

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 (F_0) 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/ F_0 relationship. The decisiveness, under certain circumstances, of the timing of F_0 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 (F_0) 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

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

1979, 1980a, and forthcoming a). I shall be concerned in this paper with F_0 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 F_0 , 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, Berinsein (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 F_0 , 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. F_0 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 Berinsein, the hierarchy for the perception of stress would be: F_0 , intensity, duration. I do not wish to dispute the primacy of F_0 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: F_0 , 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 syl-

ables 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/F₀ RELATIONSHIP

Authors are not always very specific as to the generality of the stress/F₀ 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 F_0 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 F_0 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 F_0 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/ F_0 relation may be seen as differences of timing. In a pilot experiment (Thorsen and Nielsen, 1981) designed to investigate the stress/ F_0 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 F_0 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

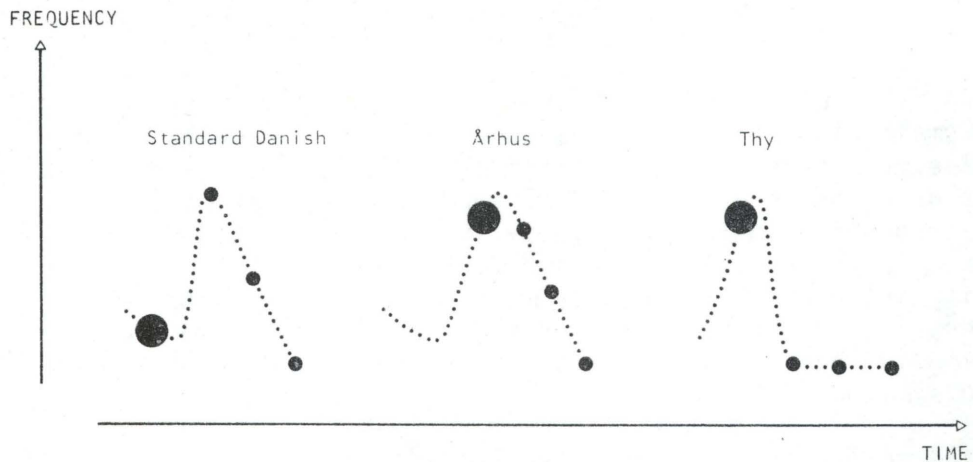


Figure 1

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 F_0 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 F_0 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 F_0 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 F_0 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 F_0 contour, i.e. the more elaborate the F_0 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).

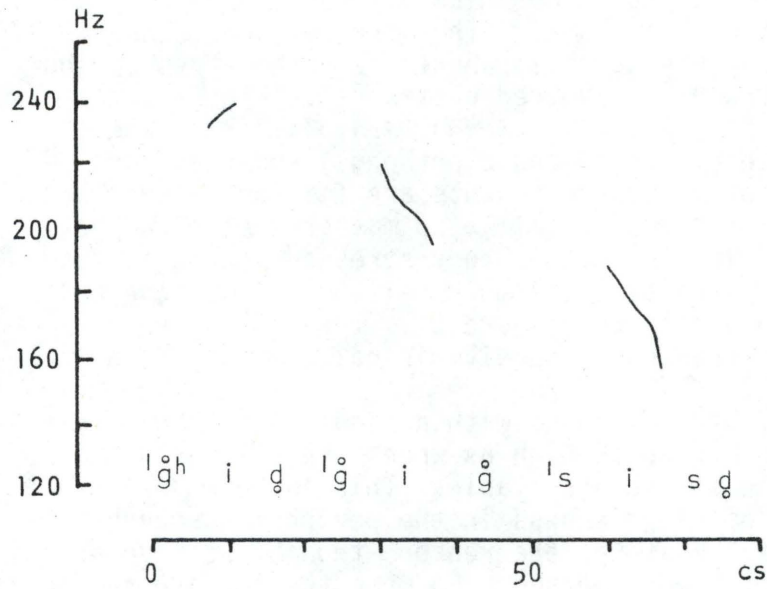


Figure 2

Fundamental frequency tracing of an utterance
Kit gik sidst. Female subject.

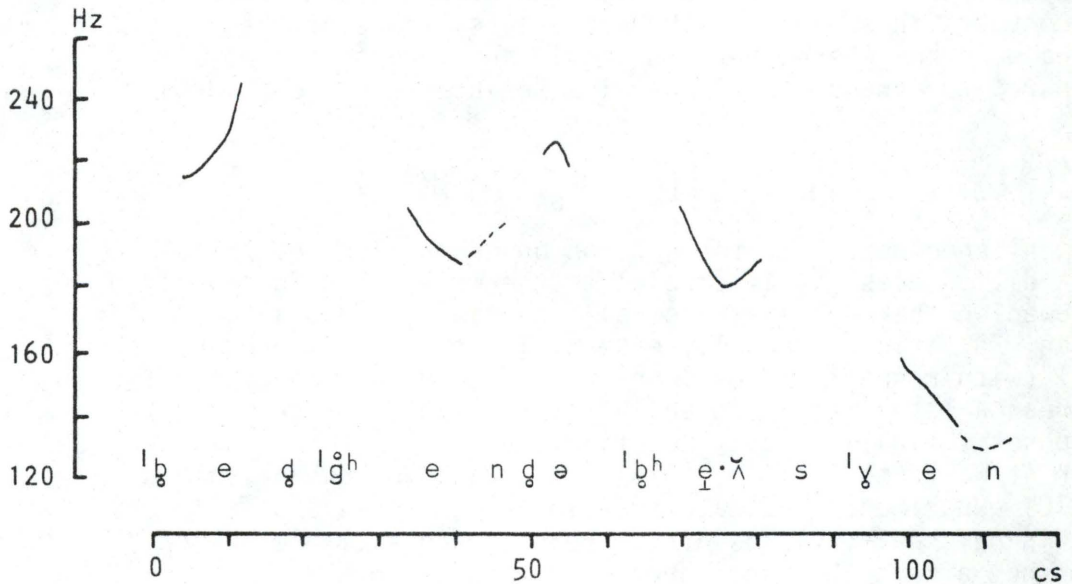


Figure 3

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

Thorsen (1980b) contains arguments and data in favour of a hypothesis of truncated rather than compressed F_0 patterns in Standard Danish, and an illustration will suffice here.

Figure 2 shows the course of F_0 in an utterance *Kit gik sidst*. (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 F_0 in the utterance *Beth kendte Pærs ven*. (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 F_0 when the two are in conflict, i.e. rather than stretch the duration of the post-tonic to make time for a complete F_0 rise, the F_0 movement is shrunk (Thorsen, 1980a). However, these incomplete rises are far from being the rule, so the sluggishness can clearly be counter-balanced. (I should also think that style of speech - distinct versus less distinct - plays a major role here.) Such 'active control' of F_0 production becomes evident in utterances with emphasis for contrast which have considerably more elaborate F_0 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 F_0 rises and falls be timed appropriately. In Dutch, F_0 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 F_0 movement. When words like *billigst - bilist* [¹bi:li:q̥ - bi¹li:q̥] (cheapest - motorist) are

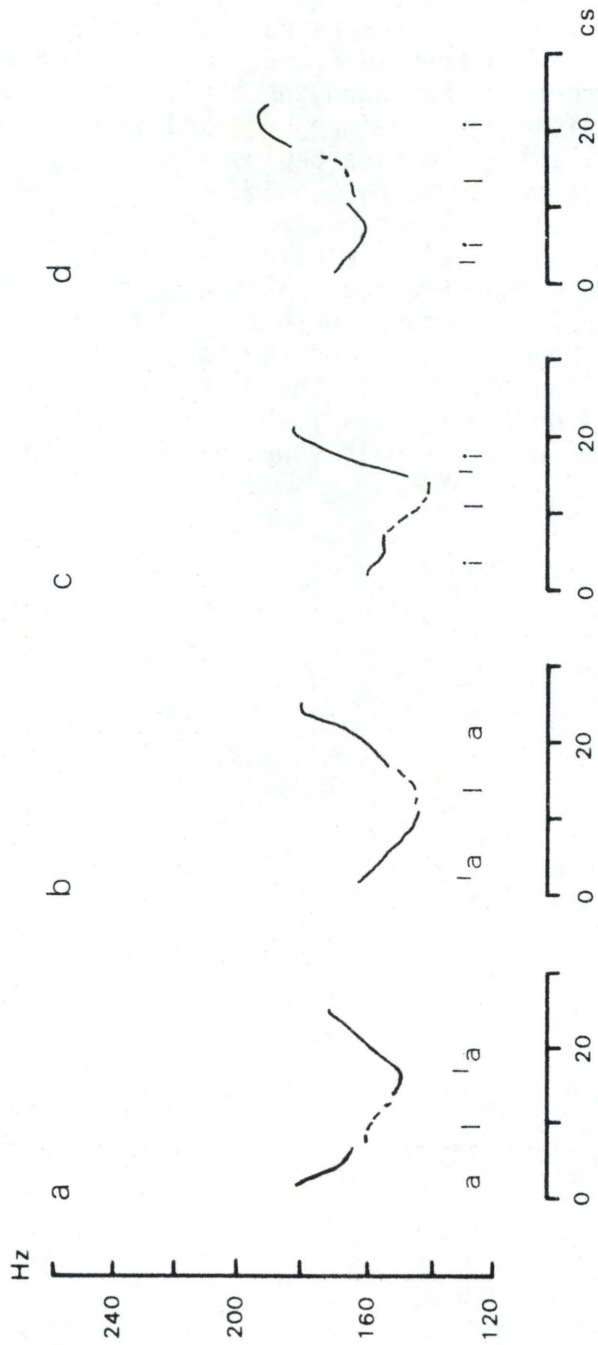


Figure 4

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

pronounced in isolation or preceded exclusively by unstressed words, both will have an F_0 rise from the first to the second syllable, *billigst* because this is the normal pattern on a stressed plus post-tonic syllable, and *billst* 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 *billigst* - *billst*, uttered in an unstressed frame. Eli Fischer-Jørgensen writes of this word-pair that when the stress is on the first syllable, the F_0 rise begins before [i], and when the stress is on the last syllable, the rise begins after [i]. Figure 4 depicts F_0 tracings of two pairs, *paláds* - *bállast* [*b^ha¹las - 'b^halasq*] (palace - ballast) and *billst* - *billigst*, 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, [i] continues the falling movement in the preceding pre-tonic vowel and when stress is on the first syllable, [i] initiates the rise on the succeeding post-tonic vowel. The turning points

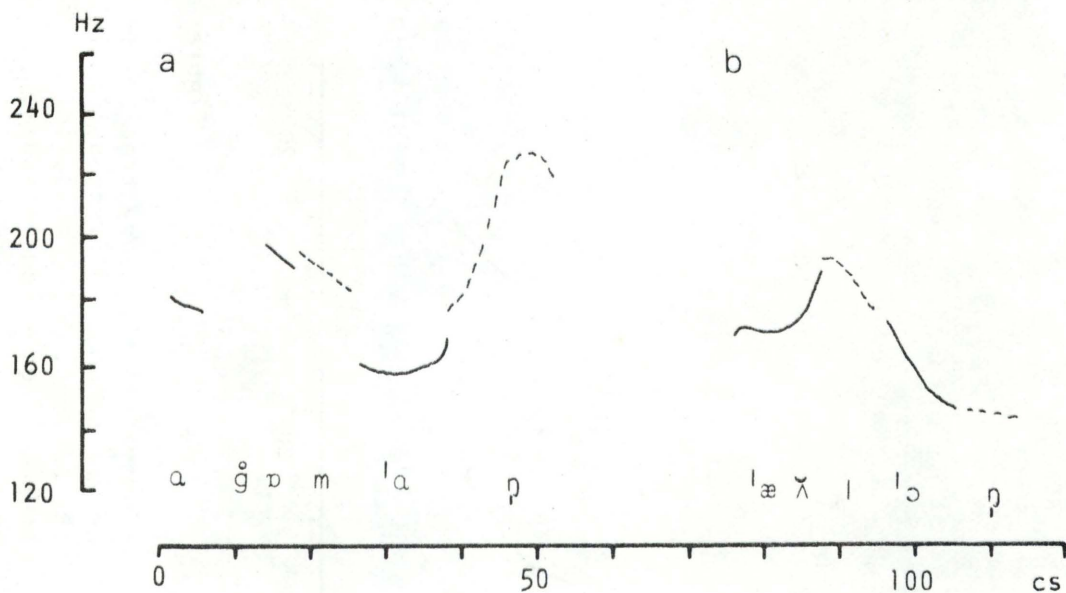


Figure 5

Fundamental frequency tracings of (a) the capitalized passage of an utterance *DER GÅR MÅNGE bússer fra Tiflis.* with contrast emphasis on *månge*, 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 mange (bússer fra Tiflis.)* (There are many buses out of Tiflis. - with contrast emphasis on *mange*), the [m] seems to associate tonally with the preceding unstressed sequence. The second example is even stranger: In *(Dén øl) ér lín(ken)*. (That beer is tepid.), the [l] from *línken* 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 F₀ TIMING IN DANISH

In order to see whether the difference in F₀ 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 [bilisɔ] sequence which with a monotone F₀ was as good a hybrid of *billigst* and *bilíst* as possible. See the spectrogram 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 *billigst*.) [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 F₀ 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 Chafkoulouff 1977 and von Békésy 1960, p. 463), one stimulus (a) 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 (b) had an [l] of

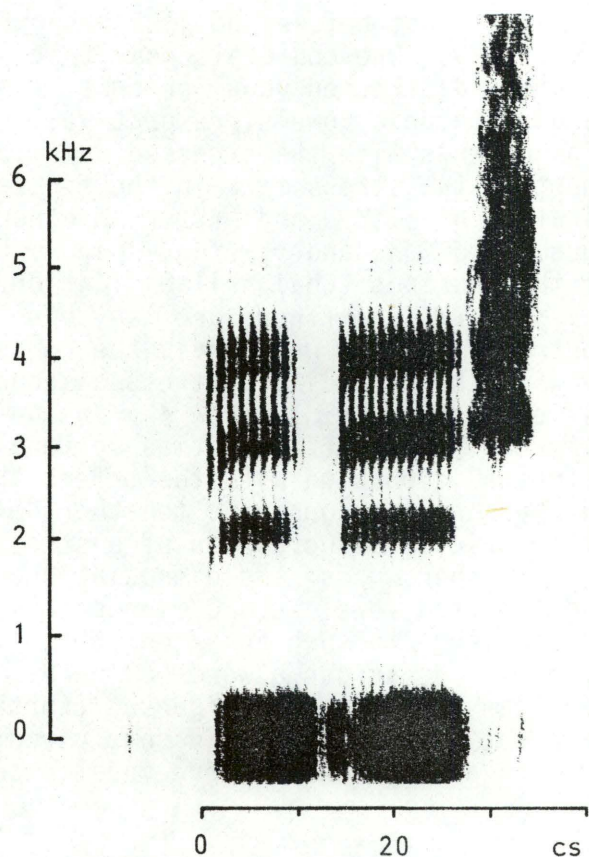


Figure 6

Spectrogram of a synthesized disyllabic sequence [b̥ilis̥d̥].

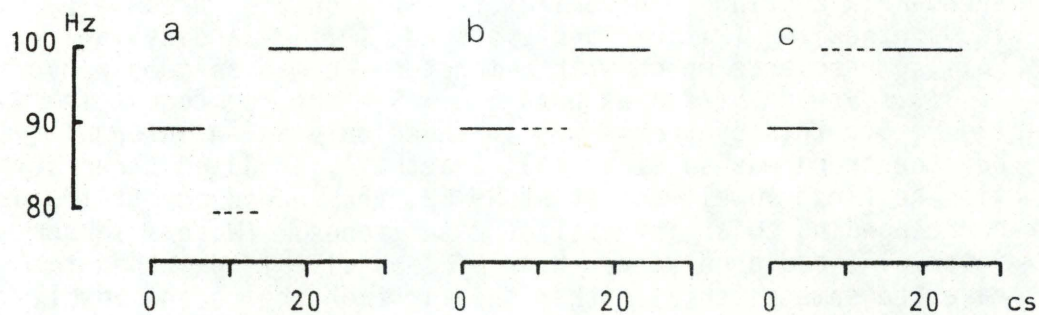


Figure 7

Stylized F_0 contours in three synthesized disyllabic sequences [b̥ilis̥d̥], 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 [l] 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 [l] 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.

	Stimulus <u>a</u>	<u>b</u>	<u>c</u>
Response			
<i>billigst</i>	29 = 15.5%	59 = 31.6%	163 = 92.6%
<i>bilist</i>	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.

REFERENCES

- Abercrombie, D. 1964: "Syllable quantity and enclitics in English", In: *In Honour of Daniel Jones* (eds.: Abercrombie, D., Fry, D.B., MacCarthy, P.A.D., Scott, N.C., and Trim, J.L.M.) (Longmans, London), p. 216-222.
- Bannert, R. 1982a: "Temporal and tonal control in German", *Working Papers, Department of Linguistics and Phonetics, Lund University* 22, p. 1-26.
- Bannert, R. 1982b: "An Fo-dependent model for segment duration?", *Reports from the Institute of Linguistics, Uppsala University* 8, p. 59-80.
- Basbøll, H. 1968: "The phoneme system of Advanced Standard Copenhagen", *Ann. Rep. Inst. Phon. Univ. Copenhagen* 3, p. 33-54.
- von Békésy, G. 1960: *Experiments in Hearing*, (McGraw-Hill, New York).
- Berinstein, A.E. 1979: "Stress". *Working Papers, University of California, Los Angeles* 47, p. 1-59.
- Bolinger, D.L. 1958: "A theory of pitch accent in English", *Word* 14, p. 109-149.
- Bolinger, D.L. 1970: "Relative height", In: *Prosodic Feature Analysis* (eds.: Léon, P., Faure, G., and Rigault, A.) (Marcel Didier, Paris), p. 109-125. Also in: *Intonation* (ed.: Bolinger, D.) (Penguin Books, Harmondsworth), 1972, p. 137-153.
- Botinis, A. 1982: "Stress in Modern Greek: An acoustic Study", *Working Papers, Department of Linguistics and Phonetics, Lund University* 22, p. 27-38.
- Brown, G., Currie, K.L. and Kenworthy, J. 1980: *Questions of Intonation*, (Croom Helm, London).

- Bruce, G. 1977: *Swedish word accents in sentence perspective*, Travaux de l'Institut de Linguistique de Lund 12.
- Bruce, G. 1982: "Developing the Swedish intonation model", *Working Papers, Department of Linguistics and Phonetics, Lund University* 22, p. 51-116.
- Bruce, G. and Gårding, E. 1978: "A prosodic typology for Swedish dialects", In: *Nordic Prosody* (eds.: Gårding, E., Bruce, G. and Bannert, R.) (Department of Linguistics, Lund University), p. 219-228.
- Carlson, R., Erikson, Y., Granström, B., Lindblom, B. and Rapp, K. 1974: "Neutral and emphatic stress patterns in Swedish", *Preprints from Speech Communication Seminar, Stockholm, Aug. 1-3, vol. II*, p. 209-218.
- Collier, R. and 't Hart, J. 1978: *Cursus Nederlandse Intonatie*, (Wetenschappelijk Onderwijs Limburg, Diepenbeek).
- di Cristo, A. and Chafkoulouff, M. 1977: "Les faits microprosodiques du français: voyelles, consonnes, coarticulation", *8^{es} Journ. d'étude sur la parole, Aix-en-Provence, vol. I*, p. 147-158.
- Dyhr, N.J. 1980: "A pilot investigation of the Fo pattern in American English", *Ann. Rep. Inst. Phon. Univ. Copenhagen* 14, p. 95-99.
- Erikson, Y. 1973: "Preliminary evidence of syllable-locked temporal control of Fo", *Speech Transm. Lab. Q. Progr. Status Rep., R. Inst. Technol. Stockh.* 2-3, p. 23-30.
- Fant, L. 1980: "Functions of sentence prosody and word order in European Spanish", *Reports from Uppsala University, Department of Linguistics* 6, p. 1-124.
- Fischer-Jørgensen, E. forthcoming: "Segment duration in Danish words and its dependency on higher level phonological units", will also appear in *Ann. Rep. Inst. Phon. Univ. Copenhagen* 16 (1982).
- Fry, D.B. 1958: "Experiments in the perception of stress", *Language and Speech* 1, p. 126-152.
- Halliday, M.A.K. 1967: *Intonation and Grammar in British English*, (Mouton, The Hague).
- 't Hart, J. and Cohen, A. 1973: "Intonation by rule: A perceptual quest", *J. Phonetics* 1, p. 309-327.
- 't Hart, J. and Collier, R. 1975: "Integrating different levels of intonation analysis", *J. Phonetics* 3, p. 235-255.
- Hombert, J.-M. 1978: "Consonant types, vowel quality, and tone", In: *Tone - A Linguistic Survey* (ed.: Fromkin, V.) (Academic Press, New York), p. 77-111.

- Isačenko, A. and Schädlich, H.-J. 1970: *A model of Standard German Intonation*, (Mouton, The Hague).
- Janota, P. 1979: "Some observations on the perception of stress in Czech", *Proc. 9th Int. Cong. Phon. Sc.*, vol. II, (Institute of Phonetics, Univ. Copenhagen), p. 403-409.
- Klein, W. 1980: "Der Stand der Forschung zur deutschen Satzintonation", *Linguistische Berichte* 68, p. 3-33.
- Kohler, K. 1977: *Einführung in die Phonetik des Deutschen*, (Erich Schmidt Verlag, Berlin).
- Lehiste, I. 1978: *Suprasegmentals*, (M.I.T. Press, Cambridge, Mass.).
- Lieberman, P. 1960: "Some acoustic correlates of word stress in American English", *J. Acoust. Soc. Am.* 32, p. 451-454.
- Lyberg, B. 1981: "Some observations on the vowel duration and the fundamental frequency contour in Swedish utterances", *J. Phonetics* 9, p. 261-272.
- Ohalá, M. 1977: "Stress in Hindi", In: *Studies in Stress and Accent, Southern California Occasional Papers in Linguistics* 4 (ed.: Hyman, L.) (Department of Linguistics, University of Southern California, Los Angeles), p. 327-338.
- Öhman, S.E.G. 1965: "On the coordination of articulatory and phonatory activity in the production of Swedish tonal accents", *Speech Transm. Lab. Q. Progr. Status Rep. R. Inst. Technol. Stockh.* 2, p. 14-19.
- Rischel, J. 1968: "Notes on the Danish vowel pattern", *Ann. Rep. Inst. Phon. Univ. Copenhagen* 3, p. 177-205.
- Rischel, J. forthcoming: "On unit accentuation in Danish and the distinction between deep and surface phonology", *Folia Linguistica* 17.
- Rischel, J. and Lystlund, S.-E. 1979: "The IPUC speech synthesizer", *Hamb. phon. Beitr., Misc. IV* (= Band 22), p. 143-160.
- Tevajärvi, K. 1982: "Intonation in Finland Swedish: word and sentence stress in the Helsinki dialect", *Working Papers, Department of Linguistics and Phonetics, Lund University* 22, p. 175-180.
- Thorsen, N. 1978: "An acoustical analysis of Danish intonation", *J. Phonetics* 6, p. 151-175.
- Thorsen, N. 1979: "Interpreting raw fundamental frequency tracings of Danish", *Phonetica* 36, p. 57-78.

- Thorsen, N. 1980a: "Neutral stress, emphatic stress, and sentence intonation in Advanced Standard Copenhagen Danish", *Ann. Rep. Inst. Phon. Univ. Copenhagen* 14, p. 121-205.
- Thorsen, N. 1980b: "A study of the perception of sentence intonation - Evidence from Danish", *J. Acoust. Soc. Am.* 67, p. 1014-1030.
- Thorsen, N. forthcoming a: "Standard Danish sentence intonation - Phonetic data and their representation", *Folia Linguistica* 17.
- Thorsen, N. forthcoming b: "Two issues in the prosody of Standard Danish: the lack of sentence accent and the representation of sentence intonation", to appear in the proceedings from the *European Psycholinguistic Association Workshop on Prosody, Paris 21-23 April 1982*. (Also in this volume.)
- Thorsen, N. and Nielsen, B. Jul 1981: "Fundamental frequency patterning and sentence intonation in two Jutlandic dialects - A first approach", *Ann. Rep. Inst. Phon. Univ. Copenhagen* 15, p. 1-12.