. Klatt 1973.

Harris and Umeda (1974) object that words in frames are said in a specific mode. Since the sentences do not give any information to the listener, the rhythm is mechanical, whereas in connected speech semantic importance and syntactic structure overrule the mechanical phonetic features, so that in connected speech no difference according to syllable number is found. It may be true that in connected speech these differences are overruled more or less by other factors, but that does not mean that the tendency does not exist; it only means that there is an interplay of various factors, and to single out one individual factor you have to use sentences of a similar type. It is true that speakers may tend to make a pause after the test word in a frame or to give it a particular prominence, but this is not necessarily done. Lehiste's finding (1980a) that the length of the frame influences the test word seems to show that the test word has been integrated into the sentence.

In any case, the examples of differences in other than final positions and particularly the results of Klatt and Cooper (1975) do not permit a simple reduction of the rule concerning syllable number to utterance final position or to final position in a frame.

What is still problematic is the role of the word versus the foot. A tendency to equal length of consecutive feet or - to put it differently - to equal distance between stressed syllables (i.e. isochrony) has often been maintained for English. It has been shown by Lehiste (see, e.g., her summaries 1977, 1980b and 1982) and by others, that isochrony is mainly a perceptual phenomenon, but a certain tendency can also be found in production. Lehiste (1972) showed that in the type *speed kills*, the word *speed* has a longer stem and a longer stressed vowel than in the type *speed increased*. Kohler et al. (1982) found a shortening effect of a following syllable in the foot (*'...Seite täglich...'* compared to *'...Seite bestimmt...'*), but he thinks that the word boundary may have a supporting effect. Lehtonen (1974) gives examples from Finnish where the word division is without influence. Elert (1964) assumes that the measure is more important than the word boundary. But of course, isochrony does not explain the differences in isolated words. Donovan and Darwin (1979) remark that the perceptual illusion can be considered as a perceptual compensation for the deviations from an intended isochrony disturbed by different types and number of syllables.

Lehiste (1972) observes that in the type *the stick fell* the word *stick* is shortened just as much (in fact more) than in *sticky* compared to the isolated word *stick*, and that in *the stick is broken* the word *stick* is of the same duration as in *stickiness*. She concludes that there is no clear difference between morpheme boundaries and syntactic boundaries, in other words, the word unit is not important. As far as I can see, her material only proves that there is reduction in both cases, not that it is of the same extent, for the positions are different: The isolated words *sticky* and *stickiness* are in final position, whereas this is not the case in *the stick fell* and *the stick is broken*, so that here shortening due to non-final position (another stressed word following) is not separated from the effect of syllable number. In order to prove definitely that word boundaries are irrelevant, one should compare phrases like *the sleepy farmer, sleep refreshes, the sleepy professor, sleepiness stops it*, etc.

II. SOME CHARACTERISTIC FEATURES OF THE DANISH PROSODIC SYSTEM

The Danish simplex word of the central native vocabulary consists of a stressed syllable with full vowel followed by 0-2 (rarely 3) unstressed syllables with schwa. Derivatives and compounds normally have secondary stress on the second member and full vowels. Compounds can be formed very freely. Words with prefixes generally have stress on the stem, and foreign words may be stressed on any syllable and have full vowels in unstressed syllables. This is just as in German. But the Danish syllables with schwa are perceptually weaker than in German, and the [ə] is often very short and may disappear completely in colloquial speech, particularly after sonorants. However, it usually leaves a lengthening of the consonant, and generally the number of syllables is perceptually preserved, also because at least part of the pitch movement is preserved. In the present material only one of the subjects (who has a Jutlandish dialectal background) has apocope finally in the frame, e.g. [dann̩] for [danə] and even [bast] for [bastə]. The other subjects may have apocope in the first member of compounds like *malekasse*. In word final position in frames the duration of [ə] is usually 3-5 cs.

Vowel quantity is phonologically relevant in Danish, and it has quite a considerable functional load in words of two and three syllables, e.g. [mi:lə/milə]. There is hardly any difference in vowel quality between short and long equivalents except for short and long [a] [o] and [ɔ]. Postvocalic consonants do not show any difference of duration after long and short vowels (Fischer-Jørgensen 1964 and Riber Petersen 1973).

Almost all monosyllables and final stressed syllables with a long vowel and most monosyllables with a short vowel + sonorant consonant have 'stød', i.e. a specific accent (transcribed [?]) which in its typical form is characterized acoustically by a drop in intensity and Fo often ending in creaky voice in the latter half of the long vowel or the beginning of the consonant after a short vowel. But the creaky voice may be practically absent and there is, on the whole, a rather large variation in the manifestation of the 'stød' (Riber Petersen 1973, see also Smith 1944). Thus comparing the duration of long Danish vowels in monosyllabic and disyllabic words would mean comparing words with and without stød, and that would give an unclear picture because for most speakers the stød has a shortening effect on the vowel. Stød is, however, found in many disyllables ending in *-er -el -en*, and in a few inflected forms in *-e*, so that mono- and disyllables with long vowels and stød can be compared, but generally the segmentation makes difficulties because of the creaky voice which may continue into the following consonant. Monosyllables with short vowel and sonorant consonant also make difficulties because of the stød, but there is a small number of words of this type without stød.

Monosyllables with a long vowel without stød are extremely rare. The word *far*, mentioned by Rask, is a concentrated form of *fader*. But since Rask's time final *r* has been vocalized and assimilated to [ɑ:], so that the pronunciation is now [fɑ:], and a comparable disyllable *fare* is pronounced [fɑ:ɑ̯], where no segmentation is possible. Moreover, the words *lagde* and *sagde* may be monosyllabic [la:, sa:], particularly with weak stress, but they may also perceptually have a trace of a second syllable. In the speech of the younger Copenhagen generation one may hear long [ɑ:] and [ɒ:] without stød, due to an assimilation with a following *r*, e.g. *stork* [sdɒ:g]. Finally, monosyllables with long vowel without stød are found as first member of compounds. But most old compounds of this type have shortened the vowel, and many more recent compounds have varying length of the first member, so that it is difficult to find reliable examples. This leaves us with the possibility of comparing monosyllables and disyllables with short vowel, and moreover, as Danish has no voiced obstruents (except *v*, which is not found after short vowel), they can be compared only before voiceless consonants and sonorants. According to experiences from other languages, the differences are, however, most obvious for long vowels and before voiced consonants.

Thus it seems as if Danish is not a particularly good choice for this type of investigation. However, it may be an interesting choice, because some earlier more restricted measurements seem to indicate that it might present an exception both to the rule of shortening in disyllables and to the rule of final lengthening. In a paper on sound duration and place of articulation (1964) I mentioned in passing that all eight subjects had a longer vowel in disyllables than in monosyllables. However, the word type was rather specific: nonsense words with high vowel followed by a stop consonant and preceded by the same stop consonant or by [h], thus e.g. [bib bibə] spoken in a quick series [bib, did, gig], etc. This was rather far from natural speech. It might be worth while trying real words. As for final lengthening, Holtse (1977) found that the words *læs, læsse, læssene* and *læse, læselig, læsende, læsesal, læsesale* (plus some still longer words) spoken by himself nine times each, partly finally in the frame *det kaldes...* ('it is called...') and partly in the frame *det kaldes... denne gang* ('it is called ... this time'), did not show any difference in vowel length in the two frames (there was a difference of only about 1 cs for the word *læssene*). He concludes that it would be worth while investigating a larger corpus in order to find out whether there is really no final lengthening in Danish. This would not be very surprising. Lindblom relates final lengthening to the nuclear stress rule (final lengthening being the more general phenomenon (1978 and Lindblom et al. 1976)). But Danish has no general nuclear stress rule, and there is no sentence accent on the last lexically stressed word in neutral sentences as is the case in Swedish, English and German. In neutral sentences Danish has equal stress on the stressed words (see Thorsen 1980). This, by the way, may be related to the fact that Danish makes a clear distinction between equal stress and 'uniting stress', e.g. *han lǽser románen* 'he reads the novel' and *han læser románer* 'he reads novels', *han går i vándet* 'he walks in the water' and *han går i vándet* 'he goes swimming' (see, e.g., Rischel 1980 and 1982).

As for the difference between the stressed vowels in disyllabic and trisyllabic words, Holtse (1977) showed on the basis of a large corpus consisting of nonsense words of the type CVCə and CVCəCə(Cə) in frame sentences that the vowel in trisyllabic words is, on the average, shorter than the vowel in disyllabic words. The difference is small (generally less than 1 cs) and there are exceptions, but due to the extensive material the tendency comes out clearly.

III. INFORMANTS, MATERIAL AND MEASUREMENTS

The basic data used in this investigation were recorded by seven main informants, five male and two female. They are all phoneticians or dialectologists. (For measurements of small differences of duration it is an advantage to use speakers who are accustomed to read silly sentences without hesitation.) They have all lived in Copenhagen for several years and speak Standard Danish (SD) but with different dialectal background.

NR, born 1942; spent his childhood in Gl. Holte, North of Copenhagen; he has lived in Copenhagen since 1964 and speaks "Advanced Standard Copenhagen Danish" (ASC).

EF, born 1911 in Nakskov, Lolland; spent her childhood in Faaborg, Funen, has never spoken Funish but learnt a conservative SD from her parents, which is now modified by influence from ASC; has lived in Copenhagen since 1929.

PH, born 1947 in Nakskov, Lolland; has lived in Copenhagen since 1966, speaks SD with a slight tint of Lolland regional language. He has a relatively weak stød.

OT, born 1928 in Aars, Himmerland in Jutland; has spoken Jutlandish urban dialect as a child; he has lived in Copenhagen since 1943 but has a slight Jutlandish accent, particularly in the rhythm.

NK, born 1915 in Odense, Funen; has lived there until he came to Copenhagen in 1944. He speaks SD with a perceptible Funish accent.

BJ, born 1946; spent his childhood near Kolding, Jutland at the boundary between the West- and East-Jutlandish dialect areas. He spoke dialect with his playmates and regional standard language with his parents. He has lived in Copenhagen since 1952. He speaks SD with a perceptible Jutlandish accent, particularly in the rhythm.

IE, born 1926 in Vrinsted, Salling, Jutland; has spoken urban dialect as a child. Her SD has a very clear Jutlandish background. She has, e.g., consistent apocope. She has lived in Copenhagen since 1945.

I have, on purpose, chosen informants with a varied dialectal background in order to see how general the characteristic features of their segment durations are. All have the Copenhagen pitch contour with low stressed syllables and a jump up to the first post-tonic syllable (see Thorsen 1980), at least when the syllable belongs to the same word, but the last four have a somewhat different contour in compounds.

The material read by these seven informants consisted in (1) the nonsense words *mam, mámam, mámamam, mamám, mamamám,* spoken finally in the frame *han sagde ...* [han sa:] ('he said ...'), (2) real words with different syllable number spoken in the frame *han sagde ... fem (to) gange* ('he said ... five (two) times') (in a few cases, for one subject *han sagde ... een gang* (i.e. 'once')). Many of the words were also spoken finally in the frame *han sagde ...*; (3) small sentences of the type *han så sine sønner* ('he saw his sons'), *hans sønner kommer* ('his sons are coming'). More details are given in the relevant sections. All three types were mixed in four different randomizations. It turned out not to be a good idea to mix the nonsense words with the other words because they stood out as special, and were sometimes spoken with extra emphasis or speed. The subjects were asked to read the sentences in a neutral tone and in a constant tempo without internal pauses. Most of them succeeded, but one often made a small pause after the test word in the frame 'he said ... five (two) times', and one gave the test word a certain degree of emphasis. The list was repeated twice, so that there are 8 examples of each word for each speaker, in a few cases 10. Most words were spoken in one session, but a smaller part was read in another session. Only words from the same session are compared. Some sentences were only read by four subjects, a few by three, and one subject read a number of extra sentences.

The sentences were recorded on a semi-professional tape recorder in a sound-treated room at the Institute of Phonetics, Copenhagen University.

A more restricted material was recorded by 16 informants, all living outside of Copenhagen and speaking various rural or urban dialects or types of regional standard Danish (RSD). There were three from Zealand, seven from Funen, and six from Jutland. The informants were:

(a) Zealand

ET, born 1894 in Dragør on Amager, where she has spent her whole life. She speaks the coastal North Zealand dialect.

KH, born 1910 in St. Havelse, North Zealand, about 40 km North-west of Copenhagen. He has spent some years in

Jutland but has now for several years lived in his native village. He speaks dialect with his friends.

OR, born 1909 in Nordrup; is now living in Bjeverskov, and has spent all his life in a rather narrow area on the border between the North- and South Zealand dialect area in Eastern Zealand near Køge.

(b) Funen

IP, born 1914; has spent her whole life in Vissenbjerg in the West Funish dialect area.

HV, born 1933 in Haastrup in the westernmost corner of the East Funish dialect area. He has lived in Haastrup only and speaks an old-fashioned and genuine dialect.

MA, born 1960 in Frørup, on West Funen; has lived in Frørup only, or in the close vicinity of Frørup. He speaks South-West Funish dialect.

LA, born 1956 in Frørup (MA's sister); lived in Frørup until 1976, since then in Copenhagen, but she speaks dialect at home.

EK, born 1932 in Odense and still living there; speaks urban dialect, not too far from the Odense RSD.

EA, born 1932 in Nyborg; has lived in Odense since 1936. Speaks the same dialect as EK.

HC, born about 1910 in Svendborg; has lived in Odense for many years, but still has Southern Funish features, e.g. generally no stød.

(c) Jutland

LH, born 1946 in Århus, where she still lives. Speaks a typical Århus regional standard (e.g. with rather fronted [a].

BT, born 1940 in Uldum in the South-Eastern corner of the West Jutlandish dialect area; has spoken urban dialect as a child and still speaks it occasionally. She has lived in Århus since 1962 but speaks Copenhagen Standard language, which she has learnt from teachers and friends.

TA, born 1948 in Villerslev in South Thy in Northwestern Jutland; has lived in Århus since 1967 but still speaks the dialect.

EA, born 1951 in Mors, speaks West Jutlandish like TA. She has lived in Århus since 1970.

JD, born 1914 in Vridsted in Fjends Herred South of Skive, i.e. in the West Jutlandish dialect area; studied in Copenhagen, but has lived in Århus since the forties. She still cultivates her dialect.

PN, born 1910 in Børglum, Vendsyssel, still uses his dialect. He now lives close to Århus.

The four latter informants all speak rural dialects and a regional Jutlandish standard language (not specifically the Århus type).

The dialectal speakers read short sentences containing partly the same words as those read by the speakers from Copenhagen. The five bilingual Jutlandish speakers read the same sentences in dialect and in their standard language.

Two more informants read a few sentences:

SR, born 1940 in Hjerting, South Jutland; spoke dialect as a child and still speaks it when visiting his family. His SD has a clear Jutlandish rhythm. He has lived in Copenhagen since 1960.

PM, born 1946 in Himmerland, Jutland; spoke dialect only until he was 10 and still speaks it when going to see his family; his SD has a perceptible Jutlandish tone. He has lived in Copenhagen since 1967.

The tape recordings of the Zealandish dialect speakers were made in their private homes, using a transportable tape recorder. The Funish recordings were made partly in the homes of the informants, partly at the Institute of Linguistics in Odense, and (in the case of IP) at the Institute of Phonetics in Copenhagen. The recordings of the Jutlandish speakers were all made on a Nagra tape recorder at the Institute for the Jutlandish Language and Culture at the University of Århus.

All the tape recordings were transferred to mingograms in the Institute of Phonetics in Copenhagen, each recording combining a duplex oscillogram, and Fo-curve, and two intensity curves (one high fidelity, one highpass filtered at 500 Hz).

The segmentation was made by hand with an accuracy of 5 ms. Generally my uncertainty did not exceed ±2.5 ms, but there were exceptions: In the words [pla:ʔn, pla:ʔnɒ], [a:ʔ] and [n] could not be delimited for two of the four speakers who read these words, because the creaky voice continued into the consonant. The West Jutland stød also gave some difficulties. The most difficult problem, however, was the delimitation of utterance final sounds. In final stops only the closure was measured. This did not give any problems for the main informants from Copenhagen. However, for the dialect speakers it was often problematic to locate the release, e.g. after the West Jutlandish stød, where the stops were unaspirated, and for some of the Funish speakers. In the case of [s] the noise ends rather abruptly, and the few cs of uncertainty do not matter since the consonant is very long. A real problem arises for final vowels and nasals because they generally fade out gradually. For the main informants two measures were used for final [n]: (1) the point where the vibrations stop or get almost invisible (this point is somewhat arbitrary), (2) the point where the unfiltered intensity curve starts decreasing abruptly, the highpass filtered intensity curve has almost reached zero, and the Fo curve changes from rise to fall.

This point, which (according to a few control spectrograms) corresponds to a point where only the fundamental is left, is generally well defined for four of the seven main informants, whereas for the other three the criteria do not always coincide.

The point where voicing ends gives almost the same duration for the latter three subjects, but this does not correspond to perception. Two have perceptually a normal Danish final [n], whereas the third has a conspicuously long [n]. (It may also be of importance that her [n] is of rather high intensity and keeps this high level till the end.) But choosing the point where the highpass filtered curve reaches zero gives very short [n] for some other subjects. A solution to this problem would require a special investigation. The point where voicing ends has been used in the graphs of figure 1, but the consequences of a different delimitation have been mentioned in the text. For the dialect speakers the problems with final [m] and [n] were even worse. In various cases the delimitation was given up. The dialect speakers also gave more problems because they did not read the sentences as fluently as the main informants. Corresponding problems arise for final vowels, but they have been excluded from this investigation.

The boundary between a vowel and a following consonant was placed where the intensity curve and the Fo curve decrease abruptly, except for vowel plus [s], where the boundary was placed at the start of the high frequency noise of [s]. This exception was made because it was the only reliable point in the cases of vowel with stød before [s], and there was a number of words of this type. But it means that the indications of vowel duration before [s] are about 2 cs longer than they would have been using the normal criterion.

The significance of the differences was tested by means of the Mann-Whitney U-test and in some cases by the usual t-test, according to the type of distribution.

In the following sections the words are given in phonetic transcription. Initial consonants are of peripheral interest only for the investigation. The only postvocalic consonants used in the examples are [b̥, d̥, g̊] (written [b d g] for typographical reasons) and [s] [m] [n]. [b̥ d̥ g̊ s] are referred to as "obstruents" or as "voiceless consonants" (the two designations being synonymous in this case), [m] and [n] as "sonorant consonants". In the historical section (IV B) the term "obstruents" or "voiceless consonants" also covers *f*, and the term "sonorants" *l*, *m*, *n*, ð, *r* and the semivowels *w* and *j*.

IV. RESULTS

A. INFLUENCE FROM NUMBER OF SYLLABLES

As mentioned in section II, Holtse (1977) found a tendency to shorten the stressed vowel in trisyllabic words of the type CVCəCə in comparison with disyllabic words. This tendency is confirmed by the present material. The following words were compared: [ˈsœnɒ/ˈsœnɒnə], [ˈbasdə/ˈbasdəðə] (read by 4 and 6 informants, respectively, both in final and in medial position in the frame), [ˈdanə/ˈdanəðə], [ˈbasə/ˈbasɒnə] (read by 5 and 6 informants, respectively, in medial position); moreover [ˈmisə/ˈmisəðə] and [ˈlɑgə/ˈlɑgəðə], read by one informant both medially and finally. This amounts to 29 individual averages, each comprising 8 tokens. 23 (or 79%) of the averages have a longer vowel in the disyllabic word. The difference is, however, small (0.5 cs on the average), and it is only significant in 2 of the 29 cases. It is slightly larger in final than in medial position in the frame (0.8 and 0.4 cs, respectively). The two informants who took part in Holtse's investigation had a difference of 0.8 cs in the present investigation, which is in agreement with his own results. An example with long vowel and stød [ˈpla:ʔnɒ/ˈpla:ʔnɒnə] showed the same difference (0.7 cs). There is no difference in the following consonant, and the initial consonant is only insignificantly shortened in the trisyllabic words (0.3 cs).

As for the difference between monosyllables and disyllables, a graphic display is given in figures 1-2. The vowel differences are displayed in the left column and the differences in the following consonant of the same words in the right column. There was no consistent difference in the initial consonant.

The words were either spoken finally in the frame (marked (fin.) in the graphs) or medially (marked (med.)), in most cases in medial position in the frame, in some cases, however, medially in short sentences (this is the case for the words [sœn, sœnɒ, pla:ʔn, pla:ʔnɒ, mad, madə, pʰɑg, tʰɑgəðə]). In the case [pʰɑg/tʰɑgəðə] the pair is not minimal, and [pʰɑg] was the first member of a compound; but NR, who also read [tʰɑg/tʰɑgə] in identical sentences, had practically the same difference in the two cases. The consonant difference has been left out for the pair [pʰɑg/tʰɑgəðə] because the delimitation of [g] was too uncertain, and because the surroundings are not identical.

It appears clearly from the graphs that in the type CVCə/ɒ the vowel is longer in disyllables than in monosyllables, the grand mean of the difference being 3.2 cs. This is true of 69 (= 96%) out of 72 individual averages, each comprising 8 tokens, and in 65 (or 90%) of the cases the difference is significant at the 1% level. The three countercases belong to the pair [bas/basɒ]. Disyllables with the weak vowel [ɒ] (orthographically *-er*), which is longer than [ə], seem to have less lengthening of the stem vowel, the [a] of [basɒ] being significantly shorter than the [a] of [basə]; similarly, the [a] of [mana] is significantly shorter than the [a] of [manə]. The vowel [i] is less length-

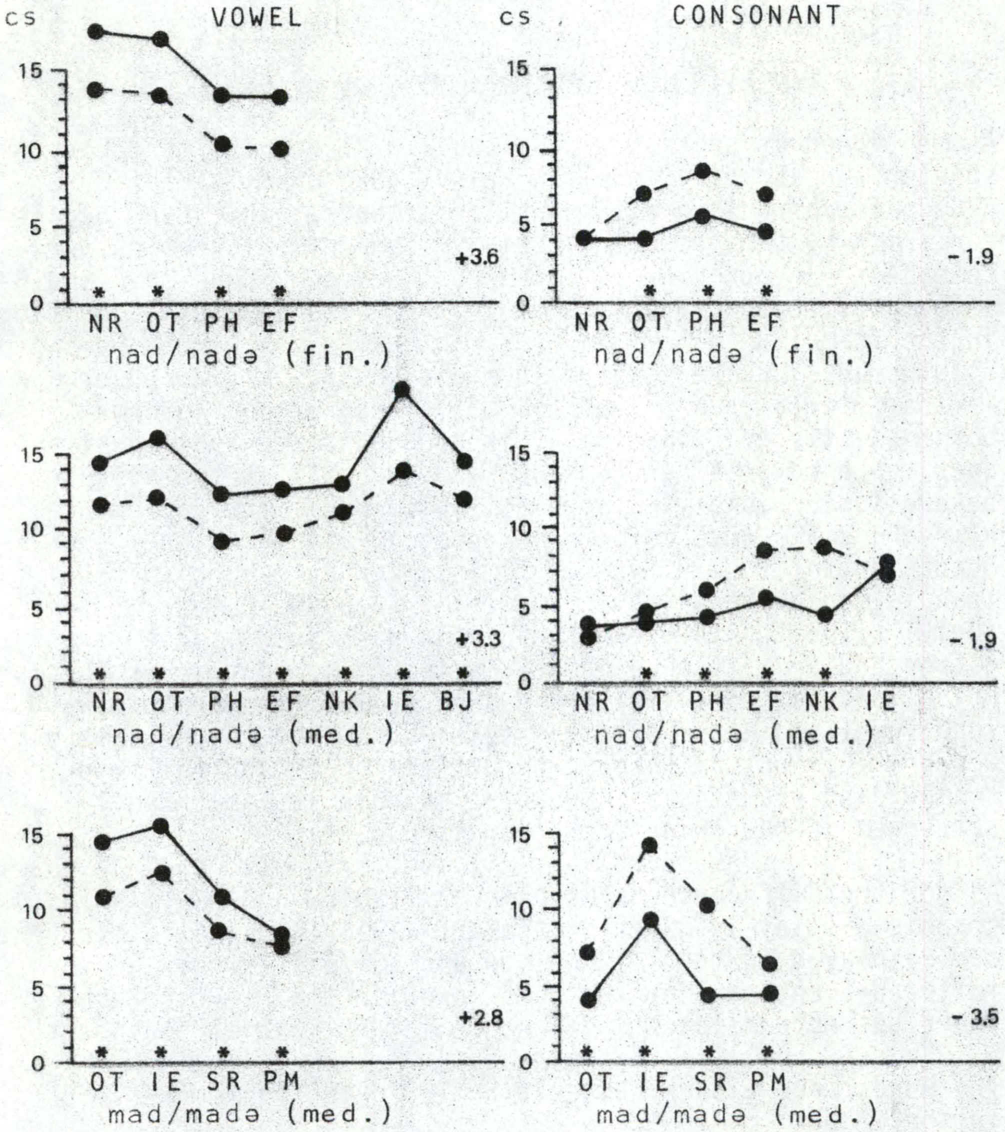


Figure 1

Duration of short vowel and following consonant in Danish disyllables (●——●) compared to monosyllables (●----●) in final (fin.) and medial (med.) position. The speakers are indicated by initials along the base line. (In a few cases there are two recordings of the same speaker.) Stars indicate that the difference is significant at the 1% level. The average difference (in cs) is given in the lower right-hand corner of the single graphs. Subject IE is not included in the average of the consonants.

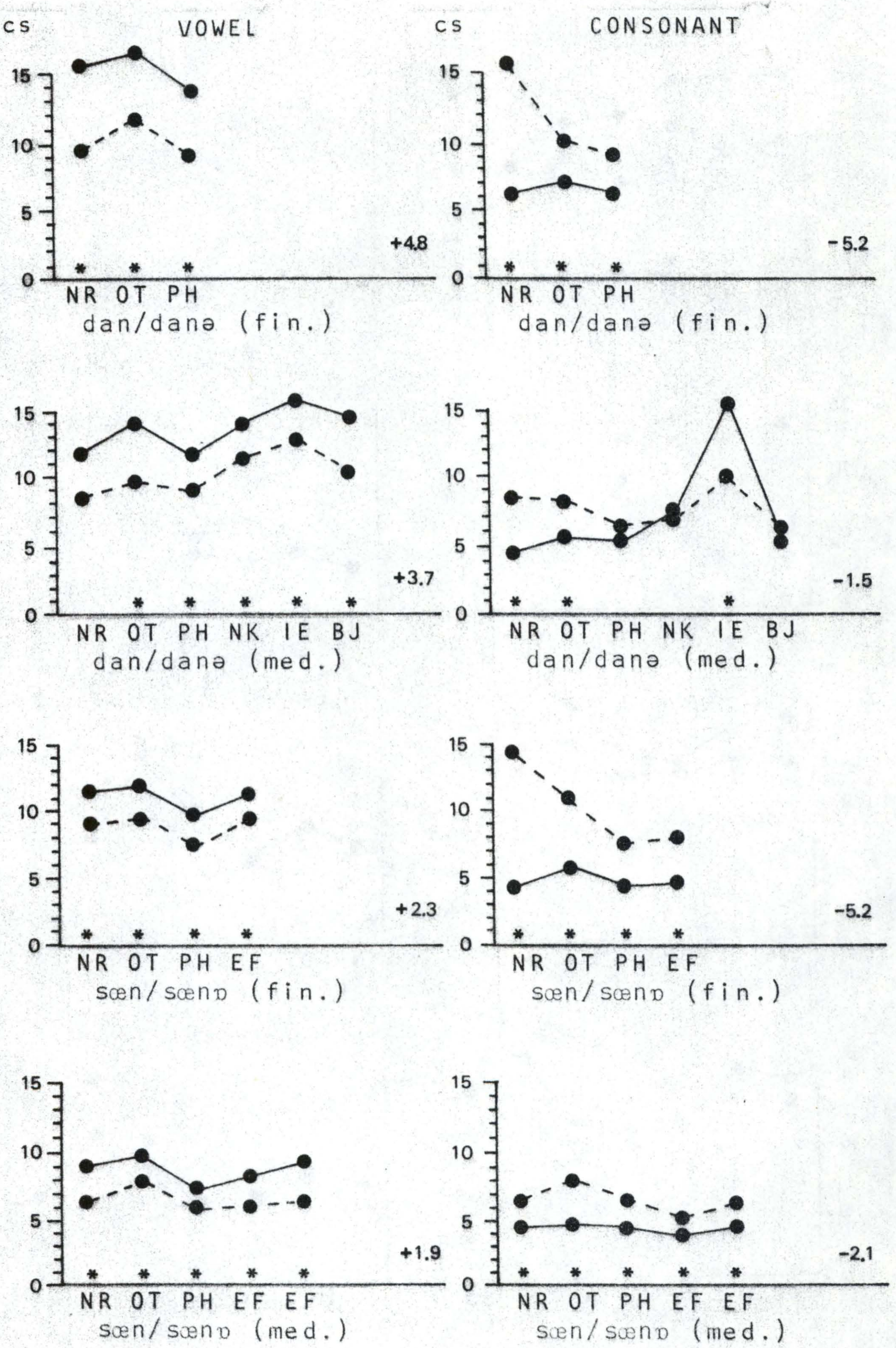
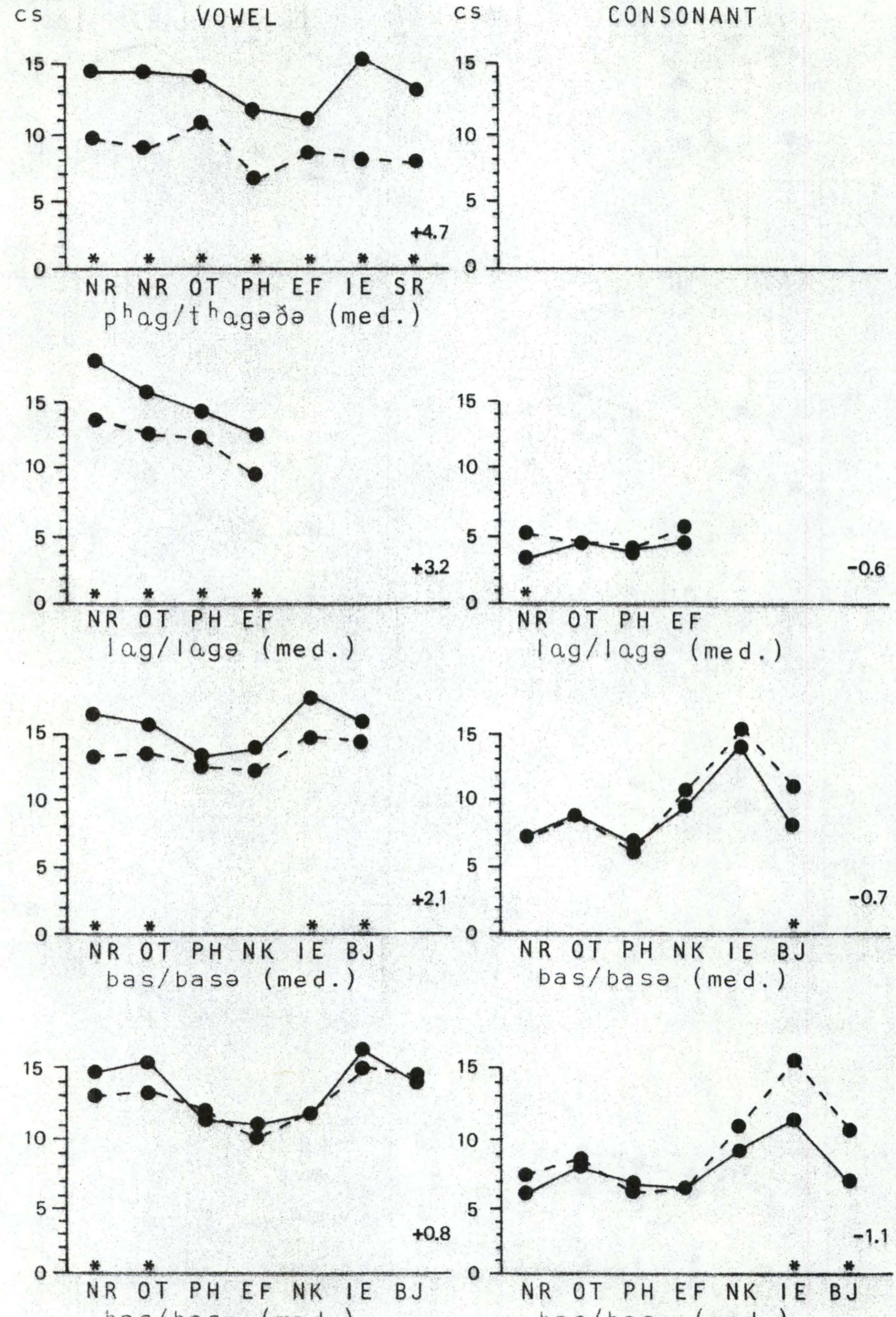


Figure 1, continued



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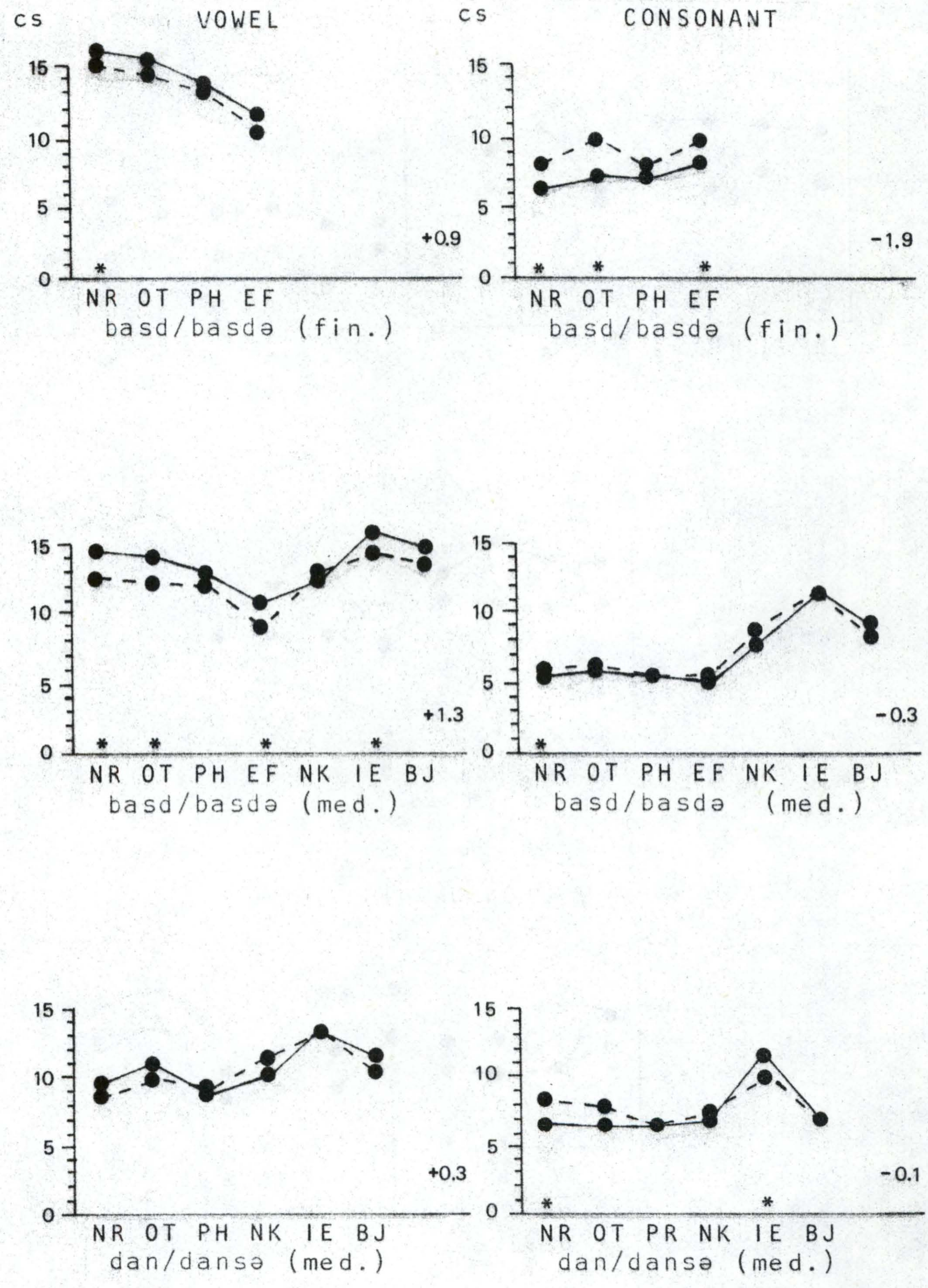

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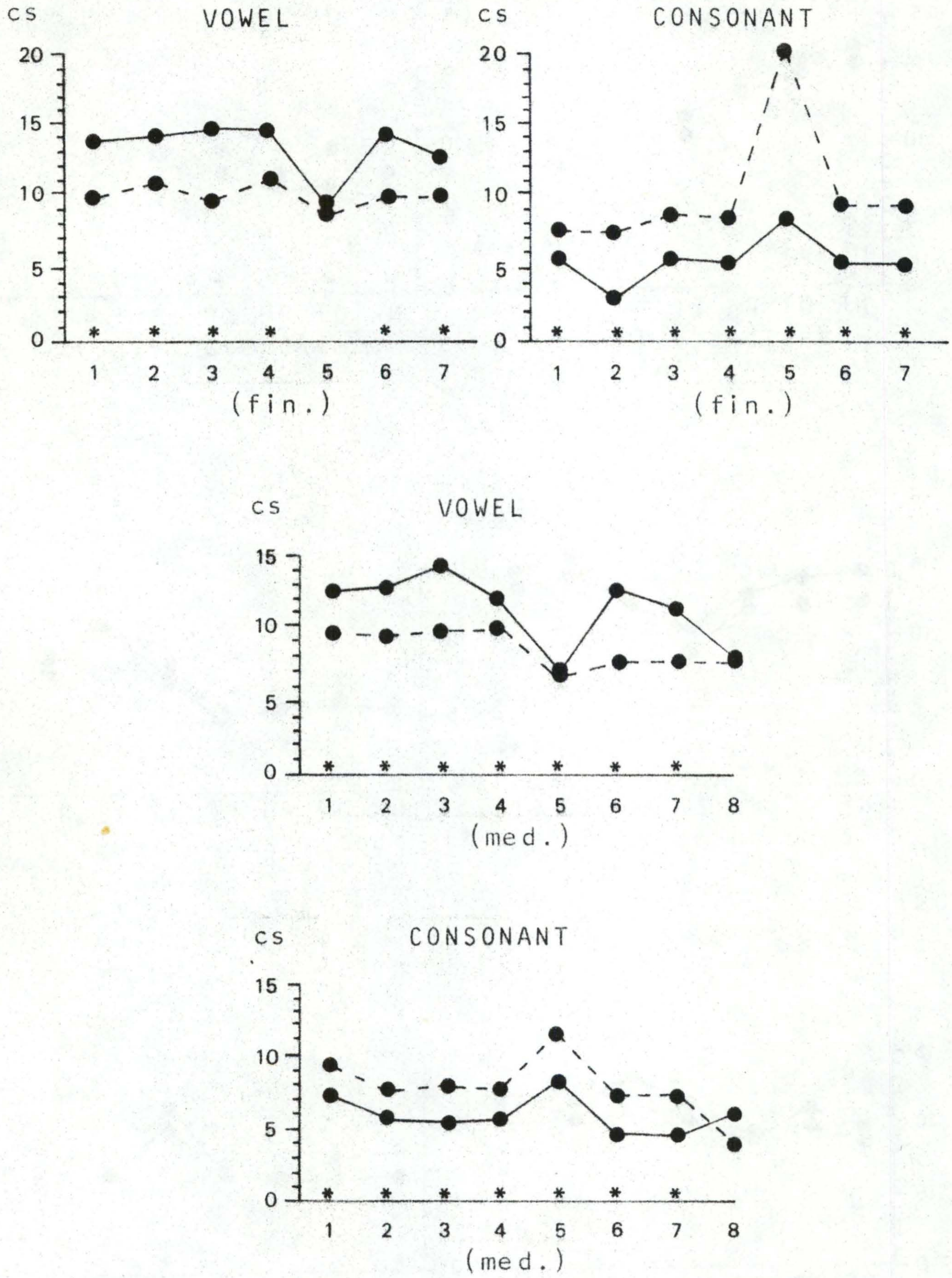


Figure 2

Duration of short vowel and following consonant in Danish disyllables (●——●) compared to monosyllables (●----●) in final (fin.) and medial (med.) position. Speaker EF (extra examples). Stars indicate that the difference is significant at the 1% level. Word pairs: 1. [lad/ˈladə], 2. [muˈlad/muˈladɒ], 3. [lɑg/ˈlɑgə], 4. [pʰoˈlɑg/pʰoˈlɑgɒ], 5. [mis/ˈmisə] 6. [man/ˈmanə], 7. [man/ˈmana], 8. [man/ˈmansə] ened than [a] and [œ], and the difference is not significant (see figure 2, No. 5). High vowels have generally been found to have less clear differences. Therefore [a] was chosen in most word pairs in this investigation. But the significance of the difference for high vowels as well has been demonstrated in my 1964-paper. The difference is of only slightly larger magnitude finally than medially (0.3, 1.1 and 0.4 cs in three comparable pairs of sentences).

In words of the type CVCC(ə), represented by two pairs [basd/basdə] and [dan/dansə], there is less lengthening of the vowel in the disyllabic word (0.8 cs). The vowel is lengthened in 14 (= 82%) of the 17 individual averages, but the difference is only significant in 5 (= 30%) of the pairs. Moreover, one speaker read the pair [man/mansə] (figure 2, No. 8). Here the disyllable had a small non-significant lengthening of the [a]. In [dansə] and [mansə] there is, of course, also an extra [s]. ([dansə] was compared to [dan] instead of [danʔs] because the latter word has stød.)

In contradistinction to the vowel the following consonant is shortened in disyllables, the average being 1.4 cs in medial position and 3.7 cs in final position in the utterance. The subject IE has been left out in these averages because she has apocope and thus (in three out of seven cases) a particular lengthening of the consonant in disyllables.

In final position shortening is found in 22 (= 96%) out of 23 individual averages, the difference being significant in 21 (= 91%) of the cases. In medial position the shortening is found in 40 (= 79%) out of 51 individual averages, and it is significant in 26 (= 51%) of the cases.

The shortening in final position varies according to the consonant. The fricative [s] (see figure 2, No. 5) is very long finally, and the relative shortening in the disyllable therefore considerable. Four speakers who read the word [bas] in final position also had an extremely long final [s]. There is also a relatively large difference for the consonant [n]. But here the delimitation is dubious. It was made where voicing stops. If it had been made where the high-pass filtered intensity curve reaches zero, the difference would have been 1-2 cs instead of 5.4 cs. The closure of stop consonants is not much longer in final position in the utterance, but the aspiration (which has not been included in the measurement) is longer. - Since the vowel is lengthened and the following consonant shortened in disyllables, there is no consistent difference between the stems of monosyllables and disyllables.

In the nonsense words [mɑm] and [ˈmɑmɑm] all speakers had a longer stressed [ɑ] in [ˈmɑmɑm], but the difference was only 0.7 cs and only significant for two of the seven speakers.

For long vowels without stød the only examples were the compounds [ˈlɔːnˌtʰaːʔɣɒ/ˈlɔːnəˌkʰasə] read by seven informants, and [mɔːlˌsgiːvə/mɔːləˌsgiːvə] read by one informant.

These words showed a lengthening of the vowel in the disyllabic first member of the compound of 3.3 cs.

The addition of a weak derivative suffix like [-li] has very little influence on the vowel of the stem. Seven speakers read the word [ˈnadli] in the same frame as [nad], and none of them had any significant difference in the duration of the vowel. The average was 0.3 cs shortening. One speaker read the derivatives [ˈsœnli, ˈmanli, ˈmisli] finally and medially in the frame. There was no difference in vowel length between these words and the corresponding simplex words. There is thus neither lengthening nor shortening of the vowel in these cases.

In compounds with secondary stress on the last member the vowel of a monosyllabic first stressed member is consistently shortened compared to the simplex word in the same frame. But the shortening is of very small magnitude. In [ˈnadˌlɑmbə] read by seven informants the first [a] was shortened compared to [nad] by 0.9 cs on the average, and the shortening was only significant for one speaker. In the word [ˈdanˌfɔs] read by seven informants the first vowel was shortened by 1.0 cs, and the difference from the simplex word was significant for three speakers. The compounds [ˈmisˌlyð?] and [ˈmanˌfɔl?g] read by one informant, showed significant but modest shortenings of 1.5 and 1.4 cs, respectively.

With a disyllabic first member the shortening of the vowel of the stressed first member is somewhat more pronounced. In [ˈnadəˌfrɔsd], read by seven informants, the [a] was shortened by 2.1 cs compared to [nadə],and the difference was significant for five speakers. In [ˈdanəˌvɑŋ?], also read by seven informants, the first [a] was shortened by 2.0 cs compared to the word [danə], and the shortening was significant for six speakers. In [ˈmisəˌkʰad] and [ˈmanəˌfal?] read by one informant, the first vowel was significantly shortened (1.4 and 2.6 cs, respectively). However, in spite of these shortenings the [a] of [ˈdanəˌvɑŋ?] is still significantly longer than the [a] of [ˈdanˌfɔs], and the [a] of [ˈnadəˌfrɔsd] significantly longer than the [a] of [ˈnadˌlɑmbə], irrespective of the number of syllables in the whole word. This means that it is the type CVCə which has vowel lengthening compared to the type CVC. It is not a simple question of syllable number.

Words with long vowel and stød behave differently. Four subjects read the words [pla:?n, pla:?nɒ] in final position and in two different positions medially. It was only possible to delimit [a:?] and [n] for two of the four speakers. They did not have any consistent difference in the vowel. All had, however, a significant shortening in the disyllable of the combined segments [a:?n] of [pla:?nɒ] in final position, but no consistent difference medially in the sentence. The pair [ma:?s/ma:?sɒ] was read by four informants. One had a non-significant shortening of the vowel in the disyllabic word, the other three had no difference. The pair [kʰaˈla:?s/kʰaˈla:?sɒ] was read in final and medial position by one speaker. In both cases the vowel was significantly shortened in [kʰa'la:ʔsɒ]. Moreover, the pair [sbi:ʔs/sbi:ʔsɒ] was read by four informants finally, by seven medially in a frame, and by four in short sentences. The result is shown in figure 3. It appears from the graphs that the vowel is shortened in the disyllabic word in 13 out of 15 individual averages (87% of the cases), and the difference is significant in 10 averages (67%). The consonant [s] is shortened drastically in the disyllabic word when the words are in final position in the utterance, otherwise only slightly. The difference is significant in final position, but medially in four averages only, and the significant differences go both ways.

On the whole, this word is in accordance with the tendency known from other languages. None of the words with stød have any significant lengthening of the vowel in disyllables.

According to Lindblom, the addition of preceding syllables does not influence the stressed vowel as much as the addition of following syllables. This was investigated for eight Danish word pairs: [nad/go'nad] and [lad/mu'lad], both read in medial position in a frame by six speakers, [bad/de'bad], read in final position by four speakers, and moreover the following pairs read by one informant, both in medial and final position: [lad/mu'lad], [ladə/mu'ladɒ], [lɑg/pʰo'lɑg], [lɑgɒ/pʰo'lɑgɒ], [sbi:ʔs/be'sbi:ʔs], [sbi:ʔsɒ/be'sbi:ʔsɒ], [la:ʔs/kʰa'la:ʔs]. There were thus 30 individual averages. The vowel of the stem is practically of the same duration in all pairs, thus neither lengthened nor shortened. For the following consonant there is a slight tendency to shortening, but the average is only 0.5 cs and the difference is never significant. The initial consonant is, however, shortened by the addition of a prefix. This is true of 86% of the averages, and the difference is significant in 57% of the cases, the grand mean being 1.7 cs.

Moreover, the vowel of the preceding word in the frame (the [a:] of [sa:]) has been measured in 21 pairs, and it was shortened in all cases, the difference being significant in 67% of the individual averages. The grand mean was 2.3 cs. The word [sa:] ('said') has relatively weak stress in this position. In one pair where a stressed word precedes [en 'lø:s 'bad/en 'lø:ʔs de'bad] this preceding word was shortened for three of four speakers, in two cases significantly, but one shortened the [ø:ʔ], one the [s], and one all three sounds. The subject who did not shorten the preceding word had a significant shortening of the initial [b]. Two other subjects has small shortenings of the [b].

In the nonsense words [mɑm] and [mɑ'mɑm] there was no difference in the stressed vowel, but the second [m] in [mɑ'mɑm] was shortened by all subjects (and significantly so by five of the seven speakers), the grand mean being 2.2 cs.

The fact that the addition of a weak prefix shortens the preceding word seems to indicate that rhythmically the weak syllable belongs to the preceding foot, irrespective of the word

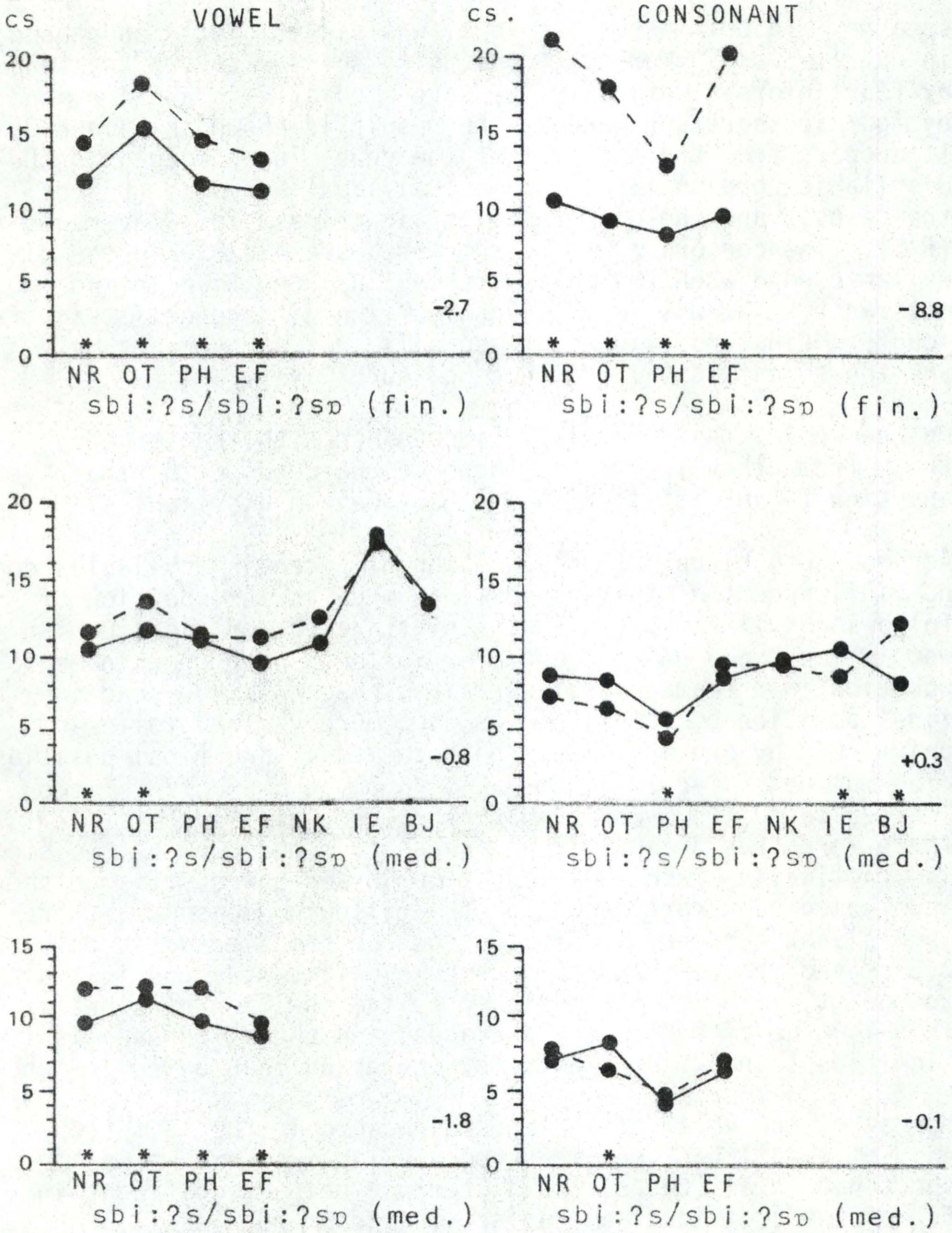


Figure 3

Duration of long vowel with stød and following consonant in the disyllabic word [sbi:?sɒ] (●——●) compared to the monosyllabic word [sbi:?s] (●----●) in final (fin.) and two different medial (med.) positions. See further the legend to figure 1.

boundaries (as is the case with the pitch contour of Danish stress groups (Thorsen 1980)). The fact that the initial consonant of the stem is shortened might be taken as an indication that stress starts with the vowel. However, it should be mentioned that although the addition of a following weak syllable does not generally influence the initial consonant, the addition of a syllable with secondary stress does shorten the initial consonant in the examples measured in this investigation, although less so than the addition of a preceding weak syllable (0.9, 1.1, 1.5 and 0.6 cs for the words [ˈdanˌfɔs], [ˈdanəˌvɑŋʔ] [ˈnadəˌfrɔsd] and [ˈnadˌlambə], respectively, compared to 1.7 cs for the type [muˈlad]).

B. DISCUSSION OF THE BACKGROUND OF THE VOWEL LENGTHENING IN DANISH DISYLLABLES.

The lengthening of the vowel in disyllables which has been demonstrated in the preceding section is, though consistent, not of a very large magnitude. It should, however, be audible in most cases. Zwirner (1938) found that the JND for short vowels in natural words is between 2 and 3 cs. When the difference reaches 3 cs, the discrimination is 100% correct. Rossi (1972) made discrimination experiments with 23 listeners judging the isolated vowel *a*. He found a difference limen of 3.3 cs for short vowels. Klatt and Cooper (see Klatt 1975) found a minimum JND of 2.5 cs for the vowel *i* in English "dealer" in various sentence environments. Reinholt Petersen (1975) found correct discrimination at a difference of 2.0 cs with short vowels in a synthetic word. However, in normal conversation comparable mono-and disyllables rarely occur at close intervals, and since the difference is not phonologically relevant, it is generally not observed. For Standard Danish it has not been observed by phoneticians either. Nevertheless, the difference is of interest, in the first place because it is in direct contradiction to the tendency to shorten vowels in disyllables, which has been considered to be rather universal, and in the second place because it may signal an ongoing development, which may even in the future create phonological relevance due to the increasing tendency to apocope in modern Standard Danish .

It is therefore worth while raising the question why Danish differs from other languages on this point. Put in this simple form the question can probably never be answered, but it might be possible to throw some light on the development by looking for other characteristic phonetic features of Danish with which the lengthening might have some connection, viz. by investigating whether it may have a connection with (1) the tendency to apocope, or (2) the weakening of intervocalic consonants, or (3) particular Fo contours.

In order to be able to give some very preliminary answers to these questions, it is necessary to look at some features of Danish sound history and dialectology.

Around 1100-1300 the Danish phonological system underwent a series of important changes. Vowels of unstressed syllables were weakened to [ə] in all dialects, except that *i* was retained in a number of cases in Jutlandish and *a* was generally retained in Skåne and Bornholm. In Jutland this weakening continued and entailed complete loss of final unstressed vowels. Loss is documented in manuscripts as early as 1300, and there are many examples in the 14th century (Ringgaard 1963). (In the dialects of the Danish islands a similar development started considerably later.) In approximately the same period as the weakening and subsequent loss of unstressed vowels one also finds a lengthening of short vowels before single consonants. This lengthening took place in all dialects with weakened unstressed vowels. Skautrup (1944) formulates the rule as a lengthening in open syllable (thus in disyllables) with a number of secondary analogical lengthenings in monosyllabic words. This is the generally accepted view. But Aage Hansen (1962) finds evidence for quite a number of early lengthenings in monosyllables as well. These lengthenings were in part given up later in the Standard language, particularly before *m, n, s* and ð. A third general development taking place in the same period is the weakening of postvocalic stops, *p t k* being weakened to *b d g* and subsequently to fricatives, with somewhat varying results in different dialects. It is tempting to assume a connection between these different developments. Skautrup (1944) attempts a common explanation, assuming that a stronger concentration of energy on the first syllable of the word has resulted in (1) weakening of the following unstressed syllable, (2) weakening of the postvocalic consonant, and (3) lengthening of the stressed vowel. This is a very attractive hypothesis, but it is of course difficult to prove whether it is correct. Skautrup sets up the following chronological order: (1) weakening of unstressed syllables (around 1100), (2) weakening of *ptk* (12th century), (3) vowel lengthening in open syllable (around 1250), (4) shortening of geminated consonants (1300-1350). He bases his chronology mainly on spellings in old manuscripts. Cases of weakened unstressed vowels are, e.g.,(according to Skautrup) documented as early as 1100 on runic stones, and around 1300 unstressed vowels are generally written *e* and *æ*. Lengthening is documented around 1300 by writing of double vowels. However, this chronology is very uncertain. Quantitative changes are only very sporadically rendered in writing. Moreover, observations of modern ongoing sound change make it quite probable that these changes may have been going on more or less simultaneously for a very long time, and with variations according to individual habits, tempo and style. But there may have been some mutual support among them. The only dating which seems quite safe is the placement of the reduction of geminates after vowel lengthening, since the latter took place only before ungeminated consonants.

The Jutlandish apocope did not cause general merger of monosyllables and disyllables. In some Southern Jutlandish dialect areas the two types were - and still are - kept completely apart by means of different word tones (corresponding to the word tones in Swedish and Norwegian). Moreover, in former disyllables both vowel and consonant have been lengthened; in words with a long vowel it is mainly the vowel that lengthens, in words with a short vowel plus a sonorant consonant it is mainly the consonant, and in words with a short vowel plus a voiceless obstruent it is both (see Bjerrum 1948). Thus we find an allophonic vowel lengthening in disyllables which is quite appreciable: According to Bjerrum the lengthening before voiceless consonants is, on the average, 3.8 cs for short vowels and more for long vowels. Moreover, she finds that the old disyllabic word has two dynamic peaks.

Traces of word tone differences have also been found in other parts of the Jutland dialect area, e.g. on Anholt and Djursland (Nielsen 1959), and in Thy in Northern Jutland combined with lengthening (Nielsen, ms.).

In the rest of Jutland (except for a small area in the South) old disyllables and monosyllables with long vowel or with short vowel before long sonorant consonant are kept apart by the fact that the monosyllabic words have developed stød (except for some types with sonorant plus obstruent). This is also assumed to have taken place around 1200. The problem of merger is thus reduced to the case of short vowels followed by short sonorants and voiceless obstruents.

In the northernmost dialects (Vendsyssel) there is a clearly audible lengthening of short vowels in almost all old disyllables which have undergone apocope, so that no merger takes place.

In the Western Jutlandish dialects, including the Western part of Slesvig in Southern Jutland (covering about two thirds of the whole area), monosyllabic and former disyllabic words with short vowel plus stop consonant (and sonorant plus stop consonant) are kept apart by means of the so-called West Jutland stød, which - in contradistinction to the normal stød - occurs in old disyllabic words before *ptk* (originating from old geminates) after short vowel or sonorant consonant. It consists of a glottal closure at the start of the stop consonant (see Ringgaard 1960a) and is reminiscent of the glottal stop found in many types of British English, particularly in North-Eastern dialects, in words like *not, better*, etc.

In former disyllables with short vowel before sonorant consonant (as well as in former disyllabic words with long vowel) there is, according to Ringgaard (1959 and 1963) "dynamic circumflex", probably combined with a certain allophonic lengthening. Thus there is only merger in the types with short vowel before voiceless fricative (*s* and *f*), and even in this type the Northern West Jutlandish dialects make a distinction due to lengthening of the vowel in old disyllables.

It is thus in Eastern Jutlandish dialects only, and in a small area in the South, that a considerable amount of merger has taken place (Jensen 1944). Here all monosyllables and former disyllables with short vowel plus voiceless obstruent or short sonorant (thus without stød in the monosyllabic word) have merged. But this is a relatively recent development. The old grammarian Høysgaard (1747) mentions lengthening of a final sonorant in former disyllabic words having an optional pronunciation without [ə]. Lengthening of final sonorants in old disyllables is also documented for Samsø in the 19th century (Ringgaard 1960c). Moreover, in Himmerland, in the Northern part of the East Jutlandish area, the older generation has still retained the lengthening in words with sonorant. Molbæk Hansen (1980) has undertaken an instrumental investigation of the pronunciation of the older generation and he found a difference in duration which was distributed over vowel and consonant, but mainly concentrated on the consonant. In his own speech he maintains to have complete merger. However, in a recording of his pronunciation of the words [kʰan] (= Standard Danish *kan*) and [kʰan] (= Standard Danish *kande*), placed in similar positions in utterances, I found a significant difference of 1.9 cs in the final consonant. This is an interesting example of the phenomenon that a speaker may make a difference which he cannot hear himself, if it has lost its social value.

It can thus be stated generally that on top of the old vowel lengthening in (preferably) open syllable, Jutlandish dialects have a number of phonological and allophonic length differences between monosyllables and old disyllables. It has been generally assumed that these length differences have been developed as a compensation for the apocope. However, Ringgaard (1959) observes that the sonorant consonants were in many cases originally long, so that they simply remained long, supported by the circumflex, and as for the vowel lengthening in open syllable he assumes that it has preceded the apocope, since we know from Swedish and Norwegian dialects that apocope generally starts after long syllables. He seems to assume that originally short sonorant consonants have also been lengthened before the apocope, so that all syllables were long. Here again the developments seem to be connected, but the chronology is uncertain. (General surveys of Jutlandish dialects are found, e.g., in Ringgaard 1971 and Nielsen 1959.)

There are certain parallelisms between the vowel lengthening in disyllables in Standard Danish found in the present investigation and these older lengthenings. Like the old lengthening the recent lengthening was preferably found in open syllable (e.g., very little lengthening in [basdə] and [dansə]) and before a weak second syllable, not before derivative endings or second members of compounds, and to a limited degree before [ɒ], which is slightly heavier than [ə] (cp. that the old vowel lengthening did not take place before derivatives and parts of compounds either; on the contrary, we here find shortenings, cf. Old Norse *félagr*, modern Danish *fællig*).

It is more problematic whether the recent lengthening is connected with the apocope, i.e. if it matters whether the unstressed syllable is weakened or totally disappearing.

The dialects of the Danish islands did not, like the Jutland dialects, have apocope in medieval times, but there has been an increasing tendency to apocope during the last 200 years or so.

In older descriptions of Funish dialects apocope is mentioned after sonorants (e.g. Rask, ed. 1938) and Jacobsen (1885, ed. 1929). In more recent descriptions forms with apocope are mentioned as the normal forms in all cases, but it is always possible to pronounce the [ə], cf., e.g., Andersen's description of Eastern Funish (1958), based on informants born 1838-66). Final sonorants are lengthened in cases of apocope, but no lengthenings of vowels are reported. On the contrary, in Eastern Funish Andersen (1958) has found lengthening of short vowels in monosyllables, not in disyllables (except for a particular class of monosyllables with high vowels), and he demonstrates this convincingly by instrumental means.

In Zealand elision of [ə] seems to be more general than in Funish (Ejskjær 1971). Descriptions from the end of the last century report a number of retained endings, but also apocope, and there seems to have been general facultativity in many dialects (Brink and Lund 1975). In more recent descriptions some dialects, e.g. in East Zealand (Ejskjær 1970) are reported to have almost obligatory apocope. Larsen (1971) also found obligatory apocope in West Zealand.

The Copenhagen pronunciation is mainly based on North Zealand dialects. In Copenhagen, both in the lower and the higher norm, there is an increasing tendency to apocope, which seems to have started later than the apocope in the surrounding Zealand dialects.

Brink and Lund emphasize that loss of [ə] in the dialects of the Danish islands and in Copenhagen is a quite different phenomenon from the Jutlandish apocope. In the first place the Jutlandish apocope is an old development, which has not been productive for many centuries, so that new forms with [ə] have developed (e.g. from *-ig, -er, -et*), whereas in the islands it is a recent development, and there is still facultativity. In the second place, the process is quite different. In Jutland it is a real apocope, i.e. loss of final [ə] but not of medial [ə]. In the dialects of the islands it starts as a loss of medial [ə] with lengthening of neighbouring sounds and general preservation of the number of syllables. It is particularly early in the endings [əl, ən, əð] developing into syllabic [l̩ n̩ ð̩] (they therefore prefer to call it "ə-assimilation"), and loss in final position is late. They have followed the development of the Copenhagen pronunciation by listening to gramophone records of informants born in the period 1840 (in one case 1816) to 1955. Assimilations occur earlier after sonorant consonants than after obstruents and earlier medially than finally. In sentence final position it is rare after voiceless consonants, and even informants born in the forties of this century have more often [ə] than apocope in this position.

As for accompanying lengthenings a preceding sonorant consonant is normally lengthened both in the dialects of Zealand and in Copenhagen, but Larsen (1971) also reports cases of lengthening of the preceding vowel. In the case of voiceless consonants there are conflicting reports. Some Zealandish informants, particularly informants from West Zealand, consider monosyllabic and disyllabic words to have merged in this case, whereas others, particularly informants from Eastern Zealand, state that there is a difference. Larsen (1971) has measured segment durations for two informants, one from West Zealand and one from South East Zealand. The former has a weak tendency to lengthen the vowel before sonorant consonants, but hardly any significant difference. The latter has a clear tendency to lengthening before sonorant consonants, and a weak, non-significant tendency to lengthening before voiceless consonants. However, for the dialects in North Zealand and for the lower sociolect in Copenhagen lengthenings have been reported by various observers. Andersen (1954) mentions a general lengthening of short vowels in the Copenhagen dialect. Brink and Lund (1975) have noticed facultative lengthening of short vowels in the lower sociolect of Copenhagen during the period investigated. But according to their examples this lengthening is not restricted to open syllables. Their observations for this sociolect are, however, based on six informants only and some notes from the end of the last century. They suppose that this lengthening is now on its way into the higher sociolect, but apart from the diphthong [ai] they only quote the word [fragə]. They further advance the hypothesis that facultative lengthening may also have been found earlier in the higher norm, because they have observed some cases in the speech of the author Karen Blixen, who spoke a very oldfashioned Danish. Again, several of the examples are from closed syllables. These lengthenings may, however, be stylistically conditioned.

Aage Hansen (1956) states that in Zealand and in the lower sociolect of Copenhagen there is a tendency to lengthen short vowels (particularly open vowels) in open syllable. He quotes a number of examples before *b d g f*, and a single example before *n*. There is also lengthening of vowel before [ʁ] plus obstruent, the [ʁ] being assimilated to the vowel, and in this case the lengthening takes place in closed syllables as well.

On the whole, lengthening in the lower Copenhagen sociolect is clearly audible, and according to my own impression and that of various colleagues, it is most obvious in open syllable. Molbæk Hansen (personal communication) has recorded sentences with 16 comparable word pairs with long and short vowels from seven speakers of this sociolect (all in open syllables in disyllables). There is great variation according to speaker and phonetic structure of the words. The tendency to lengthening is most pronounced for low vowels before stops, particularly [g]. According to a survey I have had occasion to see, there are at least seven cases where the duration of the short vowel exceeds 90% of the duration of the long vowel, and there are various cases above 80%.

In a recent recording of an informant ST, speaking the same sociolect (though not a very extreme variant) I found the following percentual values for the relation between short and long vowels: [basə/ba:sə] 90%, [vɛgə/vɛ:gə] 82%, [sdɔgn̩/sdɒ:gn̩] 78%, [mɔdn̩/mɒ:dn̩] 72%. These percentual relations may be compared with Bundgaard's measurements of vowel duration in Advanced Standard Copenhagen (ASC) (1980). As an average of four speakers, pronouncing nonsense words ([bVbə] with varying vowels) in a frame, he gets 71%. Holtse (1977) found a relation of 67% for three speakers using a somewhat more conservative norm. (For vowels of the same degree of opening their results are practically identical.) In a material from 1974 I found a percentage of 71 for [a/a:] without much difference between somewhat older and younger speakers. For the most open vowels Bundgaard's percentual values are higher (for [a/a:] and [ɑ/ɑ:] 78% and for [ɔ/ɒ:] 80%). These values are not very different from those found by Molbæk Hansen and myself for the lower sociolect. Probably the absolute values are also of importance for the impression of lengthening. Bundgaard's longest short vowels (before *-b*) are about 14 cs, ST's short [a] in [basə] has a duration of 21.6 cs and the [ɛ] [vɛgə] 21.8 cs. That is very much for a short vowel. Molbæk Hansen's informants reach similar values for open vowels (but before [l] the short [a] may reach similar durations, also in the Copenhagen Standard language). What is of more direct interest in this connection is, however, whether there is also a difference between mono- and disyllables in this sociolect. That cannot be seen in Molbæk Hansen's data. The differences for my informant ST are given in table I compared to the average differences of similar words for the main informants.

Table I

Differences in cs between vowel durations in disyllables and monosyllables for speaker ST (each average representing 8 tokens) compared to roughly comparable average differences for the main informants (see figure 1). (m) = medial position, (f) = final position.

ST		cs	main informants		
(m)	mad/madə	2.9	(m)	mad/madə	2.8
(m)	smɔd/mɔdn̩	5.9	(m)	nad/nadə	3.3
(f)	sdɔg/sdɔgn̩	4.3	(m)	pʰɑg/tʰɑgəðə	4.2
(f)	vɛg/vɛgə	8.1	(m)	lɑg/lɑgə	3.2
(f)	bas/basə	4.0	(m)	bas/basə	2.1
(m)	sœn/sœnɒ	2.0	(m)	sœn/sœnɒ	1.9

All differences are significant. It appears from table I that ST has a clear difference between monosyllables and disyllables, showing that the lengthening in the lower Copenhagen sociolect is somewhat more pronounced in disyllables. Her absolute differences are somewhat larger than those of the main informants (particularly for [ɛg]). The percentual lengthening in disyllables is very variable since her vowel durations differ much. The average is 40.5%, which can be compared to the percentage of the main informants, which is 30.5, i.e. slightly lower. This means that an influence from the lower sociolect on the higher sociolect is not excluded, but it may, of course, be a parallel development. - ST had no loss of final [ə] except after [ŋ].

I have also made recordings of three dialect speakers in various parts of Zealand. The word pairs used were: [mad/madə], [sœn/sœnɒ], [tʰɑg/tʰɑgə], [ˈlanˌkʰɒʁd/ˈlanəˌplaːɣə], [bas/basə], [mis/misə] and [lasd/lasdə]. The first two pairs were placed medially and finally in short sentences, the third only medially, and the others only finally. The sentences were read six times each. This gave very diverging results.

KH (St. Havelse, 40 km Northwest of Copenhagen, has consistent apocope. He has no difference whatsoever between vowels in mono- and disyllables before obstruents. There was no difference in the following consonant either, except that the [s] of [bas] was longer than the [s] of [bas(ə)]. In the words with nasals, however, he had lengthening, in the former disyllables [kʰɔm(ə)] and [lan(ə)] both of the vowel and of the consonant, in [sœnɒ] of the vowel only (with a non-significant shortening of the consonant). The lengthenings are quite appreciable here: [ɔ] 2.3 cs, [m] 2.8 cs (total lengthening 5.1 cs), [a] 3.7 cs, [n] 3.3 cs (total lengthening 7.0 cs). [sœnɒ] has a lengthening of 3.7 cs of the vowel in final position and 2.3 cs in medial position. - This is more than for the other informants. The situation is reminiscent of the situation in Himmerland for the old generation, except that there is less evidence for the lengthening in the type [sœnɒ]. Only one of Molbæk Hansen's informants had lengthening in [kʰann̩] compared to [kʰan]. Molbæk Hansen has, however, found a tendency to lengthening of the vowel in other examples. He has himself a lengthening of the vowel in [kʰanɒ] but not in the former disyllable [kʰan(ə)]. - What <u>may</u> have happened in KH's dialect is that the apocope (or ə-<u>assimilation</u>) has come first; [ə] has been assimilated to the voiced sequence in [kʰɔmə] and [lanə] but has been lost without traces after obstruents. Then the vowel lengthening has reached the dialect, lengthening [sœnɒ], and perhaps [kʰɔm(ə)] and [lan(ə)] still more, whereas the former disyllables of the type [basə] - which are now normal monosyllables - are not affected by the lengthening in open syllable.

A second informant was OR (from Bjeverskov, about 40 km South of Copenhagen). He had apocope (except in reading), and he showed a consistent though weak and non-significant tendency to lengthen the vowel in former disyllables but not in the actual disyllable [sœnɒ]. The only significant vowel lengthening was in [lan(ə)] (3.7 cs). In the latter word as well as in [kʰɔm(ə)] he had a significant lengthening of the consonant.

Thus these recordings did not show any particular lengthening. However, in order to study the relations to Copenhagen speech, it might be more profitable to look at the dialects of North East Zealand. The problem is that the dialects in this area have almost disappeared. I had, however, an opportunity to make a recording in Dragør on Amager (which belongs to the specific coastal Øresund dialect area and is situated about 10 km from Copenhagen). The informant ET has still retained her dialect. She has very clear lengthening of vowels in disyllablic words: 8.4 cs in [madə] in final position, and 4.4 cs medially; 5.7 cs in [lanə], 2.2 cs in [misə], 2.3 cs in [basə] and 2.7 cs in [lasdə]. The lengthening is significant in all averages and more pronounced than in comparable words read by the main informants. She did not have any apocope. Since there was noise on the tape, the vowels before [g] and [n] could not always be measured exactly, but the lengthenings were obvious. I have also listened to a tape recording of continuous speech by the same speaker recorded by Jan Katlev. Here I was not always able to hear the lengthenings before obstruents, but before sonorants they were obvious, particularly in the case of [ɔ] and [ε]. In a number of cases I was inclined to identify them with normal, long vowels.

Since it turned out to be difficult to find informants, I listened to a number of older tape recordings of North Zealand dialects undertaken by the Institute of Danish Dialectology in Copenhagen. OA (Uvelse), EO (Tisvilde) and KP (Karlebo) had hardly any audible lengthenings. Their pronunciation was rather close to the standard language. LH (Snostrup) and NJ (Græse) had audible lengthening of short vowels in some disyllabic words, both with obstruents and sonorants, but there were also countercases. LH (Stenløse) had more consistent lengthening in disyllables (and not in monosyllables). I noticed six cases with obstruents and seven with sonorants (the recording was relatively short). In the case of sonorants either the vowel or the sonorant was lengthened. He had inconsistent apocope. Finally, KJ (Gilleleje) had very clear and consistent vowel lengthening in almost all disyllables (not in monosyllables). I listed about 25 examples and very few countercases. He did not have apocope (this <u>may</u> be a case of coastal dialect).

Although this material is very limited, I think that some preliminary conclusions can be drawn:

1) A number of dialect speakers, particularly in the North Eastern part of Zealand, have vowel lengthening in disyllabic words, and it is very probable that there is a connection between this lengthening and the lengthenings found in Copenhagen speech (both in the lower and in the higher sociolect).

2) The lengthening may be connected with the weakness of unstressed syllables in Danish (as argued above), but there is no evidence for any connection with the tendency to apocope.

On the contrary: KH, who had consistent apocope, did not have any lengthening in the words with obstruents which had undergone apocope, only in those that were still disyllabic. OR, who had normal, but not consistent apocope, had a slight lengthening. EP (Dragør) and KJ (Gilleleje), who had very clear lengthenings in open syllable, did not (KJ practically not) have apocope. Moreover, the main informants, who had vowel lengthening, did not use apocope in the recordings, although they read the sentences rather quickly, except now and then in the first member of compounds like [maːləkʰasə]. (However, in normal conversation they would often have cases of apocope. It is, e.g., quite common in my own conversational speech, also after obstruents.) The only exception was IE, who had consistent apocope in the recordings, even finally after obstruents. But that is evidently Jutlandish influence.

Thus, both the loss of final [ə] and the lengthening of vowels in open syllables may be connected with the weakness of the unstressed syllables (this is obvious for the apocope), but the two phenomena (apocope and lengthening) do not seem to be directly interconnected, at least not in Zealand.

(3) There is some evidence for a connection with the weakening of the following consonant: Danish intervocalic consonants are generally weak and short, and the lengthening seems to be particularly pronounced before [g], which has a very weak closure so that the delimitation often makes difficulties. Sometimes there is no closure at all. Molbæk Hansen's Copenhagen informants showed a particular tendency to lengthenings before [g]. The same was true of my Copenhagen informant ST (who, however, had very much lengthening before [s] as well). [-ɑg] has the largest difference in medial position for the main informants.

Now, if the vowel lengthening in open syllable is a specific North Zealand-Copenhagen feature, one may wonder why the informants NK, IE and BJ, who have an audible Funish and Jutlandish background, have exactly the same lengthenings as the other speakers. It might simply be because they have spent many years in Copenhagen, but the possibility cannot be excluded that the lengthening is supported by tendencies in the Funish and Jutlandish dialects. It has already been mentioned above that there are many types of lengthenings in different Jutlandish dialects.

In order to throw some light on this question, I made a number of recordings of Funish and Jutlandish dialect speakers who, as in the other cases, read small sentences containing the words to be compared in similar positions.

For the Funish speakers the results were rather heterogeneous. Table II gives a survey of the differences in vowel duration between monosyllables and disyllables for different speakers. [sœn/sœnɒ] occurred medially in the sentences, the other words finally.

Table II

Differences in vowel duration (in cs) between disyllables and monosyllables for Funish speakers. - indicates shorter duration in disyllables, stars indicate that the difference is significant at the 1% level. The transcription is given in Standard Danish. Apocope is indicated by +ap. or -ap. for the individual speakers. D means "Dialect", RSD means "Regional Standard Danish".

	MA	LA	HV	IP	EK	EH	HC
	Frørup	Frørup	Haastrup	Vissen-bjerg	Odense	Odense	Odense/ Svendborg
	D +ap.	D +ap.	D +ap.	D +ap.	RSD -ap.	RSD -ap.	RSD -ap.
mad(ə) mad	0.1	0.8	1.7*	0.2	1.1	2.5*	1.9
snɑg(ə) snɑg	0.3	1.6	1.9*	1.5*	0.4	0.8	
kʰɛb(ə) kʰɛb	0.2	3.0*		2.7*			
tʰɑg(ə) tʰɑg				-0.4			1.1
sœnɒ sœn	0.1	0.7	1.0	1.8*	-0.3	0.8	0.5
kʰɔm(ə) kʰɔm	-2.0*	-1.7	1.4	4.1*	2.8*	0.8	
bas(ə) bas	0.9	4.3*	0.0	2.4*	2.3*	0.9	
lasd(ə) lasd				2.0*			

MA and LA are young dialect speakers from Frørup. Frørup lies just South of the boundary between East and South Funish, but as far as vowel durations is concerned it belongs to the Eastern Funish area described by Andersen (1958). As mentioned above, he found differences in vowel duration which were the exact opposite of what has been found in Zealand. Except for a small class of words with high vowels, disyllables had shorter vowels (and a higher tone) than monosyllables. This distinction has evidently not been retained in the youngest generation, except for [kʰɔm(ə)], where MA has a significant shortening of the vowel, and LA has a clear tendency to shortening. Apart from this word, MA (who has spent all his life in Frørup) has no difference at all, whereas LA, who has attended the secondary school in the neighbouring town and studied in Copenhagen for six years, has a consistent tendency to lengthening in disyllables, although generally with very small and non-significant differences except for [kʰɛb(ə)] and [bas(ə)] which have a significant lengthening of the vowel. These lengthenings are probably due to influence from the Copenhagen standard, particularly when her speech is compared with that of MA (her younger brother). Both speakers have apocope.

More interesting is the general tendency to vowel lengthening in disyllables found for the older genuine dialect speakers HV and IP. IP is from West Funen (Vissenbjerg), HV from the westernmost point of the East Funish dialect (Haastrup). They have spent all their life in their native villages, and it is not very probable that their vowel lengthenings should be due to influence from the standard language. The differences are significant in most cases for IP, but only in two cases for HV. Moreover, IP's lengthenings do not follow the general pattern. She has more lengthening before *s* and *n* than before *d* and *g*, whereas the main informants had the opposite distribution. IP has apocope, whereas HV used full forms.

The remaining three informants, EK, EH and HC, are all from Odense (the main town on Funen) and speak urban dialect very close to the regional standard language (RSD). HC has spent the first part of his life in Svendborg on South Funen and has no stød. The other two have spent almost all their life in Odense and were described to me as typical Odense speakers. They all have a weak, and rarely significant tendency to lengthening in disyllables, which may be due to influence from Standard Copenhagen speech, but which may also, particularly in view of the lengthenings found for the dialect speakers HV and IP, be an independent tendency. - In any case, it is possible that the speaker NK, who is from Odense, has had some tendency to lengthenings before he came to Copenhagen.

The four dialect speakers have consistent apocope, whereas the urban speakers did not have apocope. As for the following consonants, their duration is very irregular, the only consistent feature being that the four dialect speakers have a considerable lengthening of the [m] in the former disyllable [kʰɔm(ə)] (4.5 - 7.2 cs). For the other three speakers [m] could not be measured exactly. The informants from Odense, who did not have apocope, had a large difference in the [s] of [bas/basə] which was utterance final in [bas]. The dialect speakers with apocope had a long [s] in both cases.

For the Jutlandish speakers a survey of differences in vowel duration is given in table III. All test words were placed medially in the sentence in this case. ([dan] and [danə] were said in the compounds [ˈdanˌfɔs] and [ˈdanəˌbro:ʔɣ]. The word [basə] turned out not to be a dialect word and was not read by all informants.)

LH is from Århus, the main town in Jutland, and speaks the regional standard Danish (RSD). She was described to me as a typical Århus speaker. She has consistent and significant vowel lengthening in all disyllables of the type CVCə (with the exception that it is not significant in [basə]). She has non-significant lengthening in [dansə] and none in [lasdə]. This is in complete agreement with what was found for the main informants, of which five cannot have been influenced by a possible Jutlandish standard. LH's lengthenings can hardly be due to the situation in the surrounding East Jutlandish dialects since there is merger in all cases in these dialects. And an allophonic difference is not very probable when all types without stød have merged, also the words with sonorants. (By mistake I did not make any recording of East Jutlandish dialects.) It is therefore very probable that the Århus standard is influenced by the Copenhagen standard on this point. The Copenhagen standard is now spreading rapidly (Brink and Lund 1975).

The other five speakers are bilingual. They speak both dialect and standard Danish. Except for BT they keep the tonal pattern of their dialect unchanged when speaking standard Danish. PN speaks Northern Jutlandish dialect (he is from Vendsyssel), the others speak Western Jutlandish. TA is from Thy, EA from Mors, and JD from Fjends Herred, just South of Salling. They have West Jutland stød in [tʰɑʔgɒ] and in the former disyllables [tʰɑʔg] and [maʔd]. All have consistent apocope in their dialect, but not syncope in [danəbroʔɣ]. I had expected BT to speak Eastern Jutlandish, but she turned out to come from the West Jutlandish area, just beyond the dialect boundary between East- and West-Jutlandish. Whereas the others speak rural dialects, she speaks an urban dialect, which is influenced from the standard language on various points. She has learnt her standard Danish (SD) from non-Jutlandish teachers and friends and, in contradistinction to the others, she keeps dialect and SD completely apart as far as the tonal movement is concerned.

A glance at the RSD (Regional Standard Danish) columns in the table shows that all have (generally significant) vowel lengthening in the CVCə type with very few exceptions (TA has no lengthening in [sœnɒ] and [danə], BT not in [basə] and [basɒ]. There is generally no lengthening in the CVCCə type. PN has

Table III

Difference in vowel duration (in cs) between disyllables and monosyllables for Jutlandish speakers. - indicates shorter duration in disyllables, stars indicate significance at the 1% level. The transcription is given in Standard Danish. Apocope is indicated by +ap. or -ap. for the individual speakers. D means "Dialect", RSD means "Regional Standard Danish". Speakers are indicated by initials.

	LH Århus	BT Uldum		TA Thy		EA Mors		JD Fjends Herred		PN Vendsyssel	
	RSD	D	SD	D	RSD	D	RSD	D	RSD	D	RSD
	-ap.	+ap.	-ap.	+ap.	-ap.	+ap.	-ap.	+ap.	-ap.	+ap.	-ap.
mad(ə) mad	3.3*	0.4	3.4*	0.1	0.8	-2.4*	1.2	0.3	3.5*	5.8*	2.6
tʰɑg(ə) tʰɑg	2.5*	1.9*	5.4*	0.2	2.7*	-0.8	6.0*	0.2	4.6*	5.0*	3.1
tʰɑgɒ tʰɑg	3.0*	3.5*	2.4*	2.2*	2.2*	2.3*	3.0*	1.5	4.1*	3.0*	4.3
sænɒ sæn	1.8*	0.6	1.5*	0.5	0.0	2.8*	2.5*	3.9*	1.8*	0.4	1.4
kʰɔm(ə) kʰɔm	1.9*	1.5*	1.3	2.1*	1.9*	1.6*	3.4*	2.3*	6.3*	5.0*	4.1
danə dan-	1.6*	0.8	1.2*	0.4	-0.6	-0.5	1.2	3.2*	2.7*	2.8*	3.1
dans(ə) dan?s	1.8	0.6	2.2*	-0.1	0.5	0.8	1.4*	-0.2	-0.1		
bas(ə) bas	1.8	0.5	0.1		-1.8*		1.7				
basɒ bas	1.2*	1.3	-0.5	-0.4	2.3*						
lasd(ə) lasd	-0.7	-0.6	-0.6	6.0*	0.8	0.3	-0.6	0.2	0.6	5.4*	0.4

only made four recordings of the RSD words. That is why the differences are not significant at the 1% level, but he has no overlapping between mono- and disyllables. For the other informants six examples of each word have been measured.

A comparison between the lengthening in the dialect and the RSD of the informants shows some interesting differences. PN has vowel lengthening in old disyllables with apocope, as should be expected for his Vendsyssel dialect. The lengthening before sonorant in [kʰɔmə] is not in agreement with Jensen's description of the dialect (1897-1903) but, as pointed out to me by the specialists in Århus, Jensen had been led astray by Marius Kristensen's theories on this point (PN should not, however, have long vowel in [tʰɑgɒ]. This must be an analogy from the infinitive [tʰɑgə] (dial. [tʰɑ:g])). One should thus expect agreement between PN's dialect and his RSD in most of the words. It is, however, worth while noticing that he does not transfer his dialectal (phonological) lengthening in the old disyllable [lasdə], nor his dialectal lack of (allophonic) lengthening in [sœnɒ] to his RSD speech. TA, EA and JD have no lengthening in their dialect in vowels before stops (which have West Jutland stød), except for [tʰɑgɒ], but they do have lengthening in the corresponding words in their RSD (BT also has lengthening in [tʰɑgə] in her dialect). TA, who has lengthening in the old disyllable [lasdə] in his Thy dialect, as should be expected, does not transfer this lengthening to his RSD.

Finally it can be stated that there is no general vowel lengthening in actual disyllables in the dialects (except for JD). TA, PN and BT have no significant lengthening in [sœnɒ], TA and EA have no lengthening in [danə]. All have, however, a longer vowel in [tʰɑgɒ] than in [tʰɑg]. This may be due to the weakness of the medial [g]. It is, however, of some interest to notice that BT, TA, EA and JD have a longer [ɑ] in [tʰɑgɒ] (i.e. [tʰɑʔgɒ]) than in [tʰɑgə] (i.e. [tʰɑʔg]) in their dialect, whereas the relation is reversed in their RSD, in agreement with the relations in the Copenhagen standard.

It is thus very clear that the speakers do not simply transfer their dialectal lengthenings or lack of lengthening to their RSD speech. Their RSD is a different norm, which is in accordance with the Århus RSD of LH and which was found to be very close to and probably in general influenced by the Copenhagen standard. The lengthenings found in the speech of the main informants IE and BJ from Jutland may thus simply come from their Jutlandish RSD, only enhanced by their stay in Copenhagen.

As for the following consonant, LH has shortening in disyllables in accordance with the Copenhagen standard, and the same is true in almost all cases of the RSD of the other speakers. In the dialect recordings it was very often impossible to measure the duration of the consonant after West Jutland stød, because the stop is unaspirated and sometimes not exploded, and as for [g] in [tʰɑʔg] it was sometimes replaced by a creaky voice stød. The [n] of [sœnɒ] and the [n] of [danə] were shortened. The [m] of [kʰɔm] could not always be measured. It was somewhat lengthened by PN, TA and EA in the disyllable, but not by JD. The vowel was always lengthened.

The final problem raised was whether there could be any connection between the lengthening in open syllable and the particular North Zealand and Copenhagen pitch contour. In Copenhagen ASC the stressed syllable has a relatively low pitch followed by a jump or glide up to the first posttonic syllable, with the following unstressed syllables moving gradually down to the next stressed syllable. This has been thoroughly investigated and described by Thorsen (e.g. 1980). And the higher pitch on the unstressed syllables has also been observed for the dialects of North Zealand. It is mentioned by Andersen (1954) and discussed in detail by Kroman (1947). This contour seems to be relatively recent in the higher sociolect of Copenhagen. It is not mentioned by Jespersen (1897-99 and later), nor by Bo (1933). Arnholtz (1939-40) mentions it as a recent development (I have, however, heard this contour used regularly by Copenhagen standard speakers born in the eighties of the last century). All main informants of this investigation have this pitch contour (although the speakers from Funen and Jutland, IE, BJ, NK (and partly OT) do not use it in compounds). The same is true of the Copenhagen speaker ST and of the Zealandish dialect speakers who had general vowel lengthening in disyllables, as well as the Jutlandish speaker BT. It is not generally so that the pitch movement in the stressed syllable is particularly extensive; it may be rather level, but the preparation of the jump up might be expected to require some time. However, the vowel lengthening is just as consistent in the RSD of the Jutlandish speakers, and apart from BT they all have the normal Jutlandish pitch contour with high (generally) rising pitch on the stressed syllable and low falling pitch on the following unstressed syllables (see Thorsen and Jul Nielsen (1982) for a preliminary investigation); and BT, who has the Copenhagen contour in her RSD and the Jutlandish contour in her dialect, does not generally have more lengthening in her RSD than in her dialect. The speaker KH (Zealand) who had vowel lengthening in actual disyllables had a pitch contour corresponding to the one found for the Jutlandish speakers. There is thus no necessary causal relation between the two phenomena.

C. FINAL LENGTHENING

A number of words were placed both in final and medial position in the utterance, in most cases finally and medially in the frames [han sa:] and [han sa: ··· tʰoʔ gaŋə], some also in small sentences. Frames and sentences are not distinguished in the survey given in this section, since the differences were small. They will be compared in section D. A survey of the results is given in figure 4.

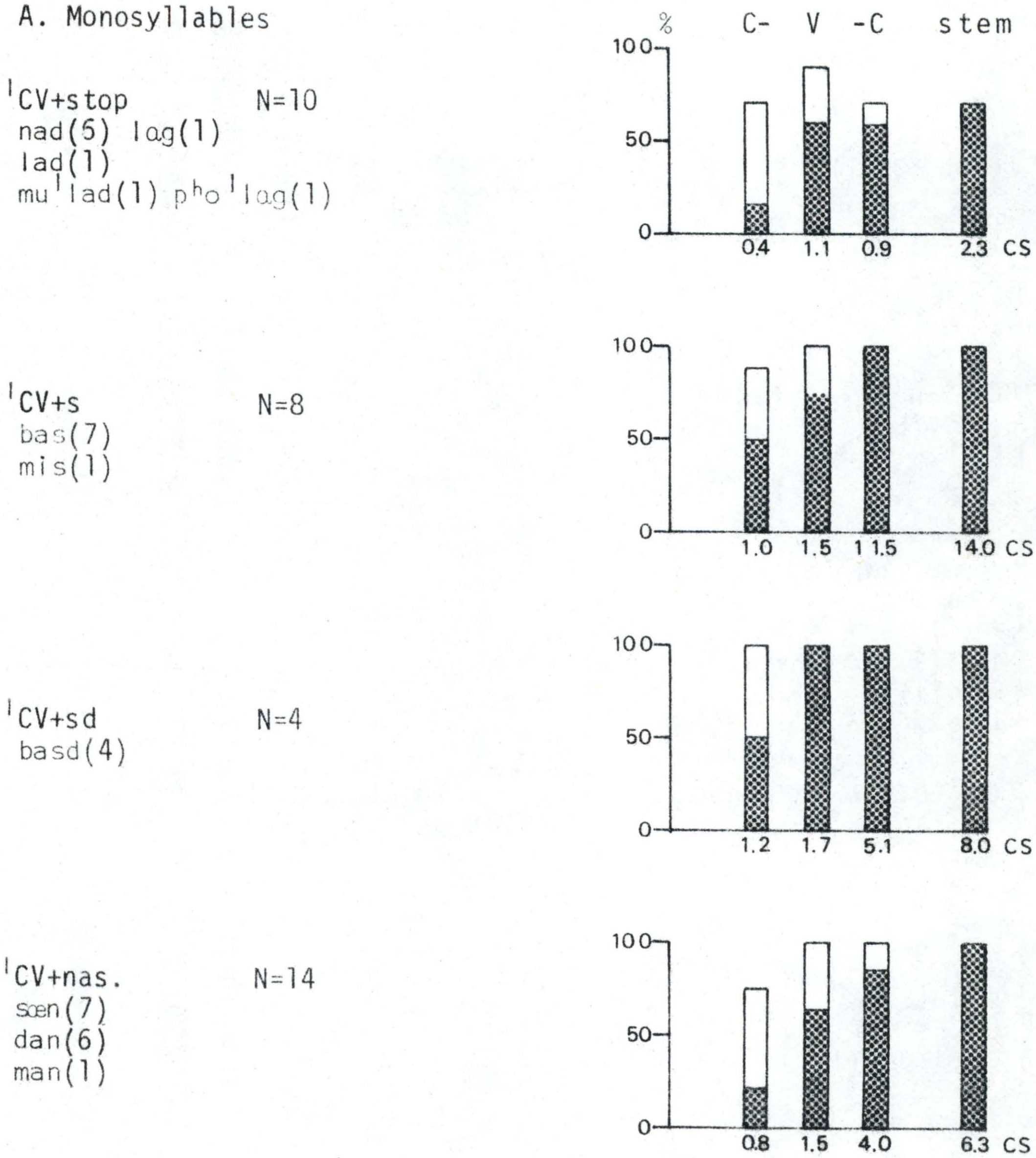
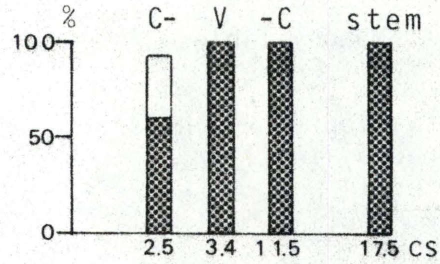


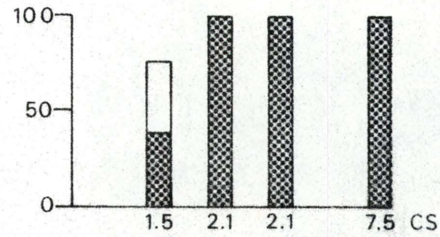
Figure 4

Duration of different word types in utterance final and medial position. The numbers in parenthesis after the single words indicate the number of pairs of averages. (The following sounds could not be delimited: the initial [s] of ['sœn(ɒ)] (6 averages), the [a:ʔ] and [n] of ['pla:ʔn(ɒ)] (2 averages), and [l] and [ə] of ['ma:lə] (2 averages). N should be reduced accordingly for these sounds; in these cases the difference for the stem is not = the sum of the differences for the individual sounds.) The columns indicate the percentage of averages in which there is lengthening in final position (C- (initial consonant(s)), V (vowel), -C (final consonant(s)), and stem). The hatched area is the percentage of significant differences. The average difference in cs is given below each column.

ˈCV:ʔ+s N=15
la:ʔs(1)
kʰaˈla:ʔs(1)
sbi:ʔs(12)
beˈsbi:ʔs(1)

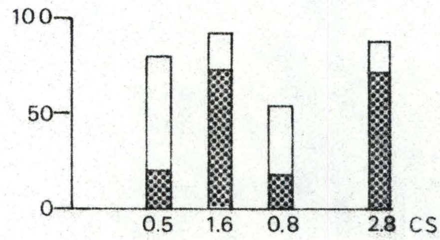


ˈCCV:ʔ+n N=8
pla:ʔn(8)

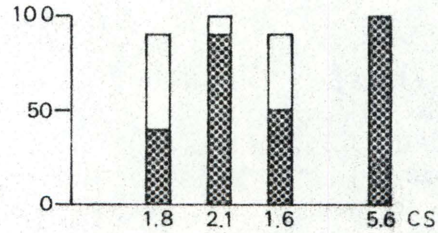


B. Disyllables

ˈCVC(C)ə/ɒ N=26
ˈnadə(4) ˈsœnɒ(7) ˈmisə(1)
ˈladə(1) ˈdanə(3) ˈbasdə(4)
muˈladɒ(1) ˈmanə(1)
ˈlɑgɒ(1) ˈmana(1)
pʰoˈlɑgɒ(1) ˈmansə(1)



ˈCV:ʔsɒ N=10
kʰaˈla:ʔsɒ(1)
ˈsbi:ʔsɒ(8)
beˈsbi:ʔsɒ(1)



ˈCCV:ʔnɒ N=8
ˈpla:ʔnɒ(8)

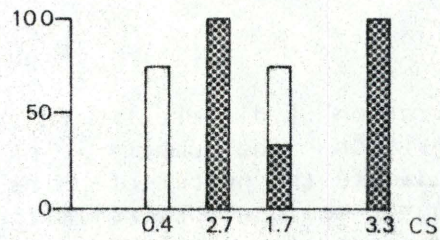
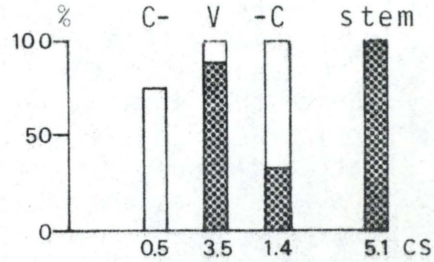


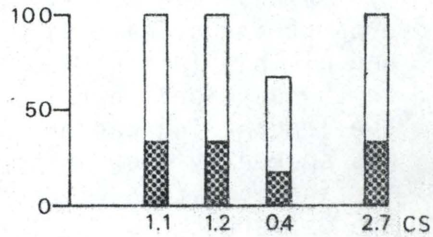
Figure 4, continued

ˈCV:Cə N=8
ˈma:lə(4)
ˈma:sə(4)

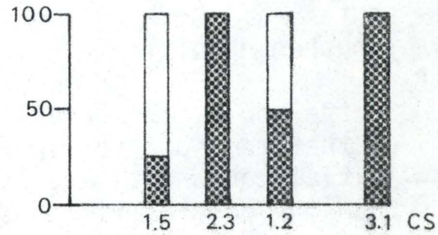


C. Trisyllables

ˈCVC(C)əCə N=7
ˈsœnɒnə(4)
ˈlɑgəðə(1)
ˈmisəðə(1)
ˈbasdəðə(1)

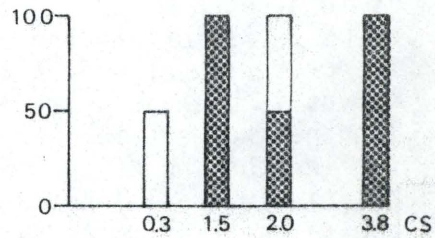


ˈCCV:ʔnɒCə N=4
ˈplaʔnɒnə(4)



D. Derivatives

ˈCVCli N=4
ˈnadli(1)
ˈsœnli(1)
ˈmanli(1)
ˈmisli(1)



E. Compounds

ˈCVC-
ˈCVCə- N=7
ˈnadˌpʰɔdə(1) ˈnadəˌfrɔsd(1)
ˈlɑgˌfɑ:və(1) ˈmanəˌfalʔ(1)
ˈmanˌfɔlg(1) ˈmisəˌkʰad(1)
ˈmisˌlyðʔ(1)

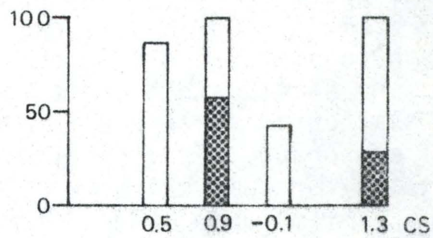


Figure 4, continued

It appears clearly from the figure that Danish does have final lengthening. However, the lengthening of the vowel (about 1.5 cs for short vowels and 3.5 cs for long vowels) is less pronounced than in a number of examples from other languages, particularly English (see, e.g., Lehiste 1972, Oller 1973, Klatt and Cooper 1975, Cooper and Danly 1981), where differences of 5-8 cs are frequent.

As mentioned in section I, Holtse (1977) did not find any difference in recordings of his own speech. His words [lɛs] and [lɛ:sə] can be compared to the words [bas] and [ma:sə] of the present investigation. [bas] was spoken by seven subjects, and all had lengthening of the vowel in final position (1.5 cs on the average), but for two subjects, one of them PH (Holtse), the lengthening was only 0.8 cs and non-significant. [ma:sə] was spoken by four subjects. All had lengthening of the vowel in final position (3.6 cs on the average). For one subject the difference was non-significant, but PH had a significant lengthening of 2.4 cs. In his own experiment Holtse seems to have spoken very quickly and with almost no pause between the sentences. Both he and the other subjects have a considerable lengthening of final [s].

On the whole, the lengthening is distributed over all sounds of the stem, but the vowel is always lengthened more than the initial consonant, and in polysyllables it is lengthened more than the postvocalic consonant (the only exceptions are the derivatives in [-li], where particularly [n] is lengthened before the voiced [l]). In monosyllables the final consonant is lengthened more than the vowel, this is particularly true of [s]. As for [n] the indications in the figure are based on the criterion of end of voicing. If drop of the intensity curves is used as a criterion, only 50% of the examples have lengthening, and the average is only 0.8 cs instead of 4.0; the lengthening of the stem is reduced correspondingly. The relatively small lengthening of final stops (0.9 cs) is partly due to the fact that most examples were only spoken by one subject (EF) who used the frame [han sa: ··· ˈʔe:ʔn ˈgɑŋʔ] for words ending in stops, whereas the others used [han sa: ··· ˈfɛmʔ ˈgɑŋə] in this case. The word [ʔe:ʔn] starting with a hard attack has evidently caused a lengthening of the preceding stop so that the final consonant of the word in medial position in the frame is almost as long as the utterance final consonant. For the other subjects, the difference is 1.5 cs, and for some extra examples spoken by EF in the frame [han sa: ··· fɛmʔ gɑŋə] the difference is of the same order.

In disyllables the final [ə] is also lengthened. It has not been included in the survey because of the problematic delimitation. When the criterion for the end of the vowel is end of voicing the difference will be 3-4 cs, when the criterion is drop of the intensity curves it will be only 1 cs, or even less.

It might be hypothesized that the difference in duration between words in the frame *han sagde* ... and in the frame *han sagde ... to gange* might be due to the length of the frame and not to the final vs. medial position of the test word (cp. that Lehiste (1980a) found a difference in the duration of the test word according to the length of the frame). But this explanation cannot be applied to the words *søn, sønner, sønnerne* and *plan, planer, planerne*, which were placed in sentences of the type *han så sin sǿn - hans sǿn kómmer* and *man frémmer hans plán - hans plán frémmes*. And in these sentences, which were spoken by 3 and 4 subjects, respectively, the differences were at least as great as in the examples in frame sentences.

The finding mentioned in section I, viz. that it does not matter whether one or two stressed words are added (cp. Lindblom et al. 1976 and Kohler et al. 1982), was confirmed by the sentences *han lod Spíes réjse* 'he let Spies go' and *han lod Spíes réjse ságen* 'he let Spies bring the matter up', spoken by one subject. All the segments of *Spies*, [s b i:? s], have almost exactly the same length in the two sentences. However, the words *bast, baste* and *bastede* placed in the frames *han sagde ... fem gange* and *han sagde ... igen* were shorter in the first frame, and the difference was significant for *bast* and *baste*. The difference was mainly in the *s*, and in *bast* the shortening might be due to the three-consonant group *stf*, but this explanation cannot be applied to *baste*.

D. SYNTACTIC BOUNDARIES AND WORD BOUNDARIES

The sentences were not constructed specifically for the investigation of syntactic boundaries, but a few sentences can be compared from this point of view. The boundary between the test word and the following adverbial of the frame *(two (five) times)* may be expected to be more pronounced than the boundary between subject and verb in the sentence. This expectation is borne out by the measurements. The word *Spies* in *han sagde Spíes tó gánge* is significantly longer than *Spies* in the sentence *mon Spíes kómmer?* ('I wonder whether Spies is coming?') for all three subjects (3.2 cs), and it is significantly longer for one of the three subjects than in *mon Spíes betáler?* ('I wonder whether Spies will pay'). For one subject it was possible to compare *han sagde Spíes tó gánge* with *han lod Spíes réjse* ('he let Spies go'). Again, there was a significant difference (1.6 cs). - Moreover, the word *spiser* ('eats') was significantly longer for three subjects in *han sagde spíser tó gánge* compared to *han spíser bǿffen* ('he eats the beefsteak') (3.9 cs). - In all cases the words *spis* and *spiser* were still longer in utterance final position, so that three steps of duration according to sentence structure can be observed.

A larger number of examples were constructed with the purpose of comparing the importance of the word unit with the rhythmic foot. However, Danish is not well suited for this purpose. In English you might ask whether *stick* is shortened more in *a sticky surface* than in *the stick is broken*, but in Danish the former word type ('(C)CVCV) has lengthening of the vowel (see section IV A). One may, however, ask whether this lengthening is confined to the word. For this purpose a comparison was undertaken between the sentences *hans sǿn er kómmet* [hans ˈsœn ə ˈkʰɔməð] 'his son has arrived' and *hans sǿnner kómmer* [hans ˈsœnɒ ˈkʰɔmʔɒ] 'his sons arrive'. In the sentences *hans sǿn kómmer* and *hans sǿnner kómmer* the vowel of *søn* had been found to be significantly shorter than the vowel of *sønner* (1.7 cs). But in *søn er* .. [sœn ə] vs. *sønner* [sœnɒ] the difference is reduced to 0.5 cs for the same four subjects, and it is not significant (in another recording by one subject it is 0.9 cs). Thus there seems to have been influence across the word boundary. However, in a different pair: *mon min lák er for týnd?* [mon min ˈlɑg ə fɔ ˈtʰønʔ] 'I wonder whether my varnish is too fluid' and *han vil lákke sit brév* [han ve ˈlɑgə sid ˈbʁeʔu̯] 'he will seal his letter' the difference was preserved. In the sentences *han sagde lák tó gánge* and *han sagde lákke tó gánge* the [ɑ] of *lakke* had been found to be 4.4 cs longer than the [ɑ] of *lak* for one subject. The same subject had a difference of 3.0 cs in the two sentences with *lak er* [lɑg ə] and *lakke* [lɑgə], and four subjects all had a significant difference (3.3 cs). Thus, although a certain influence across the word boundary can be observed, this boundary is not irrelevant.

In order to see whether shortenings of Danish words are more pronounced when a following weak syllable belongs to the word itself or not, one must compare disyllables and trisyllables or words with stød. The trouble is that in these cases the shortenings are not consistent medially in the sentence. There is no consistent difference between the durations of the vowel [œ] in *hans sǿnner kómmer* and *hans sǿnner betáler* nor between *hans sǿnner kómmer* and *mon sǿnnerne kómmer*. Therefore one does not find any difference either between *hans sǿnner betáler* and *mon sǿnnerne kómmer*.

For the word [sbi:ʔs] there is a significant shortening (for all four subjects) both when a syllable is added to the word (*mon Spíes kómmer* vs. *han spíser bǿffen*) and when it belongs to the following word (*mon Spíes kómmer - mon Spíes betáler*), but two subjects have a greater difference in the first case, and two in the second case.

In the pairs *hans pláner frémmes* vs. *plánerne frémmes* and *hans pláner frémmes* vs. *hans pláner forkástes* one subject similarly had a difference in both pairs, but of the same magnitude, so that there was no clear difference between *hans pláner forkástes* and *mon plánerne frémmes*. The others had no clear differences at all.

In the sentences *hans plán frémmes* vs. *hans pláner frémmes* and *hans plán frémmes* vs. *hans plán forkástes* three subjects had more shortening in the second pair, thus more shortening in *plán forkástes* than in *pláner frémmes*, i.e. more shortening when the weak syllable belonged to the following word.

Thus these examples do not support the assumption that there is more shortening within the word.

Finally one can investigate whether the addition of more heavy syllables shorten the stem more when they belong to the same word (e.g. in compounds) than when they are separate words. As mentioned in section IVA the first member of a compound is shortened compared to the simplex when they stand in the same frame, e.g. *han sagde målekasse tó gánge* vs. *han sagde mále tó gánge*. Four subjects had a significant shortening of both the vowel (2.7 cs) and the whole first member of the compound (*male* 4.2 cs) compared to the simplex *male*. (Similar shortenings were found in four other compounds with disyllabic first member, whereas the shortening is less pronounced in monosyllabic first members.) However, when the words are placed in sentences of equal length: *han vil mále kássen nú* [han ve ˈmaːlə ˈkʰasn̩ ˈnu] 'he will paint the box now' vs. *han tog málekassen méd* [han tʰo ˈmaːləˌkʰasn ˈmɛð] 'he took the painting box along', then the shortening of the [aː] in the compound is only 0.5 cs and the shortening of the first member is only 1.5 cs, the differences being significant for only 2 of 7 subjects. Similarly, in the sentences *hendes gás brǽnder dårligt* [henəs ˈgas ˈbʁæn?ɒ ˈdɒːlid] 'her gas burns badly' and *hendes gásbrænder sóder* [henəs ˈgasˌbʁænɒ ˈsoːðɒ] 'her gas jet is sooty' there is only a very small and non-significant shortening of the first member of the compound. These sentences were spoken by 4 subjects. Four similar pairs of sentences spoken by one of the subjects who had shortening in *malekasse* showed no shortening of the vowel in the first part of the compound, but in three cases this subject had some shortening of the first member as a whole.

This probably means that the sentence length or the length of the foot ([ˈmaːləˌkʰasə] vs. [maːlə]) in the frame sentences has had more influence than the word unit.

V. CONCLUSIONS

The following conclusions can be drawn from the Danish material presented here:

(1) Shortening of stressed vowels according to the number of following syllables in the word is not a universal. It is not valid for Danish disyllables of the type CVCə, which, on the contrary, have a significant lengthening of the vowel compared to the corresponding monosyllabic words. This lengthening is also found medially in sentences and in first members of compounds, but the first member of compounds is somewhat shortened compared to a simplex word in the same frame. Trisyllabic words of the type CVCVCə have a slight shortening of the stressed vowel compared to disyllables. Vowels in words of the type CVCCə *(danse)* are only slightly lengthened. There is no lengthening of vowels with stød. It is the syllabic type which is decisive. The postvocalic consonant in the words of the type CVCə is, however, shortened compared to the monosyllabic words. Not a single standard or dialectal speaker had longer vowels in monosyllables with short vowel.

The vowel lengthening in disyllables seems to have originated in the North Eastern dialects of Zealand close to Copenhagen. It is argued that there is no connection between this lengthening and the tendency to apocope. Nor is there any evidence for a causal relation between the lengthening and the specific North Zealand-Copenhagen pitch contour, although it is an attractive hypothesis. But it is probable that there is a connection with the weakness of Danish unstressed syllables including the intervocalic consonants. It may thus be considered as a lengthening in open syllable like the old medieval vowel lengthening. A tendency to lengthening was found in a West Funish dialect, though not consistently, and there was a slight tendency in the Odense regional standard. The Jutlandish dialects were not found to have general lengthening of vowels in CVCə disyllables; but there was lengthening in all the West- and North-Jutlandish dialects investigated, in the word [tʰɑgɒ] (before the weak consonant [g]) and in the apocopated originally disyllabic word [kʰɔm(ə)]. The Jutlandish regional standard language, however, has consistent lengthening. This is probably due to the rapidly increasing influence from the Copenhagen Standard language.

(2) Danish has final lengthening, i.e. lengthening of utterance final words of at least one to three syllables. The lengthening is distributed over the segments, but is more pronounced in the vowel than in the initial consonant. Final consonants in monosyllables, particularly the consonant *s*, may be lengthened considerably. In polysyllables the postvocalic consonant is less lengthened than the vowel. The lengthening is significant but of less magnitude than in English, generally from 1 to 3 cs for the vowel.

(3) There are also examples of 'phrase final lengthening', i.e. different durations according to the syntactic break.

(4) There is very little evidence that word boundaries play a role except for the lengthening of short vowels in disyllables.

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ON UNIT ACCENTUATION IN DANISH - AND THE DISTINCTION BETWEEN DEEP AND SURFACE PHONOLOGY*

JØRGEN RISCHEL

This paper outlines a hierarchical model of stress in Danish with special emphasis on phrasal accentuation. The model is essentially based on impressionistic data and phonological and syntactico-semantic analysis of data representing the author's own usage. The relationship between prosody and syntax is explored, and it is suggested that there is an abstract prosodic structure which is very directly coupled to syntax, whereas this is not true of the hierarchical structure found in surface phonology. A considerable shrinkage of structure from deep phonology to (low distinctness levels of) surface phonology is assumed as part of the overall model.

I. STRESS AND THE HIERARCHICAL APPROACH

It is no coincidence that the first part of the title of this paper is strongly reminiscent of that of a paper read by L. Hjelmslev before the Linguistic Circle of Copenhagen twenty-five years ago (Hjelmslev 1957). In spite of obvious affinities to "metrical phonology" the present paper is not directly coupled to the work of the MIT-school (the recent advances in "lexical phonology" are crucially relevant to the whole paper, but reached the author too late to be considered here). Rather, I am trying to summarize and follow up my previous work on the hierarchical nature of Danish stress, with special

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emphasis on certain issues which have vexed me since I was exposed to Hjelmslev's and Eli Fischer-Jørgensen's views on prosodic patterning in the late fifties (also cf. Fischer-Jørgensen 1961). At the same time, of course, I am drawing heavily on theoretical advances within generative phonology. In fact, the general setting within which I am dealing with stress, is generative, but I have preferred to stick to fairly loose formulations and a minimum of formal apparatus in agreement with my earlier work. I hope that the presentation is sufficiently explicit to make my points clear, though.

Probably the most important concession to be made is that my paper does not link to any particular, fully explicit theory of syntax and semantics. Quite generally speaking, I am adhering to the generative notion of surface syntax versus (some kind of) more abstract syntax, and I furthermore assume that lexical material is specified at a level on which the order of syntactic constituents may be somewhat different from that appearing "on the surface", but it is anything but clear to me what would be the most appropriate model (among those currently available) to link one's phonology to. (It may deserve mentioning in particular that I have stuck to traditional uses of labellings such as NP for noun phrase rather than using the X-Bar convention, and that I do not comment on the relevance of Trace Theory for the analysis of the interplay between syntax and phonology.)

Some of the topics dealt with in this paper are treated in more detail in earlier papers to which I refer for further information (Rischel 1964, 1970, 1972, 1975, 1980, 1981). In the present paper one major omission is made in order not to make the presentation unduly complex, viz. that a variety of discourse phenomena are disregarded (some phenomena belonging within this sphere are dealt with, under the common heading "emphasis", in Rischel 1981). Thus, the types of data referred to here are supposed to represent a neutral, colourless rendering of phrases and utterances, or, to quote Liberman and Prince (1977, p. 251), "the null-hypothesis patterns that emerge when there is no good reason to take some other option".

On the other hand, this paper differs from my earlier reports on Danish stress in that it attempts to deal more specifically with the relationship between underlying and surface prosodic patterns (see the last sections of this paper), which is really a challenging issue.

I hope that I shall succeed in demonstrating that Danish stress is interesting both typologically (a.o. because of the dissimilarity between English and Danish stress) and from the point of view of general phonological theory.

In approaching the analysis of stress patterns and stress mechanisms it may be advantageous to start with a consideration of surface patterns and move from there towards more abstract analyses.

A. THE THEORETICAL GROUNDWORK

It was one of the major advances in American phonological (at that time: phonemic) theory when N. Chomsky, M. Halle, and Fr. Lukoff introduced the derivation of degrees of stress from underlying representations with only a binary stress contrast plus a marking of ranked boundaries. Though not so often referred to today, this paper forms an important link between Bloomfieldian phonemics and generative phonology and helps to put into relief the close connection between the two trends. What is interesting in this context is that the paper offered a more fruitful alternative to a theory that posits several degrees of contrastive stress as members of one phonemic category (which had been an obstacle to an adequate handling of the functions of stress).

Within the Copenhagen school of structural linguistics it was recognized quite early that the inventory of Danish stress prosodemes comprises just two members: /ˈ/ (manifested typically as strong stress) and /˳/ (manifested typically as weak stress), cf. the contrasting patterns in [ˈbi˳lisd] 'cheapest' and [˳biˈlisd] 'automobile driver', and that the various degrees of stress that one may attempt to distinguish in phonetic transcriptions are contextually determined variants ("varieties"). However, it was never shown in any detail what the rules of stress manifestation really look like. It was made quite explicit, though, that in defining the relevant context it is necessary to have recourse to what would be termed "higher level information" in the American tradition.

One of the important points in this approach is the emphasis on prosodic relations establishing units of different size (or, more precisely, different hierarchical rank). The relation between /˳/ and /ˈ/ establishes a stress group or "expression junction" (comprising one stress-syllable flanked by zero, one, or several zero stress-syllables on either side). In addition to the relation between /ˈ/ and /˳/ proper, there is also a relation involving reduction of /ˈ/ in constructions containing another /ˈ/. Such stress reduction was recognized as a signal of an intimate union of consecutive constituents.

Hjelmslev, in dealing with the secondary stresses of compounds (such as Danish [ˈbe:nˌknab] 'bone button') claimed that secondary stress here reflects a replacement of ˈ by ˳ under the dominance of the other ˈ, i.e., on a higher level of abstraction there is a succession of two /ˈ/ in such a compound. Likewise, according to Hjelmslev, the weak stress of the first constituent in expression junctions such as [han ˈkʌmʼʌ] 'he is coming' reflects a replacement of ˈ by ˳ under the dominance of the other ˈ in the string (see, for example, Hjelmslev 1957, p. 203; 1973, p. 253, p. 260-261). It was not made very explicit how one can predict from the formal representation that it is the second of two consecutive ˈ that is replaced by ˳ in compounds, but the first of the two in expression junctions, but it is important that the concept of stress reduction as a signal of close union was somehow built into the analysis.

This point was made in a congress paper by Fischer-Jørgensen as early as 1948 (although the Proceedings of the congress did not become available until 1961).

Fischer-Jørgensen's paper makes another important point, viz. that degrees of stress, as they occur in compounds, should be handled in terms of a hierarchical model. I shall quote one of the relevant passages of her brief paper:

> "Especially in German very complicated examples of reduction may be found, e.g. ((('Kurz,waren),,händler) ver,,,ein), where it is possible to distinguish several degrees of reduction. But this can only be done for each group of this kind separately. It is not possible to identify the different degrees of stress from one group to the other, e.g. to decide if the stress of -macher [as part of another compound, viz. 'Hand,,schuh,macher or 'Hand,schuh,,macher] is the same as that of -händler or as that of -verein. And it is completely arbitrary to maintain that a language has 3 or 4 degrees of reduced stress. It is only a way of stating the syntactical possibilities of the language. The important thing is always a comparison between two members and two members only, but this may take place on different levels."

My own paper of twenty years ago (Rischel 1964) was an attempt to outline a fully hierarchical approach to prosodic structure (comprising at least stress and syllabicity) in a structuralist format, and with emphasis on autonomous structure.

So much for the pre-generativist basis of the approach to Danish stress which I shall outline here. The remainder of this paper will contain an exposition of certain components of an all-round description of Danish stress but with particular emphasis on the mechanism of stress reduction.

In generating stress patterns from underlying forms in Danish I have not found it very promising to use the approach of Standard Generative Phonology, as explicated in the sections on English word stress and the transformational cycle in SPE (Chomsky and Halle 1968). The complex rules involved do not make it very transparent what is the basic relationship between stress patterns and the remainder of the phonology on the one side, and between stress patterns and syntax on the other side.

The principle I apply is to start strictly from the bottom up in terms of grammatical structure, the components of such an approach being the following: (1) stress placement in individual morphemes, (2) downgrading in simplex wordforms, (3) downgrading in compounds, and (4) downgrading in phrases. The stress pattern of a complex string is supposed to be derivable from these components taken together, although - as

I shall show later - the relationship between the components is somewhat intriguing.

A note on terminology and transcription: throughout this paper I use terms such as "stress pattern" and "accentuation" rather indiscriminately (I would prefer to use Accent for the more abstract category, and Stress for the phonetic category, or rather the subjective experience of extrinsically determined syllable prominence, but this would presuppose a clarification of the distinction between abstraction levels which I do not think has been achieved so far). As for the notation of degrees of stress, I have earlier (Rischel 1972) expressed my scepticism about the phonetic meaning of these elements, at least for Danish, and in this paper I prefer to avoid the notation of degrees of secondary stress. In transcriptions I have simply indicated the placement of stresses that have not undergone reduction: in the (few) cases where phonetic transcription is used, these stresses are indicated by [ˈ] before the syllable in question, but otherwise they are indicated by an acute accent over the vowel. The same mark (acute accent) is also used to mark lexical stresses in strings of morphemes in those cases where the prosodic structure is specified in terms of a tree structure with labelled branches; I hope that these two (mutually exclusive) uses of the accent mark do not cause confusion.

The term Prominence, as it is used in this paper, is an impressionistic term referring to a subjective assessment of how much a syllable stands out in relation to other syllables. Unfortunately, as is generally the case with the use of this term in phonology, it remains rather obscure what is the relation between this alleged parameter of prominence and, say, (a) the inherent syllable weight as determined by segmental structure, length and presence or absence of stød, (b) the extrinsic pitch which the syllable gets by virtue of its placement in an utterance with a specific intonation and a specific distribution of full stresses, and finally (c) linguistic stress (lexical and emphatic) on this particular syllable. I do not here take "prominence" to be an independent parameter, however.

Finally, there is the question of terminology referring to degrees of stress. There is a proliferation of terms referring either to stresses as such or to syllables, or both, and in part referring to the function of stress as a signal of subordinating constructions, cf. such pairs as "strong"-"weak", "heavy"-"light", "main stress"-"secondary stress". I have not strived at being strictly consistent in this paper, but whenever it is important to make clear that I take stress gradation (outside of emphasis) to be a matter of reduction or downgrading, I refer to the unreduced stress as full stress and to all occurrences of an underlying stress that undergoes reduction, as reduced stress. Syllables whose stress is reduced to such an extent that they might just as well be underlyingly stressed, are said to have (reduction to) weak stress. The term zero stress is used in some cases to refer to lexical absence of stress, which comes out phonetically as weak stress, of course. In many cases, however, I have found it more convenient to speak of stressed versus unstressed.

B. MORPHEME STRESS

If one looks at individual morphemes (disregarding for the moment all stress gradings that are conditioned by the larger context), there are two basic questions to be asked about accentuation: (1) is the morpheme in question inherently stressed? and (2) if so, where is the inherent stress placed?

(1) As for the question of inherent stress, it is possible to start with the formulation of a phonological condition: a morpheme cannot be inherently stressed unless it contains at least one full vowel. This takes care of inflectional endings, which contain only consonants and schwa. There are also a couple of derivational suffixes, viz. *-(l)ig* and *-(n)ing*, which are unstressed (at least if they are not followed by one or more inflectional syllables) and which may be claimed to have schwa underlyingly, although they surface with a full vowel (respectively [i] and [e]); under this analysis (which, by the way, has been current in Danish structural dialectology) the absence of stress is straightforward. It is less simple, however, with other derivational affixes.

As for prefixes, I wish to contend that these are, as a rule, inherently stressed but undergo the process of Intra-Word Unit Accentuation dealt with in the next section. The inventory of items that count as prefixes in this sense includes a variety of roots and prefixes of Latin or Greek origin, a few (but highly frequent) prefixes of Low German origin, and at least one prefix of Danish origin, viz. *u-* 'non-'. Some of these items have a complex morphosyntactic and phonological behaviour in that they behave like root morphemes (forming compounds or quasi-compounds) in some cases but like prefixes (undergoing Intra-Word UA) in other cases; this very complex issue has to be left totally aside in the present paper. There are some other items, however, such as the Low German ones (e.g. *be-*) or Greek *filo-*, *antropo-*, *theo-*, etc., which do not normally occur under stress and which might thus be defined as inherently unstressed. If, however, such items are put in relief for the sake of contrast with other prefixal material, the stress invariably falls on one specific syllable (unless it is some other syllable, rather than the whole item that is put into relief): *jeg sagde "antroposof, ikke "theosof"* 'I said a., not th.' (without such relief, both words have a main stress on the last syllable). Thus, it is relevant to know where to put the emphatic stress in such cases, in casu on the first syllable of the item in question.

This raises the question whether the specification to be made here, viz. for inherent stress placement, presupposes inherent stress or not. It depends, of course, on the definition of these concepts, and I am not sure what is the best solution. At present I am assuming, however, that the concept of inherent stress should be extended to cover not only morphemes that actually surface with a stress degree above "zero stress" but in fact all morphemes with a full vowel. "Inherent stress" then, does not imply that the morpheme in question typically occurs with a main stress but rather that there is a unique syllable within this morpheme serving as the carrier of potential stress and that the morpheme appears with a main stress unless it enters a construction conditioning some other accentuation. - Some morphemes, then, rarely or never occur under conditions where a normal main stress can occur, but they may still have inherent stress in this weaker sense.

Suffixes containing a full vowel syllable are inherently stressed, and as with prefixes, there are some idiosyncracies of word formation associated with individual suffixes. No attempt will be made here to account for these idiosyncracies. It can be mentioned, however, that there are just a couple of suffixes that behave phonologically like root morphemes, i.e. which form quasi-compounds (this set includes *-dom, -hed, -skab*, cf. German *-tum, -heit, -schaft*), and that these suffixes consistently do so. Otherwise, the vast majority of suffixes enter into a proper simplex word construction with the preceding material so that the rule for simplex word accentuation (Intra-Word UA) applies. I refer to an earlier paper (Rischel 1970) for a more detailed discussion (including the special pattern of accentuation exhibited by lexical cognates such as *mekaník, mekánisk, mekániker*).

As for root morphemes, it would be perfectly possible to claim that some function words are inherently unstressed. This would not be true of all the "small" words that are normally unstressed, however. If we take a pronoun such as *mig* 'me', it certainly is the case that this item mostly occurs with a weak stress, cf. *han besøgte mig* 'he visited me', but it should be noted that the pronoun is stressed as part of a complex noun phrase even if there is no additional emphasis: *han besøgte Péter og míg* 'he visited Peter and me'. However, it is true of certain conjunctions and of certain modal particles (such as *skam* 'certainly') that they occur with weak stress under all normal syntactical conditions (conjunctions may be emphasized, however), so that their situation resembles that of prefixes like *be-* or *filo-* (to the extent that these are synchronically morphemes at all).

Generalising the notion of inherent stress to comprise all morphemes with a full vowel might seem to create a descriptive problem, viz. that of accounting for the difference between those morphemes that actually do emerge with a main stress in phonetic strings, and those that do not (under normal conditions). However, this problem turns up anyhow: if certain lexical items are inherently unstressed, we have to try to account for that fact; if they are considered inherently stressed, the fact that they normally occur with a weak stress will largely follow from a description of the types of constructions into which they enter, which must be supplied in a complete grammar anyway. - Still, I wish to leave it open whether one should exploit the possibility of distinguishing between morphemes with and morphemes without inherent stress in formulating stress rules.

(2) Now, for morphemes with more than one syllable with a full vowel, the next question is to what extent the placement of stress on a particular syllable is predictable. The morphemes in question are almost all borrowings such as *violin, diamant* ('diamond'), *alabaster, petroleum, jeremiade*, but there are also a few fossilized compounds of Old Danish origin such as *vindu(e)* ('window', from *vind* 'wind' and *ǿghæ* 'eye'). Moreover, there are numerous items which more or less transparently consist of a prefixal part and a remainder. Among those that are historically formed with a Low German prefix there are many which are readily analysable, although they are lexicalized with a more or less unpredictable shade of meaning, e.g. *beholde* 'keep' (cf. *holde* 'hold'), whereas others contain no meaningful stem after the prefix (e.g. *begynde* 'begin': there is no **gynde*). It is obviously true of many of these borrowings from Low German (or in some cases from High German) that they form a transitional area between straightforward derivations and monomorphemic stems. The same is true of complex formations containing Greek or Latin material such as the above mentioned examples *antroposof, filosof, teosof*. Technically, there is evidence enough for a synchronic analysis into constituents, cf. that *-sof* contrasts with *-log* in *antropolog, filolog, teolog*, but again, such items are typically lexicalized with specialized meanings, and there is no sharp limit between synchronically complex and monomorphemic items of this kind.

This is well known from other languages as well. The important thing is that the stress rules must be designed in such a way that the words come out right even if they are taken to be monomorphemic; it must simply be allowed for that some speakers lexicalize them as complexes, and others as monomorphemic items.

As shown in detail elsewhere (though in a very provisional format: Rischel 1970, p. 119-130), stress placement is to a considerable extent predictable from surface segmental structure.[1] The strongest generalization is that <u>if one syllable has a long vowel, the stress falls on this syllable</u>. Otherwise there is a rank-ordering so that (with the exception of certain loans from French) <u>a closed syllable takes precedence over an open</u>

syllable in attracting the stress. If an inter-vocalic consonant is supposed to go with the following syllable from the point of view of stress assignment (which, by the way, may be in conflict with the role of syllabification in segmental phonology), the second principle takes care of the final stress in forms such as *parýk* 'wig', *stakít* 'railing', *parasól*, but there is a more general prevalence of final stress if the last syllable is closed, cf. *komplót* 'plot', *bandít* 'rascal' (this is certainly not without numerous exceptions, however). If the final syllable is open (and the vowel short), the stress is non-final: *fóto, gálla* (with a short *l*), with the exception of French loans such as *coupé* ([kuˈpe] as a designation of a shape of a car, but *kupé* [kuˈpe:ʾ] in the sense of 'compartment').

The accentuation of a variety of structure types is thus predictable, cf. the following examples (note that *-er* of *alabaster* and *-e* of *jeremiade* are schwa-syllables, spelled - as is regularly done - with *e*): *violí:ʾn, diamánʾt, alabáster, petró:ʾleum, jeremiá:de, víndu*, etc.).

> It is interesting that there is a tendency in low-standard Danish toward initial stress in root morphemes; this tendency manifests itself only sporadically but typically in cases where it is in direct conflict with the very strongest generalization concerning syllable structure and stress placement, viz. that a long vowel has stress. One such example is *remoulade*, in standard pronunciation with stress on the penultimate, which contains a long vowel: *remulá:de*, but in a low-standard usage with initial stress: *rémula:de*. It is conceivable that one should speak here of a restructuring into the prosodic structure of compounds; anyway, this tendency (possibly toward quasi-compounding) does not invalidate the stress placement rules as such, since it hits only sporadically.

The accentuation of wordforms that surface with more than one long vowel is not defined by such criteria as those above; the generalisation here is that the wordform behaves like a compound (see section I.E), and this happens also with some wordforms which do not syntactically qualify as compounds (quasi-compounding). Another problem is raised by stems with alternating placement of vowel length and hence of stress, e.g. *mó:tor*, pl. *motó:rer* (cf. Rischel 1970, p. 134-136).

Now, simple principles like those outlined above (or the more elaborate set given in Rischel 1972 without reference to syllable boundaries) predict a good proportion of the word stresses, but they are contradicted by several forms such as *abrúpt* (versus *mástiks* 'mastic'), *dámask, Cánʾada, basílʾikum*. It is possible to exploit the differential placement of syllable boundaries in clusters (thus refining the concept of "light" versus "heavy" syllable), but there will be a residue anyway, the most stubborn cases being those with non-expected stress on a non-final syllable (cf. *mástiks, dámask, Cán'ada* above). It should be noted in this context that Danish differs sharply from the other Scandinavian languages in having short stressed syllables (there is no "reverse length correlation" of V:C versus VC:); the final consonant of a stressed syllable is always short (irrespective of its historical origin). This means that we do not have consonant length at our disposal as a criterion in placing stress (incidentally, this typological aberration from the "Scandinavian" type also means that vowel length in Danish cannot possibly be predicted on the basis of information about surface properties of the consonantal parts of the syllables).

It is possible, however, to argue for the existence of underlying long consonants or clusters surfacing as single, short consonants. Such an analysis is motivated by the distribution of the stød (cf. the discussion in Basbøll 1972, p. 8-12), and if it is adopted, the same device can be used in a number of cases to define syllables as underlyingly heavy, so that they count as preferred stress placements. In itself, this is just a notational device, but it becomes more interesting because of the mutual support of the stød and stress evidence in a number of cases (cf. *Cán'ada*). If one sets up underlying long consonants, it turns out that this feature can be assumed to take precedence over the presence of clusters consisting of two different consonants, i.e., in determining the placement of stress one has to pass through a set of ordered rules (which are disjunctive in the sense that if one gives a positive result, the rest are skipped), the first such rule referring to the presence of a long vowel, the second referring to the presence of a long consonant, and the remaining ones referring to syllable boundaries and consonant clusters. The very last rule, then, assigns final stress if nothing else has applied. Such a set of rules can be made to assign stress correctly with few exceptions. I shall not go into more detail with this here, however (the reader is referred to Rischel 1970, p. 127-129: rules A-E for a provisional formulation; the formulation on p. 142-143 of the same paper is, however, quite invalid).

From the point of view of surface phonology stress placement must be considered contrastive in Danish, but it is hard to find monomorphemic relevant pairs. The two pairs that are normally cited are:

['plasdig] *plastic* versus [pla'sdig] *plastik* (gymnastics)

and

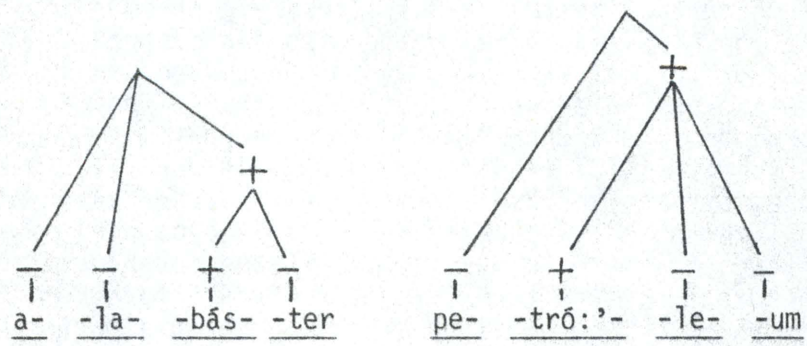
['bilisd] *billigst* 'cheapest' versus [bi'lisd] *bilist* 'car driver'

but in both of these cases the final stress of the second member is explicable by the nature of the suffixation involved (*-ik* and *-ist* are inherently stressed suffixes).

Thus, from the point of view of the lexicon, the utilization of stress placement as a distinctive feature is extremely low.

C. THE HIERARCHICAL MODEL

As it will appear from the generalisations about morpheme stress above, a monomorphemic lexical item may contain both pretonic and posttonic zero-stress syllables. Is there in this case a simple concatenation of syllables in a linear arrangement, or do they enter a hierarchical arrangement? It is dubious whether there is any evidence for such a hierarchy as far as stress is concerned. If some syllables among the unstressed ones are felt to be more prominent than others, this is probably ascribable to two factors, viz. (1) that each syllable has an inherent degree of prominence, which is a function of its phonological make-up (closed syllables having more prominence than open syllables, and syllables with a full vowel more prominence than syllables with schwa), and (2) that the pitch contour associated with a full stress (Thorsen 1980) supplies each syllable with a tone level (Fo level) which contributes to the impression of more prominence or less prominence. I have not considered it useful to build such considerations into the assignment of hierarchical structure to a clustering of zero-stress syllables around a full-stress syllable (and my model therefore comes to look somewhat different from those posited for English in recent work such as Liberman and Prince 1977 and Selkirk 1980). However, there seems to be more of a break between the pretonic part and the remainder than between the posttonic part and the syllables preceding it; this appears in that it is possible to hesitate between the (last) pretonic syllable and the stress-syllable rather than elsewhere, and that there may be an extremely sharp intonational break here. I therefore venture to suggest a hierarchical arrangement as follows, where each branch that has the stress-syllable as one of its ultimate constituents is supplied with the label "plus", and all other branches are supplied with the label "minus" (corresponding, respectively, to the labels s = "strong" and w = "weak" of the nomenclature used in metrical phonology):



It appears from these examples that there is a redundancy built into such a hierarchical representation, since the plus-labelling is associated with the presence of lexical stress /´/. It has been argued recently by Selkirk (Selkirk 1980) that the feature of stress, as something distinct from the labelling of the hierarchical trees, can and should be eliminated from phonological theory. This approach obviously eliminates both the redundancy and certain well-formedness conditions such as the following: *"only a stressed syllable may be the strong element of a metrical foot"* (Liberman and Prince 1977, p. 265, also see p. 279-280).

However, I prefer to preserve the distinction between inherent stress (in the sense in which it has been defined above) and the labelling of prosodic trees, since the properties are essentially different. Inherent stress has to do with the fact that there is a syllable which can occur with a full stress, and whose presence is a condition on the well-formedness of a hierarchical structure of a certain type. In turn, there are well-formedness conditions on syllables with inherent stress saying, for example, that such a syllable must have a full vowel. It is possible to collapse these findings into one complex set of conditions on the well-formedness of hierarchical structures, but it should be noted that lexical (inherent) stress is not fully predictable, so that some syllables must be underlyingly marked for stress anyway. Thus, it seems to me that it is more meaningful to say that the hierarchical organization refers to inherent stresses in all cases, and that there are redundancy conditions predicting where these stresses are located in a great many cases.

D. INTRA-WORD UNIT ACCENTUATION

Examples such as *plastík, bilíst* illustrate the basic mechanism of Unit Accentuation (UA), as it operates on sequences of stressed morphemes to produce simplex wordforms with one single full stress.

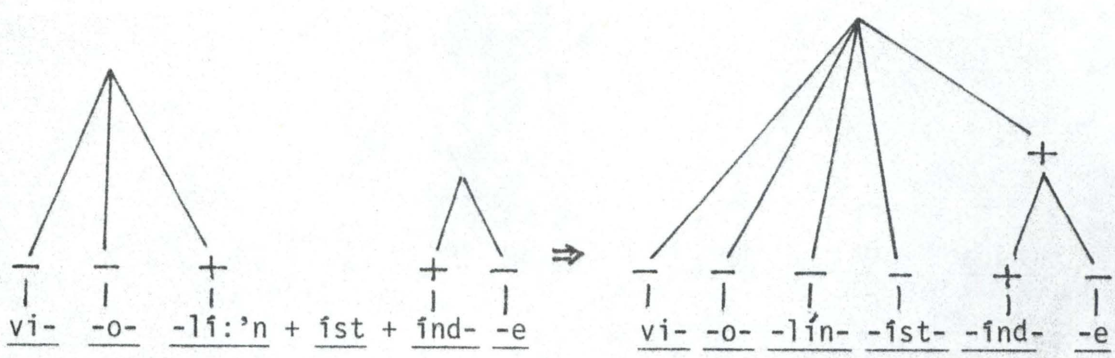
> In accordance with tradition (including O. Jespersen's insightful contributions to the understanding of how Danish stress functions) I use the term Unit Accentuation (UA) about stress reduction as a function of hierarchical patterning (in contradistinction to, say, the lower prominence associated with backgrounding under certain discourse conditions, or stress enhancement due to emphasis for contrast). It is traditionally used in Danish phonetics about phrasal stress, but I use it also about the stress mechanism in simplex words consisting of several, inherently stressed morphemes (whereas I use the term "compound stress" for the pattern of compound, although this is also a matter of unit accentuation, albeit of a different kind). The term UA is more directly suggestive of the actual function of this stress mechanism (as I see it) than other terms which are more current in phonological literature ("nuclear stress" focusses on some alleged enhancement of a stressed syllable, not on stress gradation as a signal of the union per se, and the term "phrasal stress" is obviously more restrictive than the term I have adopted here).

Like the nuclear stress rule of Chomsky and Halle (1968) this rule of word internal stress reduction simply downgrades all non-final stresses. However, provided that the impression of syllable prominence as a function of pitch contours and inherent sonority is taken care of separately, there seems to be no need for a grading of stresses beyond the distinction between full stress and weak stress (= zero stress): all non-final syllables simply appear as pretonic ones. Thus it is perfectly possible to formulate the rule of Intra-Word UA like this: delete all inherent morpheme stresses except for the last one within the wordform. Example:

> *violí:'n* 'violin'
> *violí:'n+íst* → *violiníst* 'violinist'
> *violí:'n+íst+índe* → *violinistínde* 'female violinist'

This approach has the attractive property that the output of the rule looks exactly like a monomorphemic lexical item. Thus the theory does not force the analyst to generate the accentuation of such derivatives by rule: they come out the same way if they are taken to be lexicalized as monomorphemic items (though the inherent stress on the last syllable with a full vowel is then only in part structurally predictable).

It is also possible, however, to handle the operation of this UA rule in terms of stress trees. The trees for individual morphemes are then taken to be united by the application of UA (i.e., UA is a structure transformation), the rightmost inherent stress being the determinant for the selection of the resultant highest "plus" branch:



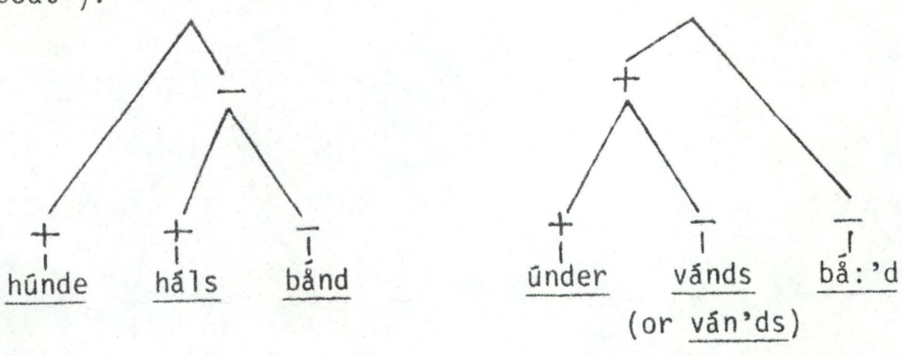
This somewhat more complex way of handling the process has the advantage that the output fits directly into the prosodic tree that will be needed anyway; it just requires a convention to the effect that pretonic occurrences of inherent stress, i.e. /´/ occurring under left branches labelled "minus", are neglected in the phonetic interpretation of the surface representation (as are the boundaries between the constituent morphemes).

In this paper I do not go into the question whether boundary symbols have a status in phonological representations except insofar as they mark the boundaries of a unit of a certain rank in the prosodic hierarchy (cf. Selkirk 1980, p. 580 for arguments against the separate relevance of grammatical boundaries in phonological representations). It is obvious, however, that grammatical structure is relevant to prosodic structuring, though there is nonconformity between the two. In the representations below I indicate morpheme boundaries and certain other boundaries, whenever it seems useful to make the type of construction clear.

E. COMPOUND STRESS

The next step is the generation of compound stress. I demonstrated in an earlier paper (Rischel 1972) what a hierarchical model of compound stress may look like for Danish. I shall just summarize the main points here without going into much detail (especially since the model I am using is quite similar to that of recent metrical phonology, and since the basic mechanism of compound stress is the same as in English). (See Basbøll 1978 for an alternative approach with 3 stress degrees.)

A tree structure being defined in accordance with the syntactic constituent structure of the compound (with or without certain adjustments), the resulting syntactic tree is matched by a prosodic tree in which the leftmost constituent on each level hangs under a branch labelled "plus", whereas all other branches are assigned the label "minus", cf. *hundehalsbånd* 'dog's collar' and *undervandsbåd* 'submarine' (literally: 'under-water boat'):



The relative degree of stress is, then, a function of this structure, there being an interpretive convention looking at the ranks of nodes and saying something to the effect that (1) a minus branch implies weaker stress than a plus branch under the same node, and (2) a minus branch under a node of rank X implies weaker stress than a minus branch under a node of rank X-1. (It is open to much debate how one should formulate such an interpretive convention; first of all, it depends on what "degree of stress" really means, but I shall not go into that here.) Accordingly, in the first example *bånd* has weaker stress than *hals*, and both of these items weaker stress than *hunde*; in the second example *vands* has weaker stress than *under* and *båd*, and *båd* in turn has weaker stress than *under*.

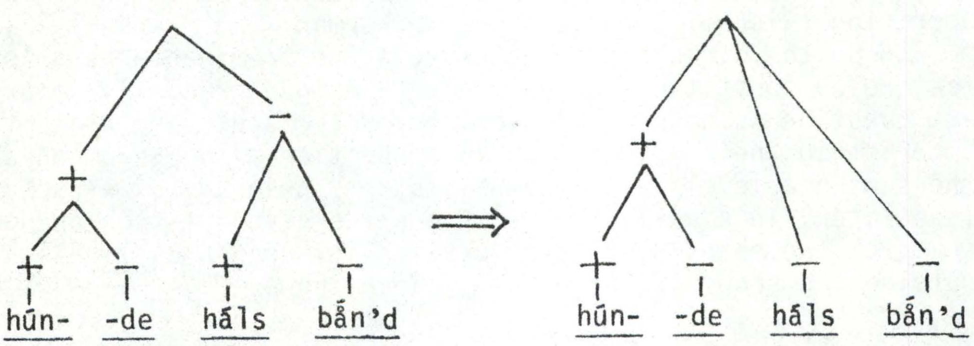
In transcription with stronger and weaker secondary stresses: [ˈhunəˌˌhalsˌbʌnˀ] [ˈɔnʌˌvansˌˌbɔːˀð].

It is typologically relevant to mention that this scheme generalizes to the vast majority of Danish compounds. It was mentioned above that basically, the prosodic mechanism of compounding is similar to that of English, but it differs in having a very much stronger preference for plus-minus (= strong-weak) rather than weak-strong marking on sister branches (the opposite, i.e. stronger stress on the rightmost constituent, occurs only in a small set of compounds typically belonging to specialized spheres of usage).

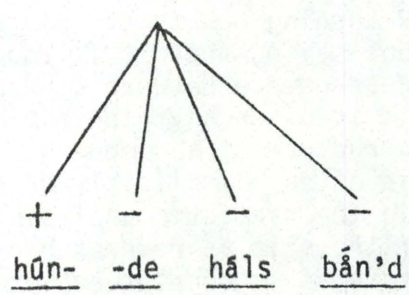
There has been some discussion as to whether such a model of accentuation makes it possible to assign stress without the use of a phonological cycle. This is an extremely important theoretical issue since the alleged cyclicality of (English) stress assignment has been used as a main argument for the very existence of such a thing as a phonological cycle. I do not wish to challenge the view that hierarchical structure assignment involves cyclic application of rules (cf. Kiparsky 1979); Liberman and Prince (1977) show the existence of "translexical" regularities in English which invite a treatment in terms of cyclicality. But in the present context the essential thing is that the specification of phonetic stress on the basis of a hierarchical representation is accomplished in one complex operation (Rischel 1972, also cf. Liberman and Prince 1977, p. 258 on the direct encoding of relative prominence as a local feature on constituent structure). - A more crucially important question is how phonological rules (prosodic and segmental) interact in their application in connection with phenomena at the sentence level such as emphasis or "shrinkage of structure" (see later) in casual speech. A consideration of such phenomena from the point of view of cyclicality or non-cyclicality is outside the scope of the present paper, however.

Returning now to the hierarchical model as such, it goes without saying that it is too simplistic to posit a one-to-one correspondence between syntactic and prosodic trees. For one thing, it is often anything but evident what is the internal syntactic structure of a compound. In actual practice the stress pattern is often - implicitly or explicitly - taken into consideration in the syntactic analysis. This is perfectly legitimate (stress is as respectable a cue to syntactic constituent structure as is constituent order), but of course such an approach means that no additional insight is gained by explaining the prosodic hierarchy in terms of syntax. Another thing is that the accentuation of Danish compounds often reflects a tree structure that is in conflict with an intuitively reasonable IC analysis. It must, then, be the case that certain structure transformations (STs) are involved in defining the relationship between syntactic and prosodic trees, unless the compound in question is lexicalized with an idiosyncratically aberrant syntactic structure (or no such structure at all). - As for compounds exhibiting no structural idiosyncracies there are several ways in which these may be handled in a linguistic description, since (1) the syntactic constituent structure may be lexically stored or generated by rule, and (2) the prosodic structure may likewise be part of the lexical representation or derived by rule. Under the assumption that we are dealing with productive patterns I prefer to assume that the relevant structural generalisations and mapping rules all exist in duplicate form: as rules for productive compound formation and as redundancy conditions on lexicalized items.

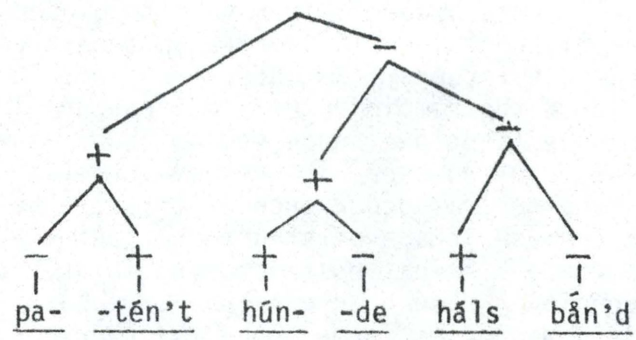
The most important ST is loss of ranking differences or, put differently, shrinkage of structure (the hierarchy ultimately collapsing into a simple concatenation). There is in Danish an overwhelmingly strong tendency to lower all but the two highest degrees of stress (as predicted from the hierarchical representation) to the lowest level, and there is even a strong tendency to lower the next highest degree of stress ("secondary" stress) in right-branching structures. What remains, then, is a sequence of weakly stressed syllables, whose relative prominence is a function of properties of the string which are not included in the labelled tree as such. If these are disregarded, the structure of *hundehalsbånd* above looks as follows if shrunk (for clarity, the branching within each lexical constituent is indicated here as well, in contradistinction to the simplified representation above):



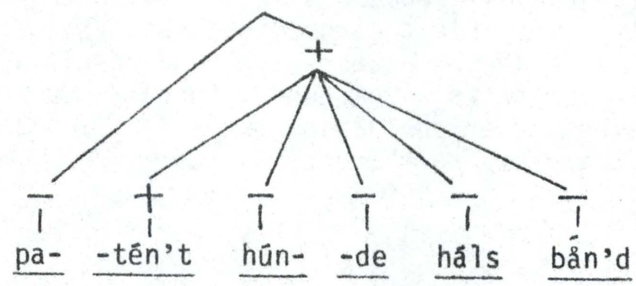
and with further shrinkage into



The same applies to more complex compounds such as *patent-hundehalsbånd* 'patented dog's collar' (possibly not in current use, but a perfectly well-formed compound):



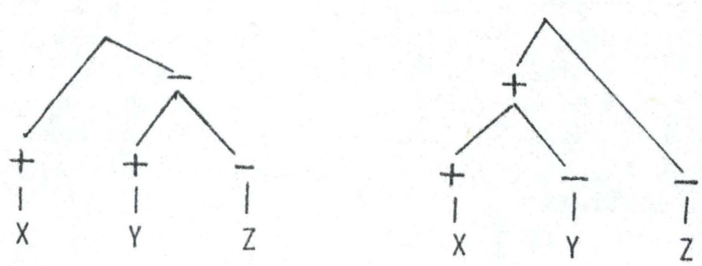
possibly with shrinkage into:



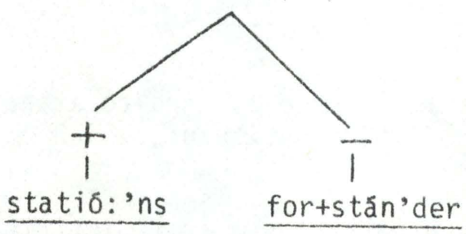
(the pretonic syllable is here assumed to attach to the reduced structure as an immediate constituent, which may not be an adequate analysis).

Left-branching structures such as that of *undervandsbåd*, on the other hand, are less likely to shrink to structures of minimum complexity, but may do so in allegro speech.

In some instances it is difficult to decide whether we really have a shrinkage of structure or a change in the assignment of branches to nodes. There may be a tendency to swing a branch that branches off to the left under a right branch and to attach it so that it branches off to the right under a left branch:



Maybe the ST involved - if this occurs - is rather to be conceived as affecting the rightmost constituent (Z in the structure above), moving this constituent from under the lower node and Chomsky-adjoining it to the remainder of the structure in terms of a new, higher node (the lower node vanishing by convention). The basic question, however, is whether there is empirical evidence for the general occurrence of this mechanism (as something distinct from shrinkage of structure). At any rate, it may be the source of lexical restructuring in several compounds with the adverbial *for* such as *stationsforstander* 'station master'. This compound is formed on *forstander* 'master' (literally 'fore-stander') with full stress on *for-*, and accordingly one would expect the right-branching prosodic structure of *hundehalsbånd*, but what actually occurs is a stress pattern with more prominence on the third constituent than on the second (unless all reduced stresses are downgraded to weak stress). It is possible to argue that this is an instance of the ST outlined above; however, the end result is rather lexical restructuring to a compound with only two word-level constituents, the latter containing prefixal *for-* (I disregard the fine structure of the hierarchy here):



Restructuring is not surprising in this very type, since adverbial (and inherently stressed) *for* is easily confused with prefixal *for-* (from Low German); in the particular example under consideration it may even have been supported by the spurious similarity with formations such as *forstắn'd* (meaning 'wit' and being semantically quite unrelated to the noun *forstander*).

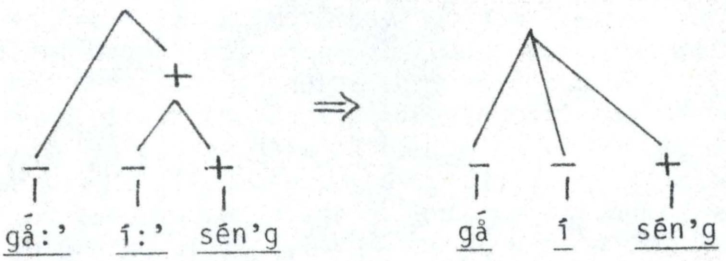
Otherwise there may not be very much restructuring of this kind, and on the whole, the accentuation of Danish compounds does not seem to require much machinery for its specification. So far I have found no compelling evidence for operating with rhythmic perturbations which are determined by the word structure itself, but then the phonetic details of Danish stress await closer investigation.

F. PHRASAL UNIT ACCENTUATION

The last component to be dealt with in this package of stress assignment mechanisms is Phrasal UA (Unit Accentuation). This operates according to the same principle as Intra-Word UA, i.e. all but the rightmost constituent hang under minus branches, and the expected hierarchical structure typically shrinks to a one-node structure, cf.

gå:' í:' sén'g → gå i sén'g

or, in the tree structure model:



Except for a high level of distinctness, the difference between inherent /´/ and zero stress seems to be ignored in such constructions, but it is an open question whether there is a structure-independent impression of differences in prominence between syllables with a full vowel and syllables with schwa (whatever its surface reflex), e.g. between the underlying full-vowel syllable *gå* and the underlying schwa-syllable *-ger* ([gɔ] versus [gʌ]) in

hun vil gå i seng [hun ve gɔ i ˈsɛŋ'] 'she intends to go to bed'

hun ligger i sengen [hun legʌ i ˈsɛŋ'n] 'she is in bed (as a patient)'

This whole area awaits further phonetic study.

I shall state the conditions for Phrasal UA in considerable detail later in this paper. For the moment the above remarks may suffice.

At this point I wish to comment on another issue, viz. the necessity for operating with a "metrical grid" as posited in Liberman and Prince (1977). One of the interesting mechanisms handled in terms of a metrical grid is "iambic reversal" (p. 319). We do find a phenomenon of this kind in Danish, but interestingly enough, it does not seem to be crucially dependent on whether the constituent in question is inherently stressed, so one may question whether the conditions set up for "iambic reversal" are really met in Danish, cf. that the prefix syllable *be-* (which never occurs with a full stress) may perhaps be experienced as more prominent than the root syllable *gå* in phrases such as *begå selvmord* (with stress on *selvmord*) 'commit suicide', although the wordform *begå* in itself invariably has stress on the root syllable. Maybe we have here a more general tendency toward a gradual downstepping in a series of pretonic syllables, which should perhaps be kept apart from the specification of the hierarchical structure proper.

G. HOW ARE THE COMPONENTS OF STRESS ASSIGNMENT RANKED?

We have seen that UA operates both within simplex words and within phrases, and that there is a compound stress mechanism (with the reversed marking of sister branches in terms of "plus" and "minus") operating on compounds in the widest sense. Now, each part of a compound may be a derivative undergoing Intra-Word UA (cf. *violinist* derived from *violí:'n+íst* as occurring in compounds such as *hofviolinist* 'court violinist' and *violinistkonkurrence* 'v. competition'), and since compounds may also occur as constituents of phrases undergoing phrasal UA (cf. the compound *indføre* 'import' with stress reduction in the phrase *indføre våben* '(to) import weapons'), there seems to be no way of avoiding to have UA apply twice: once on the word level and once on the phrase level. It is possible, however, to claim that the results of both types of UA are collapsed into one structure, and that this is true even if the last constituent of the phrase in question is a compound, as in *hun vil til violinistkonkurrence* 'she intends to go to a violinists' competition'. This implies that the highest-ranked branching in such a construction is between all material up to the boundary between the two (immediate) constituents of the compound on the one hand, and the second (immediate) constituent of the compound on the other, i.e. that the compound boundary has a higher rank than other phrase-internal boundaries (this point has been made by H. Basbøll (1977)).

There may well be a level of phonological specification for which this yields the most adequate representation. However, in surface phonology a basic rearrangement seems to take place, the syllables grouping now in clusters defined by an initial full stress. Nina Thorsen, who has demonstrated the relevance of this segmentation in connection with the specification of intonation contours, refers to such clusters as "stress groups". I shall here venture to speak of a foot, although this certainly does not fall in with the use of this term in, say, Selkirk's work (Selkirk 1980). - It will be shown toward the end of this paper how this concept of foot structure in Danish surface phonology can be reconciled with the model(s) outlined so far. As I shall argue later, this is basically a matter of more abstract versus more surfacy levels of specification. The status of Phrasal UA is crucial for the understanding of such differences in level of abstraction. I shall, therefore, consider the conditions for application of this mechanism in some detail before returning to the theoretical discussion of models of phonological description in section IV. (Section II takes stock of the phrase types in which UA occurs in Danish and hopefully demonstrates that the distribution of Phrasal UA in this language is very different from that of the other Germanic languages that have been within the sphere of interest in recent discussion. Section III deals with the accentual pattern of phrases which have become disrupted by movement transformations.)

II. SYNTACTIC AND SEMANTIC CONDITIONS FOR DANISH PHRASAL UA

Looking at phrases devoid of emphatic stress (in the widest sense), what are the basic generalisations to be made about UA?[2] We shall consider first certain modifiers with idiosyncratic behaviour, then noun phrases with a noun as head of the construction, then phrases with an adjective or adverb as head, then prepositional phrases, then auxiliary plus main verb, then verb phrases with an object, a "subject-object" (Diderichsen's term), or a subject or object predicate. Needless to say, this survey has to be very brief, and numerous problems must be left totally aside. One major omission is made for the sake of space and clarity of exposition: fixed idiomatic phrases which exhibit unit accentuation but do so without conforming to the general pattern, are here for the most part ignored, the point being to describe the productive pattern of accentuation of ordinary grammatical constructions, not to give an exhaustive account of the whimsies of lexicalized phrases.

A. A SURVEY OF PHRASE TYPES WITH UNIT ACCENTUATION

1. MINOR CATEGORIES OF WORDS WHICH NORMALLY UNDERGO STRESS REDUCTION

In order not to complicate later parts of this survey, it is necessary to start by mentioning the existence of certain restricted sets of words which normally occur with weak stress (when not emphasized), and whose lack of a full stress may be ascribed to a more generalized application of UA than the types listed below. The words in question fall into two main groups.

One group consists of certain words ranging in syntactic function and semantic content from an article-like status over a more general quantifier status to clearly adverbial, numeral or pronominal status. It comprises, for example, such items as *en* 'a, one' (neuter *et*), *lidt* 'a little', *nogen* 'some' (neuter *noget*, plural *nogen/nogle*), and personal pronouns: *jeg* 'I' (cf. section I.B above), etc. The generalisation is that these items have stress reduction to weak stress if they occur as the leftmost immediate constituent of a syntactic construction of which they are not the head (that is, the item in question must either be a modifier, or IC of an exocentric construction). Examples: *en mánd* 'a man', *lidt mére* 'a little more', *lidt sént* 'a little late', *noget óst* 'some cheese'. This occurs only if the item is semantically reduced to an indefinite article or article-like quantifier or is used anaphorically (not deictically). Accordingly, there is a difference between *en mánd* 'a man' and *én mánd* 'one man (numeral)' and between *nogen (nogle) ménnesker* 'a few persons' and *nógen (nógle) ménnesker* 'certain people' or 'quite a few people'.

> There are obviously three ways of accounting for such contrastive pairs. One is to say that *en* and *én* are simply distinct lexical items (and similarly for the other pairs), and that some such items are inherently unstressed, others stressed. Another possibility is to take them as distinct lexical items but to claim that all these items take stress underlyingly, although one subset (definable on semantic grounds) normally appears with weak stress due to UA. Finally, one may use the same explanation in terms of stress reduction due to UA, but attempt to group the forms with and without susceptibility of UA as pairwise variants of one lexical item each. The question of how to handle such phenomena lexically is of course outside the scope of this paper; I shall just point to the possibility of speaking of UA even in these cases.

With the personal pronouns there are additional generalisations to be made, however, since weakly stressed forms occur also finally in constructions: *han sér mig* 'he sees me', *han gik éfter hende* 'he followed her' (literally: 'went after her'), i.e., stress reduction occurs as a general feature of these items unless a syntactic or semantic condition blocks stress reduction. One syntactic feature blocking it is occurrence in construction with a sister constituent, cf. *han sér mig og Péter* 'he sees me and Peter', and one semantic feature blocking it is distinctly deictic function.

The other main group comprises certain conjunctions such as *og* 'and', *at* 'that'. I shall confine myself to just stating that these are normally weakly stressed, as are certain modal particles such as *skam* 'certainly' (which are probably inherently unstressed, cf. I.B above).

2. NOUN PHRASES

Although most types of NPs do not exhibit UA, there are some that do (in addition to those containing the items mentioned above). This is true of constructions indicating unit of measure + species: *en sum pénge* 'a sum of money', etc. Quantifiers not belonging to the category mentioned in A.1 are not included in the domain of UA, however, cf. *tré* in *tré liter mǽlk* 'three litres of milk', *dénne* 'this' in *dénne liter mǽlk*. - The measure nouns are stressed outside such constructions, i.e. phrase finally: *en (stór) súm, en (hálv) líter*, or if the following constituent is not of NP status: *et kílo af dét dér* 'a kilo of that'.

Other such noun phrases likewise take UA. Various subgroups may be distinguished, depending on whether the constituent parts are proper names or not, and depending on the type of reference involved (unique reference or other), cf. such subsets as:

(a) *Anker Jǿrgensen,*[3] (b) *Dronning Margréthe* 'Queen Margrethe', (c) *Margrethe den Ånden* 'Margrethe the Second', (d) *linie tólv* '(bus) no. 12', *hjerter dáme* 'queen of hearts', (e) *pastor eméritus* 'retired clergyman'.

A considerably more complex situation is found with clearly hypotactical proper names, viz. those consisting of modifier plus head. If the second constituent is in itself a compound, the general rhythmical tendencies favour UA: *Kongens Nýtorv* ('the King's New Square', a place name in Copenhagen), *Østre Lándsret* 'the High Court of East Denmark' (*østre* means 'eastern'). We can also recognize UA in several proper names consisting of an N in the genitive plus a (not otherwise determined) simplex N. Such names are normally written as single words, although they fit perfectly into the pattern of two-word phrases and in spite of their being in conflict with the regular accentuation of compounds; an example is *Christiansbórg* (literally: 'Christian's Castle'), as against the regular compound type *Chrístianskirken* 'Christian's Church', *Fólketinget* 'The Parliament' (note the definite article on these compounds!). - Note that proper names whose second constituent is a simplex common N, do not normally exhibit UA but rather occur with compound accentuation like *Chrístianskirken* (with or without this phonological compounding being reflected in spelling).

Complex noun phrases other than the types mentioned above but consisting of separate nouns and/or adjectives (i.e. not compounds) fail to exhibit UA. If there is no emphasis, there simply is not any stress gradation. Unlike the alleged pattern of English, for example, the adjective and the noun have equal stresses in phrases such as *en gámmel mánd* 'an old man'.

The most general statement about noun phrases, then, is that UA does not apply except in certain rather well-defined types of constructions.

3. PHRASES WITH AN A OR ADV AS HEAD

Modifiers of type A.1 above left aside, such constructions do not normally exhibit UA. (There is a marginal exception, viz. the type *derhénne* 'over there', *herínde* 'in here', with a largely anaphoric function, as against the overtly deictic *dérhénne* 'over there', *hérínde* 'in here'.)

4. PREPOSITIONAL PHRASES

The statements below only refer to the accentual relationship between preposition and remainder, the latter constituent being in itself an NP (which follows the rules of accentuation as outlined in A.2 above, if the head is a noun).

The "remainder", i.e. the constituent part governed by the preposition, is in itself fully accented. As for the preposition, it is true of most of the frequent, monosyllabic prepositions that these trigger the application of UA in prepositional phrases, provided that the preposition is immediately followed by the material it governs. Prepositions seem to have a very different susceptibility to stress reduction, however. This is in part a matter of their phonological "heaviness", inherently short syllables being more strongly affected than long syllables, and monosyllables more so than bisyllables (this scale may be exemplified by *ved, bag* [bæ:'i̯], *bagved: ved åen* 'at the river', *bág/bag húset, bágved húset* 'behind the house'. Semantic factors are also involved, although their role is still poorly understood (cf. that there may be a discernible difference in meaning between *han sprang over åen* and *han sprang óver åen*, both literally meaning 'he jumped across the river', but with the possible difference that the former focuses on the route, and the latter rather on the accomplishment of crossing the river).

The generalisation above about UA is contradicted by the occurrence of two types of constructions, in which the preposition does not undergo stress reduction.

One of these types is defined by the occurrence of only a "light" pronoun in the NP slot of the PrepP. Light pronouns include personal pronouns and the (closely related) anaphoric *den* 'it', neuter *det*, plural *de* 'they' (also in suppletion with the third person personal pronouns). Such pronominal forms as NPs are weakly stressed in anaphorical function and acquire stress only under emphasis. A PrepP consisting of a preposition and such a pronoun accordingly preserves the inherent word stress of the preposition: *på mig* 'on me', *méd ham* 'with him', *fóran hende* 'in front of her', etc. (note that these phrases agree with phrases with normal UA by having only one main stress). If there is additional, heavier material in the NP slot, however, UA applies instantly: *på mig sélv* 'on myself', *på os bégge* 'on both of us', and if the function is not strictly anaphoric (but more or less clearly deictic), the pronoun takes word stress, and UA applies as expected: *med hám* 'with him (over there)'; also cf. *med hám vi besøgte* 'with the one we visited'.

The other type is defined by the occurrence of an infinitival or sentential construction after the preposition, and with no pronominal constituent intervening. In this case there are, as pointed out by Hansen (1977, p. 161), two options: the preposition may loose its main stress by UA, or the stress may be retained:

> *tænker Óle på/pǻ at réjse?* 'Is Ole thinking of leaving?'
>
> *tror dú på/pǻ at han har gjórt det?* 'Do you think he did it?'

Now, why is this? Hansen suggests that diachronically speaking, the construction is moving from an earlier type in which the infinitival or sentential constituent is in extraposition, towards a modern type in which that constituent is incorporated in the preceding sentence (viz. as the material governed by the preposition). The occurrence of UA with stress reduction on the preposition, then, represents the latter type, while the stressed preposition reflects the former type, being stressed by virtue of its standing alone as an adverbial phrase.

Old Danish had a construction with the preposition governing pronominal *det* 'it' followed by the remainder in extraposition. This would be literally reflected in Modern Danish as something like

tænker Ole på det at rejse?

tror du på det at han har gjort det? (stresses ignored)

According to Hansen's explanation, the option with a stressed (adverbial) preposition before *at* reflects an intermediate step between this old construction and the expected construction with UA uniting the preposition and all of the remainder.

It seems to me that this is plausible enough, and in synchronic grammar it seems indeed warranted to seek a description along these lines.

5. AUXILIARY PLUS MAIN VERB

The normal pattern with sequences of auxiliary verb(s) plus one main verb (not carrying emphasis) is to have UA involving all verb forms (disregarding the infinitive particle *at* 'to'):

(hvád ér det vi) skál? '(what are we) supposed to do?'

(hvád ér det vi) skal háve? '(what are we) supposed to get?'

(hvád ér det vi) skal have at spíse? '(what are we) supposed to have to eat?'

also cf.

(du) skal lade vǽre 'don't do it' (literally: 'you shall let be')

(jeg) fik skrével (artíklen) '(I) managed to write (the paper)'

and even comprising stretches such as

(det) skulle kunne have været gjórt 'it should have been possible to do (it)'.

There is, on the other hand, no phrase formation with UA comprising the sequences of verb forms in examples such as

vi pléjer at spíse hér 'we usually eat here'

hun élsker at sýnge 'she loves to sing'.

The difference obviously is that UA occurs with auxiliary plus main verb but not with main verb plus main verb. (This generalisation requires, of course, that the distinction between auxiliary and main verb is well defined, and that we have independent evidence for claiming that such verbs as *lade* 'let', *få* 'get' are auxiliaries in some constructions.)

6. VERB PHRASES WITH ADVERBIAL COMPLEMENTS

This is probably the most difficult pattern to account for. There are specific problems associated with the verb 'to be', which will be left aside here. But even so, generalisations are difficult to make, especially because there is such an enormous number of fixed phrases with UA that it is difficult to test such generalisations empirically without all the time running into the question of what can be labelled a fixed phrase.

UA, as in *gå hjém* 'go home', occurs in extremely many instances. The most conspicuous (and well-known) regularity is that constructions indicating translocation of an object (be it the sentence subject or the sentence object) exhibit UA, whereas related constructions which do not involve such a change of location, fail to take UA. Examples:

(han) svømmer dérhén '(he) is swimming towards that place over there'

(han) svǿmmer dérhénne '(he) is swimming (about) over there'.

In such cases the difference in meaning is reflected not only by the accentuation but also by the quasi-inflection of the adverb. There is a small class of place adverbs which are monosyllabic when they have an allative meaning, but take an augment *-e* (phonologically /-ə/ when they have a locative meaning, and *hen* - *henne* is one of these adverbs.[4]

Needless to say, the adverbial complement may instead be one that takes no such "inflection", be it an adverb proper or a PrepP. It then occurs that the only difference is one of accentuation (there being no difference in the orthography), cf.

(han) faldt i vándet '(he) fell into the water'

(han) fáldt i vándet '(he) fell (while walking) in the water'

or

(det var dé pénge han) smed i vándet '(that is the money he) threw into the water'

(det var dé pénge han) sméd i vándet '(that is the money he) chucked away while (he was) in the water'.

7. VERB PHRASES WITH AN OBJECT, "SUBJECT-OBJECT", OR SUBJECT PREDICATE

Constructions involving verb plus a "naked" object noun take UA in Danish: *køb hús* 'buy a house' in contradistinction to constructions with an article accompanying the object noun: *køb et hús* 'buy a house' (note that in this case the meaning is so alike that it is not self-evident how to reflect it when translating), or *køb húset* 'buy the house'.

Examples are legio. It is interesting to observe how the indefinite and the definite article function alike in blocking UA, independently of the status of the article as a separate wordform preceding the noun or as an enclitic form:

kan du rede séng? 'do you know how to make a bed arrange the sheets, etc.)?'

kan du réde en séng? (same meaning, but perhaps indicating a slight scepticism on the part of the speaker as against the neutral question above)

kan du réde séngen? 'do you know how to make the bed?' (this construction is also possible as a command).

The construction also occurs with mass nouns. Here there is no contrasting alternative with an indefinite article unless the mass noun is used in the sense of species:

han købte óst 'he bought some cheese'

han købte en óst med húller 'he bought a cheese with holes in it'

jeg pléjer at købe vín fra Bordéaux-distriktet 'I usually buy wine from the Bordeaux district'

jeg pléjer at købe en vín fra Bordéaux-distriktet 'I usually buy a wine from the Bordeaux district'

or, unless the sense of a standardized quantity (a bottle, a package, or the like) is understood:

han bestilte øl 'he ordered some beer'

han bestílte en øl 'he ordered a beer'

However, there is a certain semantic equivalence between the indefinite *en, et* and the form *noget* 'some', the latter occurring before mass nouns:

han købte noget óst 'he bought some cheese'[5]

In the plural another form of the same word, viz. *nogle* (or *nogen*) performs the function of indefinite article. We thus get contrasts like:

han solgte húse 'he was selling some houses' (or 'he was a house-seller)

han sólgte nogle húse 'he sold some houses'

han sólgte húsene 'he sold the houses'.

It is a difficulty in the analysis of such data that the difference of meaning between constructions with and without the indefinite article (including the suppletive *noget, nogen/nogle*) is often extremely subtle (and virtually untranslatable into English). To the extent that there is a clear difference of meaning, the construction without the article is used when a more or less standardized type of action is referred to, and when it is the action or the result, rather than the object of this action, that is talked about.

Viewed from a slightly different angle, the constructions with an article (or *noget*, etc.) involve some kind of reference, unless the object is to be understood as generic. Thus, in the examples above, not only the definite object nouns but also *en seng, en øl, noget ost, nogle huse* may be said to have reference, albeit of a totally indefinite kind, since the existence of some particular specimen(s) or quantity somewhere in the world is implied in these cases.

Syntactically speaking, however, the overt difference is that UA occurs if there is no article, but is blocked if there is an article in the wide sense in which this term is used above.

As shown in Rischel (1980), this finding can be generalized to a syntactically much more interesting statement, viz. that UA occurs whenever the object NP is devoid of a determiner. That is, UA is not blocked by the occurrence of modifiers before the object noun (cf. *købe nýt hús* 'buy a new house', *købe flére húse* 'buy additional houses') but only if such a modifier has the function of a determiner.

This statement hinges on the independently motivated contention that proper nouns are inherently [+Det], cf. that UA fails to apply in *(han) héntede Péter* '(he) fetched Peter' versus *(han) hentede ǿl* '(he) fetched some beer'. It also hinges on the contention that some quantifiers have determiner status, others not, and that still others have determiner status in some cases and not in other cases, cf.

(de) kǿbte forskélligt tǿj '(they) bought various clothes'

(de) købte forskélligt tǿj '(they) bought different clothes'

with *forskelligt* having a syntactico-semantic feature [+Det] in the first but not in the second case. (For further examples and discussions, see Rischel 1980.)

The same generalisation applies to the type of construction exemplified by the following two examples:

(der) bor ménnesker (i húlerne) '(the caves) are inhabited by human beings'

(der) bór nogle ménnesker (i húlerne) '(there) are some persons who live (in the caves)'

(again with a rather subtle difference of meaning). Diderichsen (1946) called such a constituent of sentential subject function but occurring in object position a "subject-object" (not to be confused with a normal subject occurring after the verb because of inversion).[6]

There are exceptions to this rule about UA occurring if the object NP (or subject-object) contains no Det. Quite a few of these seem explicable if we assume that generic meaning blocks UA, cf. *(han) élsker óst* '(he) loves cheese' (i.e. cheese as such, not just some particular cheese), *(det) lígner múg* '(it) looks like mould'. Incidentally, this statement may help to explain why a sequence of verb plus (ordinary) subject NP without a Det fails to exhibit UA: the point is that in Danish a subject NP without an (explicit or implicit) Det is (almost invariably) generic: *régnorme léver af bláde* 'earthworms live on leaves' and with inversion: *sådan léver régnorme* 'that is how earthworms live', or: *óst frémstilles af mǽlk* 'cheese is made from milk', and with inversion: *sådan frémstilles óst* 'that is how cheese is made'. It is, however, not all that obvious that there is a difference in genericness between the subject of the just mentioned sentence and the object of the following: *det er sådan man frémstiller/fremstiller óst* (same, active construction). Maybe it is rather a difference of degree, the subject NP without a Det being distinctively [+Generic], whereas the "naked" object NP is rather neutral with respect to genericness. There is an obvious problem here, which has not been properly solved, and whose solution may lie elsewhere.

Finally, we shall briefly consider what happens in constructions with a subject or object predicate. The generalisation here is that, unlike verb phrases with an object, those involving a subject or object predicate have UA (removing the full stress from the verb) obligatorily, irrespective of the status of these constituents in terms of [±Det] or [±Generic]. Examples are:

han blev lǽge 'he became a doctor'
han bliver en dýgtig lǽge 'he will become a competent doctor'

han fandt kåtten død på gúlvet 'he found the cat dead on the floor'

de kaldte pígen Ída 'they called the girl Ida'

han kaldte dréngen et fjóls 'he called the boy a fool'

han gjorde hende rásk 'he cured her' (literally: made her well')

B. GENERALISATIONS ABOUT PHRASAL UA

Looking at the data presented above and the coarse generalisations made, is it now possible to arrive at some generalised statement about all occurrences of UA in Danish?

It was pointed out by Jespersen (1934, § 13.6,3) that constructions with stress on their final constituents always denote "a single concept", and he substantiated this by showing that nominalizations (involving compounding) occur as possible transforms of verb + object constructions with UA, cf.

læse románer '(to) read novels'

románlæsning 'reading of novels'

or

købe hús '(to) buy a house'

húskøb 'purchase of a house'

(similarly, participial compounds occur such as *románlæsende* 'reading novels', although these are mostly confined to strictly literary language).

Such nominalizations are not possible in the case of constructions without UA: there is no way of forming a nominal compound indicating the type of specificness and definiteness implied by constructions such as *købe et hús* 'buy a house', *købe húset* 'buy the house'. I do not want to challenge Jespersen's insightful characterization of phrases of verb plus object with UA: it is clearly true that such a construction forms a close-knit semantic unit in the instances with UA. This basic notion of semantic unity may be extended also to phrases consisting of verb plus adverbial complement and to noun phrases with UA such as *en sum pénge, linie tólv, Kongens Nýtorv* (cf. A.2 above). It is a question whether it suffices to characterize all and only the phrases with UA (see later), but it is worth pointing out that it agrees beautifully with the occurrence of UA in a wide variety of fixed phrases, including such that are in conflict with the statement that determiners block UA in constructions of verb plus object (see A.7 above). In such cases UA often occurs as an option, with considerable variation in usage among Danish speakers. The following examples are in agreement with my own usage (which may be more in favour of UA with violation of the [+Det]-constraint than that of most younger speakers of Danish), and it should be kept in mind that the notation of UA in these instances refers to the possibility of UA rather than obligatory UA.

One of Jespersen's examples is:

har du hørt mágen 'have you ever heard such a thing?'

Jespersen uses the co-occurrence of UA with the definite article in constructions of the type exemplified here as evidence against the generalisation pointed out in A.7 above, viz. that the occurrence or absence of a determiner is crucial in the case of verb + object constructions. However, although I agree that phrases such as *hørt mågen* point to a connection between semantically close-knit construction and phonological UA, I cannot agree that they constitute evidence against the generalisation involving the feature [+Det]. It is important to note that there are counter-examples, but the most interesting ones are such that have to do with standardized actions, cf. *tage tóget* 'take the train'. Similarly with phrases referring to the (experience of) performances of plays or compositions, and the like (inherently [+Det]): *vi skal se Élverhøj* 'we are going to see (the play) Elverhøj' versus *vi skal sé Élverhøj* 'we are going to see (the locality) Elverhøj'.

Most of the examples given by Jespersen are obvious idioms, however. If UA is a signal of semantic tightness or unity, this is indeed a type in which one may expect UA, so it is reasonable enough to include idioms from that point of view. However, it must be taken into consideration that the determiner has lost its separate semantic content in such cases. This is true of *hørt mågen* above. Now, since *magen* is morphologically a definite form consisting of *mage* 'mate' (formerly also: 'something matching') and the enclitic article *-(e)n*, it is also possible to conceive of a different reading of the typographical stretch *har du hørt magen*. This may seem far-fetched, but it is not totally unlikely that somebody might utter this very stretch in a context in which the singing of some bird is at issue. In this case it is impossible to have UA:

har du hǿrt mágen? 'have you heard its mate?'

(The full stress on *hørt* vanishes only if the verb forms a phrase with UA together with some later constituent, such as the verb *synge* in *har du hørt mågen sýnge?* 'have you heard its mate singing?'; such discontinuous phrases with UA are dealt with elsewhere in this paper.)

Thus, on the literal reading of *magen* its determiner effectively blocks UA, which shows that this blocking effect is not a matter of morphology but rather of the function of the morphological material.

Moreover, UA does not occur in all idiomatic expressions containing verb + object. For example, UA is absent in some of those referring to dying (like the English *kick the bucket*), cf. *stílle trǽskoene* ('take off the clogs') or *tåge billétten* ('take the ticket'). These expressions are certainly no less close-knit semantically than *hørt mågen* and the like, on their metaphorical reading. Thus UA is a possible but hardly a necessary accompaniment of semantic unity.

The idiom status of examples like these is evident from the impossibility of moving the object NP out of the VP: cleft sentences splitting up the VP make sense only on their literal reading. However, there is no similar indivisibility in the case of certain other verb-object constructions with UA:

købe øl	'(to) buy some beer'
du skal ógså købe øl	'you must buy some beer, too'
øl skal du ógså købe	(the same with explicit focus on 'beer')
han købte íkke øl	'he did not buy beer'
øl købte han íkke	(the same with explicit focus on 'beer').

There is a similar mobility in the case of a "subject-object":

der står mǽlk i køleskabet 'there is some milk in the refrigerator'

mǽlk står der ógså (i køleskabet) 'there is some milk, too (in the refrigerator)'

Syntactically, then, it is not very obvious that UA accompanies a specific type of construction, since the criterion of divisibility distinguishes between idioms and free constructions rather than between constructions susceptible to UA and others. What then about semantic or syntactico-semantic properties such as selectional restrictions?

In the case of a "naked" object one may claim that the object NP must denote something that can go with the verb in question, but that still leaves us with an open set of verb plus object constructions which can - and indeed do - take UA if no determiner is present, i.e., a totally productive type of construction. It cannot be the semantic relation between the basic meaning of the verb and that of the object that is decisive; the alleged semantic unity must be a function of the construction as such, not of the constellation of individual word meanings. In the case of verb plus "subject-object", the number of verbs possible is very limited unless they are passive in form: they are otherwise motoric or situative verbs. On the other hand, anything that can be situated somewhere may occur as "subject-object", so that the productivity is again in principle unlimited. It is hard to see what would be implied by claiming that the construction signals some particularly close-knit unit of meaning, any more than constructions involving subject and verb do quite generally.

If we look at the total array of constructions with UA (noun phrases, prepositional phrases, and various kinds of verb phrases, to mention the main categories), there is something intuitively very attractive in Jespersen's statement about UA constructions denoting a "single concept", at least for constructions with verb + object or complement. But as I have tried to demonstrate, this criterion is not <u>generally</u> valid unless it is formulated in such vague terms that it can hardly be considered an operational criterion.

It should be noted, nevertheless, that there are various rather solid generalisations to be made about the individual types of phrases taking UA, as shown in A.1-7 above. Thus, since UA goes with absence of object determiner in verb phrases, we have at our disposal not only a quasi-explanation of why there is UA but - what is perhaps more interesting - a criterion which can be used in syntactico-semantic analysis, viz. in the analysis of quantifiers. Similar kinds of criteria may be established for other types of constructions with UA.

From the point of view of phonology it is essential to determine to what extent phrase formation with UA reflects syntactic phrase formation of a specific and well-defined kind. Is there any difference in syntactic gross structure between sentences such as, on the one hand

han købte hús 'he bought a house'

han faldt i vándet 'he fell into the water'

and, on the other hand

han kǿbte et hús 'he bought a house'

han kǿbte húset 'he bought the house'

han fáldt i vándet 'he fell (while he was) in the water'

and, if so, on what level of abstraction? I would like to suggest that such phenomena be accounted for in terms of syntactic structure, since it is otherwise hard to see how reasonably generalized phonological rules can be worked out. This means that there must be a rather surfacy syntactic process of phrase adjustment establishing close-knit phrases under a number of semantico-syntactic conditions (absence of [+Det] in sequences like *købte hús* being just one among several such conditions). This solution may seem like pushing a phonological problem into some other compartment of grammar in order to obtain a spurious simplicity, but I hope to demonstrate below that the problems do belong in syntax, and as shown already, there is really quite a few solid statements to be made even at the present state of research. I assume that what really need to be done is for syntacticians to make full use of the important evidence furnished by UA as a reflex of syntactic structure.

III. UNIT ACCENTUATION AND DISCONTINUOUS CONSTITUENTS

The next question is: why should UA be analysed as a reflex of syntactic structure rather than a property of an autonomous phonological hierarchy?

If we look at the examples given earlier in this paper, it will be apparent that the phrases with UA are in some cases broken up by syntactically extraneous material. This is in fact quite normal, although it may render it somewhat obscure what the phrase limits really are. Among Jespersen's examples adduced to demonstrate that UA may apply in spite of presence of a definite article is *ta hatten 'av* 'take off your hat!' (in my system of notation: *tag hátten áf*, since there are two essentially equal main stresses if there is no special emphasis). Here it is not a matter of idiom formation, cf.

tag fråkken på 'put on your coat!'

læg bógen vǽk 'put the book aside!'

and so on. The type is perfectly productive, but still it does not contradict the rule about [+Det] blocking UA. The reason for UA is obviously that verb and adverb form a phrase on a more abstract level, cf. that these occur adjacently in examples like

hvád skal jeg tage på? 'what shall I put on?'

Danish has simply generalized a word order according to which the object NP must intervene between verb and adverb if it is not placed frontally in the sentence.

More generally, it holds true that a string exhibiting UA may be broken up by extraneous material without the accentual pattern being disturbed (except insofar as certain rhythmical adjustments may apply if, for example, the resulting sequence contains an awkward sequence of unstressed items). Let us start with another example of the same type as those above:

dén skal du tage méd 'take that one with you'

det er dén bóg du skal tage méd 'that is the book you are supposed to take with you'.

These examples show the unbroken phrase *tage méd* (literally: 'take with'), which can then be made discontinuous by, say, an intervening object NP:

du skal tage bógen méd 'take the book with you'

or, with more material intervening:

du skal tage dén bóg der står dérhénne méd

'take the book (standing) over there with you'

The lack of stress on *tage* is still directly dependent on the construction *tage méd*, cf. that UA fails to apply the moment there is no such adverb in the construction:

du skal táge den bóg der står dérhénne

'take the book (standing) over there'

since now we have a simple verb + object construction with an object NP containing [+Det] and hence blocking UA.

Now let us look at another type:

du skal tåge med dén hånd 'you are supposed to use that hand (when putting something on your plate)'.

Here we have UA in PrepP introduced by *med*. In this case a still more drastic rupture of the unity of the phrase is possible, since the NP governed by the preposition may be moved out of the phrase (as in English):

det er dén hånd du skal tåge med 'that is the hand you are supposed to use'.

The effect of such movement transformations on accentuation has been discussed for English by Bresnan (1972) and others. Thus, there is nothing novel in pointing to the fact that accentual patterns may survive such moving around of constituents, but it is important to emphasize that such observations must be somehow integrated into a general model of accentuation. Obviously, if we say that UA is dependent on a surface-syntactic phrase adjustment, this statement must be modified so that it refers to a level of abstraction beyond that of movement transformations ("root transformations") of the type exemplified by the last mentioned example. Maybe that is the level that is sometimes referred to as "shallow surface syntax".

Finally, let us look at a construction involving phrase formation with UA on two levels. A verb indicating transposition followed by an adverbial phrase undergoes stress reduction by UA, as shown in A.6 above. As for the adverbial phrase, this may be implemented as a PrepP with UA within its own bonds. Similarly, there may be a sequence of auxiliary and main verbs exhibiting UA. We see the operation of three such applications of UA (V+V̄, Prep + N̄, V + PrēpP) in the following examples:

du skal tage med bússen 'you must go by bus'

du skal tage med dén bús 'you must take that bus'.

Again, as above, the phrase (or phrases) may be made discontinuous by movement transformations, cf.

det er dén bús du skal tage med 'that is the bus you are supposed to take'.

Now it may be useful to confront the phonological results to be expected from these three kinds of phrase manipulation, viz.

det er dén bóg du skal tage méd

det er dén hånd du skal tåge med

det er dén bús du skal tage med.

These are the accentuations that would be predicted from a simple application of UA (as long as we stick to just marking main stresses), and indeed, it is perfectly possible to make an accentual difference along these lines. On the syntactic surface the sequences look suspiciously alike as long as we disregard phonology, since they are perfectly analogous in terms of lexical material. From the point of view of phonology, in turn, there is no way of accounting for the accentual differences unless we have recourse to a more abstract level of syntax. I think the inevitable conclusion must be that the relevant phrasal structurings originate somewhere at a level more abstract than surface syntax, that they are reflected as partly discontinuous phrasal constituents of a special type in surface syntax (although such constituency has been more or less neglected in syntax based on written language), and finally that they trigger the occurrence of UA.

So much for accentuation as directly dependent on syntax or syntactico-semantic features and structurings. It should be added that the last sentence above will tend to be uttered with some degree of stress on *med* which makes this word more prominent than *tage*, there being a range of possible prominence all the way from a weak stress to a main stress as in *méd* of the first sentence. That is, the first and last sequence may optionally sound alike, due to the range of variation possible in the last sentence. Another option is to have less stress reduction on *tage*, with the result that the last sentence becomes more similar in accentuation to the second rather than to the first one.

We see here that the application of UA, combined with movement transformations, may cause a string of weakly stressed wordforms to occur in succession without any main stress following, and that in such cases there is a tendency to remedy the situation by restoring the main stress to a greater or lesser extent on one of the wordforms. What is at stake here is probably some rhythmical constraint, which of course deserves closer scrutiny in a comprehensive analysis of Danish accentuation.

IV. DEEP AND SURFACE PHONOLOGY: PHRASE STRUCTURE AND FOOT STRUCTURE

A. MOVEMENT TRANSFORMATIONS AND PHRASE CONTINGENCY

Let us now take stock of the types of structurings that emerge at various levels of abstraction.
(1) At some syntactic level the constructions which eventually exhibit UA must be established as a specifically marked type of phrase. Furthermore, the last constituent that has a lexical stress (predictable by rule or not) is marked as such.
(2) At some level UA operates in accordance with the information about underlying phrase structure.
(3) At a quite surfacy syntactic level there may be a perturbation of word order, but information about the more abstract phrase structure is preserved.

Now the next important question is whether these more or less perturbated phrases provide the basis for surface-phonological rhythmicization, or whether there is a separate, purely phonological mechanism of foot formation, or the like, in Danish. I think there is, and I think that this is the very unit which Thorsen has found useful as a unit of reference in describing Danish intonation (cf. her contribution to this volume). The stress-correlated pitch contour in Danish starts with a stressed syllable and comprises all material up to the next stressed syllable, unless there are major syntactic breaks signalled as such. This provides us with a further relevant level:
(4) At a rather surfacy phonological level, the phonological material is divided up into consecutive feet, each comprising a syllable with main stress plus some number (from zero upwards) of syllables with lower stress.

This foot, of course, divides up the sequence of syllables in a way which may be totally at variance with the phrase structuring responsible for UA, cf.

Phrase marking:	*Péter*	*fáldt i*	*vándet*
UA:	*Péter*	*faldt i*	*vándet*
Foot marking:	*Péter faldt i*		*vándet*

'Peter fell into the water'

or, with a moved constituent:

Phrase marking:	*Jóan*	*kán følges*	*méd hám*	
UA:	*Jóan*	*kan følges*	*med hám*	
Perturbation:	*Hám*	*kan*	*Jóan*	*følges med*
Foot marking:	*Hám kan*	*Jóan*	*følges med*	

'Joan can accompany him'

In the last example the two underlying phrases *kan følges* and *med ham* have been split up so that no phrase is left quite intact except for the one-word phrase *Jóan*. One may speculate whether there is a way of dividing the surface sequence of words into linear stretches such that each corresponds to a phonological phrase; this is possible only if we take the last word to form an unstressed tail, which is at variance with the generalization about phrase-final stress:

Hám *kan Jóan* *følges med*

I doubt that it is useful to posit a phonological level of description at which there are such intermediate phrases. Anyway, the surface structure emerging is the one that is organized in terms of stress initial feet, as shown above.

In the exposition above the operation of UA is inserted between a more abstract and a less abstract level of syntactic specification. This is certainly a possibility (cf. the argumentation in Bresnan 1972), but it should be noted that this really amounts to assuming that UA requires for its operation that the constituents of the phrase in question occur in a linear sequence without discontinuities (cf. the phrases *kan følges* and *med ham* above). That may be a meaningful assumption, but in fact the fulfilment of this requirement is possible only if one permits linear orderings of constituents on a non-surfacy level which are quite remote from the orderings that actually can surface in the language. Let us see what happens in sentences containing sentential *ikke* 'not':

Péter købte íkke hús 'Peter did not buy a house'

Here, the phrase taking UA is obviously *købte hús*, not *købte íkke*, cf.

Péter købte hús 'Peter bought a house'

Péter kǿbte íkke 'Peter did not buy'

but there is no way to place the two words of this phrase *købte* ... *hus* adjacent to each other unless one is willing to claim that UA operates at an extremely abstract and remote level at which *ikke* stands outside the remainder of the sentence (as an immediate constituent of the whole sentence).

To me it seems more attractive to start from the observation that *købte hus* is a discontinuous phrase and to assume that its constituents are nevertheless syntactically marked as belonging together in one phrase. UA, then, operates on such phrases, regardless of whether they are discontinuous or not, and each phrase affected by UA thus acquires final stress. Further, if UA applies after surfacy movement transformations, we can only uphold this principle of phrase-final stress if the constituent that is underlyingly phrase-final, preserves some positional marker in spite of the moving around of constituents. This amounts to saying (cf. Bresnan 1972) that the diacritic marking of tree structures for UA is part of syntax, although the actual implementation of stresses is of course a matter of phonology.

B. THE TOTAL SCENARIO OF PROSODIC STRUCTURING IN DEEP AND SURFACE PHONOLOGY

Let us return now to the question of how the various mechanisms of (non-emphatic) accentuation in Danish cooperate or interact to form an accentual output. The mechanisms involved are: (1) Morpheme Stress by Rule, (2) Intra-Word UA, (3) Compound Stress by Rule, and (4) Phrasal UA (see sections I.A-F above).

It is necessary to consider first to what extent these mechanisms belong to an abstract level in the sense that they are associated with syntactic structures occurring only at not quite surfacy levels. This was shown above to be the case for Phrasal UA. What about the other mechanisms?

Although the inherent accentuation of morphemes (i.e., whether a morpheme is accented or not) has a connection with syntactic categorization, Morpheme Stress by Rule obviously presupposes a specification of the phonological structure of the morpheme in terms of syllable number and syllable structure. Intra-Word UA, in turn, operates on morpheme stresses in the string it applies to. This just tells us that both of these mechanisms presuppose the occurrence of specific lexical material in syntactic slots; they might for that matter be quite surfacy processes. On the other hand, these two mechanisms are closely associated with the lexical component in the sense that there is a structural and functional equivalence between stress redundancy conditions and these stress insertion mechanisms. If a given lexical item has irregular stress placement, this must of course be part of the underlying phonological representation in the lexicon of Danish, but if the stress placement is regular, there are obviously two ways in which this accentuation can be implemented: (a) it may be part of the underlying lexical representation, although its presence is predictable, or (b) it may be inserted by rule. I think it is important to emphasize this dual access to intra-word accentuation as an important aspect of language: the language is designed in such a way that the specification of intra-word accentual patterns is possible, but alternatively, it is possible to arrive at the same result by rule. Obviously, in studying the way language is actually mastered, and the ways in which lexical material is actually retrieved in language use, one must operate with both of these options, and one must reckon with the possibility that a given word is handled differently by different speakers of the language, or differently at different stages in one speaker's linguistic development.

This means assuming that the accentual mechanisms in question are part of an abstract sub-component of phonology which is associated with - and in fact integrated in - certain morphosyntactic mechanisms (word formation).

As for Compound Stress by Rule, the same line of reasoning is valid. In this case it is further supported by the occurrence of modifications such as shrinking of accentual tree structure and rhythmic perturbations (cf. the *stationsforstander* case, section I.E above), suggesting that the full hierarchy of binary accentual contrasts which can be predicted from the syntactic structure of the compound, belongs to a relatively abstract level of phonology.

Finally, Phrasal UA operates on word stresses in the string it applies to (cf. the relationship between Morpheme Stress and Intra-Word UA, as mentioned above). Since it seems clear that Phrasal UA belongs to a level more abstract than surface syntax, we may conclude that the specification of word stress belongs to such an abstract level as well. Thus, all the evidence points in one direction: there is an abstract component of phonology which is presupposed by surface syntax, and to which both the specification of (morpheme and) word stress and phrasal UA belong.

It may be necessary to forestall a possible objection to the line of reasoning pursued above, viz. that it is not strictly compelling with regard to the specification of intra-word accentual patterns by rule. It would be possible, in principle, to argue that the properties of the strings which allow us to insert stresses by rule also allow us to predict on what structures UA can operate, i.e. that it is possible in principle to formulate UA in such a way that it blocks stress insertion in certain morphemes or words rather than performing a stress reduction. Stress insertion would then operate afterwards, inserting stresses according to rule except in cases where the UA has added a diacritic mark blocking stress insertion. However, apart from the fact that this is a rather roundabout way to account for accentuation, it has one major drawback: it fails to account for the fact that there are some (in fact several) stresses which must by necessity be present underlyingly as part of lexical representations, since they are unpredictable. As for these, they must be processed anyway in connection with the application of Intra-Word or Phrasal UA, and thus it is a most undesirable complication to handle the stresses inserted by rule in a different format. I take it that this is strong enough evidence in favour of the contention that UA implies a full stress specification of each of the constituents in the string it applies to (be it Intra-Word or Phrasal UA).

We have seen that there is an implicational relationship between stress insertion rules and UA rules. Is it possible to set up a full chain of implications among the four mechanisms listed above? The keypoint in this context is Compound Stress.

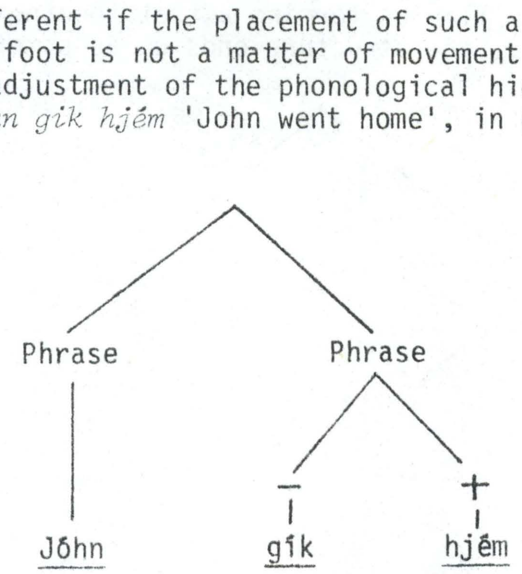
Compound stress is generated in terms of various separate structures and mechanisms: (a) a hierarchical structure furnished by syntax and/or the lexical representation of the compound, (b) a phonological marking of right branches as + (or "strong") and left branches as - (or "weak"), (c) phonologically conditioned modifications of the hierarchical structure (to the extent that aberrations from the underlying hierarchical structure are not lexically represented), and finally (d) interpretive rules (and conventions) for translating the surface representation into a phonetic representation. Of these components, the first (a) and the second (b) do not seem to presuppose diacritic markings showing what lexical items are capable of carrying stress, and what lexical items are able to qualify as separate constituents of such a structure.[7]

I do not think that there is any unique answer to the question whether the basic hierarchical structure of compounds is generated "before" or "after" the specification of morpheme stresses and the application of Intra-Word UA. As for components (c) and (d) of Compound Stress by Rule, however, these evidently presuppose morpheme stress assignment and UA at the word level. Further modifications occur as a result of UA at the phrase level, as a result of syntactic movement transformations, and finally as a result of foot assignment. (The prosodic behaviour of compounds as a consequence of such conditioning has not been studied in any detail, however.) Thus, the mechanism of compound stress generation is a complex, ranging from the most abstract level to the most concrete level of phonology.

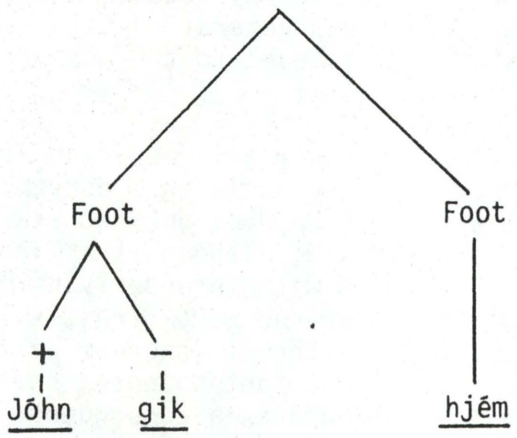
Phrasal UA is, in a sense, equally all-embracing if all components of stress adjustment are included under this heading. As noted earlier, this type of UA does not necessarily convert full stresses into "zero stress", although this is very often the case in Danish. Syllables with an underlying main stress may remain more prominent than true zero-stress-syllables, but this is to a large extent a matter of inherent differences in segmental structure. It is important to note, however, that syllables whose stress is reduced as a consequence of Phrasal UA, may retain their stød (except if it is a matter of a word-final open syllable, since vowel shortening occurs regularly in such cases), see Basbøll 1972, 1978 for details.

The most important readjustments are those having to do with foot structure. As said earlier, the Danish foot starts with a fully stressed syllable and comprises the following syllables up to the next fully stressed syllable. A "minus-branch" of a phrase that has undergone UA may come to stand finally in such a foot because of movement transformations, cf. such examples as cited above, and in that case there is optionally the possibility of giving the syllable in question added prominence. This clearly shows that the status of the word in question as underlyingly stressed is not lost at this stage.

It is different if the placement of such a syllable in the tail of a foot is not a matter of movement transformations but of readjustment of the phonological hierarchy as such, cf. *gik* in *Jóhn gik hjém* 'John went home', in phrase structure:



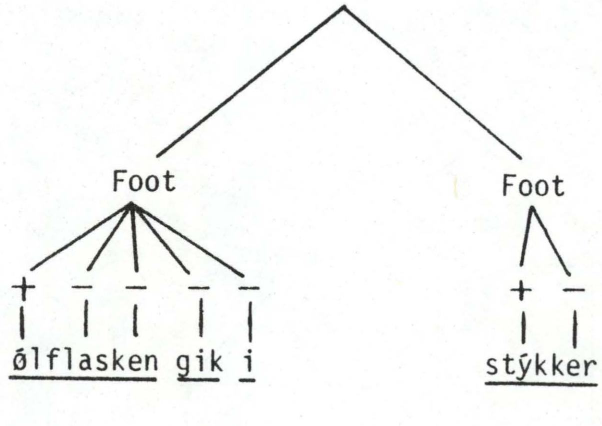
but in foot structure the sequence is reorganized into the following (lexical stresses are here erased under minus-branches, although the implications of such erasure are not dealt with):



In this case the tendency for such syllables that have been reassigned to a different structural unit is to behave like syllables that are underlyingly devoid of stress. The same is true of the reduced stress-syllable of the second part of a compound, although the distinction "stressed" : "unstressed" may be quite resistive to such shrinkage of structure, being possibly upheld by durational relationships in particular.[8] Thus, in

Ølflasken gik i stýkker 'the beer bottle broke'

the normal rendering in casual speech is probably with a tail of weakly stressed syllables forming a foot together with the first syllable, i.e., the structure ends up as something like



Let us see, finally, how a more complex sentence involving both compounding and intra-word and phrasal UA undergoes a stepwise metamorphosis from the syntax-based phrase structure to a foot-based surface structure. The example is

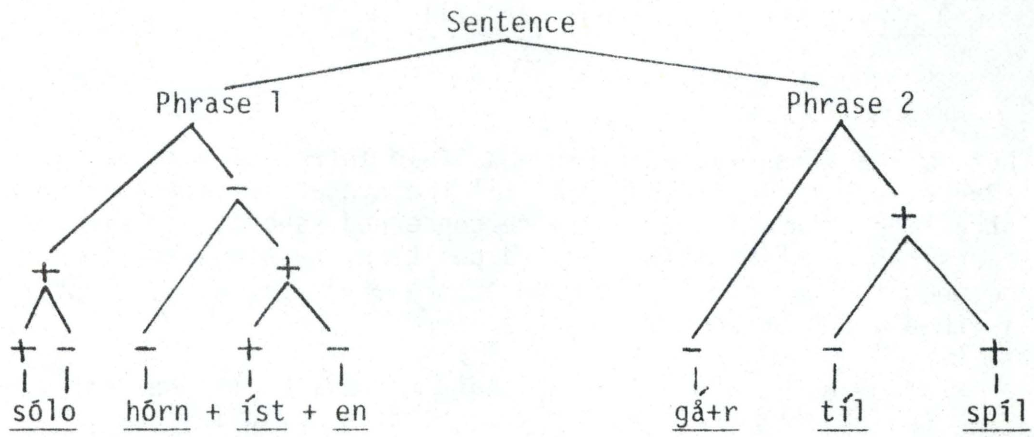
sólohornisten går til spíl 'the solo horn-player takes music lessons'

Here we have firstly a compound whose second constituent: *hornisten* is in itself an example of Intra-Word UA, the main stress being on the second syllable according to the UA rule:

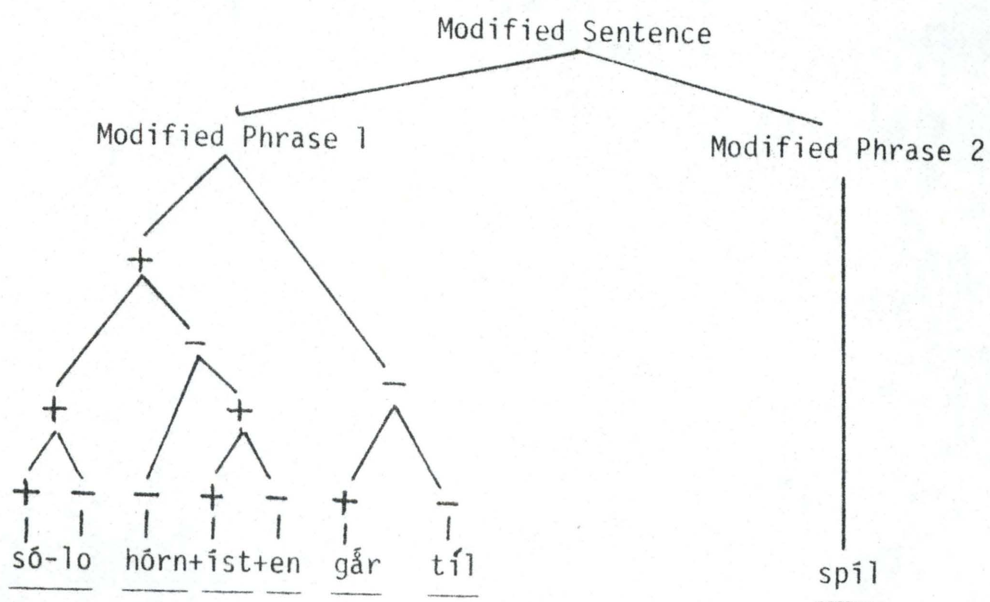
hórn+íst+en → *hornísten*

(This stress may or may not be audible in the surface rendering of the string above.)

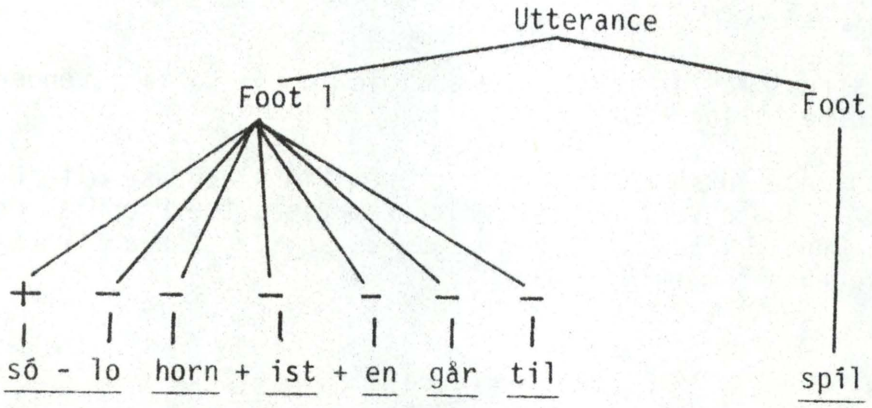
The sentence further contains a prepositional phrase with UA: *til spíl*, and a verb phrase (which comprises the PrepP as one constituent), likewise with UA: *går til spíl*. The abstract structure is something like:



If this were transformed into a sequence of two hierarchies in which the "pretonic" syllables of Phrase 2 are attached to Phrase 1 with preservation of their mutual ranking by a plus-minus labelling, we would get the following:

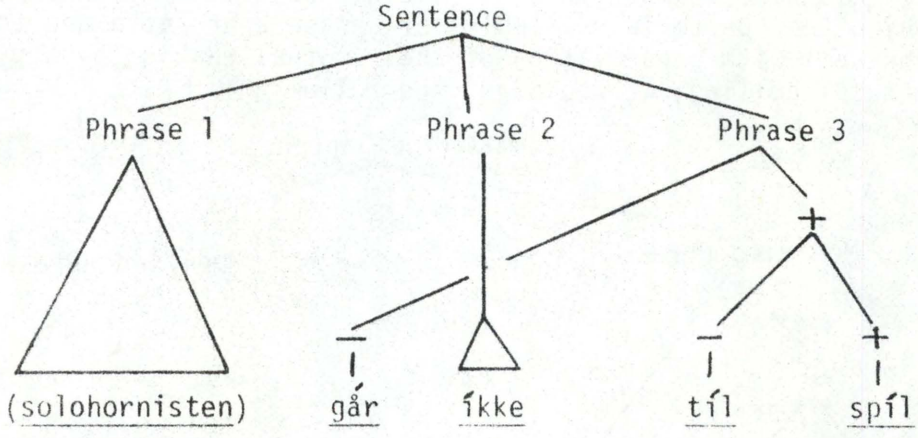


In actual rendering, this structure is shrunk, however, and this may possibly be done to the extent that all syllables between the first and the last are unstressed (taking into account the inherent differences of prominence associated with segmental structure). Thus, with the strongest reduction that is conceivable, the underlying sentence with its phrase constituency may appear as an utterance with the foot constituency illustrated below:

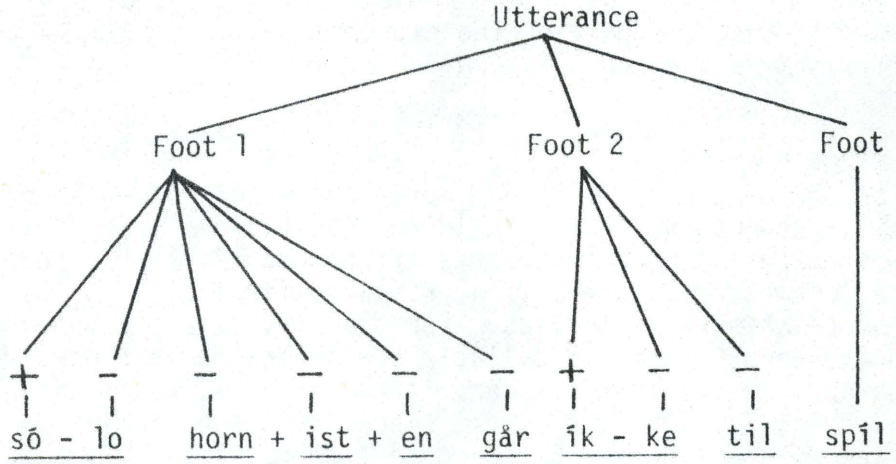


Let us see, finally, what happens if we introduce a sentential adverb such as *íkke* 'not'. At all the syntactic levels of abstraction with which we are here concerned, such a constituent turns out to stand in an awkward position, pushing itself in between the two parts of the verb phrase *går til spíl*, which is thus a discontinuous phrase:

sólohornisten går íkke til spíl 'the s.h.pl. does not take music lessons'



When transformed into an utterance with foot structure, however, the whole hierarchy regains well-formedness in terms of non-crossing branches. It is here rendered with maximum shrinkage of structure like the examples above:



V. CONCLUDING REMARKS

One may dispute the proper formalization of the mechanism of accentuation in Danish. I hope, however, that the exposition given in this paper suffices to show that irrespective of formalization there are some basic points to be made which are typologically and theoretically important.

Typologically it is interesting that Phrasal UA in Danish is largely confined to certain types of phrases, so that for instance most noun phrases do not take UA. This has the effect that Danish is characterized by sometimes very close succession of heavy stresses, an effect that is further enhanced because Danish, as pointed out by Thorsen (see the paper in this volume), has no "sentence accent". It is perfectly possible to have rather long utterances without any single focal point signalled by prosodic means.

The other typologically interesting feature is that the foot in Danish goes from a stressed syllable up to the next syllable, and that the preferred internal structure is the prosodically most reduced one, i.e. with just an initial stress-syllable followed by unstressed syllables.

Since there is a glaring non-conformity between the underlying phrase-based hierarchy and the surface hierarchy, quite heavy readjustments are necessary to get from one representation to the other. The nature of the transformations involved is so far somewhat obscure, but it seems obvious that the gap between these two representations speaks in favour of a distinction between a level of deep phonology and a level of surface phonology, at least with regard to prosody. - Thus, the evidence of Danish stress suggests not only that one should recognize a self-contained prosodic hierarchy, but that there are different hierarchical organizations on different phonological levels of abstraction. Surface prosody is phonology not syntax; the abstract prosodic hierarchy, on the other hand, is an integral part of the expression side of (sign-based) syntax and word formation.

VI. NOTES

1. For convenience, the Danish forms are mostly given in normal orthography, which should not cause trouble if it is remembered that double consonants are pronounced short, and *ld, nd, rd* mostly as short *l, n, r*. Word final *e, en, er* are in most cases schwa-syllables. For clarity, vowel length and the presence of stød in a syllable are indicated in these orthographic renderings by : and ', respectively (this is only done in Section I, however, since it is not crucial in the later discussions). By doing so I do not imply anything about the role of the stød in the phonology of Danish, an issue which I have preferred to keep entirely out of consideration in this paper (see Basbøll 1972 and elsewhere for an analysis of this aspect of Danish phonology).

2. This account is extremely sketchy. A detailed description of the conditions under which words appear with a full stress in Danish, will soon be available in a forthcoming monograph by Erik Hansen and Jørn Lund. Unfortunately, their manuscript became available to me only too late to be utilized in the text of this paper, except for this and the following footnotes.

3. UA does not always occur in the rendering of personal names (see further Erik Hansen and Jørn Lund, forthcoming), but it is definitely a possible option.

4. As pointed out to me by Erik Hansen, it requires a more explicit syntactic analysis of the relation between the verb and other sentence members than the one I have employed here, to account for the accentuation of the verb, cf. that *er* 'is' is stressed differently in the following two sentences:

den ér óppe på lóftet 'it is (to be found) up there in the attic'

han er óppe på lóftet 'he is (temporarily) up in the attic'

(note, however, that even in this pair a movement is implied in the case with weak stress). - Unfortunately, I cannot incorporate the necessary elaborations and corrections in the present paper.

5. As pointed out by Hansen and Lund (forthcoming), this applies also to constructions with *lidt* 'a little', and even if this word occurs adverbially as in *han fík lidt bédre tíd* 'he became somewhat less pressed for time' versus *han fík bédre tíd* 'he got less pressed', which is really intriguing.

6. The difference between "subject-object" and a true subject appears overtly in that an adverbial constituent such as *ikke* 'not' always appears before the subject-object: *der bor íkke ménnesker i húlerne* 'the caves are not inhabited by human beings', or *hvórfor bor der íkke ménnesker i húlerne?* 'why aren't the caves inhabited by human beings?', whereas it comes after the true subject in the case of inverted word order: *ménnesker kan íkke léve af grǽs* 'humans cannot live on grass (as a nourishment)', *hvórfor kan ménnesker íkke léve af grǽs?* 'why cannot humans live on grass?', *hvórfor léver ménnesker íkke af grǽs?* 'why don't humans live on grass?' (incidentally, the verb *leve(r)* may not be fully stressed in these constructions, which is immaterial in the present context, however).

7. The existence of "quasi-compounds" which are syntactically and semantically derivatives, has been touched upon above. One suffix behaving (regularly) in this way is *-hed* '-ness', cf. that it patterns just like the adjective *hed* 'hot' in examples such as

[ˈdøgdi‖he:ˀð] *dygtighed* 'cleverness'

[ˈfe:ˀbʌ‖he:ˀð] *feberhed* 'burning with fever'.

8. According to an ongoing instrumental investigation by Eli Fischer-Jørgensen secondary stress and weak stress in otherwise analogous words (occurring in short utterances read from a list) are distinguished by duration and in part also by tone. The phenomena occurring at lower levels of distinctness have not been instrumentally investigated. (Personal communication.)

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ARIPUC 16, 1982, p. 241-245

INTERPRETATION OF ELECTRO-GLOTTOGRAPHIC RECORDINGS*

BØRGE FRØKJÆR-JENSEN**

The general interpretation of the electro-glottographic wave form states that a glottal closure results in a decrease of the electrical resistance, and that this decrease depends on the degree of closure. The more firm the closure (i.e. the greater the area of contact between the vocal folds), the lower is the electrical resistance. An alternative hypothesis (Loebell 1981[1], Smith 1981 and 1982) explains the wave forms as electrical resistance curves showing the summation of the acoustic compression of the muscular tissue above glottis and below glottis. The sound wave compresses the tissue according to the variations in sound pressure, and as the sound pressure wave above glottis is 180° out of phase relative to the sound pressure wave below glottis, the resulting compression of the tissue at the level of glottis can be expressed as the summation of the compression below and above glottis, which in turn is assumed to be proportional to the summation of the sound pressure levels above and below glottis.

As this hypothesis sounded interesting, I wanted to test it, and I did it by means of glottography in helium, which has a velocity of sound three times the sound velocity in air.

Simultaneous recordings of electroglottography and two accelerometers positioned just above and just below glottis in air and in helium were made.

Figure 1 shows the three curves recorded during phonation of a sustained /i:/ with a sound pressure level of 75 dB measured 40 cm from the mouth and with a fundamental frequency of approximately 130 Hz. The upper curve registers changes in sound

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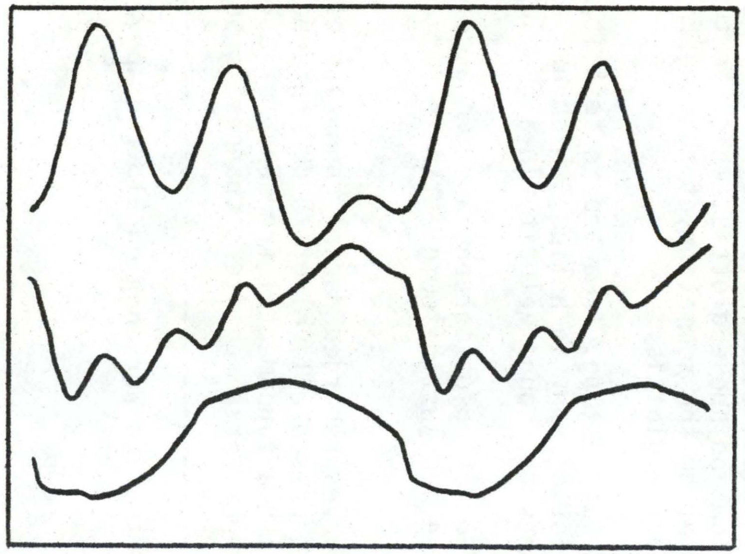
* Abstract of a paper for the 2nd Workshop on Glottography in Rotterdam, June 1982.

** Audiologopedic Research Group.



A

B

C

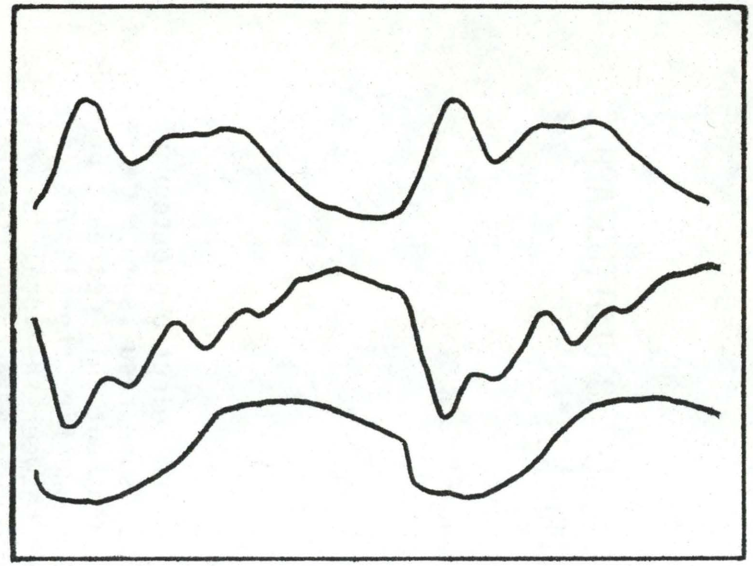


Figure 1

Recording in air:

A: Sound pressure above glottis
B: Sound pressure below glottis
A,B: Increased pressure indicated by downward deflection of the curve
C: Electro-glottogram.
Increased electrical resistance indicated by upward deflection of the curve.

Figure 2

Same traces as shown in figure 1, but recorded in helium:

A: Sound pressure above glottis
B: Sound pressure below glottis
A,B: Increased pressure indicated by downward deflection of the curve
C: Electro-glottogram.
Increased electrical resistance indicated by upward deflection of the curve.

pressure recorded from the neck just above larynx, the middle curve registers changes in sound pressure recorded from the neck below larynx, and the bottom curve shows the electro-glottographic wave form.

According to the alternative hypothesis the electro-glottogram should represent some sort of combination or sum of the two upper curves. If this is correct, then the wave form of the electro-glottogram must change if the wave form of one of the two upper curves is altered. In order to test that, a phonation of a sustained /i:/ vowel was made with the vocal tract above glottis filled with helium.

Figure 2 shows the recording made with a helium-filled vocal tract. The helium was introduced in the lower part of the pharyngeal cavity through a flexible plastic tube. The phonation started with an air-filled vocal tract which resulted in the voice quality depicted in figure 1, then helium was introduced keeping the phonatory and articulatory positions unchanged. When maximum distortion of the sound quality was obtained, the recordings in figure 2 were made.

It is seen in figure 2 that the upper curve representing the sound pressure wave above glottis is drastically changed without any important changes in the middle curve representing the sound pressure below glottis. This is in accordance with what could be expected, since the velocity of sound is changed above but not below glottis.

However, the most important observation is that the wave form of the electro-glottogram does not show any appreciable changes. This suggests that the electro-glottogram is not (to any considerable extent) sensitive to the compression of the tissue above glottis. On the contrary, the electro-glottogram seems to be rather constant even though the pharyngeal sound pressure wave is changed drastically.

A good deal of glottograms have been made in connection with this pilot study, but all the wave forms showed to be relatively insensitive to the acoustic sound pressure, even at a high voice effort.

This paper is to be considered only as a note on ongoing research. In a more definitive analysis the position of the electro-glottographic skin electrodes must, of course, be monitored very accurately, and the variations in the glottogram with alternative placings must be examined (Lecluse 1977). The approximate position of the electrodes in the present experiment appears from figure 3.

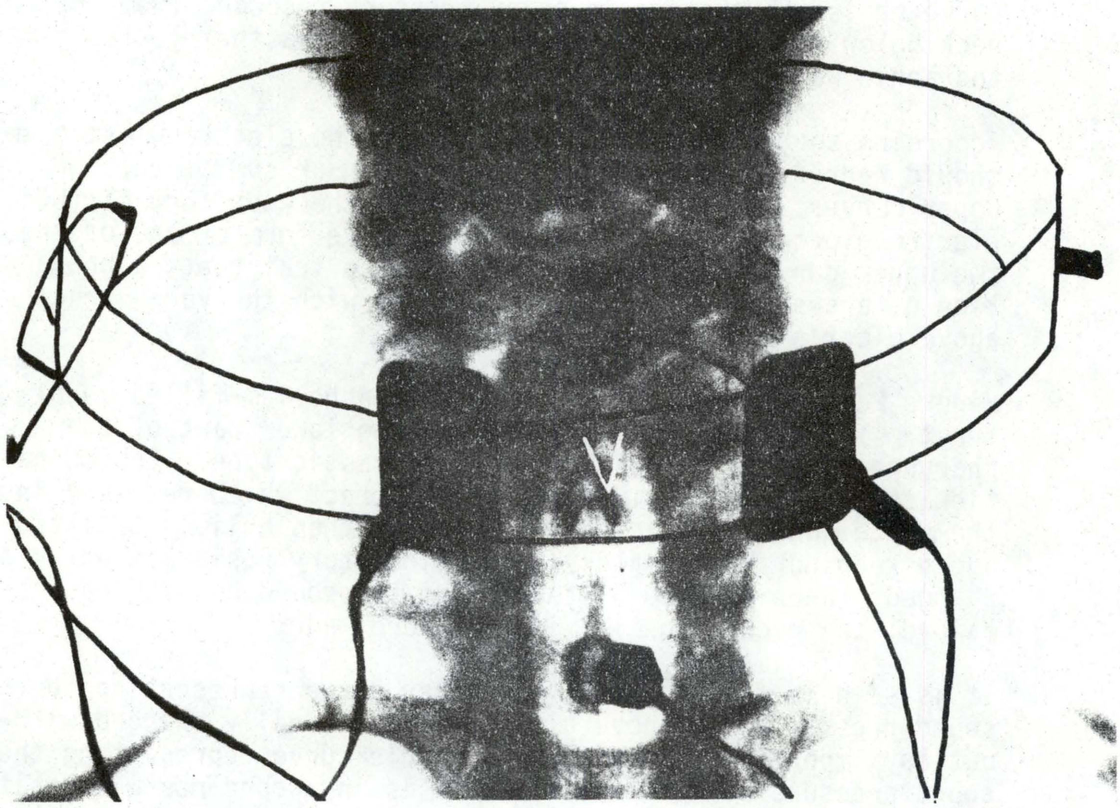


Figure 3

X-ray photo of subject BFJ. The photo is tilted approximately 20^0.

(1) The position of the two accelerometers above the thyroid cartilage and below the cricoid cartilage. The upper accelerometer is seen in a position which is further tilted relative to the vertical plane, because the neck surface is sloping at the point of fixation.

(2) The position of the skin electrodes of the glottograph positioned by the neck belt (which is drawn by hand on the X-ray photo) at the same horizontal level as the lower edges of the arytenoid cartilages.

(3) Rima glottidis is drawn by hand with white ink.

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NOTE

1. Cf. Loebell 1981: "*1. Schalldruckänderungen:* Smith weist darauf hin, dass die Technik eine akustische Registrierung und eine Spektralanalyse erlaubt. *2. Luftdruckänderungen:* Smith macht darauf aufmerksam, dass der Abfall der Impedanz am Anfang der phonatorisch-glottographischen Periode zweigeteilt sein kann und auf 2 Faktoren zurückzuführen ist: -- 1. auf die Zunahme des Druckes im Gewebe und 2. auf den Anfang der akustischen Periode."

Comment from Professor Svend Smith:

I never explained the wave forms of the so-called glottograms as a summation of acoustic compression of tissue above glottis and below glottis, neither at the symposium in Hannover 1981 (Loebell 1981) nor in later publications.

ARIPUC 16, 1982, p. 247-255

FIELDWORK ON THE MLABRI LANGUAGE: A PRELIMINARY SKETCH OF ITS PHONETICS

JØRGEN RISCHEL

The present report deals with the phonetics of the Mlabri ("Mrabri") language spoken by a small hill tribe in Northern Thailand. This informal sketch gives an impressionistic phonetic survey of the vowel and consonant systems; more definitive analyses of this and other aspects of the language will be worked out later by the research group, viz. Professor Søren Egerod, Professor Therapan L. Thongkum, and the present author.

In September of this year the author of the present sketch had the opportunity of joining a fieldwork project set up by Professor Søren Egerod* and Professor Therapan L. Thongkum**, and to participate in a two weeks' trip to the province of Nan in northern Thailand. The object of study was the language of the hill tribe which is known as "The Spirits of the Yellow Leaves" or Phi Tong Luang, but which is also - more properly - referred to as Khon Pa, "Men of the Forest", a Thai designation which is considered appropriate by the tribal people themselves. - This is the tribe and the language also known as Yumbri (Bernatzik 1938) or Mrabri (Kraisri 1963)[1], the latter term reflecting the designation mla? bri·? (literally the equivalent of Thai khon pàa) which we found to be used by our informants.

The tribe in question has been studied only on a few occasions, and the fieldwork done previously did not include an investigation of the language by professional linguists, the scanty information available in the literature being the work of anthropologists and others (cf. Bernatzik 1938; Kraisri

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1963; Trier 1981[2]). The origin of this tribe, and its ethnic affinities with other tribes, must still be considered as enigmatic; it would lead too far to refer to the various speculations about these issues here. As for the language it has been pointed out by Kraisri (1963, p. 182) that "the Yumbri and Mrabri languages are close to Mon-Khmer languages and they should belong to this group", and recent handbooks classify the language with the Khmuic branch of the Mon-Khmer family. However, the exact nature of this affinity has not been definitely stated so far. One reason for this is that comparativists have not had access to extensive data given in an accurate transcription and comprising not only single words but also syntactic constructions of various kinds. Kraisri's data and linguistic comparisons (1963) are highly valuable in their own right, but since the words were rendered in Thai letters it takes a bold restatement, like the one ingeniously performed by Smalley (1963), to arrive at an approximation to a strictly phonetic or phonemic transcription. Needless to say, a first-hand study involving a.o. a thorough phonemic analysis is a necessary prerequisite to comparative and typological work of a more definitive kind.

It is estimated by the local authorities that today there are only between 80 and 90 members of this tribe left (including children). Since its material culture represents an extremely low level of technology (the tribesmen are food-gatherers and to some extent hunters), this small population is very vulnerable. It may thus be doubted that their language will survive very long.

With the aid of the local Welfare Department we succeeded in getting into contact with three male speakers of Mlabri, who in spite of their general reluctance to approach permanent settlements consented to staying with us and informing about their language. Unfortunately, one of them turned out to be attacked by illness so that he had to discontinue his cooperation with us after some hours, but the other two informants were with us during most of our stay. - Thus, in total, we had constant contact with speakers of the language for eleven days. (In addition to these three male speakers we had a brief encounter with one more man and two women, who did not seem ready to engage in any communication with us, however.) The linguistic data was elicited primarily by Professor Therapan via the medium of Central or Northern Thai (of which the informants understood some) assisted by an interpreter speaking the Meo or Hmung language (of which they also had some passive or active knowledge). Towards the end of our stay we had proceeded so far that we could ask very simple questions to them in Mlabri, which enormously stimulated their interest in communicating with us. On the whole, however, it must be kept in mind, when considering this and other sources of information on the language, that there are considerable problems with regard to social interaction and effective communication in dealing with this language.

The purpose of the present sketch is to report - on a low level of ambition - on some aspects of the phonetics of this language, as it immediately presented itself to us. The account is based on field-notes of an impressionistic kind and on preliminary discussions during the trip. The presentation is largely confined to inventories of vowels and consonants, which - even in an extremely tentative presentation like the present one - may be of some typological interest. The most obvious and non-controversial phonemic distinctions are reflected in the survey, but on other points the phonemic interpretation is deliberately left quite open (this is true, e.g., of quantity), and in principle what is given here is a relatively broad phonetic transcription of the "sounds" of the language rather than a phonemicization in a strict sense. A more penetrating and more comprehensive account must await the opportunity of the joint group to perform a systematic study of the entire bulk of data (including tape recordings in which all words and sentences elicited from our informants are said twice or mostly several times by each informant). It must be emphasized that the information given in this sketch is open to thorough revision as our work with the data proceeds.

In its contents, the present sketch reflects the joint work of the research group, but the presentation is coloured by the author's background as a phonetician without any schooling in Mon-Khmer linguistics. Thus the present author is alone responsible for the format of presentation (as well as possible errors in the wordforms given[3]). The more general emphasis of the project being on allround typology and genetic comparison (and hence also on lexicon), the present comments should, of course, not be taken as a real status report.

As for the general rhythm of the language there are two immediately striking features, viz. (1) the occurrence of pretonic syllables and (2) the differences in vowel length (and to some extent consonant length).

(1) The minimum rhythmical unit, which is also the typical structure of individual words (lexemes) consists of a stress-syllable with or without a preceding pretonic syllable ("minor syllable", "pre-syllable"), cf. [kɛh] 'goat-antelope (Nemorhaedus)', [kᵊnˈdiːŋ] 'navel', [r̩ˈphɛːp] 'butterfly'. The phonological structure of pre-syllables is typically strongly reduced compared to that of stress-syllables[4], even though a pre-syllable often reflects the phonological material of the following stress-syllable in a kind of reduplication, as in [ŋl̩ʔˈŋlɛʔ] 'neck', sometimes with a kind of weak tap occurring as a substitute for the full vowel: [kɾ̩lˈkiːl] 'knee'.

There are also several lexical items which contain more than one full-vowel syllable. In this case the last syllable seems to have always the main stress: [khiʔˈʔdɯːn] 'mygale (Melopaeus albostriatus)', [ɟakˈʔdaːr] '(species of) squirrel'. We are not yet sure about the relevance of degrees of stress (e.g. weak versus secondary stress) on the non-final syllable(s) of a word.

(2) Vowel-length is at least to a very considerable extent a function of rhythm, the vowels of final (strongly stressed) syllables being often extremely long, and the vowels of pre-syllables extremely short, whereas a range of intermediate length is found in other cases, e.g. in utterance-medial full-vowel syllables. The extreme duration of vowels in some utterance-final syllables constitutes one of the most striking phonetic characteristics of the language (also cf. Trier 1981), as does the brevity and reduction of some pre-syllables. - Consonants also occur with varying degrees of length but the differences are not nearly as striking as with vowels.

It is tempting to try to reduce not only stress but also vowel and consonant length to a non-phonemic status by assuming that the distribution of these prosodic features is a matter of position within the utterance (or phrase): a syllable occurring before a major break tends to have both stronger stress and longer duration than the preceding syllables. There is some support to the assumption that length is a feature of the syllable since there is in some cases a vacillation between pronunciations with a somewhat lengthened vowel and pronunciations with a somewhat lengthened syllable-final consonant. However, we have not so far been able to account for the variation and especially the more or less consistent differences in length we hear, cf. that there are lexical pairs like [diŋ] 'older sibling' versus [ʔdi:ŋ] 'gaur' or [pol] 'blanket' versus [po:l̥] 'barking deer'.

In the following, words that typically occur with a very long vowel or a long consonant are written accordingly (with [:]), and words with a sound which is variable or at least not short are sometimes written with half-length (i.e. [·]), but in view of the really rather puzzling variation we have encountered it does not make sense at this preliminary stage to try to arrive at a consistent transcription.

The vowels (in syllables that are not reduced) seem to form a symmetric pattern of 10 (or possibly 11) items, there being clearly four distinctive degrees of aperture and in the other "dimension" a distinction between a front-unrounded series, a mid/back-unrounded series, and a back rounded series:

i	ɯ	u
e	ɤ	o
ɛ	ʌ	ɔ
	a	

The uppermost row, viz. [i ɯ u], are comparable in "auditory height" (Ladefoged) to Cardinal Vowels no. 1 and no. 8 but are slightly lowered in comparison with these. The next row, [e ɤ o], are somewhat diphthongized half-close vowels whose final portion glides towards a closer vowel quality, perhaps especially in the case of [e] and [o] ([eᶥ], [oᵒ]). The row [ɛ ʌ ɔ] are rather open vowels in the range of Cardinal Vowels no. 3 and no. 6 or slightly more open.

We are not at present sure about the analysis of the "lower" end of the system: the range of variation associated with the item symbolized as [a] here, is quite large, and it cannot be excluded that there are two phonemes involved. Moreover, the boundary between [a] and [ʌ] is not quite easily drawn, especially with regard to unstressed syllables.

To the extent that a reduplicating pre-syllable exhibits any vowel at all that vowel is typically somewhat raised compared to the full vowel of the following syllable (unless the latter is a high vowel). Moreover, there is some colouring of the first vowel by the second, at least in terms of rounding. In this paper such vowels are rendered as a raised schwa.

Examples of the ten vowels are: [bri·ʔ] 'forest', [ʔje·k] 'bee', [twɛr:] 'rabbit', [ʔɯ:ŋ] 'bull-frog' (Thai word), [wɤ:k] 'water', [plʌ·k] 'to hiccup', [ju:k] 'rice', [co:k] 'big knife', [boŋ'bɔ:ŋ] 'big', [ba:k] 'to dig deeply'.

As for the consonants the inventory of contrastive single items is not uniquely defined (at this stage, at least) since a number of features such as aspiration, glottalization and prenasalization permit alternative analyses, i.e. in terms of unit phonemes or in terms of consonant clusters. In the presentation below the former approach is implied so that a maximum number of manners of articulation emerge (which seems immediately most informative from the point of view of phonetic typology).

It will be seen that there are four (clearly distinctive) places of articulation: labial, dental, prepalatal and velar, plus laryngeal in the case of [ʔ h]. There are four well-defined classes: stops, nasals, glides and liquids (laterals and trills); sibilants also occur, but these constitute a special problem (see later). The stops exhibit (at least) four manners of articulation: voiceless aspirated, voiceless unaspirated, plain voiced, and glottalized voiced (often implosive); the voiced:voiceless distinction is also found with nasals, glides and liquids, and the difference plain: glottalized is also found with glides.

The terms "glottalized" and "voiceless", as used here, must be further qualified. The glottalization in question is associated with the onset of the consonant, [ʔb ʔd] being fully voiced and often clearly implosive, and [ʔw ʔj] being likewise preglottalized and fully voiced. - Voicelessness in continuants is not in fact the same thing as voicelessness in stops. In articulatory terms it may be more meaningful to correlate the voiceless continuants with the aspirated than with the unaspirated voiceless stops (we have not had any possibility of investigating the production of any of these consonant types, however). Another thing, which complicates the analysis, is that we sometimes hear a very slight voiceless phase before or in the beginning of otherwise voiced continuants; it must be further investigated whether this is distinctive and what it reflects.

Phonetically it would be possible to add one more row of stops, viz. prenasalized voiced stops [^{m}b], etc.). However, even if these items are distinct from plain voiced stops it seems problematic to include them in the chart as long as we have not drawn a clear boundary line between material which reflects a reduced pre-syllable and material which uniquely belongs to the onset of the stress-syllable.

With these reservations in mind the initial consonants can be presented as follows, the slots that are marked off by parentheses representing items that might perhaps be expected from the point of view of pattern congruity, but which are not attested (or at least not safely attested) in the data considered so far:[5]

ph	th	ch	kh
p	t	c	k
b	d	ɟ	g
?b	?d	( )	( )
m̥	n̥	( )	ŋ̊
m	n	ɲ	ŋ
w̥		( )	
w		j	
?w		?j	
	l̥ ( )		
	l r		

and: ? h

The items rendered as [ch c] constitute the most confusing part of the whole consonant system. We hear a range of more or less affricated prepalatal or lamino-alveolar obstruents, and even true sibilants occur, most often with audible aspiration ([s^h], and the like). However, we have noted a considerable variation in the speech of each informant, as well as an idiolectic difference between our two main informants, and so far we do not find any basis for positing a contrast between a sibilant phoneme and the palatal stops. It is, however, worth noting that as phonetic entities sibilants occur quite frequently in this language (at least with some speakers).

Initially in pre-syllables the inventory of consonants is reduced. In this position we have noted an apparently free variation between voiced and voiceless stop articulation (this is not reflected in the transcriptions given here).

Syllable-finally (in syllables with a full vowel) there is only one (distinctive) series of stops and one series of nasals as well as glides, the inventory being as follows:

p	t	c	k
m	n	ɲ	ŋ
w		j	
		ɕ	
	l̥ ( )		
	l r		
		and:	? h

The most problematic items in this position are the continuants rendered as [ɕ] and [h]. The former is more or less sibilant in character and apparently palato-alveolar; a striking feature of this sound is its very lax articulation, which makes it sometimes resemble [h] after the high front vowel. In this position [h] has a somewhat [ç]-like quality, whereas after high back vowels it approaches [x].

The consonants tabulated above for initial and final position may be illustrated by the following words (note that, as stated above, the length marks do not reflect any attempt at notational consistency):

Stops, initial position:

[r̩'phɛ:p] 'butterfly', [tho:k] 'bamboo with big and long-jointed leaves (Bambusa tulda)', [che:?] 'head louse', [khi?'?dɯ:n] 'mygale', [po:l̥] 'barking deer', [ta:l] 'sun', [t(r̩)l'ce:l] 'mushroom', [ko:c]'large bamboo rat', [cə'bu:t] 'pig', [diŋ] 'older sibling', [ɟak] 'to go, walk', [ga:t] 'to tighten', [ᵐbra:w] 'coconut', [ⁿdrʌ·ʔ] 'to belch', [ᶮɟʌɕ] 'fragrant, strong', [ᵑgaɕ] 'nine', [ʔbʌ(·)n(·)] 'thick', [ʔdi:ŋ] 'gaur'.

Stops, final position:

[kɛp] 'stone', [tʌ'ka:t] 'to have fever', [ʔa:c] 'bird', [ɟak] 'to go, walk'.

Nasals, initial position:

[m̥ʌŋ] 'to bleed', [n̥ɛl·] 'rat', [ŋ̊u:h] 'to stay', [mʌ:ʔ] 'reticulated python', [no:l] 'lineated silver pheasant (Eu-poclamus lineatus)', [ɲa:k] 'tightly', [ŋa(·)m(·)] 'to listen'.

Nasals, final position:

[la(·)m(·)] 'tree', [ʔbʌ(·)n(·)] 'thick', [braɲ] 'dog', [jo:ŋ] 'male person'.

Glides, initial position:

[kom'w̥a:p] 'to yawn', [wɔ:k] 'spirit', [jo:ŋ] 'male person'.

Glides, final position:

[ᵐbra:w] 'coconut', [rwa:j] 'tiger'.

Liquids, initial position:

[l̥əŋ] 'bracelet', [le·h] 'to come', [ra:p] 'to run after'.

Liquids, final position:

[kra:l̥] 'species of squirrel', [ta:l] 'sun', [twɛr:] 'rabbit'.

Laryngeals, initial position:

[ʔul·] 'mousedeer (chevrotain, of the genus Tragulus)', [hot] 'to fall'.

Laryngeals, final position:

[mʌ:ʔ] 'reticulated python', [ŋ̊u:h] 'to stay'.

In addition to the "single" consonants and vowels tabulated and exemplified above the language exhibits a variety of consonant clusters and diphthongs. These will not be dealt with in the present sketch.

As a final remark it may be appropriate to point to the remarkable similarity of the sound system as sketched here with that posited for "Yumbri" by Smalley on the basis of Bernatzik's material (Smalley 1963). Thus the basic principles of his restatement, in which he drew heavily on typological comparisons with the phonologies of Mon-Khmer languages, seem to be corroborated.

ACKNOWLEDGEMENTS

We are grateful to the National Research Council of Thailand for permission to carry out this research, and to the provincial government and administration of Nan and its Welfare Department for the generous help we received throughout our fieldwork trip. We also gratefully acknowledge the financial support of the Danish Carlsberg Foundation and of the Scandinavian Institute of Asian Studies. Finally, we wish to express our indebtedness to our patient and singularly cooperative Mlabri informants, Mr. Ai Tha and Mr. Ai Thorng.

NOTES

1. It has not been shown with certainty to what extent the terms "Yumbri" and "Mrabri" refer to the same tribe and to the same language (which we assume to be the case).

2. We are very grateful to Dr. Jesper Trier, Moesgaard Museum (Denmark), who generously put his own tape recordings of the language at our disposal.

3. For technical reasons it was possible only to subject a first draft of this paper (which employed a somewhat different transcription) to scrutiny by all members of the research group.

4. As pointed out by Professor Therapan there is often a possibility of interpreting the consonants here treated as syllabic in a different way, viz. as the first element of a consonant cluster.

5. According to Professor Therapan a skewness in the consonant system similar to the one depicted here is quite normal in the case of preglottalized stops and voiceless sonorants in Mon-Khmer languages. Note also that it is phonetically very plausible that the system is richer with anterior articulation than with non-anterior articulation.

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Smalley, William A. 1963: "Notes on Kraisri's and Bernatzik's word lists", *Journal of the Siam Society vol. LI, Part 2,* p. 189-201

Trier, Jesper 1981: "The Khon Pa of Northern Thailand, an enigma", *Current Anthropology, vol. 22, No. 3,* p. 291-293.

INSTITUTE OF PHONETICS
JULY 1, 1981 - JUNE 30, 1982

I. PERSONNEL OF THE INSTITUTE

PROFESSOR:
Jørgen Rischel, dr.phil.

ASSOCIATE PROFESSORS:
Børge Frøkjær-Jensen, cand.mag. (seconded to the Audiologopedic Research Group)
Peter Holtse, cand.phil.
Birgit Hutters, cand.mag.
Niels Reinholt Petersen, cand.phil.
Nina Thorsen, lic.phil.
Oluf Thorsen, cand.mag.

TEACHING ASSISTANTS:
Michael Bundgaard, stud.mag.
Peter Molbæk Hansen, cand.mag.
Eva Rosenvold, cand.mag.

ENGINEERS:
Otto Bertelsen, M.Sc.
Preben Dømler, B.Sc.

TECHNICIAN:
Svend-Erik Lystlund

SECRETARY:
Else Parkmann

TEACHERS FROM OTHER INSTITUTES:
Niels Ege, mag.art. (Institute of Linguistics)

GUEST RESEARCHER:
Eli Fischer-Jørgensen, dr.phil.h.c.

II. PUBLICATIONS BY STAFF MEMBERS

Jørgen Rischel "Nogle komplicerende faktorer vedrørende verbers betoning i dansk", Arbejdspapirer II, Institut for Lingvistik, University of Copenhagen, 1981.

Jørgen Rischel "Greenlandic as a three-vowel language", Inuit Studies 5, Supplementary Issue, 1981, p. 71-80.

Jørgen Rischel "A note on diachronic data, universals and research strategies", Phonologica 1980, ed. W.U. Dressler, O.E. Pfeiffer & J.R. Rennison, 1981, p. 365-371.

Nina Thorsen "Sentence intonation in Danish", preprint for the Working Group on Intonation at the 13th International Congress of Linguistics, Tokyo 29.8.- 4.9. 1982, 10 pp.

Nina Thorsen and Oluf Thorsen Fonetik for Sprogstuderende, 3rd edition, 5th printing, Copenhagen 1982, 170 pp.

III. LECTURES AND COURSES

1. ELEMENTARY COURSES IN GENERAL PHONETICS AND LINGUISTICS

One semester course (two hours a week) in elementary general phonetics (intended for students of phonetics and linguistics) were given by Nina Thorsen in the autumn semester 1981.

Courses in general and German phonetics were given by Michael Bundgaard both in the autumn semester 1981 (one hour a week) and in the spring semester 1982 (two hours a week).

A course in general phonetics for students of Modern Greek (two hours a week) was given in the autumn semester 1981 by Eva Rosenvold.

A course in general phonetics for students of Italian (two hours a week) was given in the autumn semester 1981 by Peter Molbæk Hansen.

Courses in general and Russian phonetics (two hours a week) were given by Peter Molbæk Hansen both in the autumn semester 1981 and in the spring semester 1982.

An introductory course in general linguistics (two hours a week) was given in the autumn semester 1981 by Niels Ege.

2. PRACTICAL EXERCISES IN EAR-TRAINING AND PHONETIC TRANSCRIPTION

Based on tape recordings as well as work with informants, three semester courses of two hours a week were given as follows:

Beginners and advanced students, in the autumn semester 1981 by Oluf Thorsen.

Intermediate level, in the spring semester 1982 by Nina Thorsen.

3. PHONOLOGY

Courses in phonology (two hours a week) were given by Jørgen Rischel, for more advanced students in the autumn semester 1981, and for beginners in the spring semester 1982.

4. PHYSIOLOGY AND ACOUSTICS OF SPEECH

A course in the physiology of speech (two hours a week) was given in the autumn semester 1981 by Peter Holtse.

A course in instrumental physiological phonetics (two hours a week plus individual exercises) was given by Birgit Hutters in the spring semester 1982.

A course in instrumental acoustic phonetics (four hours a week plus individual exercises) was given in the autumn semester 1981 by Niels Reinholt Petersen.

5. OTHER COURSES

A course in statistics (two hours a week) was given by Niels Reinholt Petersen in the spring semester 1982.

Niels Reinholt Petersen presided at a series of seminars for advanced students on topics in experimental phonetics (two hours a week) in the spring semester 1982.

A course in auditory perception (one hour a week) was given by Peter Holtse in the spring semester 1982.

An introductory course in computer science (two hours a week) was given by Peter Holtse in the spring semester 1982.

A course titled "Nasality" (one hour a week) was given by Birgit Hutters in the spring semester 1982.

Courses in the phonetics and the phonology of particular languages (each two hours a week) were held as follows:

Danish, autumn semester 1981 by Nina Thorsen.

German, spring semester 1982 by Nina Thorsen.

Jørgen Rischel presided over a seminar (graduate level) on Danish diachronic phonetics/phonology (two hours a week) both in the autumn semester 1981 and in the spring semester 1982.

6. SEMINARS

Nina Thorsen gave a lecture on the present state of the description of Danish utterance prosody as the final examination for the philosophical licentiate degree.

Professor Björn Lindblom (University of Stockholm) gave two lectures titled: "Motor behaviour of speech - impressions from an interdisciplinary symposium" and "The biology of spoken language - linguistics and evolutionary theories".

Björn Granström and Sheri Hunnicut-Carlson (Royal Institute of Technology, Stockholm) lectured on "Text-to-speech synthesis of various languages".

Rolf Carlson and Björn Granström (Royal Institute of Technology, Stockholm) lectured on: "Experiments with a perceptually based sonagraph".

IV. PARTICIPATION IN CONGRESSES ETC.

Peter Holtse participated in a seminar on automatic speech recognition held in Copenhagen, October 13-14, 1981.

Birgit Hutters participated in a symposium on labial and palatal anomalies in Copenhagen, January 16-17, 1982, and gave a paper on: "Nasal airflow and velo-pharyngeal insufficiency". (To appear in Scandinavian Journal of Logopedics and Phoniatrics.)

Birgit Hutters visited the linguistic institute in Uppsala, March 30, 1982, and lectured on: "Fiberoptic and glottography in phonetic research" and on: "The glottal gesture in unvoiced obstruents".

Jørgen Rischel was president of the 14th Annual Meeting of Societas Linguistica Europaea, held in Copenhagen August 16-18, 1981.

Jørgen Rischel participated in the 2nd International Symposium on "Contact + Confli(c)t" at the Research Centre on Multilingualism, Bruxelles, June 2-5, 1982, and gave a paper on "Language Policy and Language Survival in the North-Atlantic Parts of Denmark". (To appear in the Proceedings of the Symposium.)

Nina Thorsen participated in a symposium on "Prosody and synthesis by rule" in Lund, September 18, 1981.

Nina Thorsen gave a paper on "The present state of the description of Danish utterance prosody" at the Annual Meeting of the Audiologopedic Association, March 19, 1982.

Nina Thorsen participated in European Psycholinguistic Association - Workshop on Prosody, held in Paris, April 21-23, 1982, and gave a paper on "Two issues in Standard Danish Prosody: the lack of sentence accent and the representation of sentence intonation".

V. INSTRUMENTAL EQUIPMENT OF THE LABORATORY

The following is a complete list of instruments available at the laboratory by the end of the first half of 1982.

1. INSTRUMENTATION FOR SPEECH ANALYSIS

   1 sonagraph, Kay Elemetrics, type 6061 A.
   1 sonagraph, Kay Elemetrics, type 7029 A.
   1 amplitude display/scale magnifier unit, Kay Elemetrics, type 6076 A.
   1 contour display unit, Kay Elemetrics, type 6070 A.
   1 fundamental frequency extractor ("Trans Pitchmeter")
   1 intensity meter (dual channel, with active variable highpass and lowpass filters)
   2 air-pressure manometers, Simonsen & Weel, type HB 66 (modified)
   1 photo-electric glottograph
   1 Fabre glottograph
   1 palatoscope with complete outfit for palatography
   1 segmentator, type PT.
   1 electro-aerometer, four channel, type AM 508/4
   1 audio frequency filter, type 445
   1 vocal cords fiberscope, Olympus, type VF
   1 fundamental frequency meter, type FFM 650
   2 intensity meters, Fonema
   2 fundamental frequency meters, Fonema

2. INSTRUMENTATION FOR SPEECH SYNTHESIS

   1 formant-coded speech synthesizer
   1 voice-source generator
   1 larynx vibrator with power supply.

3. FILTERS

   1 LC highpass filter (with stepwise variation of cut-off frequency)
   1 active RC lowpass filter

4. INSTRUMENTATION FOR VISUAL RECORDINGS

   1 mingograph, Elema 800 (8 channels)
   1 mingograph, Siemens-Elema, type 803.
   1 automatic frequency response and spectrum recorder, Brüel & Kjær, type 3332
   1 oscilloscope, Tektronix, type 465
   1 oscilloscope, Tektronix, type 5115
   2 oscilloscopes, Tektronix, type 564 storage

1 dual-trace amplifier, Tektronix, type 3A1
1 four-trace amplifier, Tektronix, type 3A74
1 dual-trace differential amplifier, Tektronix, type 3A3
1 time-base, Tektronix, type 3B3
1 time-base, Tektronix, type 2B67
2 dual-trace amplifiers, Tektronix, type 5A18N
1 time-base, Tektronix, type 5B10N.

5. TAPE RECORDERS

1 instrumentation recorder, Lyrec, type TR 86
1 professional recorder, Lyrec, type TR 42
2 professional recorders, Lyrec, type TR 20
10 semi-professional recorders, Revox, type A 77
1 professional recorder, Revox, type A 700
1 portable semi-professional recorder, Uher, type 4000
1 cassette recorder, Tandberg, type TCD 310 MK-2

6. GRAMOPHONES

2 gramophones, Delphon (mono, Ortofon pick-up)

7. MICROPHONES

1 microphone, Neuman, type KM 56
3 dynamic microphones, Sennheiser, type MD 21
1 1" microphone, Brüel & Kjær, type 4131/32
1 1/4" microphone, Brüel & Kjær, type 4135/36
1 larynx microphone
2 1" microphones, Brüel & Kjær, type 4145
1 microphone, power supply, Brüel & Kjær, type 2807
1 microphone, power supply, Telefunken.

8. AMPLIFIERS

1 microphone amplifier, Brüel & Kjær, type 2603
1 power amplifier, Brüel & Kjær, type 2706
2 microphone pre-amplifiers, Brüel & Kjær, type 2627
2 measuring amplifiers, Brüel & Kjær, type 2607 A
1 power amplifier, Nikko, type NA 590

9. LOUDSPEAKERS

10 headphones, Sennheiser, type 414
4 headphones, Sennheiser, type 424
2 headphones, Sennheiser, type 424 X
2 loudspeakers, Beovox, type M 70
8 loudspeakers, Philips, type RH 541 MFB

10. GENERAL PURPOSE ELECTRONIC INSTRUMENTATION

1 oscillator, Hewlett & Packard, type CD 200
1 function generator, Wavetec VGC III (0.003 c/s - 1 Mc/S)
1 frequency counter, Rochar, type A 1360 CH (5 digits)
2 vacuum-tube voltmeters, Brüel & Kjær, type 2409
1 vacuum-tube voltmeter, Radiometer, type RV 23b
1 DC millivoltmeter, Danameter, type 205
1 DC nanoammeter, Danameter, type 206
1 universal meter, Philips, type P 817
1 transistor tester, Taylor, model 44
1 Piston-phone, Brüel & Kjær, type 4220
1 component bridge C/L/R, Wayne Kerr, type B 522
1 AC automatic voltage stabilizer, Claude Lyons, type BTR-5F
4 resistance decades, Danbridge, type DR 4
1 condenser decade, Danbridge, type DK 4 AV
1 multi-generator, Exact, type 126 VCF
2 stabilized rectifiers, Danica, type TPS 1d
1 stabilized rectifier, Danica, type TPS 3c
1 impulse precision sound level meter, Brüel & Kjær, type 2204
1 attenuator set, Hewlett & Packard, type 350 D
1 band-pass filter set, Brüel & Kjær, type 1615
1 digital multimeter, Philips, type PM 2422
1 timer counter, Advance, type SC3
1 oscillator, Advance, type J2E
1 X-Y recorder, Hewlett & Packard, type 7044 A
1 noise generator, Brüel & Kjær, type 1405
1 stabilized rectifier, Danica, type TPS 21
1 capacitance meter, ECD Corp.
1 digital multimeter, Keitley, type 169
1 stabilized rectifier, Danica, type TBS 23A
Additional oscillators, rectifiers, etc., for special purposes.

11. OUTFIT FOR PHOTOGRAPHY

1 Minolta camera SR-1 (with various accessories)
1 complete outfit for reproduction
1 Telford oscilloscope camera, type "A" (polaroid)
1 timer, Kaiser, type 4033
1 enlarger, Durst, type A 300
1 rapidoprint, Agfa, type DD 1437
1 dry-machine, Durst, type 400

12. EQUIPMENT FOR EDB

1 computer, Digital, PDP8/E, 8k
1 arithmetic unit, Digital, type KE 8-E
1 bootstrap loader, Digital, type MR 8-EC
1 add-on memory system 24k, Fabri-Tek, type 8/E
1 dectape, Digital, type TD8-EM
1 tape reader, GNT, type 24
1 tape punch, GNT, type 34

1 decwriter, Digital, type LA 30P
1 teletype, Teletype, type ASR 33
1 display terminal, Tektronix, type 4014-1
1 real time clock, Digital, type DK8-EP
1 A/D converter, Digital, type AB8-EA
1 D/A converter, type PD
1 disk drive, Digital, type RK 8J-ED
1 disk drive, Plessey, type DD-8/B
1 line printer, Binder Magnete, type BM 132
3 CTR terminaler, Perkin-Elmer, type FOX 1100
1 highspeed plotter, Houston, type 12" DP-11
1 graphics tablet, Tektronix, type 4953
1 joystick, Tektronix, type 4952
1 computer, Digital, type PDP-11/60, 256k
2 disk drives, Digital, type RL02
1 analog real-time subsystem, Digital, type AR11-KT
1 8-line async. mux, Digital, type DZ11-A
1 CTR terminal, Digital, type VGT-100
1 printer, Centronics, type 739-4B
1 disk drive, Priam, type 15450
1 tape transport, Cipher, type F880.

13. INSTRUMENTATION FOR VIDEO

1 video camera, Sony, type AVC-3250 CES
1 video monitor, Barco, type CRM 2032
1 video camera, JAI, type JAI 810
1 video monitor, JAI, type JAI 710 A.

14. PROJECTORS

1 Leitz projector for slides.
1 16 mm tone film projector, Bell & Howell, "Filmsound 644"
1 projector, Leitz, type Pradovit color 250.